FINAL REPORT

Demonstration of the Replacement of the Dyes and Sulfur in the M18 Red and Violet Smoke Grenades

ESTCP Project WP-0122

SEPTEMBER 2008

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-01-0188

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1. REPORT DATE *(DD-MM-YYYY)*
10 September 2008

2. REPORT TYPE
Final Technical

3. DATES COVERED *(From - To)*
2002-2008

4. TITLE AND SUBTITLE
Final Technical Report Demonstration of the Replacement of the Dyes and Sulfur in the M18 Red and Violet Smoke Grenades

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHORS
Springer, Dr. Mark L.; Tamera Rush, Howard M. Beardsley, Kimberly Watts and Jeffrey Bergmann

5d. PROJECT NUMBER
ESTCP #WP-0122

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
USAEC, ATTN: IMAE-RTA, APG, MD 21040-5401

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
USAEC
ATTN: IMAE-RTA
Aberdeen Proving Ground, MD 21040-5401

10. SPONSOR/MONITOR'S ACRONYM(S)
USAEC, ESTCP

11. SPONSOR/MONITOR'S REPORT NUMBER(S)
IMAE-RTA-2008001

12. DISTRIBUTION/AVAILABILITY STATEMENT
Public Release

13. SUPPLEMENTARY NOTES
Project participants/contributors included: PBA, ECBC, USACHPPM &PM-CCS.

14. ABSTRACT

This report covers the results of the prototyping, limited production of red and violet smoke grenades and the toxicity testing of the current and prototype violet smoke grenades. This prototyping and limited production included the substitution of the sulfur with sugar (Fuels) and the substitution of the Disperse Red 9 and DDA with Disperse Red 11 and Terephthalic Acid. The toxicity testing including the testing of the current violet smoke grenade and the prototype violet smoke grenade. Red smoke grenades failed the testing phase of the limited production and were dropped from further testing.

15. SUBJECT TERMS
Smoke Colored Smoke Red Smoke Violet Smoke Sugar Sulfur DDA
Disperse Red 9 Disperse Red 11

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Howard M. Beardsley
UC	UC	UC	UC	89	19B. TELEPHONE NUMBER *(Include area code)* (410) 297-2528

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

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List of Acronyms and Symbols

ACE	Army Corps of Engineers
ACSIM	Assistant Chief of Staff for Installation Management
AECTP	Allied Environmental Conditions and Test Publication
ANSI	American National Standards Institute
APG	Aberdeen Proving Ground
ATC	Aberdeen Test Center
CAA	Clean Air Act
CEM	Continuous Emissions Monitoring
CFR	Code of Federal Regulators
cm	centimeter
DETP	Detailed Environmental Test Plan
DMO	Division Management Office
DoD	Department of Defense
DoDD	Department of Defense Directive
DoDIC	Department of Defense Identification Code
DoDISS	Department of Defense Index of Specifications and Standards
D&C	Drug and Cosmetic
DPG	Dugway Proving Ground
DTC	Developmental Test Command
DTP	Detailed Test Plan
ECBC	Edgewood Chemical Biological Center
ECC	Emission Characterization Chamber
ECP	Engineering Change Proposal
EDT	Engineering Design Test
EEMP	Environmental Engineering Management Plan
EES	Environmental Engineering Specialists
EICL	Environmental Issues/Criteria List
EMI	Electromagnetic Interference
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPCRA	Emergency Planning and Community Right to Know Act
ESS	Environmental Stress Screening
ESTCP	Environmental Security Technology Certification Program
ETEMP	Environmental Test and Evaluation Master Plan
ETR	Environmental Test Report
FDA	U.S. Food and Drug Administration
FD&C	Food, Drug, and Cosmetic
FTIR	Fourier Transform Infrared Spectroscopy
GC/FID	Gas Chromatography with Flame Ionization Detection
GC/MS	Gas Chromatography/Mass spectroscopy
HAZMAT	Hazardous Materials
HASP	Health & Safety Plan
HC	Hexachloroethane
IPT	In-Process Team
ISO	International Organization for Standardization
ITOP	International Test Operation Procedure
LCEP	Life Cycle Environmental Profile

LSC	Library Search Compound
LVOSS	Light Weight Vehicle Obscuration Smoke System
MAIS	Major Automated Information System
MDAP	Mandatory Procedures for Major Defense Acquisition Program
MIDAS	Munitions Items Disposition Action System
MIL-HDBK	Military Handbook
MIL-STD	Military Standard
MILSPECS	Military Specifications
mm	Millimeter
MMR	Massachusetts Military Reservation
MNS	Mission Need Statement
MSA	Mine Safety Appliance
NATO	North Atlantic Treaty Organization
NCSL	National Conference of Standards Laboratories
NDI	Non-development Item
NEPA	National Environmental Policy Act
NIOSH	National Institute of Safety and Health
NSNs	National Stock Numbers
OB/OD	Open Burn/Open Detonation
OED	Operational Environment Documentation
OEDP	Operational Environment Documentation Plan
OEDR	Operational Environment Documentation Report
ORD	Operational Requirements Document
PAHS	Poly-Aromatic Hydrocarbons
PBA	Pine Bluff Arsenal
PEL	Production Engineering Laboratory
PM_{10}	Particulate Matter (less than 10 microns)
$PM_{2.5}$	Particulate Matter (less than 2.5 microns)
PM-CCS	Program Manager – Close Combat System
PM-MAS	Program Manager – Maneuver Ammunition System
ppm	Parts Per Million
PQT	Product Quality Test
PT	Part Time
PVT	Production Validation Test
QA/QC	Quality Assurance/Quality Control
QSTAG	Quadripartite Standardization Agreements (American, British, Canadian, and Australian)
RCRA	Resource Conservation and Recovery Act
RDECOM	Research, Development and Engineering Command (formerly (SBCCOM))
SAMP	Systems Acquisition Management Plan
SBCCOM	Soldiers Biological Chemical Command
sec	Seconds
SOP	Standard Operating Procedure
STANAG	Standardization Agreements (NATO)
SVOCS	Semi-Volatile Organic Compounds
TA	Terephthalic Acid
TA/PE	Terephthalic Acid/Pentaerythritol
TD	Test Director
TDP	Technical Data Package
TECOM	Test and Evaluation Command

TEMP	Test and Evaluation Master Plan
TIC	Tentatively Identified Compounds
TSP	Total Suspended Particulates
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
USAEC	U.S. Army Environmental Center (often referred to as AEC)
VOC	Volatile Organic Compounds
WDTC	West Desert Test Center

Acknowledgements

We gratefully acknowledge the Environmental Security Technology Certification Program (ESTCP) for their financial support and encouragement in the effort to replace the sulfur, dyes and other parts of the red and violet colored smoke grenades used by Pine Bluff Arsenal (PBA).

The authors would like to thank the following organizations for their time and effort in preparing, demonstrating, collecting data, writing reports and reviewing the information collected for validity and accuracy:

- USAEC;
- PBA;
- ECBC;
- USACHPPM.

We also want to acknowledge that this program is just the beginning. The efforts put forth by the Smoke and Dye In-Process Team (IPT) created by the Program Manager – Close Combat System (PM-CCS) have been instrumental in furthering this program. The Smoke and Dye IPT and their respective members have provided many valuable tips and information that have been used in this report. The accomplishments of this project would not have been possible without the enthusiasm and support from these individuals and their respective organizations. PM-CCS was provided a copy of this report for their review and comments. PM-CCS has not provided any official comments.

Abstract

The objective of this demonstration project was to combine existing technology from the M18 green and yellow smoke grenades and the M83 smoke grenade, and use this combined technology for the replacement of dyes, sulfur and other components of the M18 red and violet smoke grenades. The substitution of a sugar-chlorate formulation smoke, as well as less toxic dyes, was successfully implemented for green and yellow M18 smoke grenades and for red, green, and yellow 40MM projectiles. The red 40mm smoke grenade was also successfully transitioned to new materials. Similar changes to the red and violet M18 smoke grenades initially proved unsuccessful due to excessive burning of the dyes, which resulted in failure of the items to meet military standards for signaling. Later, with funding provided by ESTCP, reconfiguration of the red and violet M18 smoke grenades using redesigned starter patches proved more effective. The idea to use the redesigned starter patches was based on the M90 Light Vehicle Obscuration Smoke System (LVOSS) grenade. The LVOSS grenade was fitted with a new starter patch in order to control burning, similar to the method used in red and violet M18s. The patch slowed the starter mixture's contact with the smoke mix, thus allowing the temperature of the mixture to decrease, eliminating excessive flaming. This process was successful for both smokes. However, the transition to the red was not successful due to the coloration of the smoke being less red than desired.

Toxicity testing of the current smoke formula for the violet smoke grenade (DODIC G955) and the new ESTCP formulation was completed (Appendix J). Eleven of twenty four rats died during testing of the emissions from the current violet smoke grenade while none of the rats died from the new ESTCP formulation for the violet smoke grenade. The toxicity testing standards used for this test should be adopted as the standard for future testing of military type signaling smokes but should not be adopted for obscuration type smokes because of the differences in use.

Testing of the M18s was conducted in accordance with Military Standard (MIL-STD) 810F at Pine Bluff Arsenal (PBA) in Arkansas, the Department of Defense's (DoD's) manufacturing facility for smoke grenades (see Reference 1).

1. Introduction

1.1 Background

In September 1997, the Chief of Staff of the Army directed the Assistant Chief of Staff for Installation Management (ACSIM) to establish a General Officer Steering committee to address the implications of the restrictions on operations at Massachusetts Military Reservation (MMR). The ACSIM directed and funded the U.S. Army Environmental Center (USAEC) to gather emissions data. The USAEC has developed a comprehensive program to identify the emissions resulting from range operations that involve weapons firing, smoke and pyrotechnic devices, and exploding ordnance, and to assess the environmental and health hazard impacts resulting from their use. In the execution of the program, it has identified four items (two of the colored smoke grenades, one white smoke grenade and one of the smoke pots) that contain and emit toxic and carcinogenic compounds in significant quantities. These smokes/dyes may present a risk to the soldier, to nearby receptors, and to production and test personnel, especially with regard to the hexachloroethane (HC) filled grenades. It is in the best interest of the Army and Department of Defense (DoD) to demonstrate and implement a material substitution for the dyes, smokes, fills and starter patches in these specific munition items. Several alternative materials have been identified. Under this project, the functional and operational capabilities of these items with the alternative (less toxic) dye and smoke materials will be validated prior to their implementation. Replacement has been implemented in other colored grenades, but due to excessive flaring and inadequate burn rates, replacement has not occurred in the grenades to be changed under this project.

1.2 Objectives of the Demonstration

The objective of this demonstration was to validate alternative materials/products so that they may be written into new MILSPECS, including modified formulations of the smoke grenades to be used in manufacturing. The proposed effort provided production and testing of material substitutions for two smoke munitions items that are considered essential to Army training operations. The four material replacements are for: (1) the red dye in M18 Red Grenade, (2) the violet dye in the M18 Violet Grenade, (3) an evaluation of the starter patches for use in the colored smoke grenades, and (4) replacement of sulfur with sugar. The production of the replacement for HC will not be part of this demonstration plan, but the success of the starter mixtures and patches will ensure the technical success of the replacement of the HC mixtures in the munitions containing HC.

Demonstration of this program will introduce safer smoke munitions for the soldiers in training and active service. This demonstration included the survey, testing and manufacturing of test, pilot and production type runs of these munitions (Red and Violet Smoke Grenades) to ensure they met the specifications of their predecessors and the safety requirements for our soldiers to use them safely during training and also in active service.

1.3 Regulatory Drivers

- RCRA – Resource Conservation and Recovery Act, 1976
- CERCLA – Comprehensive Environmental Response, Compensation and Liability Act, 1980
- CWA – Clean Water Act, 1972
- CAA – Clean Air Act, 1970
- PPA – Pollution Prevention Act, 1990
- Executive Order 12856, 1994
- EPCRA – Emergency Planning and Community Right-to-Know Act, 1986

1.4 Stakeholder/End-User Issues

The program is intended to make the material change completely transparent to the end-users (soldiers). The ammunition was tracked by the Military Services by utilizing National Stock Numbers (NSNs) and Department of Defense Identification Codes (DODIC) numbers. Labels identifying "reduced sulfur smoke grenades" were placed on the wire bound boxes, metal cans, and fiberboard-packing containers. The demonstration plan encompassed two main areas:

- The First Article test/standard lot testing for the corresponding smoke grenade; and
- A smoke grenade based qualification test.

Upon completion and attainment of toxicity test requirements, an Engineering Change Proposal (ECP) was submitted to the Configuration Control Board (CCB) for approval. The CCB makes the final determination as to whether the grenade meets all of the necessary requirements. The CCB is also responsible for determining whether the grenade meets the standards of the Technical Data Package (TDP) for procurement. Once approved for production and distribution, the grenade will replace the current M18 violet smoke grenade.

2. Technology Description

2.1 Technology Development and Application

The M18 colored smoke grenade as currently configured consists of a metal can and lid, which holds a mechanically initiated fuze. It is 11.84-cm (4.66-inch) high and 6.3 cm (2.48 inch) in diameter excluding the fuze. A pull pin is hinged through the fuze lever, preventing premature initiation. The output of the fuze ignites a starter slug, which in turn ignites the smoke mix fill. After a delay of approximately 15 seconds, smoke is emitted from a ½ inch core hole for 50 to 90 seconds. (See Figure 1)

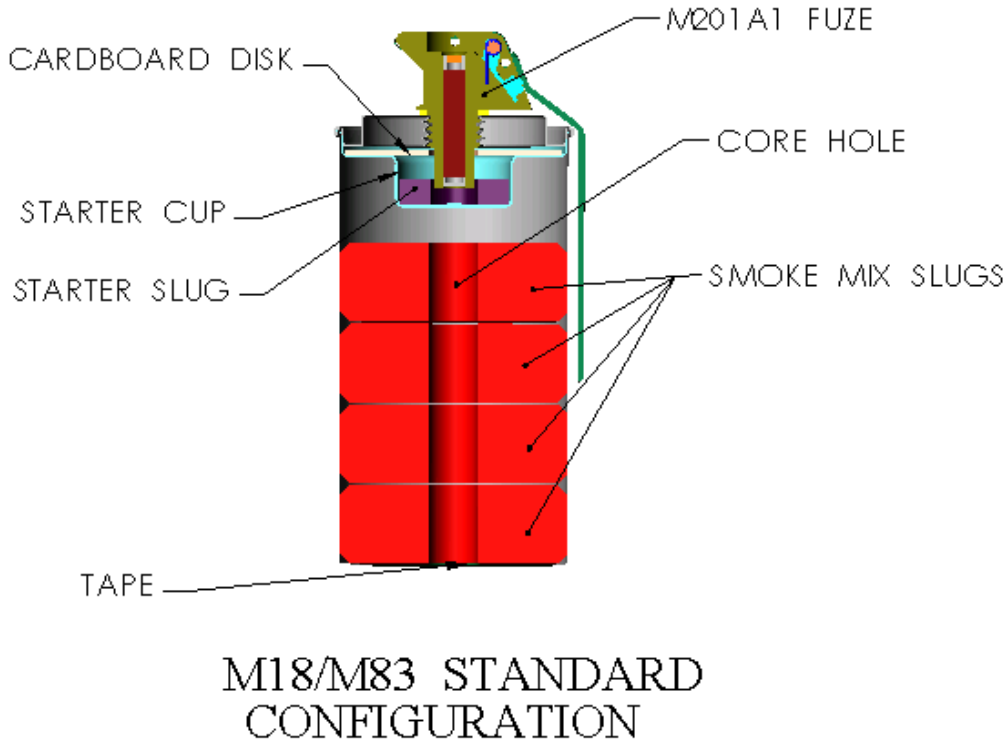

Figure 1 – M18 Grenade

In the current configuration, the green and yellow smoke mixes use the newer sugar-chlorate formulation which contains relatively non-toxic dyes. However, the red and violet smoke mixes are still sulfur-chlorate mixes containing toxic dyes. An attempt was made to change the dyes and the sulfur in the red and violet smoke grenades; however it failed due to the unacceptable flaming of the mixtures during trials. The proposed modifications include the conversion of the red and violet grenades to the sugar-chlorate formulation containing the non-toxic dyes and the use of the new starter patch ignition system. During early development of the Light Vehicle Obscuration Smoke System (LVOSS) grenade, tests indicated that the new starter patch system successfully

controlled/eliminated excessive flaming by decreasing the temperature of the starter mixture. This was accomplished by using the patch to slow/stop the starter mixture from coming into excessive, immediate contact with the smoke mixture. Because the test was successful, this new starter patch configuration (shown in Figure 2) was tested on the red and violet smoke grenades in an attempt to control excessive flaming. Both externally and in performance, the modified M18 grenade will be identical to the existing grenade.

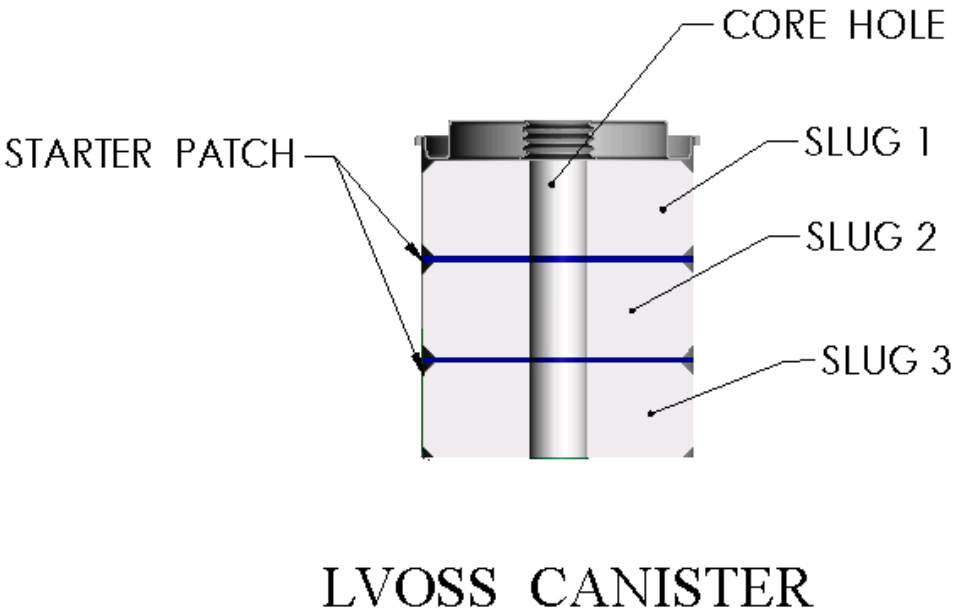

Figure 2 – Starter Patch Arrangement

While the new dyes used in the red or violet M18 grenades contain different chemical components, the function is no different from that of the old dyes. The dyes still form the visible smoke cloud typically emitted from grenades. The dyes are also still vaporized and dispersed into the atmosphere. Sugar (sucrose) and potassium chlorate react exothermically to form carbon monoxide, water vapor and potassium chloride. The reaction between sucrose and potassium chlorate is initiated at around 180°C. The most probable reaction mechanism begins with the liquefaction (melting) of sugar and its partial decomposition into fructose and one of several free radicals. The liquid sucrose and decomposition products react with the solid potassium chlorate, thus liberating heat. At around 250°C, magnesium carbonate begins to decompose endothermally into carbon dioxide and magnesium oxide. At approximately 350°C, the remaining potassium chlorate decomposes to potassium chloride and oxygen. Eventually the reaction temperature reaches the sublimation temperature of the dye(s) in the mix and the dye is vaporized and ejected through the grenade core hole. The dye vapor undergoes an

adiabatic expansion, mixes with the air and condenses into fine particles which form the visible smoke cloud. Outside temperatures were much lower for the current/original violet grenade and much higher, initially, for the new violet grenade than originally estimated. This information is presented in Figure 3 below.

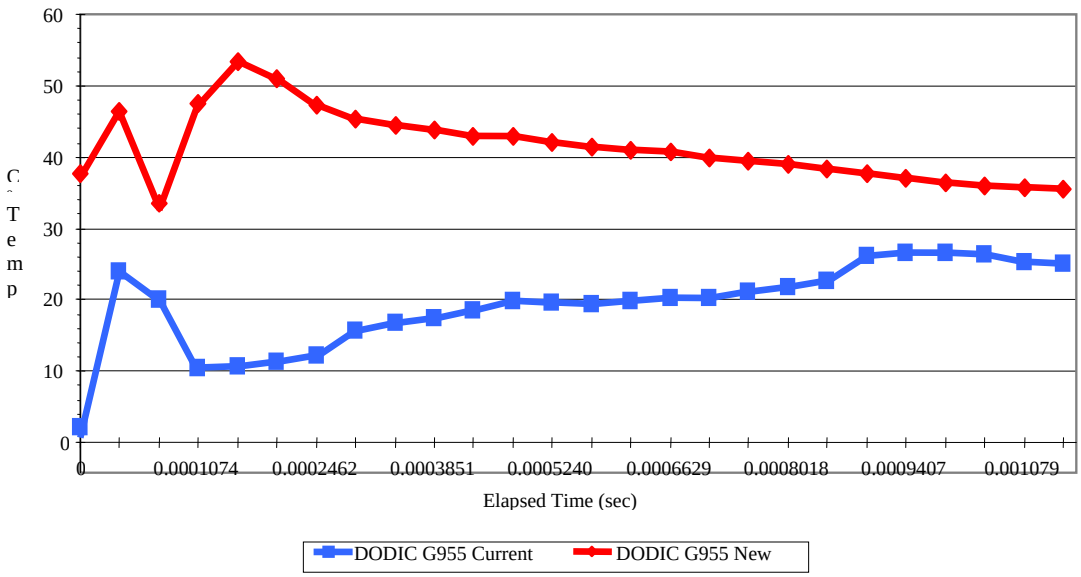

Figure 3. Outside Temperature of Current and New Violet Smoke Grenades (Temperature equals Temperature x 10)

The key design criteria were as follows: 1) new design must meet military specification, including 2) safety, health, and environmental risks assessment of dyes, 3) thermal characteristics of the dye (decomposition temperature and expected products of decomposition), 4) availability of dyes, and 5) costs.

The selection criteria consisted of those compounds having the appropriate physical and chemical properties of time-released smokes. Of these, the least toxic materials were selected for the studies. A critical selection criterion was the decomposition temperature of the dye. The decomposition temperature must be greater than a sublimation temperature. The greater the difference between the sublimation and decomposition temperatures, the better the candidate. Based on the temperatures shown in Figure 3 it is expected that these temperatures may be much higher than originally expected.

2.2 Previous Testing of the Technology

The starter patches were successfully tested in the LVOSS (M90) grenades. The M90 Grenade (LVOSS) was type classified in August 1997 with the production of this grenade beginning in FY98. The original colored smoke grenades were tested and determined to be toxic in the 1980s (see Reference 2). Due to the determination of toxicity, an attempt was made to change all four colored dyes. During testing of the developmental violet dye, it was determined that the new smoke was more toxic than the original and use of the dye (Blue Disperse 3) was abandoned (see Reference 5). The components for the original yellow and green smoke grenades were changed, successfully tested and transitioned into production. Based on that success, the yellow, green, red 40mm projectiles and the green and yellow M18 smoke grenades were type classified based on their successful transition from toxic dyes to less toxic dyes and sulfur to sugar chlorate mixes. The testing of the red and violet dyes was not successful due to excessive flaming during burning. Therefore the formulation was left unaltered to maintain functionality. Based on the use of the starter patches for the M90 grenade in FY98, it was believed that this technology would stop the excessive flaming of the red and violet smoke grenades such that the new formulation could be used. This was demonstrated in the test entitled "M18 and M83 Grenade Reliability and Performance Improvements – Report on Engineering Design Testing M18 and M83 Grenades with Starter Patch Configuration" by Mark L. Springer and Mike Farris dated 22 April 2003 (see Reference 9). Replacement of the HC with the Terephthalic Acid/Pentaerythritol (TA/PE) mix is not a part of this demonstration plan, but the success of the starter patches in this demonstration will encourage additional testing of the starter patches for this additional application (replacement of HC mixes with TA/PE mixes).

2.3 Factors Affecting Cost and Performance

The two main factors affecting the cost of the grenades are, in order of importance, the cost of the labor to make the grenades and the cost of the dye.

2.3.1 Labor

For example, the cost of labor in the current configuration is approximately $4,375.14 per 800 lb batch of red smoke grenades. Due to the new starter patch configuration, the cost of the labor is expected to be reduced by approximately 17.2% ($4,375.14 - $750.95 = $3,624.19).

2.3.2 Dye

The costs of the dye are expected to rise by approximately 333% (i.e., previous cost was $15.00 per pound, but current government costs are expected to be approximately $50.00 per pound). Searches of the internet revealed costs of $8.25 per pound delivered to the U.S. from foreign (90% solvent dye) sources. Current laws require sources to "Buy American," making it difficult to purchase from a foreign source. However, these same laws allow the purchase from a foreign source if it is determined that the price is 50% or greater. Prices of $50.00 per pound versus $8.25 per pound would meet that requirement and would allow the purchase of foreign dye.

It is currently unknown if the government will opt to take the approach of buying dye from foreign sources to curb expenses.

2.3.2.1 Contaminants

There are concerns that the purchased dyes may contain contaminants such as heavy metals (e.g., 1ead, chromium VI, barium, mercury, and antimony). Contamination will be a concern in the quest to provide a less toxic smoke product. Based on emissions testing, some heavy metals exist either in the dyes, pyrotechnic mixtures, fuze or the lead coating on and inside the grenade can itself. It appears that additional refining of the dyes to remove contaminants would be an appropriate strategy to undertake. The need to undertake additional dye refining will obviously add to the costs of the dye. However, if refining activities are completed at the production source, there could be significantly reduced costs depending on the technology used here (for U.S. acquired dyes) versus there (for foreign acquired dyes). The Smoke and Dye In-Process Team (IPT) is expected to change the requirements for dye and other materials in the future to meet this requirement for all of the dyes used in the production of colored smokes.

It may also be worth noting that there are dyes with lower contaminant levels available for the food, textile, and cosmetics industries. The U.S. Food and Drug Administration (FDA) controls the certification of color additives (i.e. dyes) used in food, drugs, and cosmetic products. To avoid confusion in the use of color additives, the FDA created three categories of certifiable color additives:

1) Food, Drug, and Cosmetic (FD&C);
2) Drug & Cosmetic (D&C); and
3) External Drug and Cosmetic (External D&C).

Due to the expectation that the final smoke products may be inhaled, only the first two categories were examined by the Smoke and Dye IPT.

2.4 Advantages and Limitations of the Technology

2.4.1 Advantages and Limitations

One advantage of the technology is that it allows soldiers to use more environmentally friendly items during training and times of conflict. It also decreases the potential risk posed to soldiers during testing and training exercises by removing potentially toxic materials. Having access to new, less toxic materials will allow for more extensive use of them during training. As a result, soldiers will be able to participate in more realistic training exercises that will ultimately increase their combat readiness. In the past, burn times of the mixes caused some limitations. However, demonstrations have shown that the new starter patch technology allows for a more uniform (cooler) temperature to be achieved during the initial burning of the grenades. This eliminates the excessive flaming of the smokes.

2.4.2 Disadvantages

One disadvantage of the technology is that while material replacements eliminate the sulfur emissions relatively cheaply, the replacement of the dyes is at a significantly greater cost. Therefore, it is essential that dye costs be aggressively controlled.

3. Demonstration Design

3.1 Performance Objectives

The colored smoke grenades have met the performance objectives listed in paragraphs 3.4, 3.5, 3.6 and 3.8 of MIL-G-12326K (EA) with Amendment 3 (21 April 1989) (see Reference 1). Destructive testing was completed in accordance with paragraph 4.4.2.2 of MIL-G-12326K and MIL-STD-105 Level S-4 and smoke emission time is equivalent to that segment of the sample specified in MIL-STD-414, Level II (see Reference 1).

Table 1: Performance Objectives

Type of Performance Objective	Primary Performance Criteria	Expected Performance (Metric)	Actual Performance Objective Met?
Quantitative	Better than or equal performance to mil-spec.(paragraphs 3.4, 3.5, 3.6 and 3.8 of MIL-G-12326K w/Amendment 3)	Pass individual product tests as prescribed in the military standard	Met
Quantitative	Reduce hazardous materials released during use of end items; i.e. 10mg/m^3 of HC/OSHA PEL (HC is reasonably anticipated to be a human carcinogen based on sufficient evidence of carcinogenicity in experimental animals (NTP 1989, IARC 1999) and first listed in the Seventh Annual Report on Carcinogens (1994)); 6-8 PPM Sulfur is irritating to eyes.	Zero HC used Zero sulfur used	Met Met
Qualitative	Smoke will be equal in quantity and quality.	Smoke will meet requirements of Mil-Std	Met (Violet) Coloration of red too light.

3.2 Selecting Test Site(s)

The M18 Red and Violet Smoke grenades were chosen because they had not been previously addressed. The M18 smoke grenades of other colors (green and yellow) had been changed under prior work efforts.

The test facility chosen for these studies was Pine Bluff Arsenal (PBA). PBA is the facility used by the DoD for smoke grenade manufacturing. For this reason, PBA was the ideal facility to ensure successful transition from the grenade testing stage to the manufacturing stage. Since PBA is the manufacturer, the technology transfer will be seamless and immediate upon approval of the new grenade formulations. In addition, the infrastructure for testing new formulations already exists at PBA.

Dugway Proving Ground (DPG) is the designated test facility for emissions characterization of the smoke and pyrotechnic items for USAEC's emission characterization program. Because DPG has previously tested the M18 smoke grenades (red and violet), it was the ideal facility to test the new grenades as they were produced. Test results from the old M18 smoke grenades (red and violet), could be compared to the test results from the new grenades to ensure that a more environmentally friendly alternative had been manufactured.

3.3 Test Site History/Characteristics

The grenades were manufactured on site at PBA. PBA was established in 1941 to load incendiary bombs and expanded operations during WWII to manufacture, load and store war gases; and to fill smoke and white phosphorus munitions. This mission continues today.

PBA, located in southeast Arkansas, is 35 miles southeast of Little Rock and 8 miles northwest of the City of Pine Bluff. PBA is bordered on the east by the McClellan Kerr Arkansas River Navigation System and on the west by the Union Pacific Railroad and U.S. Highway 65, making it directly accessible by rail, road, or waterway. PBA is 8 1/2 miles long by 2 3/4 miles wide and covers 14,944 acres. It includes 952 buildings, which provide 3.3 million square feet of floor space, including storage bunkers. It also has 42 miles of railroad track and 2 million square yards of roads and paved surfaces.

The objective of the Engineering Design Test (EDT) is to determine the performance characteristics of new items or proposed modifications. For this reason, the test items input into EDT are frequently manufactured in whole or in part at the Production Engineering Laboratory (PEL) located at PBA or on specially set up pilot lines with specially trained operators. Items manufactured for the EDT are rarely marked in accordance with the technical data package (TDP). Product Quality Test (PQT) items on the other hand, are usually manufactured wholly on Arsenal Production Lines using the same operators and procedures utilized during normal operations.

DPG, covering 798,855 acres, is located in the Great Salt Lake Desert, approximately 85 miles southwest of Salt Lake City, Utah. Surrounded on three sides by mountain ranges, the proving ground's terrain varies from level salt flats to scattered sand dunes and rugged

mountains. The DoD has designated DPG as a major range and testing facility, and the primary chemical and biological defense-testing center under the Reliance Program. Testers here determine the reliability and survivability of all types of military equipment in a chemical or biological environment.

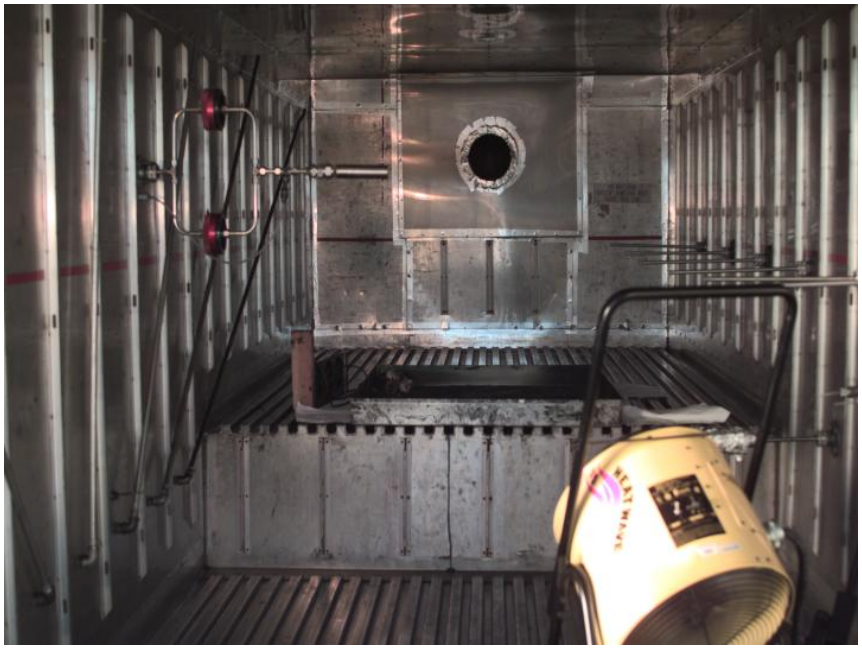

Figure 4. Inside the Smoke Characterization Test Chamber

The Smoke Characterization Test Chamber, hereinafter referred to as the Smoke Chamber, is located near the BangBox facility and adjacent to the instrument building. It is much smaller than the BangBox and is used for testing small items. It is lined with aluminum and is fairly easy to clean (See Figures 4 and 5). The Smoke Chamber was designed and constructed through a collaboration between the BangBox Test Team, the U.S. Environmental Protection Agency (EPA), the Oregon Graduate Institute (OGI), and the URS Corp.

The BangBox facility is a 1000 cubic meter dome that contains a steel blast-shield and analytical equipment. Under the air-supported roof made from the same polyvinyl material as many swimming pool covers, researchers can test up to a half-pound of explosives per blast or five pounds of propellant per burn. Its sophisticated sampling equipment provides on-the-spot readings of open burn/open detonation (OB/OD) emissions down to the parts-per-trillion level.

The Smoke Chamber is approximately 7 ft wide, 20 ft long, and 6 ft tall for 2/3 of its length and 5 ft tall for the remainder. The interior volume of the Smoke Chamber is approximately 820 ft^3. The chamber is sealed before deploying the test item. Fans inside the chamber keep the gases mixed during sampling. Gas samples are extracted from the gas chamber through short stainless steel probes. Twelve sampling ports have been installed on the Smoke Chamber for manual method sampling; two ports for sampling

volatile organic compounds (VOCs) and tracer gas, two ports for sampling semi-volatile organic compounds (SVOCs), two ports for dioxins/furans, two ports for sampling total suspended particulates (TSP), one port for particle sizing, and two ports for sampling hydrochloric acid (HCl). A dual-line filtered and heated sampling and manifold has been installed for continuous monitoring of carbon monoxide (CO), carbon dioxide (CO_2), nitrogen oxide (NOx), sulfur dioxide (SO_2), and HCl. The sample media is located immediately outside the chamber. Six, ½-in. vent lines distributed evenly along one side allow ambient air to enter the chamber to replace the gases removed by the sampling trains.

Figure 5. Outside of the Smoke Characterization Chamber

After sampling has concluded, dampers are opened and the chamber is pressurized and vented through a stainless steel stack. An electrical firing circuit has been installed that remotely deploys the test items and releases the SF6 tracer gas. Figure 5 is a picture of this facility.

3.4 Present Operations

The M18 grenade is used by troops for ground-to-ground or ground-to-air signaling. The different colored smoke signals can be seen over great distances when used against a terrain background of contrasting colors. The grenades are typically thrown a distance of 35 meters and release a cloud of smoke that lasts between 50 and 90 seconds. Such signals can be used to mark friendly force locations for other ground troops or to delineate a landing zone during a medical evacuation for example.

3.5 Pre-Demonstration Testing and Analysis

Originally it was intended that previous test results would be compared to current results. After reviewing the reports and their associated data it was determined that while the data may be good, it did not provide sufficient detail to compare to the results from the emissions and toxicity data. For example, Appendix G reflects the data from the emissions testing of the old and new red and violet smoke grenades. This allowed for comparison of the emissions from the old (baseline) to the new to determine potential changes in toxicity from the smokes. Testing included the emissions results and the toxicity results that have been completed. Sacrifices of rats were performed, followed by blood serum chemistry, electrolytes, histopath, and respiratory tract testing. This determined the toxicity of smoke at 6', 18' and the edge of the cloud when exposed for two minutes (burn time of grenade is 0.83-1.5 minutes) and ten minutes. More than one colored smoke grenade may be used; however the use of more than six colored smoke grenades at a time is not expected. By using multiple distances and times, the interpretation of results allowed for the determination of high and low dose exposure. The testing of the concentration of smoke from a colored smoke grenade at 6', 18' and edge of cloud provided results that were very similar for the edge of cloud and 18' so the concentrations for the 18' and edge of cloud were combined and an average used for the toxicity testing of the rats.

3.6 Testing and Evaluation Plan

Figure 6, below, was used as the basis of the testing and evaluation. This testing strategy is the current test methodology used by PBA to test and produce a new formula for the smoke grenades.

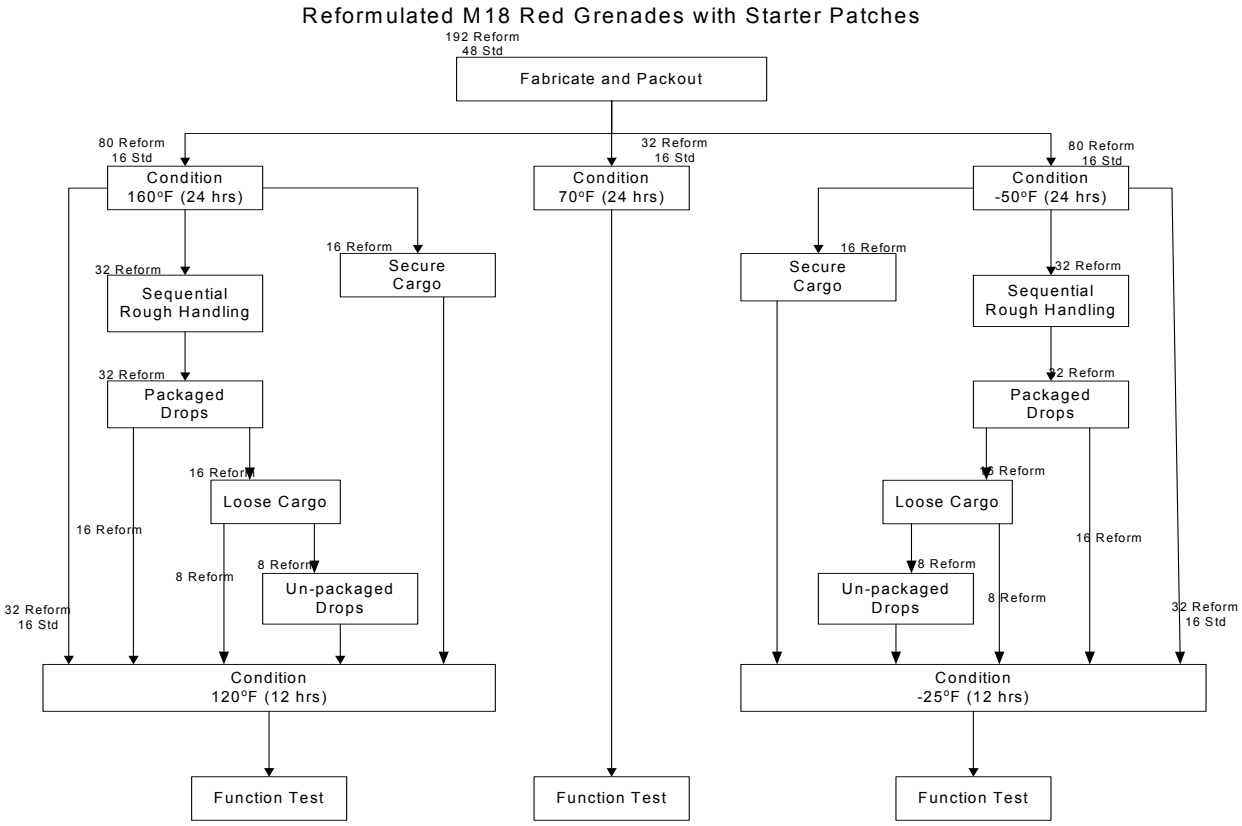

Figure 6. Chart of Method of Testing M18 Red Smoke Grenade

The average burn time for M18 grenades must fall within the range specified in the military standard (50 to 90 seconds at ambient conditions). Standard hypothesis testing techniques were used to determine whether an improvement was actually realized.

3.6.1 Demonstration Set-Up and Start-Up

3.6.1.1 Pine Bluff Arsenal Demonstration

The demonstration was performed at PBA. PBA regularly produces smoke grenades and performs acceptance testing for smoke grenades. The testing performed under this demonstration was done in accordance with standard PBA facility SOPs shown in Appendix A. The protocols identified in the PBA SOPs are inclusive of all aspects for test/demonstration operations to be conducted under this demonstration effort. Included within the SOPs are guidelines covering all aspects and concerns regarding health and safety. The attached SOPs identify all appropriate requirements for regularly scheduled briefings, hazard assessments and risk analyses, emergency procedures, operational procedures, reporting requirements, and other worker related safety information. The sulfur chlorate mixtures in the red and violet smoke grenades were replaced with a sugar- chlorate mixture. The starter mixtures in the Red and Violet smoke grenade were replaced with a starter mixture and patches similar to

those used in the M90 LVOSS grenade and then tested in the same manner as the M83 and M18 smoke grenades.

3.6.1.2 Lot Acceptance

PBA regularly performs testing of grenades on a lot-to-lot basis to ensure proper weight, material dimensions, function, and color of the smoke. The grenades must meet these requirements as outlined by the Technical Data Package Drawing# 13-19-37(M18 Red and Violet Smoke Grenade) and MIL-STD (MIL-G-12326K (EA)) (see Reference 1).

3.6.2 Period of Operation

Table 2 below is based on the actual schedule of demonstration as it occurred during this project. Due to delays in purchasing the dyes, a January 2003 accident at PBA, and delays in obtaining funding, the original schedule was modified to reflect what actually occurred.

Table 2. Schedule for Demonstration of Colored Smokes (Red and Violet)

PHASE	2003			2004	2005		
	FEB.	MAR.	JUL.		FEB.	MAR-JUL	AUG-SEP
Grenades Ready (Except Violet)	♦						
Testing							
Results	♦						
Buy Dye							
Violet Test Grenade							
Testing			♦				
Results							
Work with IPT							
Toxicity Testing							
Complete ECP							♦
Complete Final Report							♦
Complete C&P Report							♦

3.6.3 Amount/Treatment Rate of Material To Be Treated

Not applicable

3.6.4 Operating Parameters for the Technology

The new configurations use a "starter patch" rather than a "starter slug." This means that there will be no need for 30 lb batches of starter mix. A single production lot of starter patches is approximately 12,000 (a quantity sufficient enough to make 6,000 grenades). A production batch of colored Smoke Mix is 800 lbs and usually produces more than 208 grenades. Most of the test work was done using 30 lb batches of Smoke Mix made in PBA's Pilot Facility. These 30 lb batches produced the test grenades (approximately 30-40) that were used to determine if the smoke and the smoke grenades met the requirements identified in the MIL-STD. Production-sized batches were not prepared until the test grenades met the requirements and the mixture and configuration were ready for confirmation testing in the production line. The starter patches used were from a production lot.

3.6.5 Experimental Design

The preliminary testing consisted of mixing a 30 lb batch of the new materials and then using that material to fill as many grenades as possible (typically 30-40 grenades). These grenades were tested in accordance with PBA EDT procedures to ensure the batches met the operational and test criteria as outlined in the EDT protocols and as shown in both Section 3.1 Performance Objectives and Table 1. The materials used in the old versus the new smoke grenades are shown in Table 3 (Red Smoke Mix) and Table 4 (Violet Smoke Mix).

Table 3. Red Smoke Mix (Both Old and New)

COMPONENT	OLD Weight Fraction (w/w)	NEW Weight Fraction (w/w)	CAS#
Disperse Red 9	0.4000	0.0000	82-38-2
Solvent Red 1	0.0000	0.3160	1229-55-6
Disperse Red 11	0.0000	0.1390	2872-48-2
Terephthalic Acid	0.0000	0.0660	100-21-0
Sulfur	0.0900	0.0000	7704-34-9
Sugar	0.0000	0.1420	57-50-1
Magnesium Carbonate	0.0000	0.0870	546-93-0
Potassium Chlorate	0.2600	0.2160	3811-04-9
Stearic Acid	0.0063	0.0050	57-11-4
Sodium Bicarbonate	0.2500	0.0340	144-55-8
Polyvinyl Alcohol	0.0200	0.0200	9002-89-5
Components/Materials Added			
Starter Patch			
Sugar			57-50-1
Solvent Red 1			1229-55-6
Disperse Red 11			2872-48-2
Terephthalic Acid			100-21-0
Magnesium Carbonate			546-93-0
Components/Materials Eliminated			
Disperse Red 9			82-38-2
Starter Slug			
Starter Cup			
Cardboard Disc			
Sulfur			7704-34-9

Table 4. Violet Smoke Mix (Old and New)

COMPONENT	OLD Weight Fraction (w/w)	NEW Weight Fraction (w/w)	CAS#
Violet Dye Mix[1]	0.4000	0.0000	
Disperse Red 11	0.0000	0.3803	2872-48-2
Terephthalic Acid	0.0000	0.0766	100-21-0
Sulfur	0.0900	0.0000	7704-34-9
Sugar	0.0000	0.1550	57-50-1
Magnesium Carbonate	0.0000	0.1020	546-93-0
Potassium Chlorate	0.2600	0.2350	3811-04-9
Stearic Acid	0.0063	0.0050	57-11-4
Sodium Bicarbonate	0.2500	0.0510	144-55-8
Polyvinyl Alcohol	0.0200	0.0200	9002-89-5
Components/Materials Added			
Starter Patch			
Sugar			57-50-1
Disperse Red 11			2872-48-2
Terephthalic Acid			100-21-0
Magnesium Carbonate			546-93-0
Components/Materials Eliminated			
Disperse Red 9[1]			82-38-2
1,4-diamino-2,3-dihydroanthraquinone (DDA)[1]			81-63-0
Starter Slug			
Starter Cup			
Cardboard Disc			
Sulfur			7704-34-9

(1) Please note: Violet dye mix is a mixture of approximately 80% 1, 4-diamino-2, 3-dihydroanthraquinone (DDA) and 20% Disperse Red 9

The starter patches, which replaced the starter slugs, are at the heart of the success of these two grenades. The success of this program is due to PBA's hard work and persistence. The materials used to make the starter patches are shown in Table 5 below.

Table 5. Starter Patch Components

STARTER PATCH		
COMPONENT	**NEW Weight Fraction (w/w)**	**CAS #**
Terry Cloth Patch(1.5"x1.5")	NA	
Impregnating Slurry:		
Charcoal	0.3525	7440-44-0
Sodium Nitrate	0.1475	7631-99-4
Gum Arabic	0.0004	9000-01-5
Water	0.4600	7732-18-5

The starter patch components, shown above, will increase the burn time for the TA as was demonstrated for the colored smokes. Earlier work at PBA indicated that the addition of small amounts of sodium bicarbonate (approximately 0.0083%) to the mix along with the magnesium carbonate (approximately 0.0383%) decreased the temperature sensitivity of the mix. In the first phase, PBA manufactured grenades using this new starter patch configuration and fill. To validate the design, these grenades were submitted for a Production Validation Test (PVT). Approximately 30-40 grenades were produced and tested as part of the testing requirements. These grenades were tested in accordance with MIL-G-12326K (EA) (see Reference 1). Once this design is validated (not as part of this plan), the fills of all HC filled munitions can be replaced with this new fill. This follow-on effort is not included as a part of this Demonstration.

3.6.6 Product Testing

Once the material met the EDT criteria, a production batch of smoke mix was prepared (800 lbs of smoke material) from which approximately 208 grenades were manufactured. Twenty percent of the grenades manufactured were then tested in accordance with MIL-G-12326K and other appropriate MIL-STDs as required (see Reference 1).

This Demonstration did not include plans to test or produce the M4A3 (HC filled Smoke Pots). The M8 has already been type classified and fielded for training use. PBA does plan on replacing the HC mixture with the sugar chlorate mixture based on the success of the starter patches. This follow-on effort is not included as a part of this Demonstration.

The grenades were also sent to DPG and to the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) to ensure that they met the smoke requirements for performance. Edgewood Chemical Biological Center (ECBC) determined the smoke concentrations at 6’, 18’ and edge of cloud. It was determined that the 18’ and edge of cloud were so similar that only two concentrations (one for 6’ and one for 18’) were used for testing of toxicity by USACHPPM. USACHPPM also

ensured that the grenades had a reduced toxicity, which was the goal of this demonstration.

The primary thrust of this effort was to successfully complete a PVT for the M18 red and violet colored smoke grenade. The transition to less toxic dyes and compounds was successful for the green and yellow M18 grenades as well as the red, green, and yellow 40MM projectiles. The transition in the 1980's to a less toxic M18 red grenade was unsuccessful due to excessive flaming, which interrupted the production of the colored smoke. While a final full production run of over 208 grenades was completed, not all criteria were successfully met. The grenades did not flame, burned the appropriate amount of time, and met the hot and cold testing and transportation requirements, however the smoke produced by the grenades was too light. Instead of producing the necessary red smoke, a pink smoke was generated. The violet colored smoke grenade met all of the above criteria including the criteria for smoke color. Based on this success, the emissions were tested (including the old red and violet smokes, results are shown in Appendix G). Toxicity protocols and testing is currently scheduled for completion during 2005. At that time Appendix I and J will be added.

One of the technology transfers from the above work is that PBA will be able to increase the burn time of the M83 Terephthalic Acid (TA) grenade by changing the configuration and formulation of that grenade. With improved burn time, the grenade will replace the M8 HC smoke grenade.

3.6.7 Demobilization

Unused smoke grenades were burned up and sent to the incinerator complex at PBA. At that time, separation of the metal parts and containerization of the ash were performed. The ash, containerized in roll-off containers, was land filled as non-hazardous waste and the metal was sold for scrap.

3.7 Selection of Analytical/Testing Methods

USAEC established analytical and testing methods to ensure that the emissions generated from the new smokes will be more environmentally friendly than the old formulations. This test plan has been coordinated extensively within the EPA. Actual testing (functional) of the grenades was completed in accordance with MIL-G-12326K(EA) (see Reference 1).

Toxicity testing of the current formulation for the violet smoke grenade and the ESTCP formulation were completed (See Appendix J). During pilot studies (5 female and 5 male rats) one rat (female) died and based on it's death females were chosen as test subjects for the rest of the testing that was completed. Eleven of the twenty four rats used in the toxicity testing of the current formulation (DODIC G955) died during exposure to the smoke and directly after being exposed to the smoke. Because no deaths occurred during the pilot studies (testing of ESTCP formulation) a discussion with a statistician and the veterinarian concerning the reduction (based on the statistics and the ethical use of animals) in the number of rats for the ESTCP formulation was proposed and adopted. None of the rats exposed to the ESTCP formulation died during the testing. Autopsies,

blood testing, etc. were performed on the dead rats and the cause of death appeared to be asphyxiation.

3.8 Selection of Analytical/Testing Laboratory

The analytical laboratories at DPG were selected for environmental testing of the new smoke formulations. Refer to Appendix G for results of emissions testing.

4. Performance Assessment

4.1 Performance Criteria

Table 1 described the general performance objectives that were used to evaluate the performance of the M18 colored smoke grenades.

Table 6: Performance Criteria

Performance Criteria	Description	Primary or Secondary
Product Testing		Primary
Extreme Temperature Function	The lot of grenades are randomly separated into three groups; Hot, Ambient and Cold. Each group is maintained for 24 hours at 160°F, 70°F and -50°F	Primary
Sequential Rough Handling	Subjected to rough handling by a machine for 24 hours.	Primary
Secure Cargo	Subjected to secure cargo handling by a machine for 24 hours.	Primary
Packaged Drops	Subjected to drops while in packaging.	Primary
Loose Cargo	Subjected to mechanical motions simulating movements as loose cargo.	Primary
Un-packaged Drops	Subjected to dropping while unpackaged.	Primary
Extreme Temperature Function	Subjected to temperature conditioning of 120°F and -25°F for 12 hours.	Primary
Function Test	Grenades are functioned to determine quality of smoke, burn time, % of flaming and color of smoke.	Primary

The above performance criteria were used to evaluate the two candidates for replacement of the M18 red and violet colored smoke grenades. During the demonstration of these two candidates, the starter patch configuration that PBA invented worked perfectly. The M18 violet smoke grenade functioned as designed and met the performance criteria (See Figure 7). The color of the M18 red smoke grenade was lighter than intended so we conducted two more pilot tests to ensure the red was darker (See Figure 8). A determination was made that the component Terephthalic Acid (which alone creates a white smoke) was the cause of the pale coloration of the new red smoke formulation.

The M18 red smoke grenade was dropped from the test plan after several attempts to alter the color of the smoke were unsuccessful. The color of the smoke was a light red (pink) (see Figure 8). As a result, the Program Manager-Close Combat Systems (PM-CCS) did not feel the new color met the MIL-STD requirements for the smoke. The burn time, replacement of the sulfur with sugar, replacement of the dyes, and lack of flaming were successful.

Figure 7. Violet Smoke Grenade

Figure 8. Side-by-Side Comparison of New M18 Red Smoke Mix with Standard M18 Red Grenade

Note: Standard M18 Grenade is on the right.

As a result of this program, the PM-CCS created the Smoke and Dye IPT to take a much broader approach in addressing issues associated with the colored smokes. This broader approach will include research aimed at additional dyes, fuels, fuzing, plating materials, and other less toxic materials for the use in colored smoke grenades.

4.2 Performance Confirmation Methods

The colored smokes performance confirmation methods and actual performance are shown in Tables 7-8.

4.3 Data Analysis, Interpretation and Evaluation

Performance Confirmation Methods:

Table 7: Actual Performance and Performance Confirmation Methods for M18 Red Smoke

Performance Criteria	Expected Performance Metric (Pre demo)	Performance Confirmation Method	Actual Performance (Post demo)
Product Testing	Must pass individual product tests specified in the MIL-G 12326K (EA) and Mil-Std 810F summarized below.	MIL-G 12326K(EA) MIL-STD 810F	While it successfully passed all of the criteria in the specification the coloration was determined to be too light.
Extreme Temperature Function	The lot of grenades are randomly separated into three groups; Hot, Ambient and Cold. Each group is maintained for 24 hours at 160°F, 70°F and -50°F. The two extreme temperatures (Hot and Cold) had 96 grenades in each group and the ambient group had 48 grenades.	Functioned as designed.	Passed (The coloration was determined to be too light)
Rough Handling	33%, of the two extreme temperature groups, were subjected to rough handling by a machine for 24 hours.	Functioned as designed.	Passed (The coloration was determined to be too light)
Secure Cargo	16%, of the two extreme temperature groups, were subjected to secure cargo handling by a machine for 24 hours.	Functioned as designed.	Passed (The coloration was determined to be too light)
Packaged Drops	33%, of the two extreme temperature groups, were subjected to rough handling and then to packaged drops. Half of these are temperature conditioned and then function tested.	Functioned as designed.	Passed (The coloration was determined to be too light)
Loose Cargo	Half of the Packaged dropped grenades are then handled as loose cargo. The other half are temperature conditioned (2d) for 12 hours and function tested.	Functioned as designed.	Passed (The coloration was determined to be too light)
Un-Packaged Drops	The remaining half of the loose cargo test are removed from their packaged and dropped. These are then temperature conditioned (2d) and function tested.	Functioned as designed.	Passed (The coloration was determined to be too light)
Ambient Temperature Function	The ambient temperature grenades (48) were functioned as designed.	Functioned as designed.	Passed (The coloration was determined to be too light)
Extreme Temperature Function (2d)	50%, of the two extreme temperature groups, were subjected to 12 more hours of a change in temperature extreme to 120°F and -25°F respectively.	Function Tested	Passed (The coloration was determined to be too light)

During initial pilot production of the violet grenade, all of the test criteria were met.

Table 8: Actual Performance and Performance Confirmation Methods for M18 Violet Smoke

Performance Criteria	Expected Performance Metric (Pre demo)	Performance Confirmation Method	Actual Performance (Post demo)
Product Testing	Must pass individual product tests specified in the MIL-G 12326K (EA) and Mil-Std 810F summarized below.	MIL-G 12326K(EA) MIL-STD 810F	**Passed**
Extreme Temperature Function	The lot of grenades are randomly separated into three groups; Hot, Ambient and Cold. Each group is maintained for 24 hours at 160°F, 70°F and -50°F. The two extreme temperatures (Hot and Cold) had 96 grenades in each group and the ambient group had 48 grenades.	Function Tested	**Passed**
Rough Handling	33%, of the two extreme temperature groups, were subjected to rough handling by a machine for 24 hours.	Function Tested	**Passed**
Secure Cargo	16%, of the two extreme temperature groups, were subjected to secure cargo handling by a machine for 24 hours.	Function Tested	**Passed**
Packaged Drops	33%, of the two extreme temperature groups, were subjected to rough handling and then to packaged drops. Half of these are temperature conditioned and then function tested.	Function Tested	**Passed**
Loose Cargo	Half of the Packaged dropped grenades are then handled as loose cargo. The other half are temperature conditioned (2d) for 12 hours and function tested.	Function Tested	**Passed**
Un-Packaged Drops	The remaining half of the loose cargo test are removed from their packaged and dropped. These are then temperature conditioned (2d) and function tested.	Function Tested	**Passed**
Ambient Temperature Function	The ambient temperature grenades (48) were functioned as designed.	Function Tested	**Passed**
Extreme Temperature Function (2d)	50%, of the two extreme temperature groups, were subjected to 12 more hours of a change in temperature extreme to 120°F and -25°F respectively.	Function Tested	**Passed**

During the initial purchase of dyes, product searches on the Internet indicated that the most cost-effective dyes are produced in foreign countries such as India and China. However, these dyes can be somewhat difficult to obtain directly from foreign sources because current laws require sources to purchase American products. The dyes do not normally meet specifications for material content, particle size and particle shape, which often means that entire lots of grenades may not function as designed and must be

rejected. The chief concern is that testing requires a consistency of the purchased material. Material specifications are currently being modified to reflect this concern.

As part of this program it was determined that the dyes could be tested for purity using Differential Scanning Calorimetry (DSC). The dyes were tested using this process (refer to Appendix H for the report highlighting the results) with Solvent Red #1 having a purity of 98.2-98.5% and Disperse Red #11 having a purity of 98.6-98.9%. The results also mention that because of good thermal stability in the melt stage, Solvent Red#1 may be purified further by using zone-melt techniques. However, because of the volatility of Disperse Red#11 in the melt phase, it is not a good candidate for zone refining.

The overall internal profile of the grenade was reduced during manufacturing because of the use of the starter patches. This eliminated a common manufacturing problem in which the top slug was sometimes knocked out of the grenade. Grenades that were packaged with one less slug were rejected on a regular basis. In addition, the use of starter patches has reduced the number of labor hours required to produce the new colored smoke grenades. By reducing the labor hours, a cost savings of approximately 17.2% has been achieved.

5. Cost Assessment

5.1 Cost Reporting

Table 9 shows the cost comparison of the materials used for reduced sulfur smoke grenades versus the sulfur fueled smoke grenades. This is shown as a per grenade cost.

Table 9: Cost Comparison of Reduced Sulfur Red and Violet Smoke Grenades

COMPONENT	Current Red Formulation	New Red Formulation	Current Violet Formulation	New Violet Formulation
Smoke Mix	$6.44	$4.87	$2.77	$3.57
Grenade Body	$0.74	$0.74	$0.74	$0.74
Grenade Lid	$0.45	$0.45	$0.45	$0.45
M201A1 Fuze	$5.32	$5.32	$5.32	$5.32
Starter Cups	$0.071	-	$0.71	-
Cardboard Disc	$0.009	-	$0.009	-
Starter Slug	$0.114	-	$0.114	-
Starter Patch	-	$0.472	-	$0.472
Labor	$4.95	$3.93	$4.95	$3.93
TOTAL (PER GRENADE)	$18.09	$15.78	$15.06	$14.48

5.2 Cost Analysis

These costs were captured in Section 2.3. These costs were compared to determine the actual costs associated with manufacturing (See Tables 10-11).

Note: Red costs have been added because they are known based on the demonstration plan. These costs would normally be added to cleanup costs associated with original smoke grenades versus the new less toxic smoke grenades to determine the environmental cleanup costs that might result. This is calculated to determine whether there would be a cost benefit associated with the manufacture of the new grenades versus the older grenades. Unfortunately the cleanup costs for the original grenades have never been determined because no effort has been made to clean up after them. It is therefore not known what the difference in cost might be. There are ongoing efforts to determine if there is any environmental impact from perchlorates (Smoke grenades do not contain perchlorates) that are emitted from the smoke grenades (and other munitions) during the burning process or as residues, but these studies are still on going. Therefore, the cost analysis will be from the point-of-view of manufacturing, reduction of the heavy metals from the dyes, use of a safer dye, and the elimination/reduction of the sulfur from the smoke grenades.

Table 10: Violet Smoke Mix (Current and New)

COMPONENT	CURRENT Weight Fraction (w/w)	NEW Weight Fraction (w/w)	CAS#	COST PER BATCH Current/*New*
Violet Dye Mix[1]	0.4000	0.0000	81-63-0 82-38-2	$2,553.40/*$0*
Disperse Red 11	0.0000	0.3803	2872-48-2	$0/*$3,107.60*
Terephthalic Acid	0.0000	0.0766	100-21-0	$0/*$84.57*
Sulfur	0.0900	0.0000	7704-34-9	$17.28/*$0*
Sugar	0.0000	0.1550	57-50-1	$0/*$93.00*
Magnesium Carbonate	0.0000	0.1020	546-93-0	$0/*$61.20*
Potassium Chlorate	0.2600	0.2350	3811-04-9	$147.68/*$133.48*
Stearic Acid	0.0063	0.0050	57-11-4	$11.10/*$8.88*
Sodium Bicarbonate	0.2500	0.0510	144-55-8	$44.00/*$8.98*
Polyvinyl Alcohol	0.0000	0.0200	9002-89-5	$0/*$75.56*
TOTAL				$2,773.46/*$3,573.27*
Components/Materials Added				
Starter Patch				
Sugar			57-50-1	
Disperse Red 11			2872-48-2	
Terephthalic Acid			100-21-0	
Magnesium Carbonate			546-93-0	
Components/Materials Eliminated				
Disperse Red 9[1]			82-38-2	
1,4-diamino-2,3-dihydroanthraquinone (DDA)[1]			81-63-0	
Starter Slug				
Starter Cup				
Cardboard Disc				
Sulfur			7704-34-9	

(1) Note: Violet dye mix is a mixture of approximately 80% 1, 4-diamino-2, 3-dihydroanthraquinone (DDA) (CAS#81-63-0) and 20% Disperse Red 9 (CAS#82-38-2).

Table 11: Red Smoke Mix (Current and New)

COMPONENT	CURRENT Weight Fraction (w/w)	NEW Weight Fraction (w/w)	CAS#	COST PER BATCH Current/*New*
Disperse Red 9	0.4000	0.0000	82-38-2	$6,224/*$0*
Solvent Red 1	0.0000	0.3160	1229-55-6	$0/*$3,720*
Disperse Red 11	0.0000	0.1390	2872-48-2	$0/*$680.00*
Terephthalic Acid	0.0000	0.0660	100-21-0	$0/*$88.32*
Sulfur	0.0900	0.0000	7704-34-9	$17.28/*$0*
Sugar	0.0000	0.1420	57-50-1	$0/*$87.00*
Magnesium Carbonate	0.0000	0.0870	546-93-0	$0/*$76.28*
Potassium Chlorate	0.2600	0.2160	3811-04-9	$147.68/*$135.30*
Stearic Acid	0.0063	0.0050	57-11-4	$11.10/*$8.88*
Sodium Bicarbonate	0.2500	0.0340	144-55-8	$44.00/*$0*
Polyvinyl Alcohol	0.0200	0.0200	9002-89-5	$0/*$75.56*
TOTAL				$6,444.06/*$4,871.34*
Components/Materials Added				
Starter Patch				
Sugar			57-50-1	
Solvent Red 1			1229-55-6	
Disperse Red 11			2872-48-2	
Terephthalic Acid			100-21-0	
Magnesium Carbonate			546-93-0	
Components/Materials Eliminated				
Disperse Red 9			82-38-2	
Starter Slug				
Starter Cup				
Cardboard Disc				
Sulfur			7704-34-9	

After reviewing the information on costs for just the materials used in manufacturing, it appears the costs have almost doubled. However, if you look at Table 9 you will notice that isn't the case. In fact, the labor savings associated with manufacturing the new grenades, when subtracted from the cost of manufacturing the current grenades, actually results in a significant savings. The labor savings is a direct result of using starter patches rather than slugs. The use of starter patches during the current manufacturing process results in a significant cost savings. This cost savings should continue in the future, even if the manufacturing process undergoes change. This savings will become increasingly important since labor costs generally escalate from year to year. If and when it is determined that there is an environmental cost, that cost would be added to keeping the current formula versus lowering or substantially lowering the costs of cleanup.

6. Implementation Issues

6.1 Environmental Permits

PBA and DPG already had the permits required to carry out the tasks necessary for completion of this demonstration.

6.2 End-User/Original Equipment Manufacturer (OEM) Issues

End users of this demonstration will consist of all units and installations that use the end items in their current formulation. As long as military specifications are met, the transition to the new formulation will be seamless. The products affected will be the violet M18 smoke grenade. This grenade may transition from sulfur to sugar based fuels as well as less toxic dyes. It is also expected that the red M18 smoke grenade will transition from sulfur to sugar based fuels and, depending on the decisions of the Smoke and Dye IPT, will switch to a less toxic dye. In addition, based on this success, it is expected the other colored smoke grenades and the smoke pots will also be switched to the starter patches. This action will decrease the cost associated with labor hours and will also reduce the number of grenade rejects that result during production. The environmental impacts associated with the potential contamination caused by the use of these grenades will also be reduced once the transition is complete.

7. References

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2. 1985. *Occupational and Environmental Health Risk Due to Exposure to Smoke/Obscurants.*

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Appendix A:

The Department of Defense Test Method Standard (MIL-STD-810F., dated 30 August 2002) will be used in addition to the Military Specifications contained in MIL-G-12326K, MIL-G-12326K(EA), and MIL-G-12326K Amendment#3. These standards are included, as separate documents, as appendix A in the above order.

Appendix B: Analytical Methods Supporting the Experimental Design

Analytical methods supporting the testing of the experimental design are included in Appendix A as Test Method Standard 810F.

Appendix C: Additional Product Testing for non-JTP Applications

TEST PROTOCOL

FOR

ENGINEERING DESIGN TESTING

AND

PRODUCTION QUALIFICATION TESTING

FOR

THE GRENADE, HAND, SMOKE, M18

June 2002

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SECTION 1. INTRODUCTION

1.1 Background

a. Developmental items at Pine Bluff Arsenal are in general subjected to two series of tests, Engineering Design Tests (EDT) and Production Qualification Tests (PQT). The primary difference between these two series of tests is the objectives EDTs are undertaken to determine whether a given design or design modification will meet all performance criteria. PQTs are undertaken to determine if the product design meets the operational requirements.

Testing procedures differ primarily in that EDT test reporting is generally less formal than the PQT as test reports are for internal use only. EDT tests also frequently exceed the testing requirements set forth in MIL-STD-810 and the ITOP to ensure that developmental items, which pass EDT testing will ultimately pass PQT testing.

Finally, because the objective of EDT testing is to determine the performance characteristics of new items or proposed modifications, the test items input into EDT testing are frequently manufactured in whole or in part at the Production Engineering Laboratory (PEL) or on specially set up pilot lines with specially trained operators. Items manufactured for EDT testing are rarely marked IAW the TDP. PQT testing on the other hand are usually manufactured wholly on Arsenal Production Lines using production operators by procedures as they will be used during normal operations.

1.2 Test Concept

a. The purpose of the PQT is to certify the M18, Grenade, Hand, Smoke as modified.

b. This test focuses on providing data for certification and the verification of the production grenade line at PBA.

1.3 System Description

The M18 Colored Smoke Grenade as currently configured consists of a metal can and lid which holds a mechanically initiated fuze. It is, excluding the fuze, 11.84-cm (4.66-inch) high and 6.3 cm (2.48 inch) in diameter. A pull pin is hinged through the fuze lever, preventing premature initiation. The output of the fuze ignites a starter slug which in turn ignites the smoke mix fill. After a delay of approximately 15 seconds smoke is emitted from a ½ in. core hole for between 45 and 55 seconds. In the current configuration, the green and yellow smoke mixes are the more modern sugar-chlorate system with the relatively non-toxic dyes. The red and violet smoke mixes are sulfur-chlorate mixes with toxic dyes. The proposed modifications include the conversion of the red and violet grenades to modern sugar-chlorate systems with non-toxic dyes and the starter patch ignition system. Externally and performance-wise, the modified M18 grenade will be identical to the existing grenade.

SECTION 2. TESTING PROCEDURES

2.1 BASELINE PERFORMANCE TESTING

2.1.1 Objective

The objective of the baseline performance testing is to determine if the munition as modified or manufactured by Pine Bluff Arsenal meets the technical and performance requirements specified.

2.1.2 Criteria

a. The M18 grenade must meet all requirements of MIL-G-12326K(EA).

2.1.3 Test Procedures

2.1.3.1 General

All testing will be performed at approved Arsenal Test sites.

2.1.3.2 Baseline Conditioning

a. Ambient: Modified M18 grenades will subjected to ambient conditions.

b. Hot: Modified M18 grenades will be subjected to hot conditioning. The times and temperatures will be determined based on the requirements of MIL-G-12326K(EA).

c. Cold: Modified M18 grenades will be subjected to cold conditioning. The times and temperatures will be determined based on the requirements of MIL-G-12326K(EA).

2.1.3.3 Safety and Health

The Test Director (TD) is responsible for assuring that all participants have read the test plan and all safety procedures for the test program. The TD will monitor all aspects of the test for adherence to the safety procedures.

2.1.3.4 Function Testing Procedures

a. The time and location of function tests of all munitions are determined by the Operations Center based on the current meteorological conditions and forecast.

b. A test log containing the specific data required will be recorded and maintained through out testing. Any other data determined to be pertinent will also be recorded in the test log.

c. Delay time, burn time, flame and flame time along with general observations will be collected on each grenade. If requested, spent grenades may be collected and weighted.

2.1.3.5 Optical Data Procedures

A color video camera will be available for use during the comparison trials if desired.

2.2 ENVIRONMENTAL

2.2.1 Objectives

The objective of environmental testing is to determine if the performance of the munition is degraded during transportation and handling in hot and cold climatic design types.

2.2.2 Criteria

a. The modified M18 Grenade shall possess the required performance characteristics and color after transportation and handling in climatic design types hot and cold.

2.2.3 Test Procedures

2.2.3.1 Number of Test Items

The grenades required for the environmental subtest are listed in Table 1.

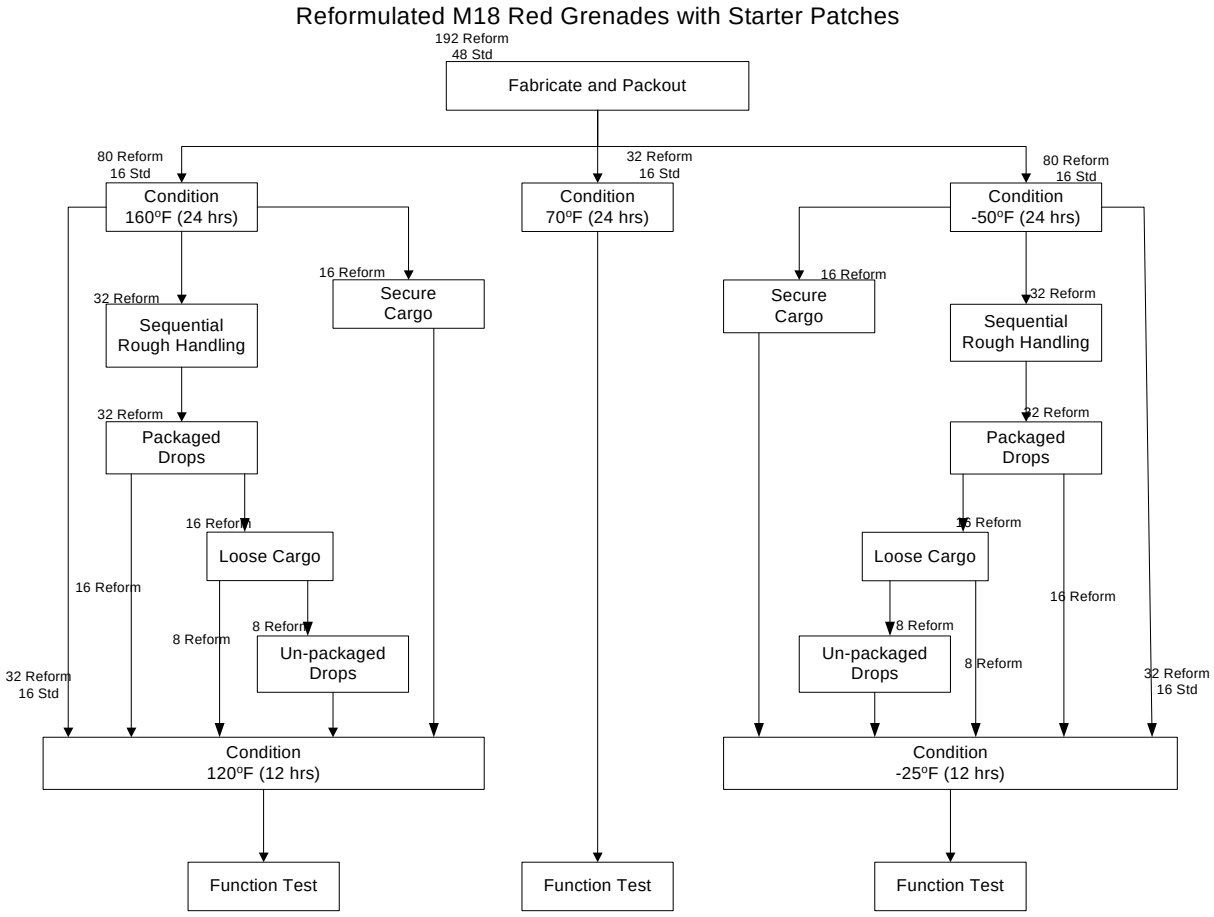


Table 1

2.2.3.2 <u>Sequential Rough Handling</u>

Grenades will be conditioned hot and cold then subjected to a sequential rough-handling (i.e., packaged drop, loose cargo and unpackaged drop) regimen IAW International Test Operation Procedures (ITOP) 4-2-602 and MIL-G-12326K(EA).

2.2.3.3 <u>Secured Cargo Vibration</u>

Boxes conditioned hot and cold will be subjected to loose cargo vibration testing MIL-STD-810F and MIL-G-12326K(EA).

Appendix D: (Not Used)

Appendix E: Data Quality Assurance / Quality Control Plan (NA)

See reporting requirements in the test protocols for data capture, data acquisition and data reporting during each of the operations.

Appendix F: Health and Safety Plan

The Safety person for the testing organization is listed below:

ORGANIZATION	PHONE NUMBER
PBA Safety Office	870-540-2919

The standard operating procedures that will be used are included when requested. Each of these SOPs also contains Risk and Hazard Analysis of each of the operations, emergency operations and other considerations for the worker safety. These SOPs ensure the well-being of the workers and contains emergency procedures for anticipated emergencies.

The Safety person for the testing organization is listed below:

ORGANIZATION	PHONE NUMBER
DPG Safety Office	435- 831-5204

The standard operating procedures that will be used are included when requested. Each of these SOPs also contains Risk and Hazard Analysis of each of the operations, emergency operations and other considerations for the worker safety. These SOPs ensure the well-being of the workers and contains emergency procedures for anticipated emergencies.

Appendix G: Laboratory Data

Includes Emission data from old and new red and violet smoke grenades.

NEW	– New Explosive Weight
NM	– Not Measured
Shaded Areas (Blue)	–

Emissions Data for Old and New Red and Violet Smoke Grenades

Comparison of Red and Violet Smoke Grenades (Old Formulation vs New Formulation)

Compound	Red Smoke Grenade (Old Formulation)				Red Smoke Grenade (New Formulation)				Violet Smoke Grenade (Old Formulation)				Violet Smoke Grenade (New Formulation)			
	NEW = 0.72 lb		No. of items = 1		NEW = 0.72 lb		No. of items = 1		NEW = 0.72 lb		No. of items = 1		NEW = 0.72 lb		No. of items = 1	
	Measured Conc. (mg/m^3), (a)		Corrected Emission Factor, (b)		Measured Conc. (mg/m^3), (a)		Corrected Emission Factor, (b)		Measured Conc. (mg/m^3), (a)		Corrected Emission Factor, (b)		Measured Conc. (mg/m^3), (a)		Corrected Emission Factor, (b)	
	Sample	Background	(lb/item)	(lb/lb NEW)	Sample	Background	(lb/item)	(lb/lb NEW)	Sample	Background	(lb/item)	(lb/lb NEW)	Sample	Background	(lb/item)	(lb/lb NEW)
Particulates																
TSP (M5)	3.10E+03	9.03E+00	1.51E-01	2.10E-01	1.04E+03	1.00E-20	9.00E-02	1.25E-01	2.67E+03	9.03E+00	1.17E-01	1.62E-01	9.50E+02	1.00E-20	4.57E-02	6.34E-02
PM10	1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.25E+03	2.76E+00	1.06E-01	1.47E-01	1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.81E+03	2.69E+00	7.76E-02	1.08E-01
PM2.5	1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.19E+03	1.84E+00	1.01E-01	1.41E-01	1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.43E+03	1.19E+00	6.12E-02	8.50E-02
Metals																
Aluminum	1.06E+00	NM (b)	5.18E-05	7.20E-05	1.40E+00	4.71E-02	1.05E-04	1.45E-04	9.57E-01	NM (b)	4.20E-05	5.83E-05	6.48E-01	3.20E-02	2.98E-05	4.14E-05
Antimony	1.52E-02	NM (b)	7.47E-07	1.04E-06	2.32E-03	1.02E-03	1.00E-20	1.00E-20	1.00E-20	NM (b)	1.00E-20	1.00E-20	1.00E-20	2.05E-03	1.00E-20	1.00E-20
Barium	1.05E-02	NM (b)	5.16E-07	7.16E-07	2.08E-01	2.56E-02	1.48E-05	2.05E-05	1.65E-02	NM (b)	7.22E-07	1.00E-06	2.52E-02	1.00E-20	1.20E-06	1.67E-06
Chromium	8.51E-03	NM (b)	4.17E-07	5.79E-07	3.52E-02	1.00E-20	2.71E-06	3.77E-06	6.95E-03	NM (b)	3.05E-07	4.23E-07	1.12E-02	1.20E-03	4.96E-07	6.89E-07
Lead	4.10E-01	NM (b)	2.01E-05	2.79E-05	7.57E-02	9.77E-03	4.71E-06	6.54E-06	3.66E-01	NM (b)	1.61E-05	2.23E-05	1.73E-02	1.00E-20	8.25E-07	1.15E-06
Magnesium	2.41E-01	NM (b)	1.19E-05	1.65E-05	1.92E+00	8.88E-03	1.51E-04	2.10E-04	1.31E-01	NM (b)	5.75E-06	7.98E-06	7.39E-01	1.62E-02	3.46E-05	4.81E-05
Manganese	8.67E-03	NM (b)	4.24E-07	5.89E-07	6.62E-03	1.00E-20	4.97E-07	6.91E-07	2.41E-02	NM (b)	1.06E-06	1.47E-06	2.65E-03	1.00E-20	1.28E-07	1.78E-07
Zinc	1.93E-01	NM (b)	9.50E-06	1.32E-05	5.64E-01	2.20E-02	4.48E-05	6.23E-05	4.92E-02	NM (b)	2.16E-06	3.00E-06	4.45E-01	1.00E-20	2.24E-05	3.12E-05
SVOCs																
2-amino-9,10-anthracenedione (TIC)			2.54E-03				1.00E-20									
Unknown (TIC)			6.18E-02				1.00E-20									
Benzoic acid	1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.09E-01	1.00E-20	1.00E-20								
Naphthalene	1.00E-20	1.00E-20	1.00E-20	1.00E-20	5.16E-01	1.00E-20	4.32E-05	6.00E-05								
Phenol	1.00E-20	1.00E-20	1.00E-20	1.00E-20	8.84E+00	3.35E-03	7.85E-04	1.09E-03								
Benzeneamine, 2-methoxy (TIC)			1.00E-20				4.12E-03									
Unknown (TIC)			1.00E-20				8.50E-03									
Unknown (TIC)			1.00E-20				3.20E-03									
Unknown (TIC)											1.14E-03				1.00E-20	
Unknown (TIC)											2.27E-02				1.00E-20	
Unknown (TIC)											2.27E-02				1.00E-20	
Benzoic acid									1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.29E+01	1.00E-20	5.84E-04	8.10E-04
Naphthalene									1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.00E-20
Phenol									1.00E-20	1.00E-20	1.00E-20	1.00E-20	1.08E+00	2.86E-03	4.37E-05	6.07E-05
Unknown (TIC)											1.00E-20				4.46E-03	
Unknown (TIC)											1.00E-20				2.23E-04	
Dioxins/Furans																
TEQ	4.75E-07	1.00E-20	2.33E-11	3.23E-11	2.80E-07	1.00E-20	2.60E-11	3.61E-11	2.73E-07	1.00E-20	1.20E-11	1.66E-11	1.80E-06	1.00E-20	8.68E-11	1.21E-10
VOCs																
TNMOC (ref. to Carbon)	1.02E+01	2.92E-01	5.07E-04	7.04E-04	1.16E+02	3.09E-01	1.19E-02	1.66E-02	2.43E+01	2.23E-01	1.13E-03	1.57E-03	8.38E+01	1.14E-01	3.93E-03	5.45E-03
Acetaldehyde	8.93E-01	1.00E-20	4.57E-05	6.35E-05	2.65E+01	1.88E-02	2.48E-03	3.45E-03	1.71E+00	1.00E-20	7.97E-05	1.11E-04	4.38E+00	2.23E-02	2.03E-04	2.82E-04
Acetone	2.15E+00	4.21E-01	8.81E-05	1.22E-04	5.29E+00	4.26E-02	5.35E-04	7.43E-04	4.08E+00	3.01E-02	1.89E-04	2.63E-04	3.38E+00	6.99E-02	1.55E-04	2.15E-04
Acetylene	1.73E+00	9.00E-04	8.85E-05	1.23E-04	2.13E+00	1.00E-20	2.11E-04	2.93E-04	3.38E+00	7.00E-04	1.58E-04	2.19E-04	9.95E-01	1.00E-20	4.66E-05	6.47E-05
Acrolein	5.07E-01	8.41E-04	2.61E-05	3.62E-05	2.06E+00	1.00E-20	2.02E-04	2.80E-04	6.54E-02	1.00E-20	3.06E-06	4.25E-06	3.96E+00	1.00E-20	1.84E-04	2.55E-04
Benzene	3.21E-01	1.45E-03	1.64E-05	2.27E-05	1.66E+01	2.76E-03	1.72E-03	2.39E-03	1.71E+00	1.00E-03	8.00E-05	1.11E-04	2.38E+01	1.00E-20	1.12E-03	1.55E-03
Carbon Disulfide	7.09E+00	2.24E-03	3.62E-04	5.03E-04	1.00E-20	1.00E-20	1.00E-20	1.00E-20	3.61E+00	1.84E-04	1.69E-04	2.35E-04	1.00E-20	1.00E-20	1.00E-20	1.00E-20
Chloroform	2.61E-01	1.00E-20	1.33E-05	1.85E-05	1.00E-20	1.00E-20	1.00E-20	1.00E-20	8.94E-02	1.00E-20	4.18E-06	5.81E-06	1.00E-20	1.00E-20	1.00E-20	1.00E-20
Chloromethane	1.00E-20	1.00E-20	1.00E-20	1.00E-20	5.91E+00	1.00E-20	6.31E-04	8.76E-04	1.00E-20	1.00E-20	1.00E-20	1.00E-20	4.78E+01	1.00E-20	2.21E-03	3.08E-03
Ethene	1.14E+00	3.50E-04	5.83E-05	8.10E-05	6.99E+00	1.00E-20	6.94E-04	9.64E-04	6.51E+00	4.00E-04	3.04E-04	4.23E-04	1.92E+00	1.00E-20	9.02E-05	1.25E-04
Propylene	2.94E-01	1.50E-04	1.50E-05	2.08E-05	3.91E+00	1.00E-20	3.88E-04	5.39E-04	9.27E-01	2.00E-04	4.33E-05	6.01E-05	6.90E-01	1.00E-20	3.25E-05	4.51E-05
CEM																
CO2	2.27E+03	7.03E+02	7.70E-02	1.07E-01	1.39E+03	8.29E+02	6.17E-02	8.57E-02	1.68E+03	7.02E+02	4.30E-02	5.98E-02	2.11E+03	8.21E+02	6.44E-02	8.94E-02
CO	1.17E+02	-6.64E-01	5.78E-03	8.03E-03	1.31E+02	1.00E-20	1.35E-02	1.88E-02	3.08E+02	-6.29E-01	1.36E-02	1.89E-02	1.97E+02	1.00E-20	9.87E-03	1.37E-02
NOX	8.66E+00	3.83E-02	4.23E-04	5.87E-04	1.45E+01	1.00E-20	1.30E-03	1.81E-03	1.12E+01	3.83E-02	4.90E-04	6.80E-04	1.84E+01	1.00E-20	9.23E-04	1.28E-03
SO2	9.00E+00	5.86E-03	4.35E-04	6.04E-04	1.00E-20	1.00E-20	1.00E-20	1.00E-20	3.72E+00	4.74E-03	1.63E-04	2.27E-04	1.00E-20	1.00E-20	1.00E-20	1.00E-20

Appendix H: Purity of Organic Red Dyes via DSC

Customer:	Elaine McHan	**Report Number*:**	R02-0548
Company:	Pine Bluff Arsenal	**Date Submitted:**	11/11/2002
Address:	Building 2337 Sibert Road Pine Bluff, AR 71602	**Report Date:**	11/18/2002
Databook #:	011	**Analyst(s):**	Lynn C. Walker
Samples:	S02-3359, S02-3360	**QC: (Initial/Date)**	KEL 11/19/02

Purity of Organic Red Dyes via DSC

Project Request

Elaine McHan requested melting point and purity analysis via differential scanning calorimetry (DSC) on two organic dye samples, designated 'Solvent Red No1' (orthomethoxyphenylazobeta-naphthol) and 'Disperse Red No. 11' (1,4-diamino-2-methoxyanthraquinone). Military specifications were provided (1). The request was part of an effort to certify dye purity for use in related analytical methods.

Experimental

The Perkin-Elmer DSC-7 and Procedure

Calorimetric measurements were carried out employing a Perkin-Elmer DSC-7 and Pyris software system (V4.3). The DSC-7 is a power-compensated instrument equipped with high sensitivity platinum resistance thermometers, and is well suited for the detection of low-level transitions, specific heats, and purity analysis using ASTM methods. The DSC-7 has an operational range of –100 to 700 °C.

Dye solids were weighed in air to passivated aluminum pans and gently tamped to maximize thermal contact to the PRT sensor. Crimped seal pans (non-hermetic) were used. Initial scans at 10 °C/min were carried out to locate the melting temperature. For the purity experiments, a scan rate of 0.5 °C/min was used with N_2 sweep in the cell enclosures. Baselines were determined using empty pans and this data used in a baseline subtraction routine.

Prior to the measurements, indium and tin standards were evaluated for melting point, since they formed the approx. upper and lower limits for the dyes. Indium was found to melt at 156.6 °C ($\Delta H_m/M$ = 28.50 J/g). For tin, T_m = 231.5 °C and $\Delta H_m/M$ = 60.1 J/g. Certificate values for these properties are, for indium, 156.6 °C, $\Delta H_m/M$ = 28.51 J/g and 231.9 °C, $\Delta H_m/M$ = 60.22 J/g for tin (2).

ASTM Method E928-85

The ASTM DSC test method for purity is suited for crystalline organic solids that do not form solid solutions (3). The method consists of a measurement of the enthalpy of melting using a slow heating rate (ca 0.5 °C/min). The enthalpy of fusion is determined by area integration. The curve is further partitioned into a series of fractional areas, usually about ten, in the first 10 to 50-

area %. Each fractional area (F) is assigned a mean temperature. A plot of temperature ('y' axis) vs. 1/F ('x' axis) is made and corrected to linearity using an iterative calculation program. High purity samples usually require a ± 4 to 6 % correction to achieve linearity, while less pure materials may require a 20 % correction. The mole fraction of the impurity is calculated employing the van't Hoff equation and the slope of the line. Subtracting the impurity fraction from 1.000 and expressing this as a mol % gives the purity of the main component. For the method to be generally applicable, the sample must be stable through the melt and be able to crystallize upon cooling. In addition, the impurity must concentrate in the early melt phase. In general, the method is applicable to samples of >98 % purity and the accuracy of the result is typically 10% of the impurity. The performance of the DSC is checked using pure phenacetin, and phenacetin doped with p-aminobenzoic acid (PABA). These materials are available from NIST as SRM1514 Purity Analysis Sample Kit.

Results and Discussion

Experimental results are summarized in Table I and illustrated in Figures 1 through 11. The tabular values include: Wt. in mg, Scan Number, Purity in mol %, T_m, °C (peak temp.), and the x-correction in %. Purity calculations were made using molecular weights of 279.32 g/mol for Solvent Red Dye No.1 ($C_{17}H_{14}N_2O_2$) and 268.27 g/mol for Disperse Red No. 11 ($C_{15}H_{12}N_2O_3$).

Solvent Red Dye No. 1

Figure 1 illustrates an initial experiment on this sample using a heating rate of 0.5 °C/min followed by cooling at 1.0 °C/min. This organic dye shows good thermodynamic reversibility; the melting process is sharp with a peak at 181.7 °C and the re-crystallization peak is at 165 °C. There were no mass losses in cycling and the energy required for the melting process is almost exactly the same as that gained back in crystallization. Two experiments gave purities of 98.4 and 98.7 mol % (Figures 2 and 3).

Disperse Red Dye No. 11

This material also shows sharp melting behavior; however, mass losses in the melt were consistently found. Two experiments gave purities of 99.2 and 98.6 mol % (Figures 4 and 5).

Phenacetin Standards

Figures 6 through 9 illustrate the results for phenacetin (99.94 mol % pure) and phenacetin doped with 0.7 mol % PABA. The results on the former are in good agreement with the certificate values; however, the latter sample calculated 0.3 mol % high.

Conclusions and Recommendations

Solvent Red Dye No. 1 has a maximum purity of 98.5 mol %, with a lower limit of 98.2 mol % if a correction is applied based on the phenacetin (99.3 mol % Std.). The shape of the curve indicates that the impurities are concentrating in the early melt phase. Supercooling of 17

degrees is observed with nearly a perfect match in process energies. Because of good thermal stability in the melt stage, this material may be further purified using zone-melt techniques.

Disperse Dye No. 11 shows an average purity of 98.9 mol %, with a lower limit of 98.6 mol % using the correction. As with Dye No. 1 the impurities appear to concentrate in the melt and probably account for some T_m lowering. In contrast to the former, this material may not be as good a candidate for zone refining, because of its volatility in the melt. Crystallization from solvents is suggested.

References

1. Military Specifications for Solvent Red Dye No. 1, DOD-D-51523(EA), 20 May 1986 and Disperse Dye No. 11, DOD-D-51522(EA), 20 May 1986.
2. National Institute of Standards and Technology (NIST), SRM2232 (Indium), SRM2220 (Tin) and SRM1514 (Phenacetins).
3. Standard Test Method for Mol Percent Impurity by Differential Scanning Calorimetry, ASTM Method E928-85 (1989).

*This analysis is provided in good faith with no warranty expressed or implied. MMI and Impact Analytical assume no obligation or liability with respect to the use of the results. If you have any questions about this analysis, please contact the lead analyst or the Impact Analytical Business Manager at (989) 832-5555, ext. 563.

Table I

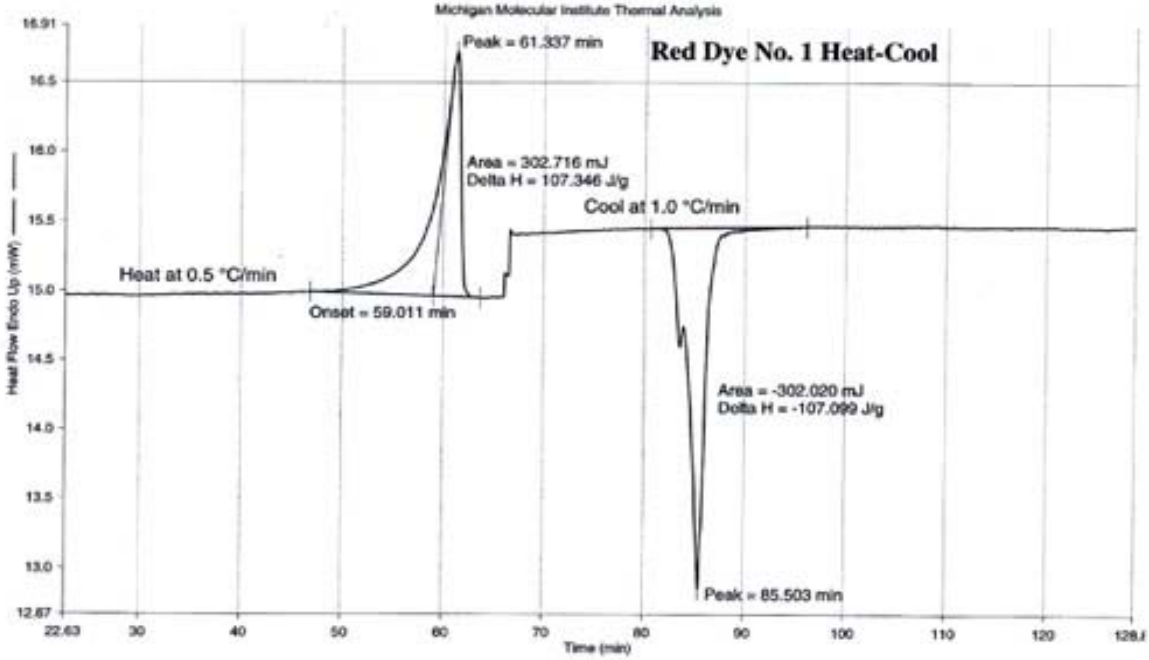
Purity of Organic Dyes

and Phenacetin Standards

Wt., mg	Scan	Purity, mol%	Tm, °C	ΔHm, kJ/mol	x-corr'n, %
Solvent Red Dye No. 1 (Lot 44)					
2.61	1	98.40	181.0	35.4	9.5
2.82	1	98.70	181.5	33.8	14.3
Disperse Red Dye No. 11 (Lot 4)					
3.14	1	99.20	236.8	29.8	13.4
3.11	1	98.60	236.6	34.3	16.2
Phenacetin 99.94 mol% Certified					
2.72	1	99.99	133.3	28.1	-4.9
2.72	2	99.99	133.3	27.5	-5.9
Phenacetin 99.3 mol% (0.7mol% PABA)					
2.12	1	99.58	133.1	28.3	7.4
2.12	2	99.55	133.2	28.2	6.6

FIGURE 1

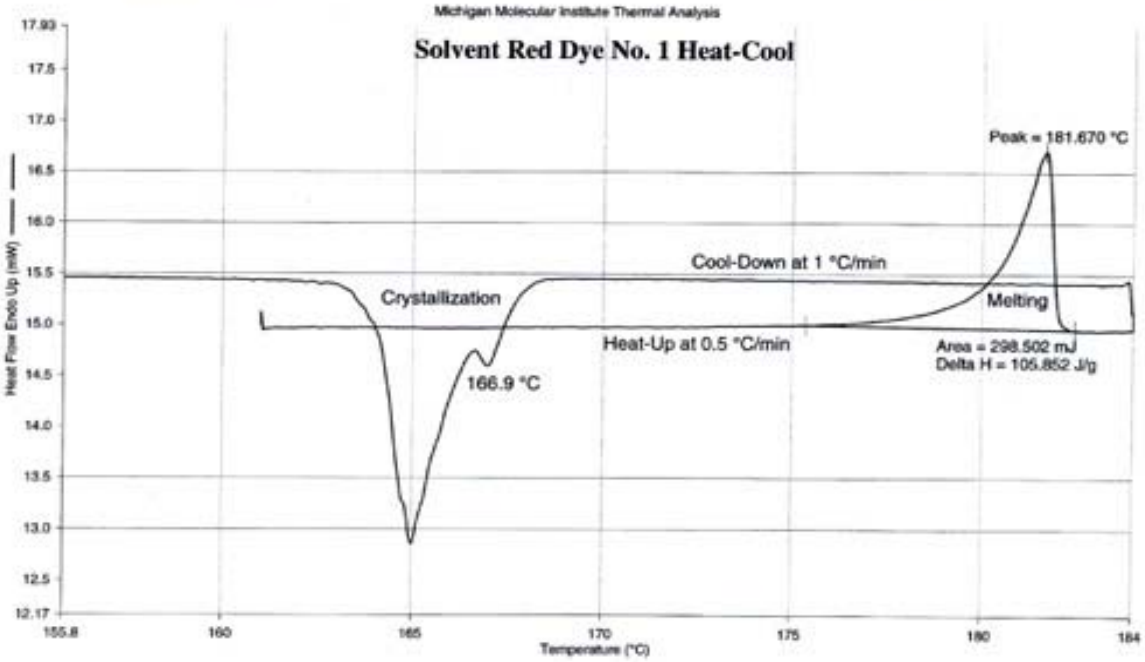
Filename: C:\Program Files\Pyris\Dat...\S02033591.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Red Dye No. 1 (Lot #44)
Sample Weight: 2.820 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 13, '02 (BaseC3)



11/14/02 10:15:48 AM

1) Hold for 20.0 min at 161.00°C
2) Heat from 161.00°C to 184.00°C at 0.50°C/min
3) Hold for 0.5 min at 184.00°C
4) Cool from 184.00°C to 100.00°C at 1.00°C/min

Filename: C:\Program Files\Pyris\Dat...\S02033591.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Red Dye No. 1 (Lot #44)
Sample Weight: 2.820 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 13, '02 (BaseC3)



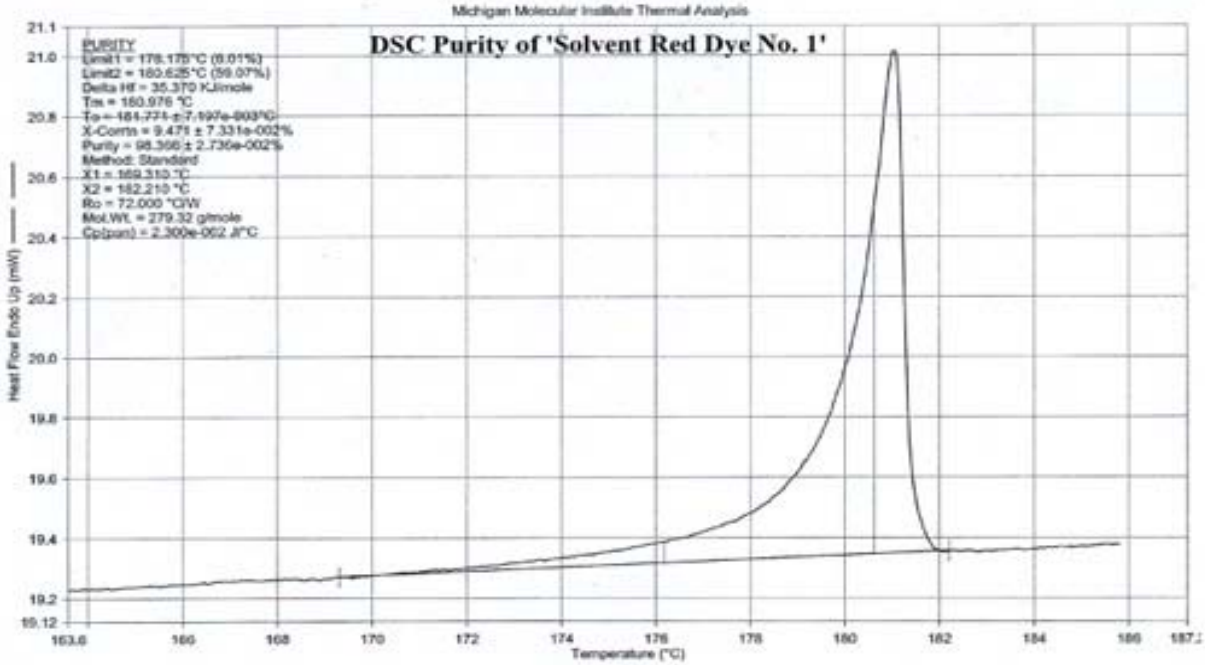
11/14/02 9:34:03 AM

1) Hold for 20.0 min at 161.00°C
3) Hold for 0.5 min at 184.00°C

FIGURE 2

Filename: C:\Program Files\Pyris\Data\Redye2.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Red Dye No. 1 (Lot #44)
Sample Weight: 2.610 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov.12, '02

Michigan Molecular Institute Thermal Analysis

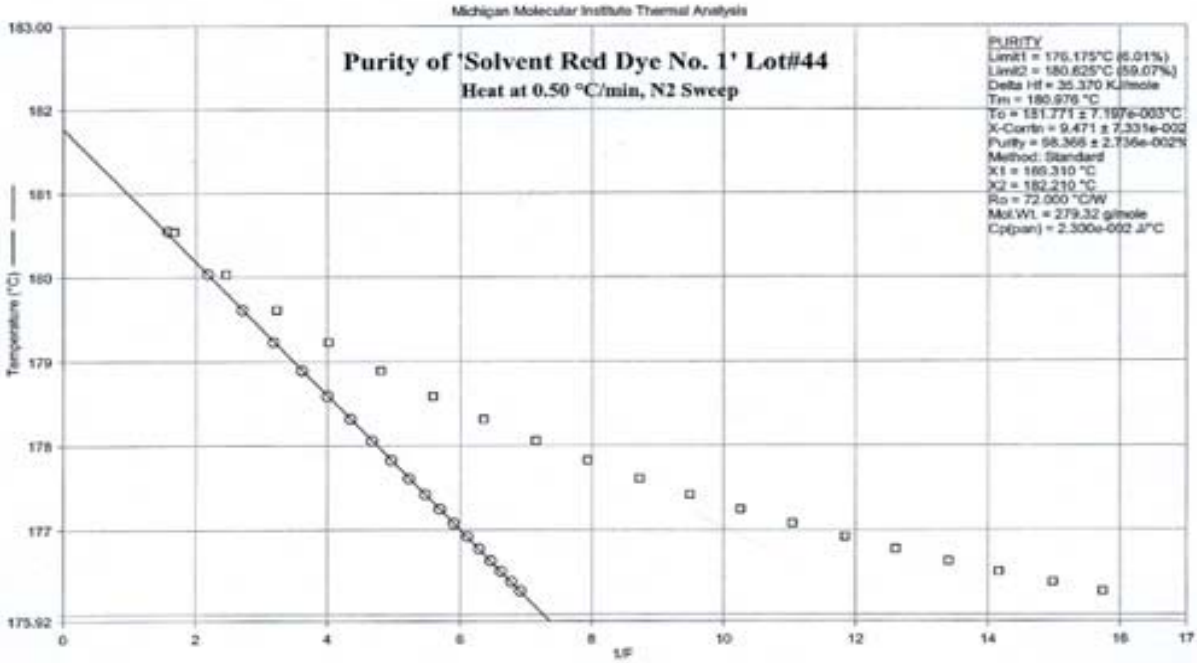


11/12/02 11:23:58 AM

1) Heat from 120.00°C to 195.00°C at 0.50°C/min

Filename: C:\Program Files\Pyris\Data\Redye2.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Red Dye No. 1 (Lot #44)
Sample Weight: 2.610 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov.12, '02

Michigan Molecular Institute Thermal Analysis



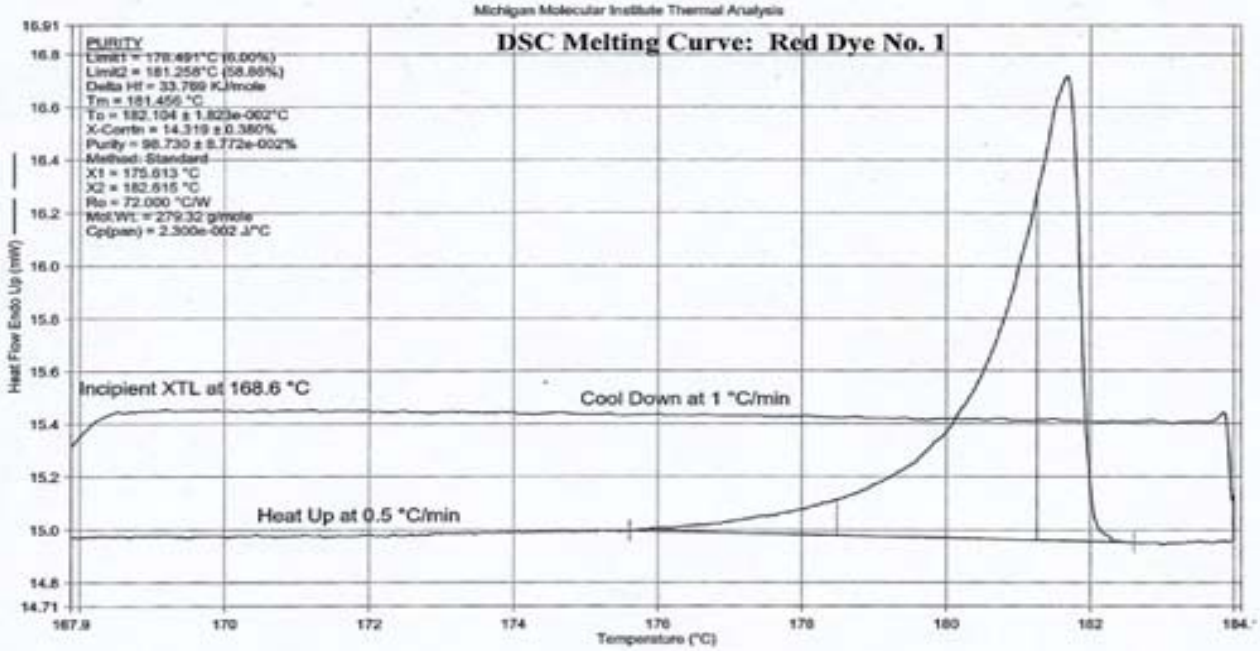
11/12/02 11:22:11 AM

1) Heat from 120.00°C to 195.00°C at 0.50°C/min

FIGURE 3

Filename: C:\Program Files\Pyris\Dat...\S02033591.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Red Dye No. 1 (Lot #44)
Sample Weight: 2.820 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 13, '02 (BaseC3)

Michigan Molecular Institute Thermal Analysis

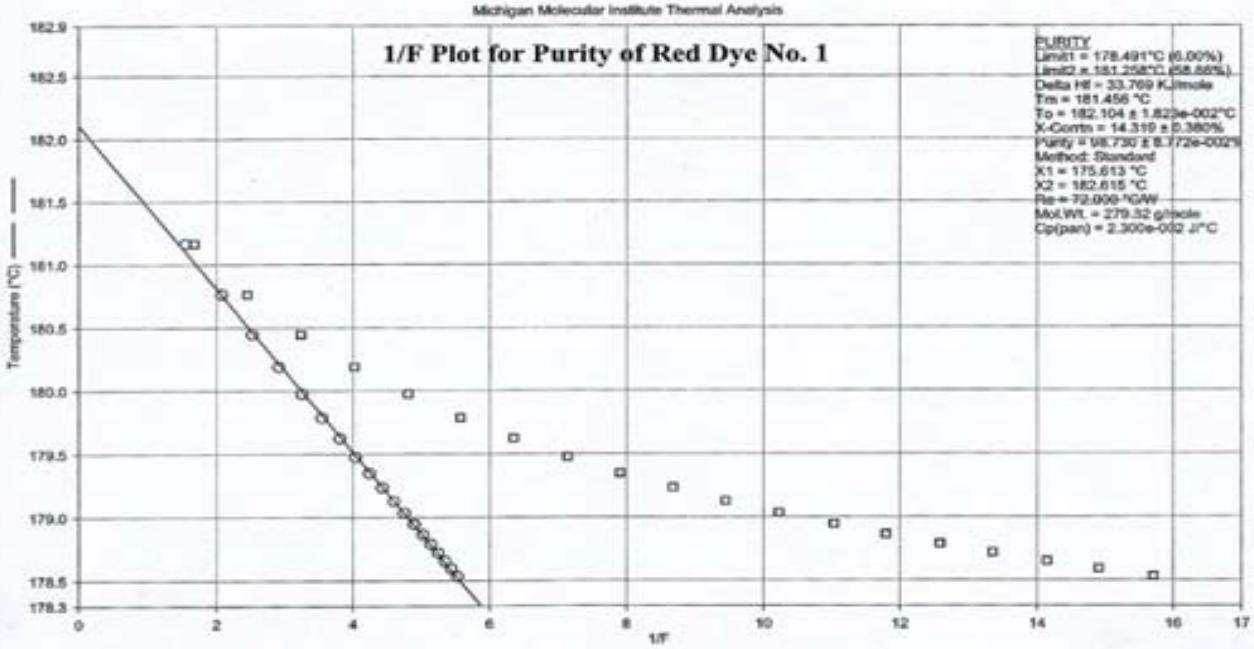


11/14/02 10:25:32 AM

1) Hold for 20.0 min at 161.00°C
2) Heat from 161.00°C to 184.00°C at 0.50°C/min
3) Hold for 0.5 min at 184.00°C
4) Cool from 184.00°C to 100.00°C at 1.00°C/min

Filename: C:\Program Files\Pyris\Dat...\S02033591.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Red Dye No. 1 (Lot #44)
Sample Weight: 2.820 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 13, '02 (BaseC3)

Michigan Molecular Institute Thermal Analysis



11/14/02 10:21:30 AM

1) Hold for 20.0 min at 161.00°C
2) Heat from 161.00°C to 184.00°C at 0.50°C/min
3) Hold for 0.5 min at 184.00°C
4) Cool from 184.00°C to 100.00°C at 1.00°C/min

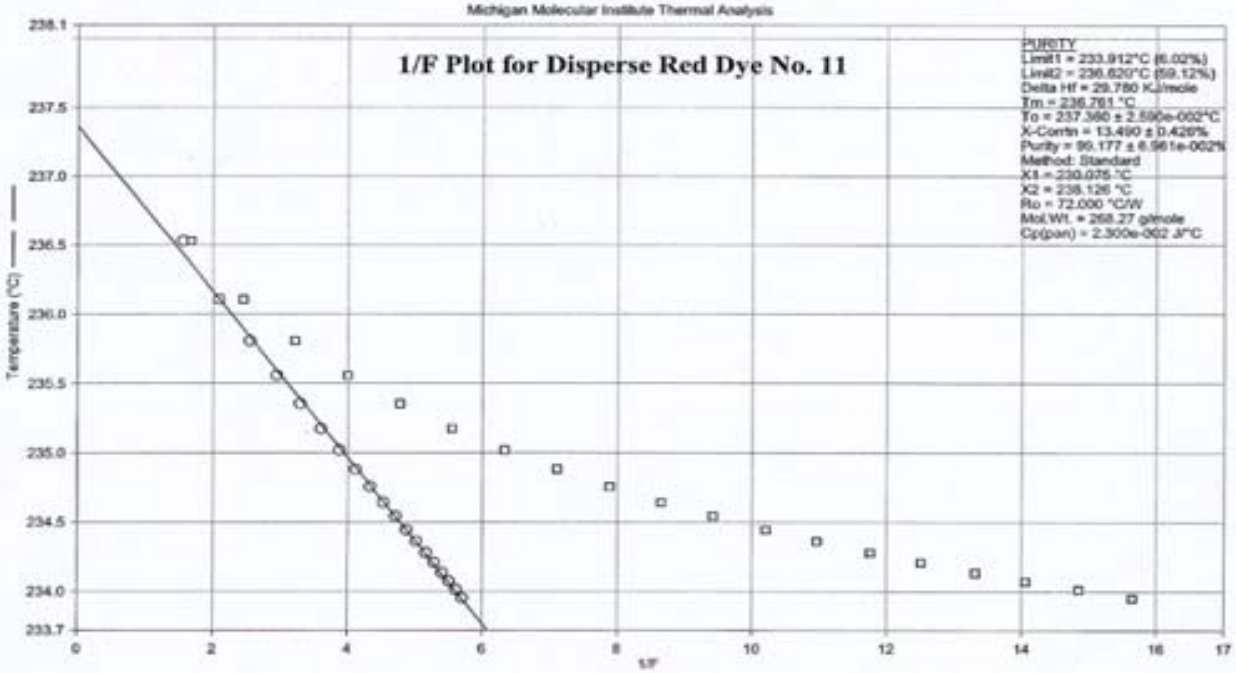
FIGURE 4

Filename: C:\Program Files\Pyris\Data\DDR2.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Disperse Dye No. 11 M.Pt. & Purity
Sample Weight: 3.140 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 13, '02 (BaseC2)

11/13/02 2:04:31 PM

1) Hold for 1.0 min at 150.00°C 2) Heat from 150.00°C to 255.00°C at 0.50°C/min

Filename: C:\Program Files\Pyris\Data\DDR2.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Disperse Dye No. 11 M.Pt. & Purity
Sample Weight: 3.140 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 13, '02 (BaseC2)



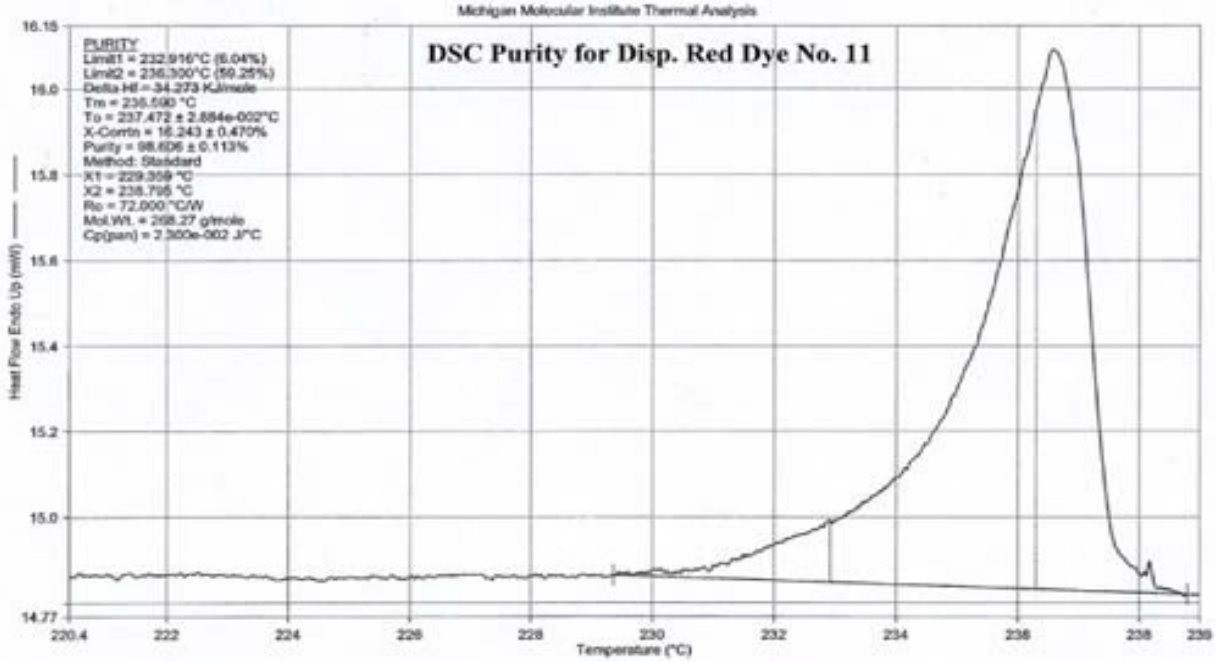
11/13/02 2:02:04 PM

1) Hold for 1.0 min at 150.00°C 2) Heat from 150.00°C to 255.00°C at 0.50°C/min

FIGURE 5

Filename: c:\program files\pyris\dat...\ddr4@copy.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Disperse Dye No. 11
Sample Weight: 3.110 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 14, '02 (BaseC2)

Michigan Molecular Institute Thermal Analysis

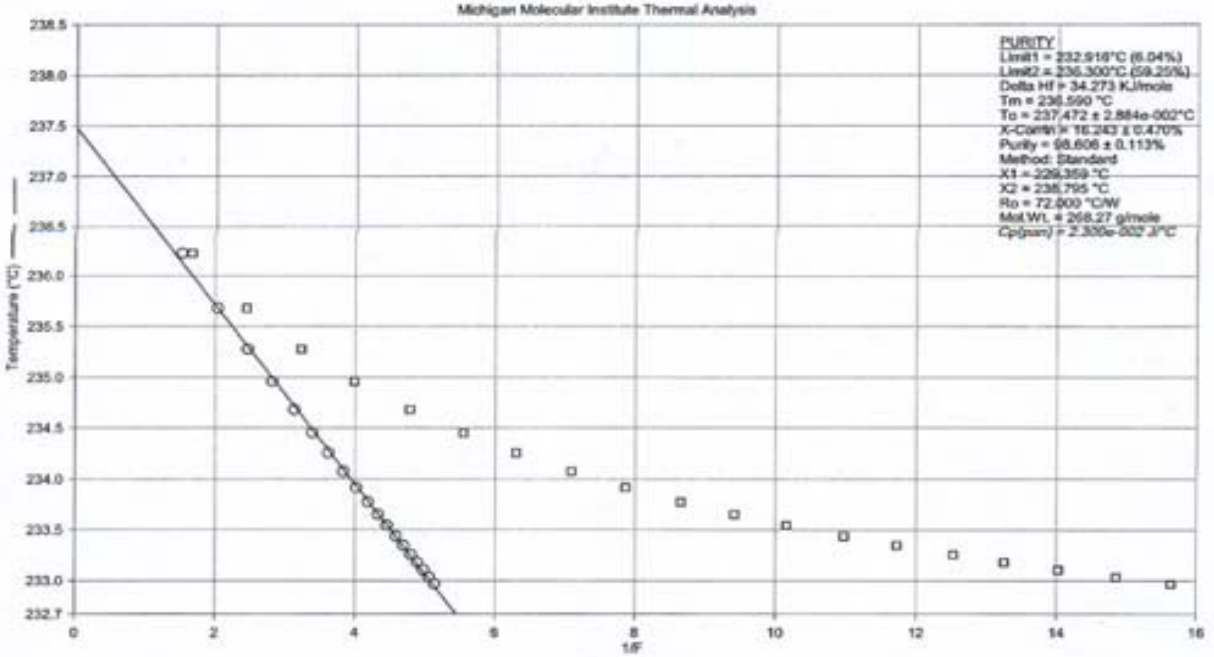


11/14/02 2:13:14 PM

1) Hold for 1.0 min at 220.00°C
2) Heat from 220.00°C to 239.00°C at 0.50°C/min
3) Hold for 1.0 min at 239.00°C
4) Cool from 239.00°C to 135.00°C at 1.00°C/min

Filename: c:\program files\pyris\dat...\ddr4@copy.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Disperse Dye No. 11
Sample Weight: 3.110 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 14, '02 (BaseC2)

Michigan Molecular Institute Thermal Analysis

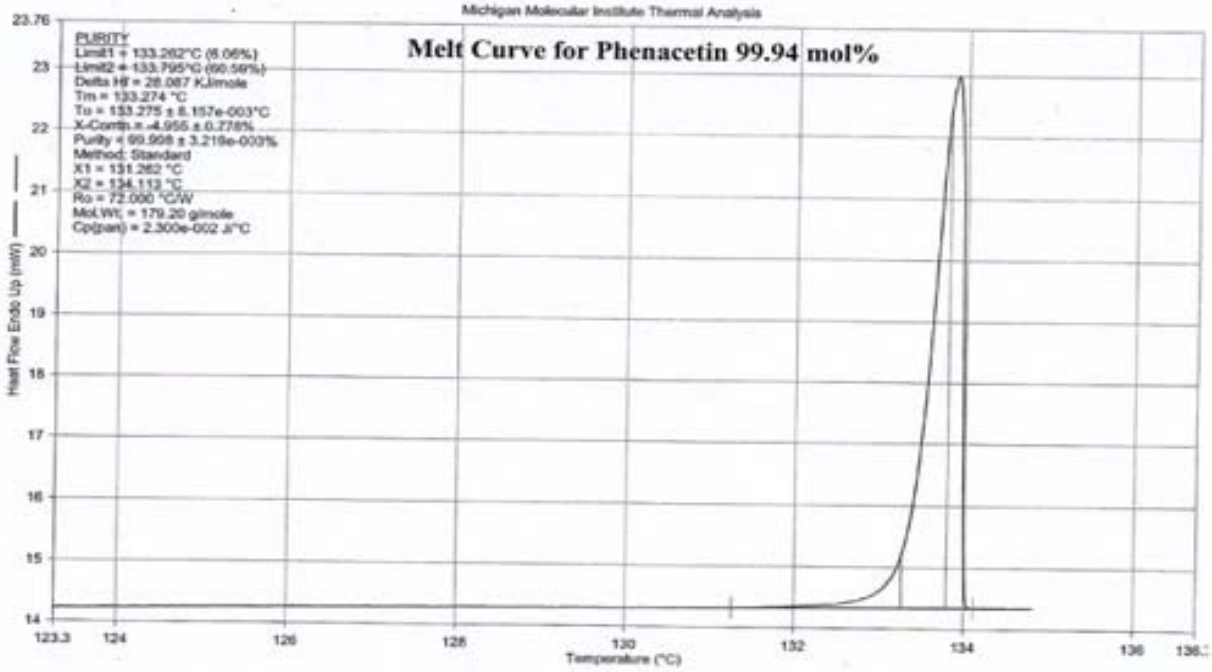


11/14/02 2:11:18 PM

1) Hold for 1.0 min at 220.00°C
3) Hold for 1.0 min at 239.00°C

FIGURE 6

Filename: C:\Program Files\Pyris\Data\PHENP3.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Phenacetin 99.94 mol% Pure
Sample Weight: 2.720 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 14, '02 (BaseC2)



Filename: C:\Program Files\Pyris\Data\PHENP3.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Phenacetin 99.94 mol% Pure
Sample Weight: 2.720 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 14, '02 (BaseC2)

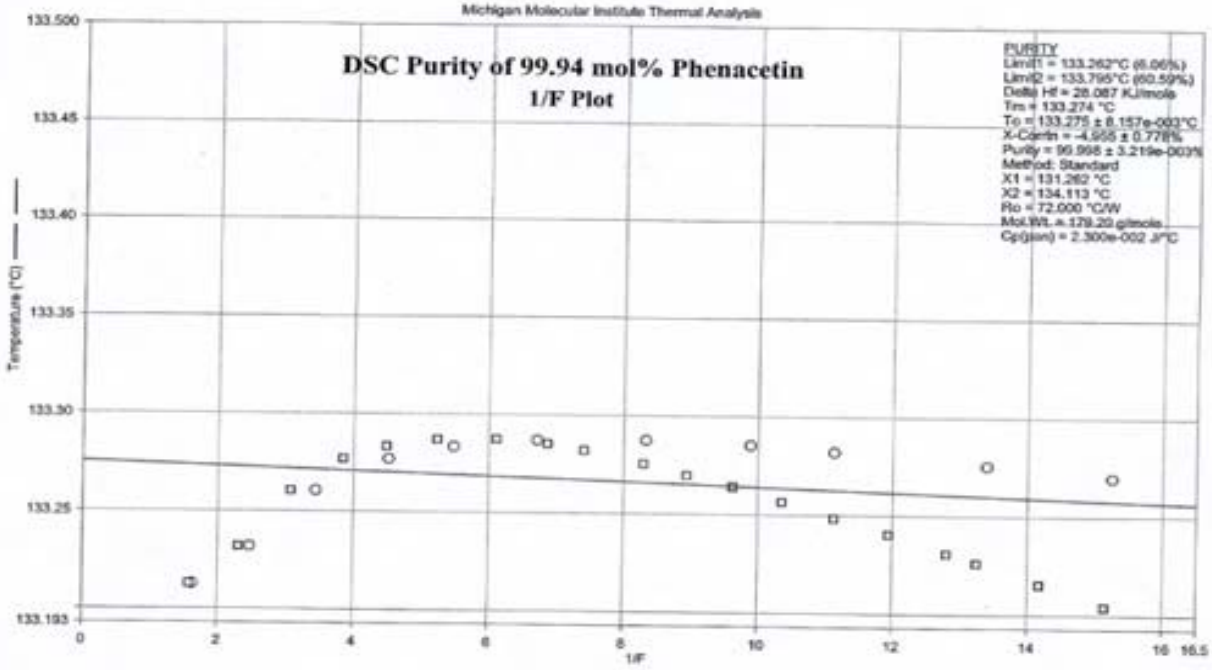
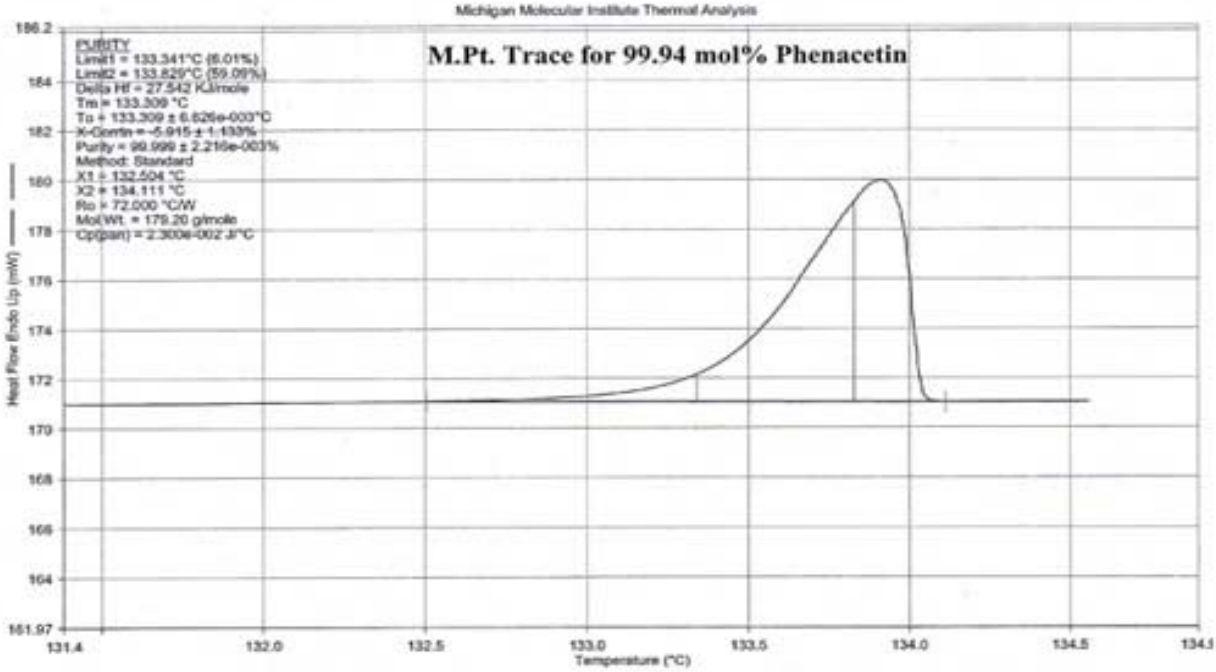


FIGURE 7

Filename: C:\Program Files\Pyris\Data\PHENHP1.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Phenacetin 99.94 mol% Pure SRM1514
Sample Weight: 2.720 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 13, '02 (BaseC2)

Michigan Molecular Institute Thermal Analysis

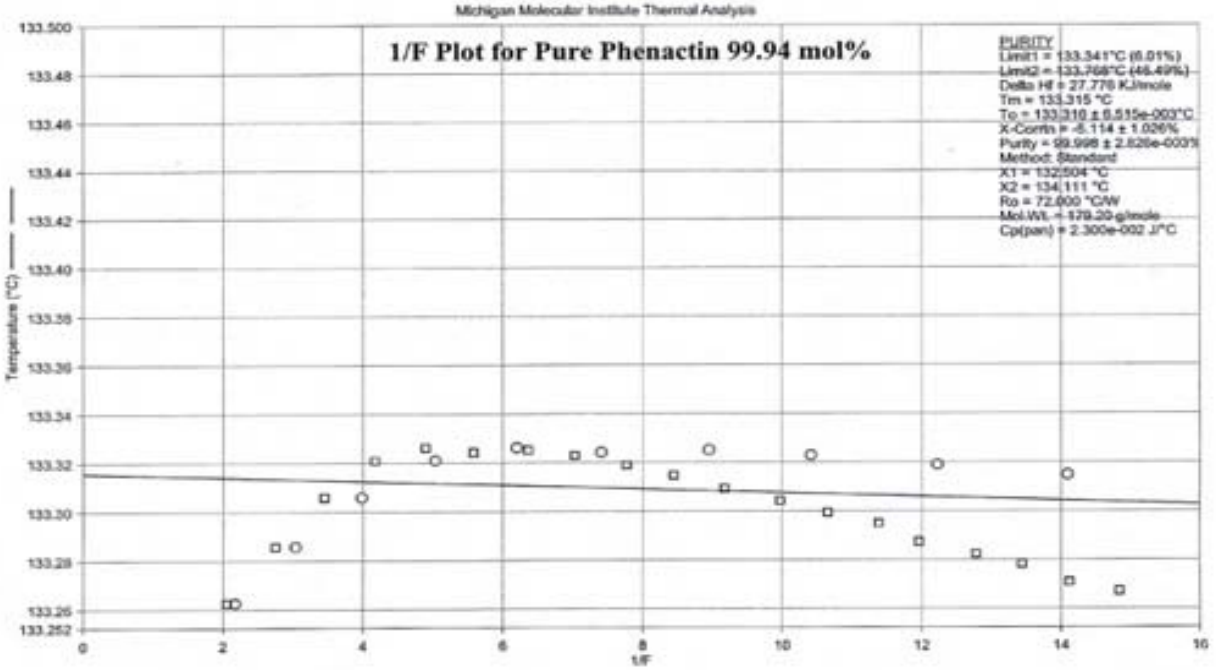


11/18/02 4:44:17 PM

1) Hold for 1.0 min at 128.00°C
2) Heat from 128.00°C to 137.00°C at 0.50°C/min

Filename: C:\Program Files\Pyris\Data\PHENHP1.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Phenacetin 99.94 mol% Pure SRM1514
Sample Weight: 2.720 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 13, '02 (BaseC2)

Michigan Molecular Institute Thermal Analysis

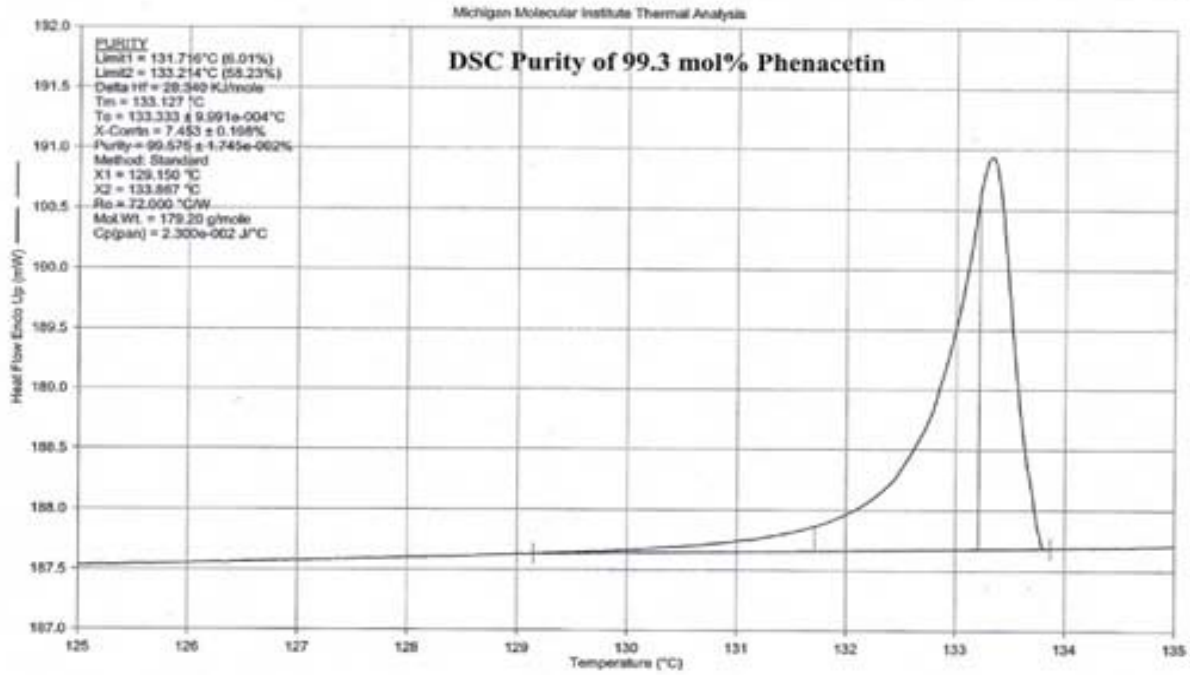


11/13/02 8:37:32 AM

1) Hold for 1.0 min at 128.00°C
2) Heat from 128.00°C to 137.00°C at 0.50°C/min

FIGURE 8

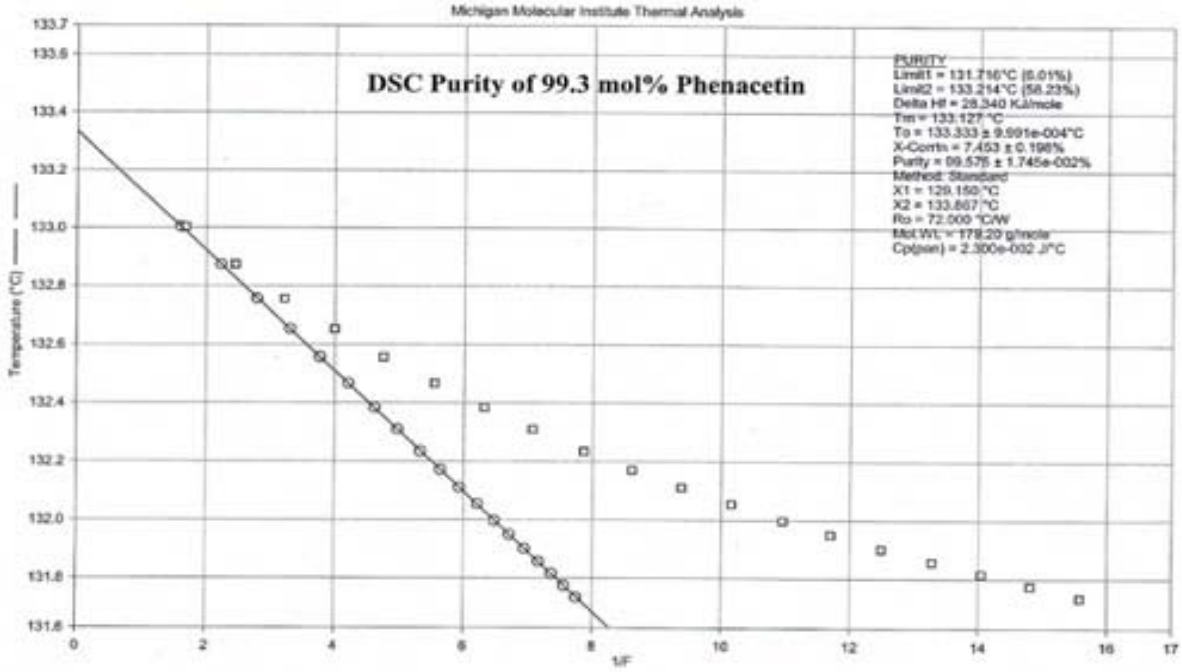
Filename: C:\Program Files\Pyris\Data\PHENMP1.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Phenacetin 99.3 mol% SRM1514
Sample Weight: 2.120 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 13, '02 (BaseC2)



11/14/02 10:29:03 AM

1) Hold for 1.0 min at 118.00°C
2) Heat from 118.00°C to 137.00°C at 0.50°C/min

Filename: C:\Program Files\Pyris\Data\PHENMP1.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Phenacetin 99.3 mol% SRM1514
Sample Weight: 2.120 mg
Comment: dT/dt = 0.5 °C/min, N2 Sweep
Nov. 13, '02 (BaseC2)

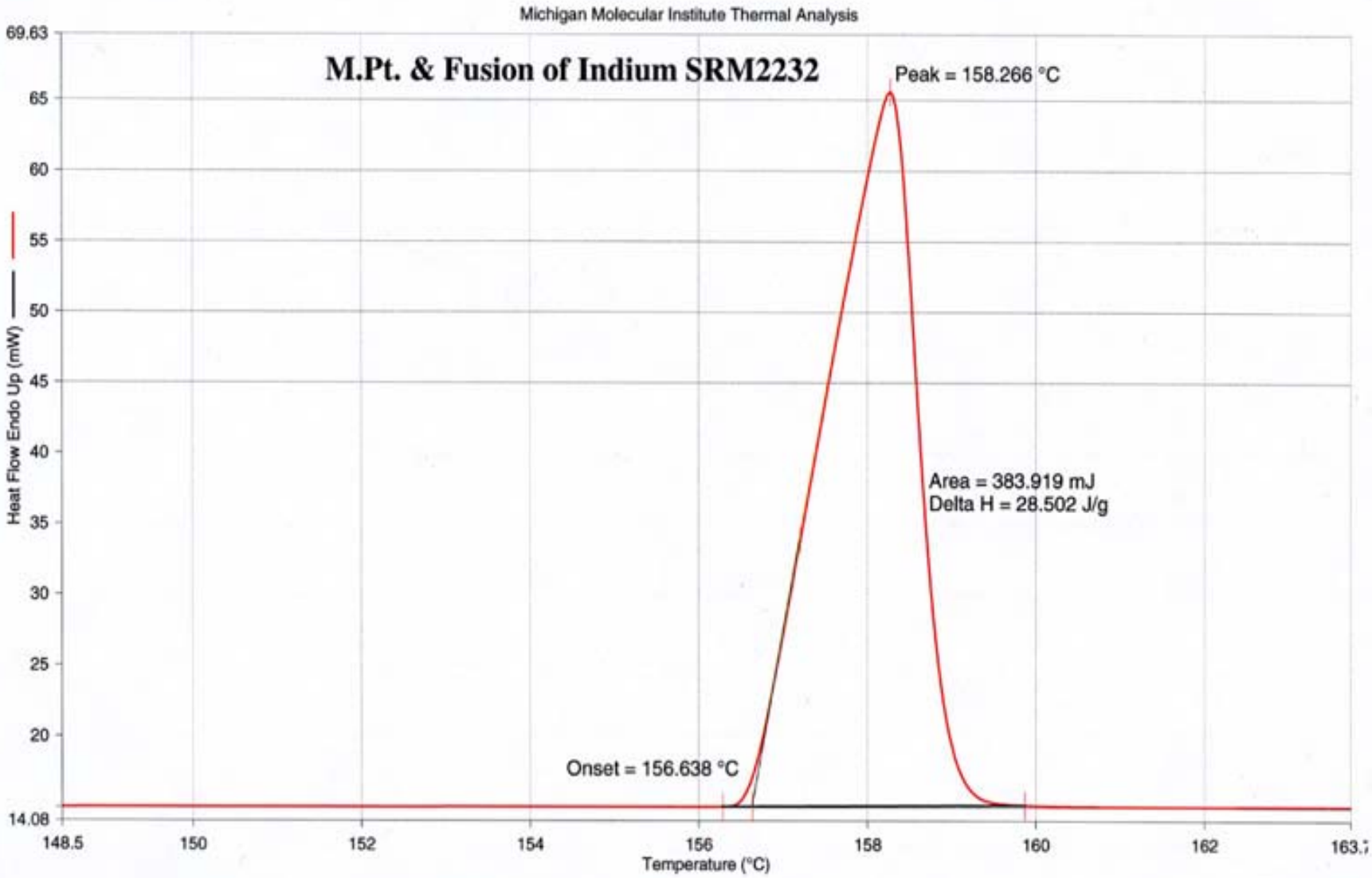


11/14/02 10:28:39 AM

1) Hold for 1.0 min at 118.00°C
2) Heat from 118.00°C to 137.00°C at 0.50°C/min

FIGURE 10

Filename: C:\Program Files\Pyris\Data\INDCK2.dsd
Operator ID: L. C. Walker, MMI
Sample ID: Indium SRM2232
Sample Weight: 13.470 mg
Comment:



11/14/02 3:38:37 PM

1) Hold for 1.0 min at 130.00°C

2) Heat from 130.00°C to 165.00°C at 10.00°C/min

Appendix I

ANIMAL USE PROTOCOL
TOXICOLOGY DIRECTORATE
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
ABERDEEN PROVING GROUND, MD 21010-5403

PROTOCOL TITLE: Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

PROTOCOL NUMBER: 0497-24

PRINCIPAL INVESTIGATOR/STUDY DIRECTOR: Jeffrey D. Bergmann
Directorate of Toxicology

CO-INVESTIGATOR (S): Lee C.B. Crouse
Directorate of Toxicology

Mark W. Michie
Directorate of Toxicology

SPONSOR: Environmental Security Technology Certification Program
901 North Stuart Street
Suite 303
Arlington, VA 22203-1853

I. NON-TECHNICAL SYNOPSIS: Groups of rats will be subjected to a single, whole-body exposure to emissions from "old" and "new" violet colored M18 smoke grenades. Exposure will be to one of two preselected concentrations and last either two or ten minutes (see table, page 5). Rats will be euthanized at 1 day, 7 days and 90 days post exposure. Necropsies will be performed and tissues harvested to assess pathological changes to the respiratory tract caused by the airborne materials.

II. BACKGROUND:

II.1. <u>Background</u>: The U.S. Army uses smokes and obscurants to shield armed forces from view, signal friendly forces, and mark positions. However, many kinds of grenade smokes contain dyes and other materials that could pose a hazard to human health and the environment. The Army smoke and dye replacement program found a sugar formulation that successfully replaces the sulfur in most M18 smoke grenades used by the U.S. military. At the program's onset, the switch to the sugar mixture was successful for green and yellow M18 grenades, but changes to the red and violet M18 smoke grenades were more difficult.

Initially, the new dyes burned instead of smoked, not producing enough colored smoke to meet strict military standards. Eventually, the violet smoke grenade was reconfigured to successfully produce the right color, amount of smoke and burn time. However, the smoke produced by the redesigned red smoke grenades was too pale compared to the original.

The Army seeks to reduce the likelihood that exposure to smokes during training would have adverse health effects on military personnel or civilians. To protect the health of exposed individuals, the Office of the Army Surgeon General requested that the National Research Council (NRC) independently review data on the toxicity of smokes and obscurants and recommend exposure guidance levels for military personnel in training and for the general public residing or working near military-training facilities. The NRC concludes that the available toxicity data base for the combustion products of the old and new smoke formulations is inadequate for use in assessing the potential health risk of exposure to these smokes and in recommending exposure guidance levels. The subcommittee recommends that, at a minimum, acute inhalation studies be conducted in experimental animals to test the toxicity of the colored smokes. The Environmental Security Technology Certification Program provided funding for toxicity testing only for the violet-colored grenades.

This study will be conducted in accordance with Good Laboratory Practice Standards, 40 CFR, Part 792.

II.2. Literature Search for Duplication:

II.2.1. Literature Sources Searched:

DTIC: 1984-present
DoD Biomedical Research Database: FY1998-FY2002

PubMed: 1966-present

DIALOG ONESEARCH database including:
BIOSIS: 1969-present
NTIS: 1964-present
EMBASE: 1974-present
PASCAL: 1973-present
CA SEARCH: 1967-present
ELSEVIER BIOBASE: 1994-present
FEDRIP: 1998-present
INSIDE CONFERENCES: 1993-present

CAB ABSTRACTS: 1972-present
MEDLINE : 1966-present
BUSINESS & INDUSTRY: 1994-present
DIALOG GLOBAL REPORTER: 1997-present
IHS INTL. STANDARDS & SPECS: 1999
ENERGY SCITEC: 1974-present
AEROBASE: 1999-present
GALE GROUP NEWSEARCH: 2005
DIALOG DEFENSE NEWSLETTERS: 1989-present
CBIAC: 1996-present
TOXNET: 1900 +
CARS: NA

II.2.2. Date of Search: 7 Jul 2005

II.2.3. Period of Search: The range of years covered varies according to the database and are individually listed in II.2.1. No limits were placed on the years to be covered in this search.

II.2.4. Key Words of Search: M18, violet, colored smoke grenades, combustion products, inhalation, toxicity

II.2.5. Results of Search: The literature search revealed no inhalation studies that would suggest that our study would be a duplicate effort. However, a health risk assessment was conducted by USACHPPM to evaluate the potential for human health effects to offsite residents breathing air emissions following use of the old M18 Violet- Colored Smoke Grenade (reference 13). Air emissions data from the smoke grenade were collected in a test chamber, and was then used in an air dispersion model to determine ambient air concentrations at a location downwind from the site where the item was activated. Modeled air concentrations were combined with exposure information to estimate the amount of substances the hypothetical resident breathes. "The study results showed no potential for health risks from inhalation of air emissions from the M18 Violet-Colored Smoke Grenade."

In one animal study, the effects of a prototype violet dye mixture (VDM) consisting of Disperse Red 11 (the dye used in the new violet grenade) and Disperse Blue 3 on F344 male and female rats have been investigated by inhalation exposure, intratracheal instillation, or gavage (reference 14). Acute 1-day inhalation exposures (6 hr) to VDM were conducted at 1000, 300, 100, 70, 40, and 10 mg/m3, with an additional exposure to 40 mg/m3 6 hr/day for 5 days. Lung burdens of dye, general histopathology, and/or liver function were evaluated at 0, 3, and 7 days post exposure. Unexpected lethality due to severe liver damage was observed with acute exposures of > or = 300 mg/m3 and in the 5-day 40 mg/m3 exposures. In addition, nasal olfactory epithelium exhibited degeneration and necrosis with acute exposures > or = 10 mg/m3.

An acute inhalation study of the combustion products disseminated from the old M18 grenade was conducted in the monkey, dog, goat, swine, rabbit, rat, and guinea pig (reference15). The animals were exposed to concentrations ranging from 1.3 to 7.8 g/m^3 for 8 to 142 min. Exposure was followed by a 30-day observation period. The results were presented as a Bliss analysis of the combined mortality of the total number of animals of all species exposed to the combustion products. The combined LCT_{50} for the combustion products was 211 $mg{\cdot}min/m^3$. Immediately after exposure, all animals showed upper-respiratory irritation and salivation. Gagging was evident in the dog, swine, goat, and monkey. Prostration was noted in all species for 1 to 4 hr after exposure. Most deaths occurred within the first week after exposure. Although rats were used in this study, the concentrations and exposure times were variable, making any comparison to the current study impractical. The report goes on to state that disseminates from M18 grenades are of a low order of toxicity. The extremely high Ct's required to produce deaths and the toxic signs exhibited by the animals after exposure are similar to the responses caused by exposure to nontoxic dusts.

III. OBJECTIVE/HYPOTHESIS: The objective of this study is to assess and compare the acute inhalation toxicity in rats following exposure to emissions from "old" and "new" formulations of violet colored M18 smoke grenades.

IV. MILITARY RELEVANCE: The U.S. Army seeks to reduce the likelihood that exposure to smokes during training would have adverse health effects on military personnel or civilians. On the basis of its review and evaluation, the NRC concluded that additional research must be conducted on the toxicity of the colored smokes before well-informed recommendations for exposure guidance levels can be made. The Army requested recommendations for four types of exposure guidance levels: (1) emergency exposure guidance levels (EEGLs) for a rare, emergency situation resulting in exposure of military personnel for less than 24 hr; (2) repeated exposure guidance levels (REGLs) for repeated exposure of military personnel during training exercises ; (3) short-term public emergency guidance levels (SPEGLs) for a rare, emergency situation potentially resulting in an exposure of the public to military-training smoke; and (4) repeated public exposure guidance levels (RPEGLs) for repeated exposures of the public residing or working near military-training facilities. Acute toxicity studies would be most relevant for recommending emergency guidance levels such as the EEGLs and SPEGLs.

V. MATERIALS AND METHODS:

V.1. <u>Experimental Design and General Procedures:</u> Details of the experimental design and general procedures are described in TOX SOP 029.05.

V.1.1. Experiment 1: <u>Pilot Study.</u> Five rats per sex will be exposed for 10 minutes to the 6 feet concentration of both the old and new smoke formulations as described below and in paragraph V.4. This exposure will serve to determine the more sensitive sex and to avoid catastrophic consequences during the main study. A total of ten rats to be used.

V.1.1. Experiment 2: <u>Main Study.</u> If there are no sex differences revealed from the pilot study, male rats will be used. Otherwise, the more sensitive sex will be used. Groups of rats will be subjected to a single, whole-body exposure to emissions from violet colored M18 smoke grenades. Exposure concentrations were determined by collecting field samples of smoke grenade emissions at 6 feet and at the edge of the smoke plume. Results showed average concentrations of 864 mg/m^3 and 482 mg/m^3 at the 6 foot and edge of plume, respectively. Each group of rats will be exposed to these field concentrations for either two or ten minutes. Rats will be euthanized at 1 day, 7 days and 90 days post exposure. Necropsies will be performed and tissues harvested to assess pathological changes to the respiratory tract caused by the airborne materials. Rat group assignments for both Experiments 1 and 2 are shown below. Experiment 1 animals are indicated; all others are treatment groups for Experiment 2:

"Old" Violet Colored M18: **10 min.Exposure**

Exposure	No. of Rats	1 day sacrifice	7 day sacrifice	90 day sacrifice
Pilot Study	10		10	
6 ft. concentration	24	8	8	8
Edge of plume	24	8	8	8
Control	18	Six to be used at each sacrifice interval		
Total	76			

"New" Violet Colored M18: **10 min. Exposure**

Exposure	No. of Rats	1 day sacrifice	7 day sacrifice	90 day sacrifice
Pilot Study	10		10	
6 ft. concentration	24	8	8	8
Edge of plume	24	8	8	8
Control	18	Six to be used at each sacrifice interval		
Total	76			

"Old" Violet Colored M18: **2 min.Exposure**

Exposure	No. of Rats	1 day sacrifice	7 day sacrifice	90 day sacrifice
6 ft. concentration	24	8	8	8
Edge of plume	24	8	8	8
Control	18	Six to be used at each sacrifice interval		
Total	66			

"New" Violet Colored M18: **2 min. Exposure**

Exposure	No. of Rats	1 day sacrifice	7 day sacrifice	90 day sacrifice
6 ft. concentration	24	8	8	8
Edge of plume	24	8	8	8
Control	18	Six to be used at each sacrifice interval		
Total	66			

GRAND TOTAL FOR EXPERIMENTS 1 AND 2 = 284

V.2. Data Analysis: Data from each treatment group will be statistically compared to controls using a one-way analysis of variance (ANOVA). If significance is observed, the data will be analyzed further using Dunnett's post-hoc tests. Statistical significance is defined at the $p \leq 0.05$ level. Data to be analyzed will include: body weights, weight gains, absolute organ weights, organ-to-body weight ratios, organ-to-brain weight ratios, hematology, and clinical chemistry values.

V.3. Laboratory Animals Required and Justification:

V.3.1. Non-animal Alternatives Considered: No tissue culture, cell culture or computer modeling procedure would replace the animal model recommended by the NRC.

V.3.2. Animal Model and Species Justification: The NRC recommended that, at a minimum, acute inhalation studies be conducted in experimental animals to test the toxicity of the colored smokes. The rat is a commonly used species in inhalation studies, and a vast data base exists to compare test results.

V.3.3. Laboratory Animals:

V.3.3.1. Genus & Species: *Rattus norvegicus*

V.3.3.2. Strain/Stock: Sprague-Dawley

V.3.3.3. Source/Vendor: Charles River Laboratories (USDA # 14-R-0144)

V.3.3.4. Age: 8-12 weeks

V.3.3.5. Weight: age appropriate

V.3.3.6. Sex: Male and female. Exact breakdown depends on results of Experiment 1. See details above.

V.3.3.7. Special Considerations: None.

V.3.4. Number of Animals Required (By Species): 284 rats. Based on previous data from an acute inhalation study in rats, a sample size of 8 in each group will have greater than 95% power to detect at least a 30% change in organ to-body-weight ratios using a two group t-test with a 0.05 two-sided significance level.

V.3.5. Refinement, Reduction, Replacement:

V.3.5.1. <u>Refinement</u>: Animals will be handled daily during quarantine and provided Nylabones. See Enclosure 3, Environmental Enrichment Plan.

V.3.5.2. <u>Reduction</u>: A pilot study will be conducted initially to determine the more sensitive sex and to avoid catastrophic consequences during the main study. Control group animals will be combined for each exposure time thereby reducing the number of control animals needed for each exposure.

V.3.5.3 <u>Replacement</u>: No nonanimal alternatives are known to exist that will provide the required data.

V.4. <u>Technical Methods</u>:

The smoke grenades will be provided by Edgewood Chemical Biological Center. The compositions of the “old” and “new” formulations are listed in enclosure 4.

The exposures will be performed in a 400-liter, dynamic airflow inhalation chamber. The smoke grenades will be activated inside a 1000-liter static chamber. The resulting smoke emissions will be allowed to mix and then be drawn through an intake pipe to the inlet of the exposure chamber. A gate or ball valve will be placed inline of the intake pipe and adjusted to produce target concentrations and to affect slight negative pressure inside the chamber. The chamber exhaust air will be filtered by a HEPA filter.

In Experiment 2, 24 or 27 rats will comprise an exposure group and be exposed to a single field concentration for either 2 or 10 minutes. Rats will be weighed to the nearest gram just prior to exposure and individually placed in a compartmentalized, stainless steel wire mesh exposure cage. Each compartment measures 6.5” long x 3.75” wide x 3” high. The exposure

cages will be positioned in the middle of the chamber and the chamber sealed. Chamber atmosphere will be sampled for particulate mass concentration, particle size, select heavy metals, volatile organic compounds (VOCs), and sulfur dioxide.

Particulate mass will be measured gravimetrically, while particles size will be measured using an 8-stage cascade impactor. Particulate emissions composition (CAD SOP CAB144.1), heavy metals (NIOSH method 7300), and sulfur dioxide (OSHA method ID 200) will be analyzed by USACHPPM Directorate of Laboratory Sciences. VOCs will be collected by personnel from USACHPPM Air Quality Surveillance Program and analyzed by EPA method TO14A at Lancaster Laboratories, Lancaster, PA.

Upon completion of the exposure, rats will be returned to their home cages and observed at least once before the end of the day for toxic signs. The rats will be held until their scheduled necropsy time, during which routine veterinary care will be maintained (see paragraph V.5.2.1.). Rats will be also weighed weekly, where appropriate, during the post exposure period.

At the end of 1 day, 7 days or 90 days, eight animals from each dose group (plus three chamber controls) will be sedated with an intramuscular injection of acepromazine/ketamine cocktail prior to blood withdrawal by intracardiac puncture. Following blood collection, rats will be euthanized by CO_2 asphyxiation (see para.V.4.6) Blood samples will be analyzed for hematology and clinical chemistry. Hematology measurements will include: red blood cell count, hemoglobin, hematocrit, mean cell hemoglobin, mean cell volume, mean cell hemoglobin concentration, platelets, white cell count (WBC) and WBC differential counts. Serum chemistry measurements will include: alkaline phosphatase, alanine aminotransferase, aspartate aminotransferase, total bilirubin, calcium, cholesterol, glucose, total protein, triglycerides, and blood urea nitrogen. The following tissues shall be harvested and weighed: brain, liver, kidneys, adrenals, spleen, testes, and lungs. Also harvested will be: pituitary, trachea, esophagus, thyroid/parathyroid, aorta, heart, stomach, duodenum, jejunum, caecum, colon, mesentery lymph, thymus, salivary, pancreas, eye, harderian gland, skeletal muscle, skin, tongue, epididymis, prostate, seminal vesicle, urinary bladder, spinal chord, peripheral nerve, nasal turbinates, bone and bone marrow. The nasal turbinates, trachea, lungs, and liver from all animals will undergo histopathological evaluation, in addition to any other tissue system showing gross abnormalities.

V.4.1. Pain/Distress Assessment:

Pain or distress is not anticipated during the conduct of these exposures.

Monitoring. In addition to routine general health monitoring done by caretaking staff, the study director or co-investigator will conduct monitoring of animals. During the study, animals will be monitored at least once in the morning and once in the afternoon. Investigators will note animal checks and animal status (including number of affected animals) in the Animal Room Log Books. Every attempt will be made to begin exposures at the beginning of the week to allow for monitoring and to minimize weekend deaths. If, at the end of the work week, no animals show signs that would meet criteria for euthanasia, animal checks and status will be conducted and recorded in the Animal Room Log Book and the assigned laboratory notebook.

Criteria for euthanasia. One or more of the following clinical signs will be indicative of a moribund animal: impaired ambulation which prevents animals from reaching food or water; excessive weight loss and extreme emaciation (loss of $\geq$ 20% starting body weight); lack of physical or mental alertness; prolonged labored breathing; or prolonged inability to remain upright. Animals demonstrating seizure-like activity will be monitored more frequently than twice per day, and if signs continue until the end of the workday, the animal will be euthanized. The Attending Veterinarian will be notified of all animal illness to evaluate moribund animals in conjunction with the PI. If the PI is unavailable, the Attending Veterinarian may make the decision to euthanize based on the above-listed clinical signs.

V.4.1.1. APHIS Form 7023 Information

V.4.1.1.1. Number of Animals

V.4.1.1.1.1. Column C: 320 rats (100%). This assessment is based on the conclusions of Owens et al, that disseminates from "old" M18 grenades are of a low order of toxicity. The extremely high Ct's required to produce deaths and the toxic signs exhibited by the animals after exposure are similar to the responses caused by exposure to nontoxic dusts (reference 15). Obviously there is no inhalation data on the prototype violet-colored smoke grenade. However it has been shown that Disperse Red 11 is not affected to a great extent by detonation of the grenade, and that toxicity testing on the dye alone showed no eye irritation and only mild skin irritation (reference 16).

V.4.1.1.1.2. Column D: 0 rats

V.4.1.1.1.3. Column E: 0 rats

V.4.1.2. Pain Relief/Prevention: NA

V.4.1.2.1. Anesthesia/Analgesia/Tranquilization: NA

V.4.1.2.2. Pre- and Post procedural Provisions: NA

V.4.1.2.3. Paralytics: NA

V.4.1.3. Literature Search for Alternatives to Painful or Distressful Procedures: NA

V.4.1.3.1. Sources Searched: NA

V.4.1.3.2. Date of Search: NA

V.4.1.3.3. Period of Search: NA

V.4.1.3.4. Key Words of Search: NA

V.4.1.3.5. Results of Search: NA

V.4.1.4. Unalleviated Painful/Distressful Procedure Justification: NA

V.4.2. <u>Prolonged Restraint</u>: NA

V.4.3 <u>Surgery</u>: NA

V.4.3.1. Pre-surgical Provisions: NA

V.4.3.2. Procedure: NA

V.4.3.3. Post-surgical Provisions: NA

V.4.3.4. Location: NA

V.4.3.5. Surgeon: NA

V.4.3.6. Multiple Major Survival Operative Procedures: NA

V.4.3.6.1. Procedures: NA

V.4.3.6.2. Scientific Justification: NA

V.4.4. Animal Manipulations:

V.4.4.1. Injections: Prior to blood withdrawal, rats will be sedated with an intramuscular injection of a ketamine/acepromazine cocktail (10:1) at a dosage of 2.2-5.0 mg/100g (based on ketamine). Injections will be administered with a 23 gauge or smaller needle.

V.4.4.2. Biosamples: Blood samples will be collected under ketamine anesthesia by intracardiac puncture using an 18 gauge or smaller needle.

V.4.4.3. Adjuvents: NA

V.4.4.4. Monoclonal Antibody (MAbs) Production: NA

V.4.4.5. Animal Identification: Animals will be identified by microchip, along with individual cage cards according to Toxicology Programs SOP 003.04.

V.4.4.6. Behavioral Studies: NA

V.4.4.7. Other Procedures:

1. Aerosol exposures as described in V.4. During exposure, the study director or a co-investigator will continuously observe the rats for toxic signs, such as gasping, dyspnea, nasal and ocular irritation, and hunched posture. After the exposed rats are returned to their home cages, the rats will be observed at least twice a day (except weekends) by one of the aforementioned personnel. Toxic signs will be recorded in the appropriately assigned notebook.

2. Daily monitoring of animals – see Paragraph V.4.1. "Pain/Distress Assessment: Monitoring".

3. Weighing: Animals will be weighed prior to exposure, upon death, on days 1 and 7 post exposure, and weekly thereafter.

V.4.4.8. Tissue Sharing: NA

V.4.5. Study Endpoint: Study endpoint is euthanasia following the designated observation period. For experiment 1 (pilot study), this will occur 7 days post exposure. For experiment 2, euthanasia will be done on 1 day, 7 days, and 90 days post exposure. In either experiment, early euthanasia may be conducted on moribund animals as described previously in paragraph V.4.1, *Criteria for euthanasia*. The rats will be weighed, euthanized as described below, and submitted for necropsy.

V.4.6. Euthanasia: Euthanasia will be performed via CO_2 as specified by TOX SOP No.066.04, Animal Euthanasia (reference 6), and in accordance with AVMA guidelines (administered from a compressed CO2 canister, using a regulated flow valve). In addition to SOP procedures, after apparent death due to CO2, a bilateral pneumothorax will be created in all animals using a #10, 11 or 15 stainless scalpel blade cutting a small incision through the thorax wall (between ribs) on both sides of the thorax, or by making a small incision under the xiphoid process and through the diaphragm. This will occur in ALL animals prior to being given to the person conducting necropsy. Early euthanasia may be conducted on moribund animals as described previously in paragraph V.4.1, *Criteria for euthanasia*.

V.5 Veterinary Care:

V.5.1. Husbandry Considerations: The rats will be pair housed by sex in 9.5" W X 8.5" D X 8"H polycarbonate cages supplied with certified hardwood chip laboratory animal bedding. Water and a certified rodent ration will be offered *ad libitum*. Room temperature will be maintained between 64 and 79 degrees F and the relative humidity maintained between 30% and 70%. A 12-hour light / 12 hour dark cycle will be maintained by automatic timers. Following a minimum 7-day quarantine/acclimation period the rats will be exposed to the test compound. During exposure, rats will be individually held in compartmentalized exposure cages described in paragraph V.4 above. This is necessary to prevent rats from huddling and thus reducing optimal exposure to the test aerosol.

V.5.1.1. Study Room: Building E2101, room 10.

V.5.1.2 Special Husbandry Provisions: NA

V.5.1.3. Exceptions: NA

V. 5.2. Veterinary Medical Care:

V.5.2.1. Routine Veterinary Medical Care: All animals will be observed twice daily by the animal care staff. Appropriate methods of animal care shall be maintained to

prevent, control, diagnose and treat diseases and injuries. If an animal becomes ill or injured, the observer will report findings to the attending veterinarian. If necessary, the animal will be euthanized by the Attending Veterinarian or animal care
staff under the direction of the Attending Veterinarian in consultation with the principal investigator. If the PI is unavailable, the Attending Veterinarian may make the decision to euthanize based on criteria listed in V.4.1.

V.5.2.2. Emergency Veterinary Medical Care: Animals will be observed daily on weekends and holidays by the animal care staff. If an animal is noted to be ill, the Attending Veterinarian will be contacted.

V.5.3 Environmental Enrichment:

V.5.3.1 Enrichment Strategy: The rats will be pair housed as much as possible, and a member of the animal care staff or PI will handle all rats daily during the acclimation period. Rats will be provided Nylabones at all times except during exposures (enclosure 3, to be posted outside animal room). However, rats will individually housed during exposure.

V.5.3.2 Enrichment Restriction: NA

VI. STUDY PERSONNEL QUALIFICATIONS AND TRAINING:

Staff Member	Procedure	Training	Experience	Qualifications
Bergmann	Chamber operation	OJT, 1977-1982, LeRoy Metker (retired), USAEHA; Inhalation Toxicology Workshop, 1982; Short Course on Aerosol Technology, 1982; Principles and Practice of Industrial Toxicology, 1984.	25 + years working in toxicology laboratories, specializing in inhalation toxicology	BS, Biology
	Manipulations	U.S. Army Veterinary Technician Course, 1977; AALAS Lab Animal Technician Course, 1983; AALAS Lab Animal Technologist Course, 1983-1984; AALAS course on Developing Technicians Skills in Evaluating Clinical Signs in Lab Animals, 1986. The Care and Use of Lab Animals, May 2000	25 + years working in toxicology laboratories, with numerous lab animal species and routes of exposure	BS, Biology Certified AALAS Lab Animal Technologist
	Euthanasia	The Care and Use of Lab Animals, May	25 + years in general	BS, Biology; Certified AALAS

2000	toxicology, laboratory animal handling, euthanasia, and necropsy procedures.	Lab Animal Technologist

Michie	Manipulations	General handling observed and verified by Attending Veterinarian, Oct 2004	25 + years working in toxicology laboratories, with numerous lab animal species and routes of exposure	BS, Biology
Crouse	Manipulations	Animal Welfare Act, Mar 2003, Implanting Microchips, Jun 2000, Necropsy procedures, bleeding, euthanasia, bones/tissue trimming, sample weighing, Apr 2000, Rodent Handling & Techniques, Nov 1996, Short Course on The Care & Use of Laboratory Animals, May 2000	10+ Yrs, Animal Research	MS, Environmental Science

VII. BIOHAZARD/SAFETY: General procedures for laboratory/animal facilities will be followed IAW Tox Programs SOP no. 083.04. The smoke grenades will be activated in a sealed 1000 liter chamber. Animal exposures will be conducted in a dynamic airflow chamber equipped with a HEPA filter downstream of chamber exhaust. The exposure chamber will be fully evacuated before animals are removed, and personnel will wear NIOSH N 95 or R 95 respirators during this procedure.

VIII. ENCLOSURES: **1.** ARCHIVES AND SUPPORT PERSONNEL
2. REFERENCES
3. ENVIRONMENTAL ENRICHMENT PLAN
4. SMOKE FORMULATIONS

IX. STUDY TIME FRAME

I.X.1 **<u>Estimated Experimental Initiation Date:</u>** Sep 2005

I.X.2 **<u>Estimated Experimental Completion Date:</u>** Oct 2005

X. ASSURANCES:

As the Study Director/Principal Investigator on this protocol, I acknowledge my responsibilities and provide assurances for the following:

A. Animal Use: The animals authorized for use in this protocol will be used only in the activities and in the manner described herein, unless a modification is specifically approved by the IACUC prior to its implementation.

B. Duplication of Effort: I have made every effort to ensure that this protocol is not an unnecessary duplication of previous experiments.

C. Statistical Assurance: I assure that I have consulted with a qualified individual who evaluated the experimental design with respect to the statistical analysis, and that the minimum number of animals needed for scientific validity will be used. The study design and number of animals are dictated by an EPA guideline.

D. Biohazard/Safety: I have taken into consideration and made the proper coordinations regarding all applicable rules and regulations concerning radiation protection, biosafety, recombinant issues, and so forth, in the preparation of this protocol.

E. Training: I verify that the personnel performing the animal procedures/manipulations/observations described in this protocol are technically competent and have been properly trained to ensure that no unnecessary pain or distress will be caused to the animals as a result of the procedures/manipulations.

F. Responsibility: I acknowledge the inherent moral, ethical and administrative obligations associated with the performance of this animal use protocol, and I assure that all individuals associated with this project will demonstrate a concern for the health, comfort, welfare, and well-being of the research animals. Additionally, I pledge to conduct this study in the spirit of the fourth "R," namely "Responsibility," which the DOD has embraced for implementing animal use alternatives where feasible and conducting humane and lawful research.

G. Scientific Review: This proposed animal use protocol has received appropriate peer scientific review and is consistent with good scientific research practice.

H. Painful Procedures: NA

Jeffrey D. Bergmann

_____

SIGNATURE **DATE (YYYYMMMDD)**

ENCLOSURE 1

ARCHIVES AND SUPPORT PERSONNEL

1. ARCHIVES.

a. The protocol, raw data, summary data, and the final report pertaining to this study will be physically maintained in Room 1026, Building E-2100, USACHPPM.

b. Archived SOPs may be found in Room 1026 or Room 3015, Building E2100, USACHPPM, Aberdeen Proving Ground, Maryland 21010.

c. Records on animal receipt, diet, and environmental parameters will be maintained in Room 3100 or Room 1026, Building E2100, USACHPPM, Aberdeen Proving Ground, Maryland 21010.

d. Wet tissues will be stored in cage 12 of Building E-1958, Aberdeen Proving Ground, Maryland 21010.

e. Histology slides, paraffin blocks and hematology slides are stored in the basement of Building E-1570, Aberdeen Proving Ground, Maryland 21010.

2. SUPPORT PERSONNEL

a. Division of Veterinary Medicine:

MAJ Ann Schiavetta, D.V.M.	Attending Veterinarian
Terry Hanna	Animal Caretaker
Robert Sunderland	Animal Caretaker

b. Toxicity Evaluation Program:

Jeffrey Bergmann	Biologist, Study director
Mark Michie	Biologist
Glenn Leach	Program Manager
Lee Crouse	Biologist
John Houpt	Biologist
Patricia Beall	Biologist

d. Archivist: Mark Michie

e. Quality Assurance Office

Gene Sinar	Quality Assurance Assessor
Mike Kefauver	Quality Assurance Assessor

f. Directorate of Laboratory Sciences

g. Air Quality Surveillance Program

h. Edgewood Chemical Biological Center

ENCLOSURE 2

REFERENCES

1. Title 40, Code of Federal Regulations (CFR), Part 792, Good Laboratory Practice Standards.

2. Guide for the Care and Use of Laboratory Animals, U.S. Department of Health, Education, and Welfare, Publication No. NIH 86-23, 1996.

3. Toxicology Directorate, TOX SOP No. 029.05, Acute Inhalation Toxicity Study

4. Toxicology Directorate, TOX SOP No. 028.04, Animal Quality Control Procedures.

5. Toxicology Directorate, TOX SOP No. 003.04, Individual Animal Identification.

6. Toxicology Directorate, TOX SOP No. 066.04, Animal Euthanasia.

7. Toxicology Directorate, TOX SOP No. 083.04, Health and Safety of Laboratory Personnel.

8. Toxicology Directorate, TOX SOP No. 047.05, Histopathology Laboratory Operations

9. Toxicology Directorate, TOX SOP No. 002.05, Pathology Laboratory Operations

10. Toxicology Directorate, TOX SOP No. 052.04, Handling and Storage of Test Records, Data and Specimens

11. Toxicology Directorate, TOX SOP No. 063.04, Test System Observations

12. Toxicology Directorate, TOX SOP No. 041.05 Aerodynamic Particle Size Measurement.

13. U.S. Army Center for Health Promotion and Preventive Medicine. (2000, September). *Pyrotechnics Health Risk Assessment No. 39-EJ-1485-00, Residential Exposure from Inhalation of Air Emissions from the M18 Violet-Colored Smoke Grenade.* Aberdeen Proving Ground, MD: USACHPPM. DTIC ADA391661.

14. Jaskot, R.H., and Costa, D.L. 1994. Toxicity of an anthraquinone violet dye mixture following inhalation exposure, intratracheal instillation, or gavage. *Fund.Appl. Tox.,* 22(1):103-112

15. Owens, E.J., and Ward, D.M. 1974. *A Review of the Toxicology of Colored Chemical Smokes and Colored Smoke Dyes*. Report No. EB-TR-74064, ADA 003827. Edgewood Arsenal, Aberdeen Proving Ground, MD

16. National Academy of Sciences, National Research Council, 1999. Toxicity of Military Smokes and Obscurants, Vol.3, National Academy Press, Washington D.C.

ENCLOSURE 3

Environmental Enrichment Plan

Protocol Number: 0497– 24-

Species: Rat

Room Number:

Pre-Exposure:

1. Rats will be pair housed and provided Nylabones.

2. After daily husbandry procedures have been completed, remove each rat from its cage and place the rat on a lab worktable. Let the animal explore for a few moments on its own, but maintain control of its activity at all times. Gently stroke the animal several times, and return it to its cage.

Post Exposure:

1. Rats will be pair housed and provided Nylabones.

_____ _____

Veterinarian Study Director

ENCLOSURE 4

Old vs. New Violet Smoke Formulations

Component	OLD Weight Fraction (w/w)	NEW Weight Fraction (w/w)
Violet Dye Mix[1]	0.4000	0.0000
Disperse Red 11	0.0000	0.3803
Terephthalic Acid	0.0000	0.0766
Sulfur	0.0900	0.0000
Sugar	0.0000	0.1550
Magnesium Carbonate	0.0000	0.1020
Potassium Chlorate	0.2600	0.2350
Stearic Acid	0.0063	0.0050
Sodium Bicarbonate	0.2500	0.0510
Polyvinyl Alcohol	0.0200	0.0200

Components/Materials Added:

Starter Patch
Sugar
Disperse Red 11
Terephthalic Acid
Magnesium Carbonate
Polyvinyl Alcohol

Components/Materials Eliminated:

Disperse Red 9[1]
1,4-diamino-2,3-dihydroanthraquinone (DDA)[1]
Starter Slug
Starter Cup
Cardboard Disc
Sulfur

(1) Please note: Violet dye mix is a mixture of approximately 80 % 1,4-diamino-2,3-dihydroanthraquinone (DDA) and 20% Disperse Red 9

Appendix J: Results of Toxicity Testing of Rats in Violet Smokes

U.S. Army Center for Health Promotion and Preventive Medicine

TOXICOLOGY STUDY NO. 85-XC-0497-07
PROTOCOL NO. 0497-24-05-08-01
TOXICITY OF ACUTE INHALATION EXPOSURE OF EMISSIONS FROM THE VIOLET-COLORED M18 SMOKE GRENADE IN RATS
JULY 2007

Approved for public release; distribution unlimited.

CHPPM FORM 433-E (MCHB-CS-IPD), OCT 03

Readiness Thru Health

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U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE

The U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) lineage can be traced back over 50 years to the Army Industrial Hygiene Laboratory. That organization was established at the beginning of World War II and was under the direct jurisdiction of The Army Surgeon General. It was originally located at the Johns Hopkins School of Hygiene and Public Health, with a staff of three and an annual budget not to exceed $3000. Its mission was to conduct occupational health surveys of Army operated industrial plants, arsenals, and depots. These surveys were aimed at identifying and eliminating occupational health hazards within the Department of Defense's (DOD) industrial production base and proved to be beneficial to the Nation's war effort.

Until 1995, it was nationally and internationally known as the U.S. Army Environmental Hygiene Agency or AEHA. Its mission is expanding to support the worldwide preventive medicine programs of the Army, DOD and other Federal Agencies through consultations/ supportive services; investigations and training.

Today, AEHA is redesignated the U.S. Army Center for Health Promotion and Preventive Medicine. Its mission for the future is to provide worldwide technical support for implementing preventive medicine, public health and health promotion/wellness services into all aspects of America's Army and the Army Community anticipating and rapidly responding to operational needs and adaptable to a changing work environment.

The professional disciplines represented at the Center include chemists, physicists, engineers, physicians, optometrists, audiologists, nurses, industrial hygienists, toxicologists, entomologists, and many other as well as sub-specialties within these professions.

The organization's quest has always been one of excellence and continuous quality improvement; and today its vision, to be the nationally recognized Center for Health Promotion and Preventive Medicine, is clearer than ever. To achieve that end, it holds ever fast to its values which are steeped in its rich heritage:

- *Integrity is the foundation*
- *Excellence is the standard*
- *Customer satisfaction is the focus*
- *Its people are the most valued resource*
- *Continuous quality improvement is its pathway*

The organization, which stands on the threshold of even greater challenges and responsibilities, has General Officer leadership. As it moves into the next century, new programs are being added related to health promotion/wellness, soldier fitness and disease surveillance. As always, its mission focus is centered upon the Army Imperatives so that we are trained and ready to enhance the Army's readiness for war and operations other than war.

It is an organization fiercely proud of its history, yet equally excited about the future. It is destined to continue its development as a world-class organization with expanded services to the Army, DOD, other Federal Agencies, the Nation and the World Community.

ACKNOWLEDGEMENTS

The authors would like to acknowledge [redacted] for his efforts on the animal use protocol completion, chamber set-up and calibration, and overall study conduct leading to the completion of the project.

Study Title

Toxicology Study No. 85-XC-0497-07
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions From The
Violet-Colored M18 Smoke Grenade In Rats
July 2007

Authors

Study Completion Date:

28 November 2006

Performing Laboratory

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Laboratory Project ID

Protocol No. 0497-24-05-08-01

STATEMENT OF NO DATA CONFIDENTIALITY CLAIMS

No claim of confidentiality is made for any information contained in this study on the basis of its falling within the scope of TSCA § 790.7 (a) – (d).

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Title_____Signature_____

Toxicology Study No. 85-XC-0497-07, Protocol No. 0497-24-05-08-01, July 2007

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Program Manager
Toxicity Evaluation

GOOD LABORATORY PRACTICE COMPLIANCE STATEMENT

The study described in this report was conducted in compliance with Title 40, Code of Federal Regulations (CFR), Part 792, Good Laboratory Practice Standards, except for the following:

1. The archive area where this study will be stored does not have adequate fire suppression protection.

No deviations from the aforementioned regulation affected the quality or integrity of the study or the interpretation of the results.

_____ _____

[redacted] Date

Study Director

_____ _____

[redacted] Date

Program Manager
Toxicity Evaluation

DEPARTMENT OF THE ARMY
US ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
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MCHB-TS-TTE

EXECUTIVE SUMMARY
TOXICOLOGY STUDY NO. 85-XC-0497-07
PROTOCOL NO. 0497-24-05-08-01
TOXICITY OF ACUTE INHALATION EXPOSURE OF EMISSIONS FROM THE VIOLET-COLORED M18 SMOKE GRENADE IN RATS
JULY 2007

1. PURPOSE. The purpose of this study was to assess and compare the acute inhalation toxicity in rats following exposure to emissions from current and new formulations of violet-colored M18 smoke grenades.

2. CONCLUSIONS.

a. Groups of rats were exposed for 10 or 2 minutes to high (1136 and 2150 mg/m^3, respectively) and low (419 and 1375 mg/m^3, respectively) concentrations of combustion emissions from the current formulation of violet-colored M18 smoke grenades and for 10 minutes to the high (1146 mg/m^3) concentration of the new formulation of violet-colored M18 smoke grenades.

b. Ten-minute exposures to combustion emissions from the current formulation resulted in the deaths of 11 rats at the high concentration upon exposure termination and no deaths at the low concentration. Two-minute exposures to the high and low concentrations of current grenade emissions as well as 10-minute exposures to the high concentration of new grenade emissions resulted in no deaths.

c. Serial necropsies of surviving rats exposed to current grenade emissions at 1, 7, and 90 days post-exposure and the resulting body weight data, organ weight ratios, hematology, serum chemistry, and histopathologic findings showed no specific evidence of long-term toxicity. Body weight data and gross necropsy results of rats exposed to the high concentration of new M18 smoke grenade emissions showed no evidence of toxicity.

d. Based on the lethality produced during the 10-minute exposures to the high concentration of current M18 violet smoke grenade emissions, exposure to high concentrations of the new violet smoke formulation appears to pose less of a toxicological risk.

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TOXICOLOGY STUDY NO. 85-XC-0497-07
PROTOCOL NO. 0497-24-05-08-01
TOXICITY OF ACUTE INHALATION EXPOSURE OF EMISSIONS FROM THE VIOLET-COLORED M18 SMOKE GRENADE IN RATS
JULY 2007

1. REFERENCES. See Appendix A for a listing of references.

2. AUTHORITY. Military Interdepartmental Purchase Request (MIPR), W74RDV62981402, July 23, 2003, requesting United States Army Center for Health Promotion and Preventive Medicine (USACHPPM) support of Environmental Security Technology Certification Program (ESTCP), for toxicity testing of M18 Violet Smoke Grenade.

3. PURPOSE. The purpose of this study was to assess and compare the acute inhalation toxicity in rats following exposure to emissions from current and new formulations of violet-colored M18 smoke grenades.

4. GENERAL BACKGROUND.

a. The U.S. Army uses smokes and obscurants to shield armed forces from view, signal friendly forces, and mark positions. However, many kinds of grenade smokes contain dyes and other materials that could pose a hazard to human health and the environment. The Army smoke and dye replacement program found a sugar formulation that successfully replaces the sulfur in most M18 smoke grenades used by the U.S. military. At the program's onset, the switch to the sugar mixture was successful for green and yellow M18 grenades, but changes to the red and violet M18 smoke grenades were more difficult (reference 1).

b. Initially, the new dyes (for the red and violet smoke grenades) burned instead of smoked; thus, they did not produce enough colored smoke to meet strict military standards. Eventually, the violet smoke grenade was reconfigured to successfully produce the right color, amount of smoke and burn time. However, the smoke produced by the redesigned red smoke grenades was too pale compared to the original.

c. The Army seeks to reduce the likelihood that exposure to smokes during training would have adverse health effects on military personnel or civilians. To protect the health of exposed individuals, the Office of the Army Surgeon General requested that the National Research Council (NRC) independently review data on the toxicity of smokes and obscurants and recommend exposure guidance levels for military personnel in training and for the general public residing or working near military-training facilities. The NRC concludes that the available toxicity data base for the combustion products of the old and new smoke formulations is inadequate for use in assessing the potential health risk of exposure to these smokes and in recommending exposure guidance levels. The subcommittee recommends that, at a minimum, acute inhalation studies be conducted in experimental animals to test the toxicity of the colored

smokes (references 2 and 3). USACHPPM was tasked to conduct these studies and the ESTCP provided funding for toxicity testing for the violet-colored grenades.

d. Table 1 provides an overview of the critical events and their corresponding dates for all phases of the study.

Table 1. Critical Study Events

Critical Event	Date of Event
Protocol approval	08/23/2005
Pilot study (current smoke) animals received	12/12/2005
Experimental start	12/14/2005
Pilot study (current smoke) exposure	12/14/2005
Pilot study (current smoke) necropsies	12/21/2005
10-minute exposure (current smoke) animals received	01/18/2006
10-minute high and control conc. (current smoke) exposures	01/24/2006
1-day hold necropsies (10 minute exposure, current smoke)	01/25/2006
7-day hold necropsies (10 minute exposure, current smoke)	01/31/2006
90-day hold necropsies (10 minute exposure, current smoke)	04/24/2006
10-minute low conc. (current smoke) exposure	01/26/2006
1-day hold necropsies (10 minute exposure, current smoke)	01/27/2006
7-day hold necropsies (10 minute exposure, current smoke)	02/02/2006
90-day hold necropsies (10 minute exposure, current smoke)	04/26/2006
2-minute exposure (current smoke) animals received	02/15/2006
2-minute high and control conc. (current smoke) exposures	02/21/2006
1-day hold necropsies (2 minute exposure, current smoke)	02/22/2006
7-day hold necropsies (2 minute exposure, current smoke)	02/28/2006
90-day hold necropsies (2 minute exposure, current smoke)	05/22/2006
2-minute low conc. (current smoke) exposure	02/23/2006
1-day hold necropsies (2 minute exposure, current smoke)	02/24/2006
7-day hold necropsies (2 minute exposure, current smoke)	03/02/2006
90-day hold necropsies (2 minute exposure, current smoke)	05/24/2006
Pilot study (prototype smoke) animals received	07/19/2006
Pilot study (prototype smoke) exposure	07/26/2006
Pilot study (prototype smoke) necropsies	08/02/2006
Final exposure (prototype smoke) animals received	11/15/2006
Final exposure (prototype smoke)	11/21/2006
Final exposure (prototype smoke) necropsies	11/28/2006
Experimental termination date	11/28/2006
Final report completion	07/11/2007

5. MATERIALS.

a. Test Substance. The grenades were provided by the Edgewood Chemical Biological Center. The current grenades were identified as lot number PB-85E067-002, and the ESTCP prototype grenades were identified as lot number 3580-JM-050623-01.

b. Animals.[*†] The pilot studies were conducted using male and female Sprague-Dawley rats, while the main studies were conducted using female rats only. The rats were obtained from Charles River Laboratories, Wilmington, Massachusetts. The rats were pair housed in polycarbonate cages supplied with Harlan Sani-Chip® certified laboratory animal bedding. Water and a certified pesticide-free rodent ration (Harlan Teklad®, 8728C Certified Rodent Diet) were offered *ad libitum* (reference 4). Room temperature was maintained between 64 and 79 ºF and the relative humidity maintained between 30% and 70%. A 12-hour light / 12-hour dark cycle was maintained by automatic timers (reference 5). A total of six animals not chosen for these studies but housed in the same room were returned to Charles River Laboratories periodically to assess the general health of the purchased animals. Following a 1-week quarantine/acclimation period, the rats were randomly placed into test and control groups. Table 2 outlines the overall study plan and the number of animals used in each phase.

Table 2. Study Plan

Current Violet-Colored M18: 10 min. Exposure				
Exposure	**No. of Rats**	**1 day sacrifice**	**7 day sacrifice**	**90 day sacrifice**
Pilot Study	5 per sex		10	
6 ft. concentration (High)	24	8	8	8
Edge of plume (Low)	24	8	8	8
Control	18	Six to be used at each sacrifice interval		
Current Violet-Colored M18: 2 min. Exposure				
Exposure	**No. of Rats**	**1 day sacrifice**	**7 day sacrifice**	**90 day sacrifice**
6 ft. concentration (High)	24	8	8	8
Edge of plume (Low)	24	8	8	8
Control	18	Six to be used at each sacrifice interval		

[*] In conducting the studies described herein, the investigators adhered to the *Guide for the Care and Use of Laboratory Animals,* Institute of Laboratory Animal Resources, Commission on Life Sciences, National Research Council. National Academy Press, Washington, D.C. 1996.

[†] The studies reported herein were performed in animal facilities fully accredited by the American Association for the Accreditation of Laboratory Animal Care.

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® Teklad Certified Rat Diet is a registered trademark of Harlan, Teklad, Madison, Wisconsin.

Prototype Violet-Colored M18: 10 min.Exposure				
Exposure	**No. of Rats**	**1 day sacrifice**	**7 day sacrifice**	**90 day sacrifice**
Pilot Study	5 per sex		10	
6 ft. concentration (High)	12 female		12	

c. Contract Studies. [redacted], DVM, PhD, Biotechnics, Hillsborough, North Carolina, performed the histopathological evaluations on animals exposed to the current smoke grenade. [redacted], DVM, MAJ, VC; [redacted], DVM, MAJ, VC; [redacted], DVM, MAJ, VC; [redacted], DVM, MAJ, VC; and [redacted], PhD, Toxicologist performed the in-house reviews on various phases of the necropsies.

d. Quality Assurance. The USACHPPM Strategic Initiatives Office audited critical phases of these studies. Appendix B provides the dates of these audits along with the audited phase.

e. Study Personnel. Appendix C contains the names of persons contributing to the performance of these studies.

6. METHODS.

a. Exposure System. The exposures were performed in a 400-liter, dynamic airflow inhalation chamber. A baffle and tangential feed at the inlet promoted aerosol mixing and uniform distribution of the test atmosphere. The smoke grenades were activated inside a 1000-liter static chamber connected via polyvinyl chloride pipe to another 1000-liter dilution chamber. The resulting smoke emissions were allowed to mix and were then drawn through an intake pipe to the inlet of the exposure chamber. A ball valve was placed inline of the intake pipe between the dilution and exposure chambers and adjusted to produce target concentrations and to affect slight negative pressure inside the chamber. After exposure, the chamber air was exhausted through a High Efficiency Particulate Air filter.

b. Exposure. The test procedures were performed in accordance with the Toxicology Directorate Standard Operating Procedure (SOP) for Acute Inhalation Toxicity Studies (reference 6). The USACHPPM Animal Use Protocol with modifications is included as Appendix D. Pilot studies were performed for both the current and prototype smokes to determine if the target chamber concentrations were set at an appropriate level, if the introduction of the rats would affect chamber calibration settings, and if either male or female rats appeared to be more sensitive to the combustion emissions. Each of the final 2-minute or 10-minute exposures for the current grenade were conducted on a Tuesday or Thursday in a given week over 2 days. On a Tuesday, the control group was exposed first, followed by the high test group. The control groups were subjected to the same procedure as the test groups but without the addition of smoke. On the second day, the low test group was exposed. Emissions from the prototype grenade were tested using a single 10 minute exposure to a nearly identical concentration as the high test group from the 10-minute exposure to the current grenade

emissions. Rats were weighed to the nearest gram just prior to exposure and individually placed in a compartmentalized, stainless steel wire mesh exposure cage. Each compartment measures 6.5" long x 3.75" wide x 3" high. The exposure cages were positioned in the middle of the chamber and the chamber sealed for each whole-body exposure. Chamber airflow was verified prior to the initiation of each exposure using and Alnor® CompuFlow® Model 8575 Multi-Purpose Meter. Since chamber airflow was monitored in the exhaust pipe of the exposure chamber, the airflow was not monitored continuously throughout the exposure to prevent possible contamination of the probe. Chamber temperature and humidity was monitored continuously throughout the exposure using an Omega® Digital Thermo-Hygrometer and was recorded at the beginning and end of each exposure.

c. Exposure Atmosphere Characterization. Chamber atmosphere was sampled for particulate mass concentration, particle size, select heavy metals, volatile organic compounds (VOCs), and sulfur dioxide. Particulate mass within the 400-liter animal exposure chamber was measured gravimetrically by drawing known volumes of chamber atmosphere from the breathing zone of the rats through a 25mm filter cassette containing a pre-weighed Gelman glass fiber (Type A/E) filter. Sampling occurred for 10 minutes at 1 liter/minute for the 10 minute exposures and for 2 minutes at 4 liters/minute for the 2 minute exposures. Filters were weighed on a Cahn Model C-30 Microbalance. The atmospheric concentration of aerosol test material was calculated from the difference in the pre- and post-sampling filter weights divided by the total volume of chamber air sampled. Samples to determine particle size distribution were taken between 1 and 9 minutes for the 10 minute exposures and throughout the entire exposure for the 2 minute exposures. Particle size distribution was determined with a Sierra® Series 210 Cascade Impactor and Sierra Series 110 Constant Flow Air Sampler set at 7 liters/minute. Particulate emissions composition (CAD SOP CAB144.1), heavy metals (NIOSH method 7300), and sulfur dioxide (OSHA method ID 200) were analyzed by USACHPPM Directorate of Laboratory Sciences. VOCs were collected by personnel from the USACHPPM Air Quality Surveillance Program and analyzed by EPA method TO14A at Lancaster Laboratories, Lancaster, Pennsylvania.

d. Post Exposure. Upon completion of the exposure, rats were returned to their home cages and observed daily for toxic signs and, where appropriate, weighed weekly during the post-exposure period.

e. Necropsy. At the end of 1 day, 7 days or 90 days, eight animals from each dose group of the current grenade exposures (plus three chamber controls) were sedated with an intramuscular injection of xylazine/ketamine cocktail prior to blood withdrawal by intracardiac puncture. Following blood collection, rats were euthanized by carbon dioxide (CO_2) asphyxiation. Blood

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samples were analyzed for hematology and clinical chemistry. The following tissues were harvested and weighed: adrenals, brain, heart, kidneys, liver, lungs, ovaries, spleen, thymus, and uterus. Also harvested were pituitary, trachea, esophagus, lung-associated lymph nodes, thyroid/parathyroid, aorta, heart, stomach, duodenum, jejunum, caecum, colon, mesentery lymph, thymus, salivary, pancreas, eye, harderian gland, skeletal muscle, skin, tongue, urinary bladder, spinal chord, peripheral nerve, nasal turbinates, bone, and bone marrow. The nasal turbinates, trachea, lungs, and liver from all animals were submitted for histopathological evaluation, in addition to any other tissue system showing gross abnormalities. At the conclusion of 7 days following exposure to the prototype grenade emissions, all animals were euthanized via CO_2 asphyxiation and submitted for gross necropsy. Blood and tissue samples were not taken for further evaluation.

(1) Hematology parameters included the following (Cell-Dyn 3700 Hematology Analyzer, Abbott Laboratories, Abbott Park, IL 60064): white blood cell count (WBC), WBC differential (% neutrophils (NEU %N), % lymphocytes (LYM %L), % monocytes (MONO %M), % eosinophils (EOS %E), % basophils (BASO %B)), red blood cell count (RBC), hemoglobin (HGB), hematocrit (HCT), mean cell volume (MCV), mean cell hemoglobin (MCH), mean cell hemoglobin concentration (MCHC), red blood cell distribution width (RDW), platelets (PLT), and mean platelet volume (MPV).

(2) Clinical chemistry included the following (VetTest 8008 Chemistry Analyzer and VetLyte Na, K, Cl Analyzer, IDEXX Laboratories, Inc., One IDEXX Drive, Westbrook, ME 04092): alkaline phosphatase (ALK P), alanine aminotransferase (ALT), aspartate aminotransferase (AST), blood urea nitrogen (BUN), calcium (Ca), cholesterol (CHOL), creatinine kinase (CK), creatinine (CREA), glucose (non-fasting) (GLU), lactate dehydrogenase (LDH), total bilirubin (TBIL), total protein (TP), triglycerides (TRIG), sodium (Na), potassium (K), and chlorine (Cl).

f. Data Analysis. For all variables, the dose groups and observation days were compared using a two-factor analysis of variance (ANOVA) at each exposure time on the parameters that were collected: blood chemistry, hematology, and body weight. Organ-to-brain and organ-to-body weight ratios were calculated and analyzed similarly to the other parameters measured. These analyses were followed by a Tukey's multiple comparison test to further compare the dose groups and observation days. If a significant interaction of necropsy day and dose group was observed, then a one factor ANOVA was performed to compare the dose groups at each exposure time and necropsy day. SPSS 14.0 was used to perform all analyses, and statistical significance was defined as $p \leq 0.05$ for all tests. A complete copy of the statistical report appears as Appendix E.

7. RESULTS.

a. Exposure Atmosphere Characterization. Table 3 presented the particulate mass concentrations and particle size data. Chamber airflows and environmental conditions are presented in Table 4. Particulate emissions composition, heavy metals, VOCs, and sulfur dioxide concentrations are listed in Appendix F.

Table 3. Particulate Mass Concentrations and Particle Size Data

Current Violet-Colored M18: 10-min. Exposure			
Exposure	**Concentration (mg/m^3)**	**MMAD (µm)**	**σ_g**
Pilot Study	829	0.77	5.4
High	1136	0.78	5.6
Low	419	0.93	4.5
Current Violet-Colored M18: 2-min. Exposure			
Exposure	**Concentration (mg/m^3)**	**MMAD (µm)**	**σ_g**
High	2150	1.24	4.1
Low	1375	1.25	4.0
Prototype Violet-Colored M18: 10-min. Exposure			
Exposure	**Concentration (mg/m^3)**	**MMAD (µm)**	**σ_g**
Pilot Study	1154	2.41	3.17
High	1146	2.01	3.4

Table 4. Chamber Airflows and Environmental Conditions

Current Violet-Colored M18: 10-min. Exposure			
Exposure	**Airflow (feet/minute)**	**Temp/Humidity (start)**	**Temp/Humidity (end)**
Pilot Study	760	71°F / 11%	not taken
High	765	72°F / 36%	70°F / 47%
Low	755	70°F / 25%	72°F / 24%
Current Violet-Colored M18: 2-min. Exposure			
Exposure			
High	950	69°F / 25%	71°F / 29%
Low	1005	72°F / 38%	73°F / 40%
Prototype Violet-Colored M18: 10-min. Exposure			
Exposure			
Pilot Study	1080	71°F / 11%	71°F / 11%
High	1150	71°F / 11%	71°F / 11%

b. Toxic Signs and Body Weights

(1) A total of 11 rats from the 10-minute high concentration exposures to emissions from the current grenade died during the exposure. Necropsies were performed on these rats upon discovery, and selected tissues were submitted for histopathologic examination. All 11 rats exhibited purple discoloration of the fur, feet, bronchus, external nares, and oral cavity. Ten of the 11 rats had purple-colored solid masses at the opening of the trachea and dark-colored livers. One rat showed purple discoloration in the lungs. All surviving animals from the 10-minute high concentration exposures showed signs of lacrimation and squinting (one of which was prostrate) upon removal from the chamber. All of these signs disappeared within 4 hours following exposure termination. Rats exposed to the high concentration for 2 minutes did not exhibit any toxic signs post-exposure except for purple discoloration of the fur.

(2) Upon removal from the chamber, all rats exposed to the low concentration of the current grenade for 10 minutes showed purple discoloration of the fur, lacrimation, and squinting. Rats exposed to the low concentration for 2 minutes did not exhibit any toxic signs post-exposure except for purple discoloration of the fur. Within 30 minutes post-exposure, the lacrimation and squinting signs had disappeared.

(3) Transient clinical signs, such as alopecia (hair loss), were noted on occasion throughout the 90-day post-exposure observation period. However, these signs were observed throughout the high, low, and control exposure concentrations and were not considered to be treatment-related.

(4) With the exception of several 1-day hold exposure groups, surviving animals in all other current grenade exposure groups gained weight on a weekly basis at a normal rate. Weight loss on post exposure day 1 is commonly observed, even in the absence of toxic signs, due to the stress associated with exposure. Statistical analysis of body weights showed no significant differences in growth rates between the exposure groups and the control group. Body weight data is presented as Appendix G.

(5) Rats exposed for 10 minutes to the high concentration of prototype grenade emissions did not exhibit any toxic signs post-exposure except for purple discoloration of the fur. These rats also gained weight at a normal rate during the 7-day post-exposure observation period.

c. Biosample Data. In general, very few exposure group differences compared to controls were observed in any of the organ-to-body/brain weight ratios, hematology, or serum chemistry. Statistically significant differences were most commonly observed between the high and low exposure groups. Dose group differences are described below. Tabulated results of these parameters are presented in more detail in Appendices H through K.

(1) Organ-to-Body/Brain Weight Ratios. The spleen-to-body and spleen-to-brain weight ratios of rats exposed to the low concentration of emissions from the current M-18 grenade for 10 minutes were significantly greater than controls at the 90-day sacrifice.

(2) Hematology and Serum Chemistry. Significant differences were found in Blood Urea Nitrogen (BUN) values between the low and all other exposure groups at the 1-day sacrifice (2-minute exposure) and between the high and all other exposure groups at the 1-day sacrifice (10-minute exposure). Glucose (GLU) values for the 10 minute exposure at the 90-day sacrifice were significantly higher in the high exposure group as compared to the control and low-dose groups. Sodium (Na) values in the control group at the 90-day sacrifice (10-minute exposure) were significantly higher than the high and low exposure groups at the corresponding sacrifice interval. For the 10-minute exposures, the low exposure group had a significantly higher percent eosinophils and a significantly lower number of platelets compared to controls, regardless of the sacrifice interval. In addition to the statistical significance versus controls reported above, significant differences between the high and low exposure groups were observed in Alkaline Phophatase (ALK P) values for the 1-day sacrifice interval (2-minute exposure), percent lymphocytes for the 1-day sacrifice interval (10-minute exposure), and in the red blood cell distribution width (RDW) for the 7-day sacrifice (10-minute exposure).

d. Histopathology. The following paragraphs summarize the histopathology report, which can be found in its entirety as Appendix L.

(1) Eleven of the 24 rats exposed to 1136 mg/m^3 for 10 minutes were found dead at the end of the exposure period (current violet smoke grenade) on Day 0. There were no specific alterations evident in the protocol-specified tissue sections to account for the deaths of these animals, nor were there any test substance-related specific alterations noted in the tissue sections. The gross alterations noted in these animals included purple discolorations/masses associated with fur and feet, external nares, oral or buccal cavity, and/or anterior trachea. These alterations were not evident in the tissue sections and were presumed to represent particulate material associated with the test substance that was not recognizable following the processing to tissue sections. The congestion that was commonly noted in the sections of liver and/or lung was considered secondary to agonal death, rather than representing a test substance-specific alteration.

(2) No clearly specific histologic evidence of toxicity related to the exposure to current violet-colored M18 smoke grenade emissions was noted in this study. Minimal degeneration was noted in the bronchioles of one of four rats exposed to 1136 mg/m^3 for 10 minutes. Due to the small number of rats examined at this time point, it is unclear if this alteration represents a reproducible test substance-related finding.

(3) A hemangiosarcoma with metastasis to the lung was noted in one of eight rats sacrificed 90 days after exposure to 2150 mg/m^3 for 2 minutes. While the specific induction of a hemangiosarcoma within 90 days would be quite unusual, it should be noted that spontaneous

hemangiosarcomas are uncommon in Sprague Dawley rats. This study was not designed with sufficient power to assess possible carcinogenic effects and, thus, it cannot be concluded that there is a specific carcinogenic effect with respect to this tumor.

(4) No clearly specific histologic evidence of toxicity related to the exposure to current violet-colored M18 smoke grenade emissions was noted in this study.

8. DISCUSSION.

a. This acute inhalation toxicity study was designed to assess and evaluate the toxic characteristics of a single-dose exposure to emissions from the violet-colored M18 smoke grenade in the rat. The protocol was designed to provide comparisons of emissions from the current and prototype violet-colored M18 smoke grenades. Based on the death of one female rat during the current smoke pilot study, it was determined that female rats appeared to be more sensitive to the effects of the combustion emissions. Therefore, the study design was modified so that only female rats would be exposed. Since no deaths resulted from the prototype pilot study (5 rats/sex), it was decided that 12 additional rats exposed to prototype grenade emissions at a similar concentration for 10 minutes would provide the same level of confidence when compared to the 11/24 mortality rate observed during exposure to the current grenade emissions. In addition, due to a lack of significant histopathologic findings in any of the surviving rats from the current smoke exposure (1-, 7-, or 90-day hold), the study design for the prototype grenade was modified so that only gross necropsies would be performed. The rationale was that if no long-term effects were observed in the histopathology results from the current smoke, which appeared to be more toxic, than there would likely be no long-term effects from exposure to the less toxic prototype grenade emissions.

b. Rats were exposed to smoke concentrations estimated to correspond to a 2-minute exposure and 10-minute exposure (smoke grenades normally only burn for 50-90 seconds) to the smokes at 6 feet (soldier standing over grenade while it is burning) and 18 feet as the worst-potential field exposures. The exposure concentrations were determined by taking the concentrations of a green smoke grenade (sugar-based) at 6, 18, and 30 feet. The difference between the field concentrations at 18 and 30 feet was so negligible that they were combined as a single-exposure concentration. Since the colored smokes are normally used as a signaling device, it is expected that most soldier exposures would be to the low concentration for less than 2 minutes. Some examples of the U.S. Air Force and medical services of the U.S. Army using the colored smoke as an obscurant were found, which would put their exposures in the low to high concentration range for 2 minutes based on their tasks. Serial necropsies were performed on rats exposed to current M-18 grenade emissions to monitor the course of any toxic effects, particularly long-term effects not heretofore studied in rats. Toxicological endpoints included clinical signs, body weights, organ weight ratios, hematology, serum chemistry, and histopathologic examination.

c. There was essentially no dose-response relationship in surviving animals between the control, low, or high exposure groups at any sacrifice interval for the 2- and 10-minute exposures. The significance observed in the spleen-to-body and spleen-to-brain weight ratios of rats exposed to the low concentration of emissions from the current M-18 grenade for 10 minutes does not appear to be a compound-related finding and was more likely due to differences in tissue trimming techniques or the overall lower body weight of that particular exposure group. Histopathological analysis confirmed this assumption and reported all spleen tissues within normal limits. Statistical significance observed in the hematology and serum chemistry data was sporadic and did not exhibit any clear dose-related trends. Comparison of the significant hematology and serum chemistry results with reference data indicated that all three exposure groups, including the group exhibiting significance, were usually either within or outside of reference ranges for a given necropsy interval (reference 7). Differences in blood sampling methods and analytical techniques can commonly lead to data outside of reported reference ranges, and histopathological analysis of selected blood-conditioning organs did not support any significance observed in hematology and serum chemistry data.

d. Gross findings from the necropsies of the 11 rats that died during exposure to the high concentration (10-minute exposure) of the current M-18 violet smoke revealed that nearly all of the rats had purple masses obstructing the anterior end of the trachea. Histopathological analysis of the tissues confirmed that the rats had no test substance-specific alterations and had likely died from a lack of oxygen associated with the masses in the trachea. In comparison, no deaths were associated with exposure to a nearly identical concentration of the prototype grenade emissions for 10 minutes and necropsies of these rats at 7 days post-exposure did not reveal any gross findings. Particle size analysis of both the current and prototype M-18 smokes showed that the current grenade has a smaller emission particle size (0.78µm MMAD) compared to the prototype grenade (2.01µm MMAD). Previous research on particle deposition in the respiratory tract of the laboratory rat has shown that particles in the 0.80 – 2.00 µm range are primarily deposited in the lower pulmonary region (8-12%), with 2-5% being trapped in the tracheobronchial region (reference 8). However, particle deposition is dependent on many factors other than particle size, including particle characteristics, respiratory-tract geometry, and ventilation characteristics. The distribution of the particle sizes (σ_g) between the two violet smokes could have also played a role in the pattern of deposition in the respiratory tract. Studies have shown that aerosols with similar median aerodynamic sizes but higher distribution values "may be deposited to a greater extent in the upper respiratory tract because of the presence of a certain fraction of large particles that were effectively removed by impaction" (reference 9). This impaction typically occurs at the tracheobronchial tree branching point when the particle velocity is slowed. Although the purple masses were observed in the rats that died during exposure anterior to this branching point (opening of the trachea), the inside of the trachea was not examined below the mass making it possible that the mass started at the tracheobronchial split and continued to the opening of the trachea. Once the tissues were placed in formalin for further analysis, the masses dissolved and were not observed by the histopathologist.

e. Perhaps the sulfur dioxide concentrations associated with the current grenade emissions compared to the prototype grenade could provide a more valid explanation of the tracheal masses observed in the gross necropsies. The sulfur dioxide concentration during the high concentration exposure to current grenade emissions for 10 minutes was reported to be 2000 µg/L (approximately 760 ppm). Sulfur dioxide is considered a primary irritant and, at toxic levels, can greatly irritate the nose and throat. "Sulfur dioxide is very soluble in, and reactive with, water. In the moist pulmonary environment, SO_2 produces sulfurous acid, a severe irritant and mucociliary transport inhibitor, in addition to bisulfate and sulfite, which in turn affect the smooth muscles and nerves involved in bronchoconstriction" (reference 10). Table 4 provides an overview of typical levels of human dose dependent effects.

Table 4. Effects of Sulfur Dioxide Exposure

CONCENTRATION	EFFECTS
5 ppm	Dryness of nose and throat; increased resistance to bronchial airflow (Threshold Limit Value – Short-Term Exposure Limit (TLV-STEL)[1]
6-8 ppm	Noticeable decrease in tidal respiratory volume
10 ppm	Sneezing, coughing, and wheezing with eye, nose, and throat irritation
20 ppm	Initiation of bronchospasms with likely eye irritation
>50 ppm	Reflex closure of glottis and last for a period of minutes
100 ppm	Immediately dangerous to life and health (IDLH)[2]
>1000 ppm	Usually fatal within 10 minutes by respiratory depression

[1] American Conference of Governmental Industrial Hygienists adopted value

[2] National Institute for Occupational Safety and Health (NIOSH) Pocket Guide, September 2005

The reported sulfur dioxide levels within the chamber during the 10-minute exposure were well within the range reported to cause bronchoconstriction, reflex closure of the glottis, and a decrease in tidal respiratory volume. The combination of these three effects likely caused the smoke particles to build up at the opening of the trachea and form a solid mass as they reacted with the moisture in the respiratory tract. In addition, the primary method of particle clearance in the upper respiratory tract and tracheobronchial tree surfaces is mucociliary transport, which is typically inhibited by exposure to sulfur dioxide. The histopathological finding that "congestion commonly noted in the sections of liver and/or lung of animals that died during exposure was considered secondary to agonal death, rather than representing a test substance-specific alteration" supports this hypothesis. Sulfur dioxide samples taken during the low concentration exposure for 10 minutes were reported to be 380 µg/L (146 ppm), which were likely low enough to not be fatal within the 10-minute exposure period. Sulfur dioxide samples taken during the 2-minute exposures at the low and high concentrations were reported to be 230 µg/L (88 ppm) and 20 µg/L (8 ppm), respectively. The sulfur dioxide analytical results for the prototype exposure (10-minute only) were reported to be below the detection limit of 4 µg/L, which is below the TLV-STEL of 5 ppm and the time-weighted average of 2 ppm.

9. CONCLUSIONS.

a. Groups of rats were exposed for 10 or 2 minutes to high (1136 and 2150 mg/m^3, respectively) and low (419 and 1375 mg/m^3, respectively) concentrations of combustion emissions from the current formulation of violet-colored M18 smoke grenades and for 10 minutes to the high (1146 mg/m^3) concentration of the new formulation of violet-colored M18 smoke grenades.

b. Ten-minute exposures to combustion emissions from the current formulation resulted in the deaths of 11 rats at the high concentration upon exposure termination and no deaths at the low concentration. Two-minute exposures to the high and low concentrations of current grenade emissions as well as 10-minute exposures to the high concentration of new grenade emissions produced no deaths.

c. Serial necropsies of surviving rats exposed to current grenade emissions at 1, 7, and 90 days post-exposure and the resulting body weight data, organ weight ratios, hematology, serum chemistry, and histopathologic findings showed no specific evidence of long term toxicity. Body weight data and gross necropsy results of rats exposed to the high concentration of new M18 smoke grenade emissions showed no evidence of toxicity.

d. Based on the lethality produced during 10-minute exposures to the high concentration of current M18 violet smoke grenade emissions, exposure to high concentrations of the new violet smoke formulation appears to pose less of a toxicological risk.

10. POINT OF CONTACT. Questions pertaining to this report should be referred to [redacted] at DSN 584-5088, Commercial 410-436-5088, or by e-mail: [redacted]@us.army.mil.

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APPROVED:

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Program Manager
Toxicity Evaluation Program

APPENDIX A
REFERENCES

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APPENDIX B
Quality Assurance Statement

For: DTOX Study No. 85-XC-0497-07, Protocol No. 0497-24-05-08-01, titled "Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats, July 2007." The following critical phases were audited by the Strategic Initiatives Office-Quality Assurance Team:

Critical Phase Inspected/Audited (SIO-QAT Checklist #)	Date Inspected /Audited	Date Reported to Management
Protocol Review (SIO-QAT checklist # 1.2)	07/22/05	07/22/05
Test System – Facilities (# 4.1)	01/26/06	02/09/06
Test System – Identification (#4.3)	01/26/06	02/09/06
Test System – Husbandry (#4.4)	01/26/06	02/09/06
Test System – Food and Water Supply (# 4.6)	01/26/06	02/09/06
Test Article – Facilities (# 5.1)	01/26/06	02/09/06
Test Article – Control (# 5.2)	01/26/06	02/09/06
Test Article – Receipt (# 5.3)	01/26/06	02/09/06
Test Article – Preparation and Analysis (#5.4)	01/26/06	02/09/06
Test Article – Inhalation (# 5.6)	01/26/06	02/09/06
Test Article – Facilities (# 5.1)	07/26/06	07/28/06
Test Article – Control (# 5.2)	07/26/06	07/28/06
Test Article – Receipt (# 5.3)	07/26/06	07/28/06
Test Article – Preparation and Analysis (#5.4)	07/26/06	07/28/06
Test Article – Inhalation (# 5.6)	07/26/06	07/28/06
Test Article – Facilities (# 5.1)	11/21/06	11/28/06
Test Article – Control (# 5.2)	11/21/06	11/28/06
Test Article – Receipt (# 5.3)	11/21/06	11/28/06
Test Article – Preparation and Analysis (#5.4)	11/21/06	11/28/06
Test Article – Inhalation (# 5.6)	11/21/06	11/28/06
Necropsy – General Requirements (# 7.1)	05/24/06	06/09/06
Necropsy – Procedures (# 7.2)	05/24/06	06/09/06
Necropsy – Solutions and Reagents (# 7.3)	05/24/06	06/09/06
Necropsy – Records (# 7.5)	05/24/06	06/09/06
Compliance w/ DTOX SOPs (# 11.1)	01/26/06	02/09/06
Compliance w/ DTOX SOPs (# 11.1)	07/26/06	07/28/06
Compliance w/ DTOX Protocols (# 12.1)	01/26/06	02/09/06
Compliance w/ DTOX Protocols (# 12.1)	07/26/06	07/28/06
Study Raw Data Review, Records and Specimen Storage, and Archiving (SIO-QAT # 14.2)	07/16/07	07/16/07
Final Study Report Review (SIO-QAT # 13.25)	07/16/07	07/16/07

Note: All findings were made known to the Study Director at the time of the audit/inspection.

[redacted] Date

GLP Assessor, SIO-QAT

[redacted] Date

Team Leader, SIO-QAT

APPENDIX C
ARCHIVES AND STUDY PERSONNEL

1. ARCHIVES.

a. All raw data, documentation, records, protocol, and a copy of the final report generated as a result of this study will be archived in room 1026, building E-2100, USACHPPM, for a minimum of five (5) years following submission of the final report to the Sponsor.

b. Records on animal receipt, diet, and facility environmental parameters will be archived by the Veterinary Medical Division, Toxicology Directorate, for a minimum of five (5) years following submission of the final report to the Sponsor.

c. Some ancillary records pertaining to this study, such as instrument maintenance logs, animal room observation logs, etc., will not be archived until those logbooks have been completed. Once complete they will be archived in room 1026, building E-2100, USACHPPM.

2. PERSONNEL.

a. Management: [redacted], Director of Toxicology; [redacted], Program Manager, Toxicity Evaluation Program (TEP).

b. Study Director: [redacted]
Biologist
Toxicity Evaluation Program

c. Quality Assurance: [redacted], Chemist, Strategic Initiatives Office.

d. Veterinary Support, Necropsies, and Animal Care: [redacted], DVM, MAJ, VC; [redacted], Biologist, TEP; [redacted], Animal Health Technician; [redacted], Animal Health Technician; [redacted], Animal Health Technician.

e. Archivist: [redacted]

APPENDIX D

ANIMAL USE PROTOCOL WITH MODIFICATIONS

ANIMAL USE PROTOCOL
TOXICOLOGY DIRECTORATE
U.S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
ABERDEEN PROVING GROUND, MD 21010-5403

PROTOCOL TITLE: Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

PROTOCOL NUMBER: 0497-24 – 05-08-01

PRINCIPAL INVESTIGATOR/STUDY DIRECTOR: [redacted]
Directorate of Toxicology
410-436-5080

CO-INVESTIGATOR (S): [redacted]
Directorate of Toxicology
410-436-5088

[redacted]
Directorate of Toxicology
410-436-5089

SPONSOR: Environmental Security Technology Certification Program
901 North Stuart Street
Suite 303
Arlington, VA 22203-1853

I. NON-TECHNICAL SYNOPSIS: Groups of rats will be subjected to a single, whole-body exposure to emissions from "old" and "new" violet colored M18 smoke grenades. Exposure will be to one of two preselected concentrations and last either two or ten minutes (see table, page 5). Rats will be euthanized at 1 day, 7 days and 90 days post exposure. Necropsies will be performed and tissues harvested to assess pathological changes to the respiratory tract caused by the airborne materials.

II. BACKGROUND:

II.1. <u>Background</u>: The U.S. Army uses smokes and obscurants to shield armed forces from view, signal friendly forces, and mark positions. However, many kinds of grenade smokes contain dyes and other materials that could pose a hazard to human health and the environment. The Army smoke and dye replacement program found a sugar formulation that successfully replaces the sulfur in most M18 smoke grenades used by the U.S. military. At the program's onset, the switch to the sugar mixture was successful for green and yellow M18 grenades, but changes to the red and violet M18 smoke grenades were more difficult.

Initially, the new dyes burned instead of smoked, not producing enough colored smoke to meet strict military standards. Eventually, the violet smoke grenade was reconfigured to successfully produce the right color, amount of smoke and burn time. However, the smoke produced by the redesigned red smoke grenades was too pale compared to the original.

The Army seeks to reduce the likelihood that exposure to smokes during training would have adverse health effects on military personnel or civilians. To protect the health of exposed individuals, the Office of the Army Surgeon General requested that the National Research Council (NRC) independently review data on the toxicity of smokes and obscurants and recommend exposure guidance levels for military personnel in training and for the general public residing or working near military-training facilities. The NRC concludes that the available toxicity data base for the combustion products of the old and new smoke formulations is inadequate for use in assessing the potential health risk of exposure to these smokes and in recommending exposure guidance levels. The subcommittee recommends that, at a minimum, acute inhalation studies be conducted in experimental animals to test the toxicity of the colored smokes. The Environmental Security Technology Certification Program provided funding for toxicity testing only for the violet-colored grenades.

This study will be conducted in accordance with Good Laboratory Practice Standards, 40 CFR, Part 792.

II.2. Literature Search for Duplication:

II.2.1. Literature Sources Searched:

DTIC: 1984-present
DoD Biomedical Research Database: FY1998-FY2002
PubMed: 1966-present

DIALOG ONESEARCH database including:
BIOSIS: 1969-present
NTIS: 1964-present
EMBASE: 1974-present
PASCAL: 1973-present
CA SEARCH: 1967-present
ELSEVIER BIOBASE: 1994-present
FEDRIP: 1998-present
INSIDE CONFERENCES: 1993-present
CAB ABSTRACTS: 1972-present
MEDLINE: 1966-present
BUSINESS & INDUSTRY: 1994-present
DIALOG GLOBAL REPORTER: 1997-present
IHS INTL. STANDARDS & SPECS: 1999

ENERGY SCITEC: 1974-present
AEROBASE: 1999-present
GALE GROUP NEWSEARCH: 2005
DIALOG DEFENSE NEWSLETTERS: 1989-present
CBIAC: 1996-present
TOXNET: 1900 +
CARS: NA

II.2.2. Date of Search: 7 Jul 2005

II.2.3. Period of Search: The range of years covered varies according to the database and are individually listed in II.2.1. No limits were placed on the years to be covered in this search.

II.2.4. Key Words of Search: M18, violet, colored smoke grenades, combustion products, inhalation, toxicity

II.2.5. Results of Search: The literature search revealed no inhalation studies that would suggest that our study would be a duplicate effort. However, a health risk assessment was conducted by USACHPPM to evaluate the potential for human health effects to offsite residents breathing air emissions following use of the old M18 Violet-Colored Smoke Grenade (reference 13). Air emissions data from the smoke grenade were collected in a test chamber, and was then used in an air dispersion model to determine ambient air concentrations at a location downwind from the site where the item was activated. Modeled air concentrations were combined with exposure information to estimate the amount of substances the hypothetical resident breathes. "The study results showed no potential for health risks from inhalation of air emissions from the M18 Violet-Colored Smoke Grenade."

In one animal study, the effects of a prototype violet dye mixture (VDM) consisting of Disperse Red 11 (the dye used in the new violet grenade) and Disperse Blue 3 on F344 male and female rats have been investigated by inhalation exposure, intratracheal instillation, or gavage (reference 14). Acute 1-day inhalation exposures (6 hr) to VDM were conducted at 1000, 300, 100, 70, 40, and 10 mg/m3, with an additional exposure to 40 mg/m3 6 hr/day for 5 days. Lung burdens of dye, general histopathology, and/or liver function were evaluated at 0, 3, and 7 days post exposure. Unexpected lethality due to severe liver damage was observed with acute exposures of > or = 300 mg/m3 and in the 5-day 40 mg/m3 exposures. In addition, nasal olfactory epithelium exhibited degeneration and necrosis with acute exposures > or = 10 mg/m3.

An acute inhalation study of the combustion products disseminated from the old M18 grenade was conducted in the monkey, dog, goat, swine, rabbit, rat, and guinea pig (reference15). The animals were exposed to concentrations ranging from 1.3 to 7.8 g/m^3 for 8 to 142 min. Exposure was followed by a 30-day observation period. The results were presented as a Bliss analysis of the combined mortality of the total number of animals of all species exposed to the combustion products. The combined LCT_{50} for the combustion products was 211 $mg{\cdot}min/m^3$. Immediately after exposure, all animals showed upper-respiratory irritation and salivation. Gagging was evident in the dog,

swine, goat, and monkey. Prostration was noted in all species for 1 to 4 hr after exposure. Most deaths occurred within the first week after exposure. Although rats were used in this study, the concentrations and exposure times were variable, making any comparison to the current study impractical. The report goes on to state that disseminates from M18 grenades are of a low order of toxicity. The extremely high Ct's required to produce deaths and the toxic signs exhibited by the animals after exposure are similar to the responses caused by exposure to nontoxic dusts.

III. OBJECTIVE/HYPOTHESIS: The objective of this study is to assess and compare the acute inhalation toxicity in rats following exposure to emissions from "old" and "new" formulations of violet colored M18 smoke grenades.

IV. MILITARY RELEVANCE: The U.S. Army seeks to reduce the likelihood that exposure to smokes during training would have adverse health effects on military personnel or civilians. On the basis of its review and evaluation, the NRC concluded that additional research must be conducted on the toxicity of the colored smokes before well-informed recommendations for exposure guidance levels can be made. The Army requested recommendations for four types of exposure guidance levels: (1) emergency exposure guidance levels (EEGLs) for a rare, emergency situation resulting in exposure of military personnel for less than 24 hr; (2) repeated exposure guidance levels (REGLs) for repeated exposure of military personnel during training exercises ; (3) short-term public emergency guidance levels (SPEGLs) for a rare, emergency situation potentially resulting in an exposure of the public to military-training smoke; and (4) repeated public exposure guidance levels (RPEGLs) for repeated exposures of the public residing or working near military-training facilities. Acute toxicity studies would be most relevant for recommending emergency guidance levels such as the EEGLs and SPEGLs.

V. MATERIALS AND METHODS:

V.1. <u>Experimental Design and General Procedures:</u> Details of the experimental design and general procedures are described in TOX SOP 029.05.

V.1.1. Experiment 1: <u>Pilot Study.</u> Five rats per sex will be exposed for 10 minutes to the 6 feet concentration of both the old and new smoke formulations as described below and in paragraph V.4. This exposure will serve to determine the more sensitive sex and to avoid catastrophic consequences during the main study. A total of ten rats to be used.

V.1.1. Experiment 2: <u>Main Study.</u> If there are no sex differences revealed from the pilot study, male rats will be used. Otherwise, the more sensitive sex will be used. Groups of rats will be subjected to a single, whole-body exposure to emissions from violet colored M18 smoke grenades. Exposure concentrations were determined by collecting field samples of smoke grenade emissions at 6 feet and at the edge of the smoke plume. Results showed average concentrations of 864 mg/m^3 and 482 mg/m^3 at the 6 foot and edge of plume, respectively. Each group of rats will be exposed to these field concentrations for either two or ten minutes. Rats will be euthanized at 1 day, 7 days and 90 days post exposure. Necropsies will be performed and tissues harvested to assess

pathological changes to the respiratory tract caused by the airborne materials. Rat group assignments for both Experiments 1 and 2 are shown below. Experiment 1 animals are indicated; all others are treatment groups for Experiment 2:

"Old" Violet Colored M18: **10 min.Exposure**				
Exposure	No. of Rats	1 day sacrifice	7 day sacrifice	90 day sacrifice
Pilot Study	10		10	
6 ft. concentration	24	8	8	8
Edge of plume	24	8	8	8
Control	18	Six to be used at each sacrifice interval		
Total	76			

"New" Violet Colored M18: **10 min. Exposure**				
Exposure	No. of Rats	1 day sacrifice	7 day sacrifice	90 day sacrifice
Pilot Study	10		10	
6 ft. concentration	24	8	8	8
Edge of plume	24	8	8	8
Control	18	Six to be used at each sacrifice interval		
Total	76			

"Old" Violet Colored M18: **2 min.Exposure**				
Exposure	No. of Rats	1 day sacrifice	7 day sacrifice	90 day sacrifice
6 ft. concentration	24	8	8	8
Edge of plume	24	8	8	8
Control	18	Six to be used at each sacrifice interval		
Total	66			

"New" Violet Colored M18: **2 min. Exposure**				
Exposure	No. of Rats	1 day sacrifice	7 day sacrifice	90 day sacrifice
6 ft. concentration	24	8	8	8
Edge of plume	24	8	8	8
Control	18	Six to be used at each sacrifice interval		
Total	66			

GRAND TOTAL FOR EXPERIMENTS 1 AND 2 = 284

V.2. Data Analysis: Data from each treatment group will be statistically compared to controls using a one-way analysis of variance (ANOVA). If significance is observed, the

data will be analyzed further using Dunnett's post-hoc tests. Statistical significance is defined at the $p \leq 0.05$ level. Data to be analyzed will include: body weights, weight gains, absolute organ weights, organ-to-body weight ratios, organ-to-brain weight ratios, hematology, and clinical chemistry values.

V.3. <u>Laboratory Animals Required and Justification</u>:

V.3.1. Non-animal Alternatives Considered: No tissue culture, cell culture or computer modeling procedure would replace the animal model recommended by the NRC.

V.3.2. Animal Model and Species Justification: The NRC recommended that, at a minimum, acute inhalation studies be conducted in experimental animals to test the toxicity of the colored smokes. The rat is a commonly used species in inhalation studies, and a vast data base exists to compare test results.

V.3.3. Laboratory Animals:

V.3.3.1. Genus & Species: *Rattus norvegicus*

V.3.3.2. Strain/Stock: Sprague-Dawley

V.3.3.3. Source/Vendor: Charles River Laboratories (USDA # 14-R-0144)

V.3.3.4. Age: 8-12 weeks

V.3.3.5. Weight: age appropriate

V.3.3.6. Sex: Male and female. Exact breakdown depends on results of Experiment 1. See details above.

V.3.3.7. Special Considerations: None.

V.3.4. Number of Animals Required (By Species): 284 rats. Based on previous data from an acute inhalation study in rats, a sample size of 8 in each group will have greater than 95% power to detect at least a 30% change in organ to-body-weight ratios using a two group t-test with a 0.05 two-sided significance level.

V.3.5. Refinement, Reduction, Replacement:

V.3.5.1. <u>Refinement</u>: Animals will be handled daily during quarantine and provided Nylabones. See Enclosure 3, Environmental Enrichment Plan.

V.3.5.2. <u>Reduction</u>: A pilot study will be conducted initially to determine the more sensitive sex and to avoid catastrophic consequences during the main study. Control group animals will be combined for each exposure time thereby reducing the number of control animals needed for each exposure.

V.3.5.3 Replacement: No nonanimal alternatives are known to exist that will provide the required data.

V.4. Technical Methods:

The smoke grenades will be provided by Edgewood Chemical Biological Center. The compositions of the "old" and "new" formulations are listed in enclosure 4.

The exposures will be performed in a 400-liter, dynamic airflow inhalation chamber. The smoke grenades will be activated inside a 1000-liter static chamber. The resulting smoke emissions will be allowed to mix and then be drawn through an intake pipe to the inlet of the exposure chamber. A gate or ball valve will be placed inline of the intake pipe and adjusted to produce target concentrations and to affect slight negative pressure inside the chamber. The chamber exhaust air will be filtered by a HEPA filter.

In Experiment 2, 24 or 27 rats will comprise an exposure group and be exposed to a single field concentration for either 2 or 10 minutes. Rats will be weighed to the nearest gram just prior to exposure and individually placed in a compartmentalized, stainless steel wire mesh exposure cage. Each compartment measures 6.5" long x 3.75" wide x 3" high. The exposure cages will be positioned in the middle of the chamber and the chamber sealed. Chamber atmosphere will be sampled for particulate mass concentration, particle size, select heavy metals, volatile organic compounds (VOCs), and sulfur dioxide.

Particulate mass will be measured gravimetrically, while particles size will be measured using an 8-stage cascade impactor. Particulate emissions composition (CAD SOP CAB144.1), heavy metals (NIOSH method 7300), and sulfur dioxide (OSHA method ID 200) will be analyzed by USACHPPM Directorate of Laboratory Sciences. VOCs will be collected by personnel from USACHPPM Air Quality Surveillance Program and analyzed by EPA method TO14A at Lancaster Laboratories, Lancaster, PA.

Upon completion of the exposure, rats will be returned to their home cages and observed at least once before the end of the day for toxic signs. The rats will be held until their scheduled necropsy time, during which routine veterinary care will be maintained (see paragraph V.5.2.1.). Rats will be also weighed weekly, where appropriate, during the post exposure period.

At the end of 1 day, 7 days or 90 days, eight animals from each dose group (plus three chamber controls) will be sedated with an intramuscular injection of acepromazine/ketamine cocktail prior to blood withdrawal by intracardiac puncture. Following blood collection, rats will be euthanized by CO_2 asphyxiation (see para.V.4.6) Blood samples will be analyzed for hematology and clinical chemistry. Hematology measurements will include: red blood cell count, hemoglobin, hematocrit, mean cell hemoglobin, mean cell volume, mean cell hemoglobin concentration, platelets, white cell count (WBC) and WBC differential counts. Serum chemistry measurements will include: alkaline phosphatase, alanine aminotransferase, aspartate aminotransferase, total bilirubin, calcium, cholesterol, glucose, total protein, triglycerides, and blood urea

nitrogen. The following tissues shall be harvested and weighed: brain, liver, kidneys, adrenals, spleen, testes, and lungs. Also harvested will be: pituitary, trachea, esophagus, thyroid/parathyroid, aorta, heart, stomach, duodenum, jejunum, caecum, colon, mesentery lymph, thymus, salivary, pancreas, eye, harderian gland, skeletal muscle, skin, tongue, epididymis, prostate, seminal vesicle, urinary bladder, spinal chord, peripheral nerve, nasal turbinates, bone and bone marrow. The nasal turbinates, trachea, lungs, and liver from all animals will undergo histopathological evaluation, in addition to any other tissue system showing gross abnormalities.

V.4.1. Pain/Distress Assessment:

Pain or distress is not anticipated during the conduct of these exposures.

Monitoring. In addition to routine general health monitoring done by caretaking staff, the study director or co-investigator will conduct monitoring of animals. During the study, animals will be monitored at least once in the morning and once in the afternoon. Investigators will note animal checks and animal status (including number of affected animals) in the Animal Room Log Books. Every attempt will be made to begin exposures at the beginning of the week to allow for monitoring and to minimize weekend deaths. If, at the end of the work week, no animals show signs that would meet criteria for euthanasia, animal checks and status will be conducted and recorded in the Animal Room Log Book and the assigned laboratory notebook.

Criteria for euthanasia. One or more of the following clinical signs will be indicative of a moribund animal: impaired ambulation which prevents animals from reaching food or water; excessive weight loss and extreme emaciation (loss of $\geq$ 20% starting body weight); lack of physical or mental alertness; prolonged labored breathing; or prolonged inability to remain upright. Animals demonstrating seizure-like activity will be monitored more frequently than twice per day, and if signs continue until the end of the workday, the animal will be euthanized. The Attending Veterinarian will be notified of all animal illness to evaluate moribund animals in conjunction with the PI. If the PI is unavailable, the Attending Veterinarian may make the decision to euthanize based on the above-listed clinical signs.

V.4.1.1. APHIS Form 7023 Information

V.4.1.1.1. Number of Animals

V.4.1.1.1.1. Column C: 284 rats (100%). This assessment is based on the conclusions of Owens et al, that disseminates from "old" M18 grenades are of a low order of toxicity. The extremely high Ct's required to produce deaths and the toxic signs exhibited by the animals after exposure are similar to the responses caused by exposure to nontoxic dusts (reference 15). Obviously there is no inhalation data on the prototype violet-colored smoke grenade. However it has been shown that Disperse Red 11 is not affected to a great extent by detonation of the grenade, and that toxicity testing on the dye alone showed no eye irritation and only mild skin irritation (reference 16).

V.4.1.1.1.2. Column D: 0 rats

V.4.1.1.1.3. Column E: 0 rats

V.4.1.2. Pain Relief/Prevention: NA

V.4.1.2.1. Anesthesia/Analgesia/Tranquilization: NA

V.4.1.2.2. Pre- and Post procedural Provisions: NA

V.4.1.2.3. Paralytics: NA

V.4.1.3. Literature Search for Alternatives to Painful or Distressful Procedures: NA

V.4.1.3.1. Sources Searched: NA

V.4.1.3.2. Date of Search: NA

V.4.1.3.3. Period of Search: NA

V.4.1.3.4. Key Words of Search: NA

V.4.1.3.5. Results of Search: NA

V.4.1.4. Unalleviated Painful/Distressful Procedure Justification: NA

V.4.2. <u>Prolonged Restraint</u>: NA

V.4.3 <u>Surgery</u>: NA

V.4.3.1. Pre-surgical Provisions: NA

V.4.3.2. Procedure: NA

V.4.3.3. Post-surgical Provisions: NA

V.4.3.4. Location: NA

V.4.3.5. Surgeon: NA

V.4.3.6. Multiple Major Survival Operative Procedures: NA

V.4.3.6.1. Procedures: NA

V.4.3.6.2. Scientific Justification: NA

V.4.4. Animal Manipulations:

V.4.4.1. Injections: Prior to blood withdrawal, rats will be sedated with an intramuscular injection of a ketamine/acepromazine cocktail (10:1) at a dosage of 2.2-5.0 mg/100g (based on ketamine). Injections will be administered with a 23 gauge or smaller needle.

V.4.4.2. Biosamples: Blood samples will be collected under ketamine anesthesia by intracardiac puncture using an 18 gauge or smaller needle.

V.4.4.3. Adjuvents: NA

V.4.4.4. Monoclonal Antibody (MAbs) Production: NA

V.4.4.5. Animal Identification: Animals will be identified by microchip, along with individual cage cards according to Toxicology Programs SOP 003.04.

V.4.4.6. Behavioral Studies: NA

V.4.4.7. Other Procedures:

1. Aerosol exposures as described in V.4. During exposure, the study director or a co-investigator will continuously observe the rats for toxic signs, such as gasping, dyspnea, nasal and ocular irritation, and hunched posture. After the exposed rats are returned to their home cages, the rats will be observed at least twice a day (except weekends) by one of the aforementioned personnel. Toxic signs will be recorded in the appropriately assigned notebook.

2. Daily monitoring of animals – see Paragraph V.4.1. "Pain/Distress Assessment: Monitoring".

3. Weighing: Animals will be weighed prior to exposure, upon death, on days 1 and 7 post exposure, and weekly thereafter.

V.4.4.8. Tissue Sharing: NA

V.4.5. Study Endpoint: Study endpoint is euthanasia following the designated observation period. For experiment 1 (pilot study), this will occur 7 days post exposure. For experiment 2, euthanasia will be done on 1 day, 7 days, and 90 days post exposure. In either experiment, early euthanasia may be conducted on moribund animals as described previously in paragraph V.4.1, *Criteria for euthanasia*. The rats will be weighed, euthanized as described below, and submitted for necropsy.

V.4.6. Euthanasia: Euthanasia will be performed via CO_2 as specified by TOX SOP No.066.04, Animal Euthanasia (reference 6), and in accordance with AVMA

guidelines (administered from a compressed CO2 canister, using a regulated flow valve). In addition to SOP procedures, after apparent death due to CO2, a bilateral pneumothorax will be created in all animals using a #10, 11 or 15 stainless scalpel blade cutting a small incision through the thorax wall (between ribs) on both sides of the thorax, or by making a small incision under the xiphoid process and through the diaphragm. This will occur in ALL animals prior to being given to the person conducting necropsy. Early euthanasia may be conducted on moribund animals as described previously in paragraph V.4.1, *Criteria for euthanasia.*

V.5 Veterinary Care:

V.5.1. Husbandry Considerations: The rats will be pair housed by sex in 9.5" W X 8.5" D X 8"H polycarbonate cages supplied with certified hardwood chip laboratory animal bedding. Water and a certified rodent ration will be offered *ad libitum*. Room temperature will be maintained between 64 and 79 degrees F and the relative humidity maintained between 30% and 70%. A 12-hour light / 12 hour dark cycle will be maintained by automatic timers. Following a minimum 7-day quarantine/acclimation period the rats will be exposed to the test compound. During exposure, rats will be individually held in compartmentalized exposure cages described in paragraph V.4 above. This is necessary to prevent rats from huddling and thus reducing optimal exposure to the test aerosol.

V.5.1.1. Study Room: Building E2101, room 10.

V.5.1.2 Special Husbandry Provisions: NA

V.5.1.3. Exceptions: NA

V. 5.2. Veterinary Medical Care:

V.5.2.1. Routine Veterinary Medical Care: All animals will be observed twice daily by the animal care staff. Appropriate methods of animal care shall be maintained to prevent, control, diagnose and treat diseases and injuries. If an animal becomes ill or injured, the observer will report findings to the attending veterinarian. If necessary, the animal will be euthanized by the Attending Veterinarian or animal care staff under the direction of the Attending Veterinarian in consultation with the principal investigator. If the PI is unavailable, the Attending Veterinarian may make the decision to euthanize based on criteria listed in V.4.1.

V.5.2.2. Emergency Veterinary Medical Care: Animals will be observed daily on weekends and holidays by the animal care staff. If an animal is noted to be ill, the Attending Veterinarian will be contacted.

V.5.3 Environmental Enrichment:

V.5.3.1 Enrichment Strategy: The rats will be pair housed as much as possible, and a member of the animal care staff or PI will handle all rats daily during the acclimation period. Rats will be provided Nylabones at all times except during exposures (enclosure 3, to be posted outside animal room). However, rats will individually housed during exposure.

V.5.3.2 Enrichment Restriction: NA

VI. STUDY PERSONNEL QUALIFICATIONS AND TRAINING:

Staff Member	Procedure	Training	Experience	Qualifications
[redacted]	Chamber operation	OJT, 1977-1982, [redacted] (retired), USAEHA; Inhalation Toxicology Workshop, 1982; Short Course on Aerosol Technology, 1982; Principles and Practice of Industrial Toxicology, 1984.	25 + years working in toxicology laboratories, specializing in inhalation toxicology	BS, Biology
	Manipulations	U.S. Army Veterinary Technician Course, 1977; AALAS Lab Animal Technician Course, 1983; AALAS Lab Animal Technologist Course, 1983-1984; AALAS course on Developing Technicians Skills in Evaluating Clinical Signs in Lab Animals, 1986. The Care and Use of Lab Animals, May 2000	25 + years working in toxicology laboratories, with numerous lab animal species and routes of exposure	BS, Biology Certified AALAS Lab Animal Technologist
	Euthanasia	The Care and Use of Lab Animals, May 2000	25 + years in general toxicology, laboratory animal handling, euthanasia, and necropsy procedures.	BS, Biology; Certified AALAS Lab Animal Technologist

[redacted]	Manipulations	General handling observed and verified by Attending Veterinarian, Oct 2004	25 + years working in toxicology laboratories, with numerous lab animal species and routes of exposure	BS, Biology
[redacted]	Manipulations	Animal Welfare Act, Mar 2003, Implanting Microchips, Jun 2000, Necropsy procedures, bleeding, euthanasia, bones/tissue trimming, sample weighing, Apr 2000, Rodent Handling & Techniques, Nov 1996, Short Course on The Care & Use of Laboratory Animals, May 2000	10+ Yrs, Animal Research	MS, Environmental Science

VII. BIOHAZARD/SAFETY: General procedures for laboratory/animal facilities will be followed IAW Tox Programs SOP no. 083.04. The smoke grenades will be activated in a sealed 1000 liter chamber. Animal exposures will be conducted in a dynamic airflow chamber equipped with a HEPA filter downstream of chamber exhaust. The exposure chamber will be fully evacuated before animals are removed, and personnel will wear NIOSH N 95 or R 95 respirators during this procedure.

VIII. ENCLOSURES:

1. ARCHIVES AND SUPPORT PERSONNEL
2. REFERENCES
3. ENVIRONMENTAL ENRICHMENT PLAN
4. SMOKE FORMULATIONS

IX. STUDY TIME FRAME

I.X.1 **Estimated Experimental Initiation Date:** Sep 2005

I.X.2 **Estimated Experimental Completion Date:** Oct 2005

X. ASSURANCES:

As the Study Director/Principal Investigator on this protocol, I acknowledge my responsibilities and provide assurances for the following:

A. Animal Use: The animals authorized for use in this protocol will be used only in the activities and in the manner described herein, unless a modification is specifically approved by the IACUC prior to its implementation.

B. Duplication of Effort: I have made every effort to ensure that this protocol is not an unnecessary duplication of previous experiments.

C. Statistical Assurance: I assure that I have consulted with a qualified individual who evaluated the experimental design with respect to the statistical analysis, and that the minimum number of animals needed for scientific validity will be used. The study design and number of animals are dictated by an EPA guideline.

D. Biohazard/Safety: I have taken into consideration and made the proper coordinations regarding all applicable rules and regulations concerning radiation protection, biosafety, recombinant issues, and so forth, in the preparation of this protocol.

E. Training: I verify that the personnel performing the animal procedures/manipulations/observations described in this protocol are technically competent and have been properly trained to ensure that no unnecessary pain or distress will be caused to the animals as a result of the procedures/manipulations.

F. Responsibility: I acknowledge the inherent moral, ethical and administrative obligations associated with the performance of this animal use protocol, and I assure that all individuals associated with this project will demonstrate a concern for the health, comfort, welfare, and well-being of the research animals. Additionally, I pledge to conduct this study in the spirit of the fourth "R," namely "Responsibility," which the DOD has embraced for implementing animal use alternatives where feasible and conducting humane and lawful research.

G. Scientific Review: This proposed animal use protocol has received appropriate peer scientific review and is consistent with good scientific research practice.

H. Painful Procedures: NA

[redacted]

2007 06 06
Date (YYYYMMMDD)

X. ASSURANCES:

As the Study Director/Principal Investigator on this protocol, I acknowledge my responsibilities and provide assurances for the following:

A. Animal Use: The animals authorized for use in this protocol will be used only in the activities and in the manner described herein, unless a modification is specifically approved by the IACUC prior to its implementation.

B. Duplication of Effort: I have made every effort to ensure that this protocol is not an unnecessary duplication of previous experiments.

C. Statistical Assurance: I assure that I have consulted with a qualified individual who evaluated the experimental design with respect to the statistical analysis, and that the minimum number of animals needed for scientific validity will be used. The study design and number of animals are dictated by an EPA guideline.

D. Biohazard/Safety: I have taken into consideration and made the proper coordinations regarding all applicable rules and regulations concerning radiation protection, biosafety, recombinant issues, and so forth, in the preparation of this protocol.

E. Training: I verify that the personnel performing the animal procedures/manipulations/observations described in this protocol are technically competent and have been properly trained to ensure that no unnecessary pain or distress will be caused to the animals as a result of the procedures/manipulations.

F. Responsibility: I acknowledge the inherent moral, ethical and administrative obligations associated with the performance of this animal use protocol, and I assure that all individuals associated with this project will demonstrate a concern for the health, comfort, welfare, and well-being of the research animals. Additionally, I pledge to conduct this study in the spirit of the fourth "R," namely "Responsibility," which the DOD has embraced for implementing animal use alternatives where feasible and conducting humane and lawful research.

G. Scientific Review: This proposed animal use protocol has received appropriate peer scientific review and is consistent with good scientific research practice.

H. Painful Procedures: NA

[redacted]

2005 Dec 06
Date (YYYYMMMDD)

ENCLOSURE 1

ARCHIVES AND SUPPORT PERSONNEL

1. ARCHIVES.

a. The protocol, raw data, summary data, and the final report pertaining to this study will be physically maintained in Room 1026, Building E-2100, USACHPPM.

b. Archived SOPs may be found in Room 1026 or Room 3015, Building E2100, USACHPPM, Aberdeen Proving Ground, Maryland 21010.

c. Records on animal receipt, diet, and environmental parameters will be maintained in Room 3100 or Room 1026, Building E2100, USACHPPM, Aberdeen Proving Ground, Maryland 21010.

d. Wet tissues will be stored in cage 12 of Building E-1958, Aberdeen Proving Ground, Maryland 21010.

e. Histology slides, paraffin blocks and hematology slides are stored in the basement of Building E-1570, Aberdeen Proving Ground, Maryland 21010.

2. SUPPORT PERSONNEL

a. Division of Veterinary Medicine:

[redacted]

Attending Veterinarian
Animal Caretaker
Animal Caretaker

b. Toxicity Evaluation Program:

[redacted]

Biologist, Study director
Biologist
Program Manager
Biologist
Biologist
Biologist

d. Archivist: [redacted]

e. Quality Assurance Office

[redacted]

Quality Assurance Assessor
Quality Assurance Assessor

f. Directorate of Laboratory Sciences

g. Air Quality Surveillance Program

h. Edgewood Chemical Biological Center

ENCLOSURE 2

REFERENCES

1. Title 40, Code of Federal Regulations (CFR), Part 792, Good Laboratory Practice Standards.

2. Guide for the Care and Use of Laboratory Animals, U.S. Department of Health, Education, and Welfare, Publication No. NIH 86-23, 1996.

3. Toxicology Directorate, TOX SOP No. 029.05, Acute Inhalation Toxicity Study

4. Toxicology Directorate, TOX SOP No. 028.04, Animal Quality Control Procedures.

5. Toxicology Directorate, TOX SOP No. 003.04, Individual Animal Identification.

6. Toxicology Directorate, TOX SOP No. 066.04, Animal Euthanasia.

7. Toxicology Directorate, TOX SOP No. 083.04, Health and Safety of Laboratory Personnel.

8. Toxicology Directorate, TOX SOP No. 047.05, Histopathology Laboratory Operations

9. Toxicology Directorate, TOX SOP No. 002.05, Pathology Laboratory Operations

10. Toxicology Directorate, TOX SOP No. 052.04, Handling and Storage of Test Records, Data and Specimens

11. Toxicology Directorate, TOX SOP No. 063.04, Test System Observations

12. Toxicology Directorate, TOX SOP No. 041.05 Aerodynamic Particle Size Measurement.

13. U.S. Army Center for Health Promotion and Preventive Medicine. (2000, September). *Pyrotechnics Health Risk Assessment No. 39-EJ-1485-00, Residential Exposure from Inhalation of Air Emissions from the M18 Violet-Colored Smoke Grenade.* Aberdeen Proving Ground, MD: USACHPPM. DTIC ADA391661.

14. Jaskot, R.H., and Costa, D.L. 1994. Toxicity of an anthraquinone violet dye mixture following inhalation exposure, intratracheal instillation, or gavage. *Fund.Appl. Tox.*, 22(1):103-112

15. Owens, E.J., and Ward, D.M. 1974. *A Review of the Toxicology of Colored Chemical Smokes and Colored Smoke Dyes.* Report No. EB-TR-74064, ADA 003827. Edgewood Arsenal, Aberdeen Proving Ground, MD

16. National Academy of Sciences, National Research Council, 1999. Toxicity of Military Smokes and Obscurants, Vol.3, National Academy Press, Washington D.C.

ENCLOSURE 3

Environmental Enrichment Plan

Protocol Number: 0497– 24-

Species: Rat

Room Number:

Pre-Exposure:

1. Rats will be pair housed and provided Nylabones.

2. After daily husbandry procedures have been completed, remove each rat from its cage and place the rat on a lab worktable. Let the animal explore for a few moments on its own, but maintain control of its activity at all times. Gently stroke the animal several times, and return it to its cage.

Post Exposure:

1. Rats will be pair housed and provided Nylabones.

[redacted]

Veterinarian

[redacted]

ENCLOSURE 4

Old vs. New Violet Smoke Formulations

Component	OLD Weight Fraction (w/w)	NEW Weight Fraction (w/w)
Violet Dye Mix[1]	0.4000	0.0000
Disperse Red 11	0.0000	0.3803
Terephthalic Acid	0.0000	0.0766
Sulfur	0.0900	0.0000
Sugar	0.0000	0.1550
Magnesium Carbonate	0.0000	0.1020
Potassium Chlorate	0.2600	0.2350
Stearic Acid	0.0063	0.0050
Sodium Bicarbonate	0.2500	0.0510
Polyvinyl Alcohol	0.0200	0.0200

Components/Materials Added:

Starter Patch
Sugar
Disperse Red 11
Terephthalic Acid
Magnesium Carbonate
Polyvinyl Alcohol

Components/Materials Eliminated:

Disperse Red 9[1]
1,4-diamino-2,3-dihydroanthraquinone (DDA)[1]
Starter Slug
Starter Cup
Cardboard Disc
Sulfur

(1) Please note: Violet dye mix is a mixture of approximately 80 % 1,4-diamino-2,3-dihydroanthraquinone (DDA) and 20% Disperse Red 9

US ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE
PROTOCOL REVIEW, SUPPORT, APPROVAL SHEET

PROTOCOL NUMBER 0497-24 -05-08-01

TITLE: Toxicity of Acute Inhalation Exposure of Emmissions from the Violet Colored M18 Smoke Gernade in Rats

PROTOCOL REVIEW:

1. **Scientific Merit (peer review)** [redacted]

Printed Name (first, mi, last)	Signature
TOXICOLOGIST	TOXICITY EVAL. PROGRAM
Title	Division
2005 07 26	410 436 2201
Date (YYYYMMDD)	Phone
410 436 6710	[redacted]
FAX	E-Mail

2. **Statistician** [redacted]

Printed Name (first, mi, last)	Signature [redacted]
Statistician	DTS
Title	Division
2005 07 29	410 436-3745
Date (YYYYMMDD)	Phone
410 436 1325	[redacted]
FAX	E-Mail

PROTOCOL REVIEW, SUPPORT, APPROVAL SHEET

3. **Quality Assurance**

[redacted]

Printed Name (first, mi, last) — Signature [redacted]

CHEMIST /QA — SIO-QAT

Title — Division

2005/07/29 — 410-436-3752

Date (YYYYMMDD) — Phone

410-436-8359 — [redacted]

FAX — E-Mail

PROTOCOL SUPPORT:

4. **Program Manager, TEP/HERP**

[redacted]

Printed Name (first, mi, last) — Signature [redacted]

PROGRAM MANAGER, TOX EVAL — DTOX

Title — Division

2005/07/29 — 410 436 2176

Date (YYYYMMDD) — Phone

410 436 6710 — [redacted]

FAX — E-Mail

5. **Attending Veterinarian**

[redacted] — [redacted]

Printed Name (first, mi, last) — Signature

Attending Veterinarian — DTOX

Title — Division

20050804 — 410-436-3863

Date (YYYYMMDD) — Phone

410-436-6710 — [redacted]

FAX — E-Mail

PROTOCOL REVIEW, SUPPORT, APPROVAL SHEET

6. **Chemistry** [redacted]

Printed Name (first, mi, last) [redacted]

Signature DLS

Title CHEMIST

Division

Date (YYYYMMDD) 20050811

Phone 410-436-8324

FAX

E-Mail [redacted]

7. **Air Quality Surveillance Program**

Printed Name (first, mi, last) [redacted]

Signature [redacted]

Title SUPV ENV SCIENTIST

Division AQSP

Date (YYYYMMDD) 20050811

Phone [redacted]

FAX

E-Mail

PROTOCOL APPROVAL:

8. **Safety Manager** [redacted]

Printed Name (first, mi, last) [redacted]

Signature

Title Safety Manager

Division

Date (YYYYMMDD) 20050804

Phone 410-436-3841

FAX 410-436-4535

E-Mail [redacted]

PROTOCOL REVIEW, SUPPORT, APPROVAL SHEET

9. Chairman, IACUC

[redacted]

Printed Name (first, mi, last)

Signature

CHEMIST

Title

DLS

Division

20050823

Date (YYYYMMDD)

410-436-8324

Phone

FAX

[redacted]

10. Study Director

[redacted]

Biologist

Title

DTOX

Division

20051214

Date (YYYYMMDD)

410-436-5080

Phone

410-436-6710

FAX

[redacted]

11. Sponsor

Printed Name (first, mi, last)

Signature

Title

Division

Date (YYYYMMDD)

Phone

FAX

E-Mail

USACHPPM PROTOCOL MODIFICATION

For use of this form, see DTOX SOP085

1. DATE: 9 Jan 06	2. PROTOCOL NUMBER: 0497-24-05-08-01	4. MODIFICATION #: 1

5. PROTOCOL TITLE: Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

6a. STUDY DIRECTOR/PRINCIPAL INVESTIGATOR:	6b. WORK PHONE:	6c. OFFICE SYMBOL:
[redacted]	410-436-5080	MCHB-TS-TTE

SECTION I. PREVIOUSLY APPROVED AND CURRENTLY IN USE PROTOCOL MODIFICATIONS

1. MODIFICATION NUMBER	2. SHORT DESCRIPTION OF PRIOR APPROVED MODIFICATION(S)	3. NO. & SPECIES OF ANIMAL REQUESTED	4. APPROVED DATE

SECTION II. CHANGE IN TOTAL # OF ANIMALS USED AND/OR CHANGE IN USDA PAIN CATEGORY

1a. CHANGE: INCREASE TOTAL APPROVED ANIMALS BY: 16	1b. N/A		

2. ORIGINAL PROTOCOL TOTAL: 284					3. PROTOCOL TOTAL AFTER MODIFICATION: 300				
USDA pain cat:	B:	C: x	D:	E:	3a. USDA pain cat:	B:	C:	D:	E:

4. Y [X] N [ ]	**Modification requires specific changes or additions to the experimental design of the protocol. (Section V.I. of the template.)**
Y [X] N [ ]	**Modification requires changes to the technical methods, i.e. procedures, routes of administration, biosample collection, etc. (Section V.4. of the protocol template.) Indicate training of personnel for new methods, procedures being used.**
Y [ ] N [ ]	**Modification requires additions or changes in personnel performing procedures. (Section VI of the protocol template.) Include training an qualification information and tasks that each individual will be performing. If changing the Study Director/PI, a signed Assurance Statement needs to be submitted with the modifications.**

Page, Paragraph, Section	**SECTION III. MODIFICATION JUSTIFICATION**
pg.5,V.1.1	**1. MODIFICATION:** Request additional 16 rats for quality control health monitoring. Grand total for experiments 1 and 2 =300.
	1a. JUSTIFICATION/REASON: Quality rats control rats were unintentionally omitted during original protocol development. It is recommended that during a study of this duration, sentinal animals be housed in the same study room as the test animals. These sentinal animals are sent back to Charles River Labs periodically throughout the course of the study for health monitoring to assess the health status of the study room.

Page, paragraph, section	*Explain the modification(s) indicated above in the area below. Indicate any changes to the 3R's (Refinement, Reduction, Replacement) resulting from changes in number of animals used.*
pg 6, V.3.4	**2. MODIFICATION:** Number of animals required is now 300 rats
	2a. JUSTIFICATION/REASON: Mathematical correction
pg 8, V.4	**3. MODIFICATION:** a) Replace harvesting and weighing of testes with ovaries and uterus. Delete harvesting of epididymis, prostate, and seminal vesicle. b) Add harvesting of lung associated lymph nodes. c) Add weighing of thymus and heart.
	3a. JUSTIFICATION/REASON: a) Only female rats will be used. b) Insoluble particles often translocate to lung associated lymph nodes and it would be prudent to save these tissues for possible histopathological examination. c) Recording the weights of the thymus and heart are consistent with regulatory guidelines for subchronic inhalation studies.
pg 8, V.4.1.1.1.1 10, V.4.4.5	**4. MODIFICATION:** Column C: 300 rats Animals will be identified by cage card and permanent marker.
	4a. JUSTIFICATION/REASON: Mathematical correction. Only one-fouth of the total number of animals will be shipped at one time, and of these, two-thirds will be sacrificedwithin one week andbefore additional shipments arrive. Therefore, microchip should not be necessary to insure rat accountability.

SECTION IV. SIGNATURES AND DATES

1. STUDY DIRECTOR: (Printed Name) [redacted]	[redacted]	**DATE:** (dd/mm/yyyy) 09/01/2006
2. PRINCIPAL INVESTIGATOR: (Printed Name)(IF DIFFERENT FROM STUDY DIRECTOR)	[redacted]	**DATE:** (dd/mm/yyyy)
3. ATTENDING VETERINARIAN: (Printed Name)) [redacted]	[redacted]	**DATE:** (dd/mm/yyyy) 09/01/2006
4. USACHPPM SAFETY OFFICER/OCCUPATIONAL HEALTH REP: (IF APPLICABLE) N/A	[redacted]	**DATE:** (dd/mm/yyyy)
CHAIR, IACUC: (Printed Name) [redacted]	[redacted]	**DATE:** (dd/mm/yyyy) 10/01/2006

USACHPPM PROTOCOL MODIFICATION

For use of this form, see DTOX SOP085

1. DATE: 20 Jan 06	2. PROTOCOL NUMBER: 0497-24-05-08-01	4. MODIFICATION #: 2

5. PROTOCOL TITLE: Toxicity of Acute Inhalation Exposure of Emmissions from the Violet Colored M18 Smoke Grenade in Rats

6a. STUDY DIRECTOR/PRINCIPAL INVESTIGATOR:	6b. WORK PHONE:	6c. OFFICE SYMBOL:
[redacted]	410-436-5080	MCHB-TS-TTE

SECTION I. PREVIOUSLY APPROVED AND CURRENTLY IN USE PROTOCOL MODIFICATIONS

1. MODIFICATION NUMBER	2. SHORT DESCRIPTION OF PRIOR APPROVED MODIFICATION(S)	3. NO. & SPECIES OF ANIMAL REQUESTED	4. APPROVED DATE
1	Increase in animal number	300	10 Jan 06

SECTION II. CHANGE IN TOTAL # OF ANIMALS USED AND/OR CHANGE IN USDA PAIN CATEGORY

1a. CHANGE: INCREASE TOTAL APPROVED ANIMALS BY:					1b. N/A				
2. ORIGINAL PROTOCOL TOTAL:					3. PROTOCOL TOTAL AFTER MODIFICATION:				
USDA pain cat:	B:	C:	D:	E:	3a. USDA pain cat:	B:	C:	D:	E:

4. Y ☐ N ☐	**Modification requires specific changes or additions to the experimental design of the protocol. (Section V.I. of the template.)**
Y ☒ N ☐	**Modification requires changes to the technical methods, i.e. procedures, routes of administration, biosample collection, etc. (Section V.4. of the protocol template.) Indicate training of personnel for new methods, procedures being used.**
Y ☐ N ☐	**Modification requires additions or changes in personnel performing procedures. (Section VI of the protocol template.) Include training an qualification information and tasks that each individual will be performing. If changing the Study Director/PI, a signed Assurance Statement needs to be submitted with the modifications.**

SECTION III. MODIFICATION JUSTIFICATION

Page/paragraph section	
V.4.4.1	**1. MODIFICATION:** a) Increase ketamine dose from (2.5-5.0 mg/100 gm) to (2.5-10.0mg/100 gm) b) Dosage for acepromazine to be from 1.0 - 2.5 mg/kg c) Xylazine may also be used at a dose of 8 mg/ml of cocktail
	1a. JUSTIFICATION/REASON: Increase in the range and number of anesthetic agents will provide greater flexibility in achieving optimal level of anesthesia.

Page, paragraph, section	*Explain the modification(s) indicated above in the area below. Indicate any changes to the 3R's (Refinement, Reduction, Replacement) resulting from changes in number of animals used.*
	2. MODIFICATION:
	2a. JUSTIFICATION/REASON:
	3. MODIFICATION:
	3a. JUSTIFICATION/REASON:
	4. MODIFICATION:
	4a. JUSTIFICATION/REASON:

SECTION V. SIGNATURES AND DATES

1. STUDY DIRECTOR: (Printed Name) [redacted]	[redacted]	**DATE:** (dd/mm/yyyy) 23/01/2006
2. PRINCIPAL INVESTIGATOR: (Printed Name)(IF DIFFERENT FROM STUDY DIRECTOR)	[redacted]	**DATE:** (dd/mm/yyyy)
3. ATTENDING VETERINARIAN: (Printed Name) [redacted]	[redacted]	**DATE:** (dd/mm/yyyy) 23/1/2006
4. USACHPPM SAFETY OFFICER/OCCUPATIONAL HEALTH REP: (IF APPLICABLE) [redacted]	[redacted]	**DATE:** (dd/mm/yyyy) 23/01/2006
CHAIR, IACUC: (Printed Name)	[redacted]	**DATE:** (dd/mm/yyyy)

USACHPPM PROTOCOL MODIFICATION

For use of this form, see IACUC SOP 1.0

1. DATE: 24 Oct 06	2. PROTOCOL NUMBER: 0497-24-05-08-01	3. MODIFICATION #: 3

4. PROTOCOL TITLE: Toxicity of Acute Inhalation of Emmissions from the Violet Colored M18 Smoke Grenade in Rats

5. STUDY DIRECTOR/PRINCIPAL INVESTIGATOR: [redacted]	6. WORK PHONE: 410-436-5080	7. OFFICE SYMBOL: MCHB-TS-TTE

SECTION I. PREVIOUSLY APPROVED AND CURRENTLY IN USE PROTOCOL MODIFICATIONS

1. MODIFICATION NUMBER	2. SHORT DESCRIPTION OF PRIOR APPROVED MODIFICATION(S)	3. NO. & SPECIES OF ANIMAL REQUESTED	4. APPROVED DATE
1	additional rats for health monitoring	16 rats	10 Jan 06
2	adjustment in anesthesia dosage	NA	23 Jan 06

SECTION II. CHANGE IN TOTAL # OF ANIMALS USED AND/OR CHANGE IN USDA PAIN CATEGORY

1a. CHANGE: INCREASE TOTAL APPROVED ANIMALS BY:						1b. N/A	
2. ORIGINAL PROTOCOL TOTAL: 300					3. PROTOCOL TOTAL AFTER MODIFICATION: 162		
USDA pain cat:	B:	C: x	D:	E:	3a. USDA pain cat:	B:	C: x	D:	E:

4. Y [X] N [ ]	**Modification requires specific changes or additions to the experimental design of the protocol. (Section V.I. of the template.)**
Y [ ] N [X]	**Modification requires changes to the technical methods, i.e. procedures, routes of administration, biosample collection, etc. (Section V.4. of the protocol template.) Indicate training of personnel for new methods, procedures being used.**
Y [ ] N [X]	**Modification requires additions or changes in personnel performing procedures. (Section VI of the protocol template.) Include training an qualification information and tasks that each individual will be performing. If changing the Study Director/PI, a signed Assurance Statement needs to be submitted with the modifications.**

PROTOCOL Page, paragraph, section	SECTION III. MODIFICATION/JUSTIFICATION
	1. MODIFICATION: Expose 12 female rats to the high concentration of the prototype grenade for 10 minutes .
	1a. JUSTIFICATION/REASON: During the high concentration exposure to the current grenade formulation, 11/24 female rats died. Histopathology showed no treatment related findings up to 90 days post exposure. The pilot study with the prototype grenade using 5 rats per sex resulted in no deaths. The original protocol states that if no sex differences are found from the pilot study, male rats will used. However, since female rats were used for the current grenade, females should be used for the prototye genade exposures. Due to lack of histopathology, we propose to conduct a single exposure to a similar concentration as that used in the prototype pilot study. After consultation with a statistician, it was decided that 12 rats would be needed to provide the same level of confidence when compared to the 11/24 mortality in the old grenade. If there is no mortality from this exposure, it can be concluded that the prototype grenade is safer. This will close out the study and significantly reduce the original number of animals approved for use.

PROTOCOL Page-paragraph section	*Explain the modification(s) indicated above in the area below. Indicate any changes to the 3R's (Refinement, Reduction, Replacement) resulting from changes in number of animals used.*
	2. MODIFICATION:
	2a. JUSTIFICATION/REASON:
	3. MODIFICATION:
	3a. JUSTIFICATION/REASON:
	4. MODIFICATION:
	4a. JUSTIFICATION/REASON:

Continued on next page YES [ ] NO [ ]

SECTION V. SIGNATURES AND DATES

1. STUDY DIRECTOR: (Printed Name) [redacted]	[redacted]	**DATE:** (yyyy/mm/dd) 2006 10 24
2. PRINCIPAL INVESTIGATOR: (Printed Name)(IF DIFFERENT FROM STUDY DIRECTOR)		**DATE:** (yyyy/mm/dd)
3. ATTENDING VETERINARIAN: (Printed Name) [redacted]		**DATE:** (yyyy/mm/dd) 2006 10 24
4. CHPPM SAFETY OFFICER/OCC HEALTH REP: (IF APPLICABLE)		**DATE:** (yyyy/mm/dd)
CHAIR, IACUC: (Printed Name) [redacted]		**DATE:** (yyyy/mm/dd) 2006 10 25

USACHPPM PROTOCOL MODIFICATION

For use of this form, see IACUC SOP 1.0

1. DATE: 15 Nov 06	2. PROTOCOL NUMBER: 0497-24-05-08-01	3. MODIFICATION#: 4

4. PROTOCOL TITLE: Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

STUDY DIRECTOR/PRINCIPAL INVESTIGATOR:	6. WORK PHONE:	7. OFFICE SYMBOL:
[redacted]	410-436-5080	MCHB-TS-TTE

SECTION I: PREVIOUSLY APPROVED AND CURRENTLY IN USE PROTOCOL MODIFICATIONS

1. MODIFICATION NUMBER	2. SHORT DESCRIPTION OF PRIOR APPROVED MODIFICATION(S)	3. NO. & SPECIES OF ANIMAL REQUESTED	4. APPROVED DATE
1	additional rats for health monitoring	16 rats	10 Jan 06
2	adjustment in anesthesia	NA	23 Jan 06
3	procedural change in exposure design	12 rats	25 Oct 06

SECTION II: CHANGE IN TOTAL # OF ANIMALS USED AND/OR CHANGE IN USDA PAIN CATEGORY

1a. CHANGE: INCREASE TOTAL APPROVED ANIMALS BY: NA — 1b. N/A ☐

2. ORIGINAL PROTOCOL TOTAL: 300 — 3. PROTOCOL TOTAL AFTER MODIFICATION: 162

2a. USDA pain cat:	B:	C: x	D:	E.	3a. USDA pain cat:	B:	C: x	D:	E:

4. Yes	No	
☐	☒	Modification requires specific changes or additions to the experimental design of the protocol. (Section V.I. of the template.)
☐	☒	Modification requires changes to the technical methods, i.e., procedures, routes of administration, biosample collection, etc. (Section V.4. of the protocol template.) Indicate training of personnel for new methods, procedures being used.
☐	☒	Modification requires additions or changes in personnel performing procedures. (Section VI of the protocol template.) Include training and qualification information and tasks that each individual will be performing. If changing the Study Director/PI, a signed Assurance Statement needs to be submitted with the modifications.

PROTOCOL Page, paragraph, section	SECTION III: MODIFICATION JUSTIFICATION *Explain the modification indicated above in the area below. Indicate any changes to the 3Rs (Refinement, Reduction, Replacement) resulting from changes in number of animals*
pg.11, para.V.5.1 line 6	1. MODIFICATION: Change sentence to read: "Following a minimum 5-day quarantine/acclimation period the rats will be exposed to the test compuond."
	1a. JUSTIFICATION/REASON: Since original approval of this protocol, TOX SOP 29.06 has been changed to state that only a 5-day minimum quarantine/acclimation period is required for acute inhalation toxicity studies.

PROTOCOL Page, paragraph, section	*Explain the modification(s) indicated above in the area below. Indicate any changes to the 3R's (Refinement, Reduction, Replacement) resulting from changes in number of animals used.*
	2. MODIFICATION:
	2a. JUSTIFICATION/REASON:
	3. MODIFICATION:
	3a. JUSTIFICATION/REASON:
	4. MODIFICATION:
	4a. JUSTIFICATION/REASON:

Continued on next page YES [ ] NO [ ]

SECTION IV SIGNATURES AND DATES

1. STUDY DIRECTOR: (Printed Name) [redacted]	[redacted]	**DATE:** (yyyy/mm/dd) 2006/11/15
2. PRINCIPAL INVESTIGATOR: (Printed Name)(IF DIFFERENT FROM STUDY DIRECTOR)	[redacted]	**DATE:** (yyyy/mm/dd)
3. ATTENDING VETERINARIAN: (Printed Name) [redacted]	[redacted]	**DATE:** (yyyy/mm/dd) 2006/11/15
4. CHPPM SAFETY OFFICER/OCC HEALTH REP: (IF APPLICABLE)	[redacted]	**DATE:** (yyyy/mm/dd)
CHAIR, IACUC: (Printed Name) [redacted]	[redacted]	**DATE:** (yyyy/mm/dd) 2006/11/15

USACHPPM PROTOCOL MODIFICATION

For use of this form, see IACUC SOP 1.0

1. DATE: (YYYY/MM/DD) 2007/06/01	2. PROTOCOL NUMBER: 0497-24-05-08-01	3. MODIFICATION#: 5

4. PROTOCOL TITLE: Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

5. STUDY DIRECTOR/PRINCIPAL INVESTIGATOR:	6. WORK PHONE:	7. OFFICE SYMBOL:
[redacted]	410-436-5088	MCHB-TS-TTE

SECTION I. PREVIOUSLY APPROVED AND CURRENTLY IN USE PROTOCOL MODIFICATIONS

1. MODIFICATION NUMBER	2. SHORT DESCRIPTION OF PRIOR APPROVED MODIFICATION(S)	3. NO. & SPECIES OF ANIMAL REQUESTED	4. APPROVED DATE
1	Additional rats for health monitoring	16 rats	10 Jan 06
2	Adjustment in anesthesia	NA	23 Jan 06
3	Procedural change in exposure design	12 rats	25 Oct 06
4	Change in qarantine period to mirror SOP 029.06 change	NA	15 Nov 06

SECTION II. CHANGE IN TOTAL # OF ANIMALS USED AND/OR CHANGE IN USDA PAIN CATEGORY

1a. CHANGE: INCREASE TOTAL APPROVED ANIMALS BY:	1b. N/A ☐
2. ORIGINAL PROTOCOL TOTAL: 300	3. PROTOCOL TOTAL AFTER MODIFICATION: 162

2a. USDA pain cat:	B:	C: x	D:	E.	3a. USDA pain cat:	B:	C: x	D:	E:

4. Yes	No	
☐	☒	Modification requires specific changes or additions to the experimental design of the protocol. (Section V.I. of the template.)
☐	☒	Modification requires changes to the technical methods, i.e., procedures, routes of administration, biosample collection, etc. (Section V.4. of the protocol template.) Indicate training of personnel for new methods, procedures being used.
☒	☐	Modification requires additions or changes in personnel performing procedures. (Section VI of the protocol template.) Include training and qualification information and tasks that each individual will be performing. If changing the Study Director/PI, a signed Assurance Statement needs to be submitted with the modifications.

Protocol Page number section	SECTION III. MODIFICATION/JUSTIFICATION *Describe the modification requested above in the approved protocol. Provide any changes to the IACUC, Permanent Radiation Protocol and resulting non-compliances in animal care.*
Approval Page, Page 1, Pages 12 & 13 (personnel qualifications), and Page 14 (assurances)	1. MODIFICATION: The study director has been changed to [redacted]. This change was effective 16 December 06. The in-life portion of the study was completed by [redacted], but [redacted] will now be responsible for managing the project through completion.
	1a. JUSTIFICATION/REASON: The original study director [redacted] passed away on [redacted]

PROTOCOL Page, paragraph section	Explain the modification indicated above in the area below. Indicate any changes to the 3Rs (Refinement, Reduction, Replacement) resulting from changes in number of animals used.
Page 1	2. MODIFICATION: [redacted] will replace [redacted] as the co-investigator.
	2a. JUSTIFICATION/REASON: [redacted] retired on [redacted]
	3. MODIFICATION:
	3a. JUSTIFICATION/REASON:
	4. MODIFICATION:
	4a. JUSTIFICATION/REASON:

Continued on next page YES ☐ NO ☒

SECTION IV SIGNATURES AND DATES

1. STUDY DIRECTOR: (Printed Name) [redacted]	[redacted]	DATE: (yyyy/mm/dd) 2007/06/01
2. PROGRAM MANAGER:: (Printed Name) [redacted]		DATE: (yyyy/mm/dd) 2007/06/01
3. ATTENDING VETERINARIAN: (Printed Name) [redacted]		DATE: (yyyy/mm/dd) 2007/06/01
4. CHPPM SAFETY OFFICER/OCC HEALTH REP: (IF APPLICABLE)		DATE: (yyyy/mm/dd)
5. CHAIR, IACUC: (Printed Name) APPROVED YES ☑ NO ☐ [redacted]		DATE: (yyyy/mm/dd) 2007/06/01

APPENDIX E

STATISTICAL ANALYSIS OF THE BLOOD CHEMISTRY, HEMATOLOGY, AND ORGAN WEIGHTS OF RATS EXPOSED TO M18

Statistical Analysis of the Blood Chemistry, Hematology and Organ Weights of Rats Exposed to M18

Prepared by [redacted]
August 25, 2006

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COMPLIANCE STATEMENT 4

Abstract:

Female rats were randomly assigned to an exposure time, 2 minutes or 10 minutes, and within each exposure time a dose group of M18 smoke, control, low or high. At days 1, 7 and 90, animals from each exposure time and dose group combination were euthanized and their blood chemistry, hematology and body and organ weights were measured. Statistical analyses were conducted using a two-factor (days and dose group) analysis of variance (ANOVA) at each exposure time (2 or 10 minutes). Comparisons between dose groups and between days were made using a Tukey's multiple comparison test.

Introduction:

Female rats were randomly assigned to three M18 dose groups (control, low and high doses). Animals were exposed once to the M18 smoke for either 2 or 10 minutes. The doses of M18 for the 10 minute exposure were 419 mg/m3 for the low dose (10x419=4190 mg/m3) and 1136 mg/m3 for the high dose (10x1136=11360 mg/m3). The doses of M18 for the 2 minute exposure were 1375 mg/m3 for the low dose (2x1375=2750 mg/m3) and 2150 mg/m3 for the high dose (2x2150=4300 mg/m3). At days 1, 7 and 90, subsets of animals were euthanized for each exposure and dose group and blood chemistry, hematology, and body and organ weights were measured.

Statistical Methods:

For all variables, the dose groups and observation days were compared using a two factor analysis of variance (ANOVA) at each exposure time on the parameters that were collected: blood chemistry, hematology, and body weight. Organ to brain and organ to body weight ratios were calculated and analyzed similarly to the other parameters measured. These analyses were followed by a Tukey's multiple comparison test to further compare the dose groups and observation days. If a significant interaction of necropsy day and dose group was observed, then a one factor ANOVA was performed to compare the dose groups at each exposure time and necropsy day.

SPSS 14.0 was used to perform all analyses and statistical significance was defined as $p \leq 0.05$ for all tests.

Blood Chemistry:

Significant differences between necropsy days were observed for many of the parameters. For the 2 minute exposure, significant necropsy day differences were observed for albumin, triglycerides, globulin, sodium (days 1 and 7 were less than day 90) and total protein (days 1 and 7 were greater than day 90). For the 10 minute exposure, significant necropsy day differences were observed for albumin, triglycerides and globulin (days 1 and 7 were less than day 90), and alkaline phosphatase, calcium, total protein, and chloride (days 1 and 7 were greater than day 90) and total bilirubin (day 1 was greater than days 7 and 90).

Significant necropsy day by dose group interactions were observed for alkaline phosphatase (2 minute exposure), BUN (2 and 10 minute exposure), glucose and sodium (10 minute exposure). Upon further analyses for alkaline phosphatase the 2 minute exposure, only on necropsy day 1 was the low dose group was significantly greater than the high dose group. For BUN the 2 minute exposure on day 1, the low dose group was significantly less than the control and high dose groups. For BUN the 10 minute exposure on day 1, the high dose group was significantly less than the control and low dose groups. For glucose and the 10 minute exposure, on day 90 the high dose group was significantly greater than the control and low dose groups. For sodium the 10 minute exposure, on day 7 the low dose group was significantly greater than the high dose group and on day 90, the control group was significantly greater than the high and low dose groups.

No other significant dose group differences were observed.

Only the variables with dose group differences are displayed in the tables below.

Table 1: Alkaline Phosphatase

Exposure time	Necropsy	Dose	Mean	Std. Deviation	N
2	1 day	Control	243.60	39.18	5
		High	202.00 *	40.27	8
		Low	284.43	34.53	7
	7 days	Control	242.50	53.39	6
		High	216.75	44.03	8
		Low	225.13	73.97	8
	90 days	Control	155.67	75.56	6
		High	133.29	39.07	7
		Low	106.00	24.60	8
10	1 day	Control	275.67	69.76	6
		High	210.75	58.62	4
		Low	235.13	48.94	8
	7 days	Control	269.00	56.22	6
		High	254.00	66.74	5
		Low	244.00	47.45	8
	90 days	Control	166.67	63.45	6
		High	211.50	52.40	4
		Low	128.25	47.64	8

* Significantly different from the low dose group, $p \leq 0.05$

Table 2: BUN

Exposure time	Necropsy	Dose	Mean	Std. Deviation	N
2	1 day	Control	23.20	1.92	5
		High	21.75	1.58	8
		Low	18.43 *	1.99	7
	7 days	Control	21.67	2.34	6
		High	21.13	1.46	8
		Low	21.38	2.26	8
	90 days	Control	22.50	2.59	6
		High	23.86	4.49	7
		Low	24.75	2.71	8
10	1 day	Control	22.50	1.05	6
		High	17.75 #	1.89	4
		Low	24.00	2.07	8
	7 days	Control	24.17	3.43	6
		High	20.20	2.39	5
		Low	23.88	2.53	8
	90 days	Control	21.50	3.02	6
		High	22.75	1.26	4
		Low	22.00	2.83	8

* Significantly different from the control and high dose groups, $p \leq 0.05$
# Significantly different from the control and low dose groups, $p \leq 0.05$

Table 3: Glucose

Exposure time	Necropsy	Dose	Mean	Std. Deviation	N
2	1 day	Control	215.2	19.3	5
		High	222.0	18.6	8
		Low	214.3	9.6	7
	7 days	Control	220.7	18.9	6
		High	231.0	20.7	8
		Low	227.9	39.5	8
	90 days	Control	237.2	45.8	6
		High	216.1	32.5	7
		Low	194.5	16.0	8
10	1 day	Control	217.8	19.3	6
		High	209.3	18.0	4
		Low	234.9	44.0	8
	7 days	Control	228.7	49.6	6
		High	198.4	9.3	5
		Low	201.9	21.1	8
	90 days	Control	226.2	21.0	6
		High	271.5 *	30.7	4
		Low	214.1	26.5	8

* Significantly different from the control and low dose groups, $p \leq 0.05$

Table 4: Sodium

Exposure time	Necropsy	Dose	Mean	Std. Deviation	N
2	1 day	Control	143.7	3.27	6
		High	145.0	1.51	8
		Low	145.4	2.39	8
	7 days	Control	146.5	1.05	6
		High	145.5	.93	8
		Low	146.3	2.12	8
	90 days	Control	148.7	3.01	6
		High	148.4	2.15	7
		Low	149.4	3.74	8
10	1 day	Control	145.3	2.58	6
		High	146.5	1.73	4
		Low	145.4	1.30	8
	7 days	Control	145.3	.82	6
		High	146.0	1.00	5
		Low	147.4 *	1.60	8
	90 days	Control	150.3 #	2.07	6
		High	146.0	2.58	4
		Low	147.4	1.69	8

* Significantly different from the high dose group, $p \leq 0.05$
# Significantly different from the high and low dose groups, $p \leq 0.05$

Hematology:

Significant differences between necropsy days were observed for many of the parameters. For the 2 minute exposure, significant necropsy day differences were observed for RBC (days 1 and 7 were less than day 90) and MCV (days 1 and 7 were greater than day 90). For the 10 minute exposure, significant necropsy day differences were observed for WBC, lymphocytes, percent lymphocytes, eosinophils, basophils, percent basophils, RBC, hemoglobin, hematocrit, and MCV. Except for MCV, day 1 was less than or equal to day 7 and less than day 90.

Significant necropsy day by dose group interactions were observed for percent lymphocytes (10 minute exposure) and RDW (2 and 10 minute exposure). Upon further analyses for percent lymphocytes, only on necropsy day 1 was the low dose group significantly lower than the high dose group. For RDW the 2 minute exposure on day 1 the low dose group was significantly greater than the high dose group and on day 7, the low dose group was significantly less than the high dose group. For RDW the 10 minute exposure on day 7, the high dose group was significantly greater than the low dose group.

Significant dose group differences were observed for percent eosinophils and platelets, both at the 10 minute exposure. For percent eosinophils, the control group was significantly lower than the low dose group. For platelets, the control group was significantly greater than the low dose group.

Only the variables with dose group differences are displayed in the tables below.

Table 5: Percent Lymphocytes

Exposure time	Necropsy	Dose	Mean	Std. Deviation	N
2	1 day	Control	81.80	3.17	5
		High	84.16	5.57	7
		Low	83.45	6.09	8
	7 days	Control	83.40	11.25	6
		High	86.38	4.67	8
		Low	85.49	4.84	7
	90 days	Control	87.28	4.32	4
		High	79.48	17.22	8
		Low	84.80	1.99	7
10	1 day	Control	83.82	2.33	6
		High	88.45	3.52	4
		Low	76.65 *	9.05	6
	7 days	Control	84.97	7.57	6
		High	82.66	2.30	5
		Low	85.19	2.73	8
	90 days	Control	86.07	5.76	6
		High	85.15	5.33	4
		Low	87.28	2.14	8

* Significantly different than the high dose group, $p \leq 0.05$.

Table 6: RDW

Exposure time	Necropsy	Dose	Mean	Std. Deviation	N
2	1 day	Control	14.56	.44	5
		High	13.96	.49	7
		Low	14.82 *	.69	8
	7 days	Control	13.72	.66	6
		High	14.56	.67	8
		Low	13.64 *	.72	7
	90 days	Control	15.13	.40	4
		High	14.96	.43	7
		Low	14.69	.57	7
10	1 day	Control	14.88	.61	6
		High	14.80	.72	4
		Low	14.40	.68	6
	7 days	Control	14.00	.90	6
		High	15.74	.97	5
		Low	14.52 *	.55	8
	90 days	Control	15.73	.53	6
		High	14.85	.60	4
		Low	15.16	.96	8

* Significantly different than the high dose group, $p \leq 0.05$.

Table 7: Percent Eosinophils

Exposure time	Necropsy	Dose	Mean	Std. Deviation	N
2	1 day	Control	1.30	.58	5
		High	.93	.23	7
		Low	1.08	.77	8
	7 days	Control	.95	1.05	6
		High	.96	.33	8
		Low	.93	.66	7
	90 days	Control	1.05	.45	4
		High	1.05	.36	7
		Low	.71	.33	7
	Total	Control	1.09	.74	15
		High	.98	.30	22
		Low	.91	.61	22
10	1 day	Control	.65	.35	6
		High	.70	.45	4
		Low	1.34	.74	6
	7 days	Control	.71	.36	6
		High	1.14	.39	5
		Low	.90	.46	8
	90 days	Control	.61	.38	6
		High	.66	.40	4
		Low	.85	.33	8
	Total	Control	.66	.34	18
		High	.86	.44	13
		Low	1.00 *	.53	22

* Regardless of day, the low dose group was significantly different than the control dose group, $p \leq 0.05$.

Table 8: Platelets

Exposure time	Necropsy	Dose	Mean	Std. Deviation	N
2	1 day	Control	392.4	373.5	5
		High	429.0	406.6	7
		Low	600.9	388.5	8
	7 days	Control	470.4	450.4	6
		High	648.8	307.8	8
		Low	600.2	433.4	7
	90 days	Control	797.0	243.2	4
		High	638.6	251.9	7
		Low	828.4	139.5	7
	Total	Control	531.5	392.0	15
		High	575.6	327.8	22
		Low	673.1	348.3	22
10	1 day	Control	947.0	129.8	6
		High	676.2	556.1	4
		Low	607.6	429.4	6
	7 days	Control	854.5	194.1	6
		High	782.8	340.9	5
		Low	634.2	374.1	8
	90 days	Control	821.8	130.1	6
		High	806.8	97.2	4
		Low	595.4	343.6	8
	Total	Control	874.4	154.9	18
		High	757.4	348.8	13
		Low	612.8 *	360.8	22

* Regardless of day, the low dose group was significantly different than the control dose group, $p \leq 0.05$.

Body Weight and Organ to Body Weight Ratios:

As expected, the body weight of the animals significantly increased with time for both exposure times, 2 and 10 minutes. A significant decrease over time was also observed for both exposure times for most of the organ to body weight ratios: adrenals, brain, heart, kidneys, liver lungs, ovaries and thymus. For the 10 minute exposure, a significant interaction of the necropsy day and dose was observed for the spleen to body weight ratio, which implies that the relationship of the doses of M18 vary with respect to the necropsy day. A further analysis was performed on each day for the 10 minute exposure to compare the doses. For the 10 minute exposure on day 90, the low dose group had a significantly greater mean spleen to body weight ratio than the control group. The results are displayed in Table 9 below.

No other significant dose group differences were observed.

Table 9: Spleen to Body Weight Ratio

Necropsy Day	Time	Dose	Mean	Std. Deviation	N
1 day	2	Control	.257	.035	6
		High	.273	.037	8
		Low	.274	.030	8
	10	Control	.261	.025	6
		High	.261	.023	4
		Low	.250	.014	8
7 day	2	Control	.278	.046	6
		High	.259	.035	8
		Low	.239	.020	8
	10	Control	.230	.025	6
		High	.280	.036	5
		Low	.255	.038	8
90 day	2	Control	.225	.031	6
		High	.221	.053	8
		Low	.189	.033	8
	10	Control	.186	.004	6
		High	.200	.023	4
		Low	0.223 *	.025	8

* Significantly greater than the Control dose for the 10 min exposure at the 90 day necropsy, $p \leq 0.05$.

Organ to Brain Weight Ratios:

A significant increase over time was observed for both exposure times for most of the organ to brain weight ratios: heart, kidneys, liver lungs, thymus and uterus. For the 2 minute exposure, a significant difference between dose groups was observed for the spleen to brain weight ratio. The high dose group had a significantly greater mean spleen to brain weight ratio than the low dose group. For the 10 minute exposure, a significant interaction of the necropsy day and dose was observed for the spleen to brain weight ratio, which implies that the relationship of the doses of M18 vary with respect to the necropsy day. A further analysis was performed on each day for the 10 minute exposure to compare the doses. For the 10 minute exposure on day 90, the low dose group had a significantly greater mean spleen to brain weight ratio than the control group. The results are displayed in Table 10 below.

No other significant dose group differences were observed.

Table 10: Spleen to Brain Weight Ratio

Necropsy Day	Time	Dose	Mean	Std. Deviation	N
1 day	2	Control	31.06	4.33	6
		High	33.07	4.29	8
		Low	31.64	2.91	8
	10	Control	31.11	4.59	6
		High	28.85	3.78	4
		Low	29.02	1.97	8
7 day	2	Control	36.27	7.00	6
		High	33.66	4.19	8
		Low	30.34	2.01	8
	10	Control	29.74	2.28	6
		High	35.55	4.81	5
		Low	31.73	4.48	8
90 day	2	Control	34.43	5.91	6
		High	42.55	13.49	8
		Low	30.75	3.72	8
	10	Control	28.72	1.47	6
		High	31.61	2.31	4
		Low	34.51*	2.48	8

* Significantly greater than the Control dose for the 10 min exposure at the 90 day necropsy, $p \leq 0.05$.

Compliance Statement

The statistical analysis of the blood chemistry, hematology and organ weights data for the M18 study in rats was conducted in compliance with Good Laboratory Practices (GLP).

[redacted]
Statistician

Date

APPENDIX F

EXPOSURE ATMOSPHERE CHARACTERIZATION

Table F-1
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

10-Minute Exposures

Particulate Emissions	Current M-18 Grenade				ESTCP Prototype Grenade
Analyte	Pilot Study Concentration (ug/L)	High Concentration (ug/L)	Control Concentration (ug/L)	Low Concentration (ug/L)	High Concentration (ug/L)
1- Aminoanthraquinone	40	55	<2.0	16	
2-Aminoanthraquinone	<5.0	<2.1	<2.1	<2.1	
DDA (Violet Dye Mix)	5.6	<5.9	<5.9	<5.9	
Disperse Red 11	<5.0	<2.0	<2.0	<2.0	520
Disperse Red 9	290	380	<4.2	120	
Disperse Violet 1	460	640	<4.0	190	

Sulfur Dioxide	Current M-18 Grenade				ESTCP Prototype Grenade
Analyte	Pilot Study Concentration (ug)	High Concentration (ug)	Control Concentration (ug)	Low Concentration (ug)	High Concentration (ug)
Sulfur Dioxide	250	2000	2.4	380	<4.00

Metals	Current M-18 Grenade				ESTCP Prototype Grenade
Analyte	Pilot Study Concentration (ug/filter)	High Concentration (ug/filter)	Control Concentration (ug/filter)	Low Concentration (ug/filter)	High Concentration (ug/filter)
Aluminum	3.61	3.73	<2.50	<2.50	4.17
Antimony	<0.500	<0.500	<0.500	<0.500	<0.500
Barium	<0.500	<0.500	<0.500	<0.500	<0.500
Chromium	<1.00	<1.00	<1.00	<1.00	<1.00
Lead	1.15	1.19	<0.500	1.89	0.95
Magnesium	<2.50	<2.50	<2.50	<2.50	<2.50
Manganese	<0.500	<0.500	<0.500	<0.500	<0.500
Zinc	<2.50	<2.50	<2.50	<2.50	<2.50

VOC ANALYSIS RESULTS
(ANALYZED BY LANCASTER LABORATORIES, INC)

EXPLANATION OF ABBREVIATIONS USED BY LANCASTER LABORATORIES, INC FOR VOC ANALYSIS

Lancaster Laboratories
2425 New Holland Pike • Lancaster, PA 17601

Explanation of Symbols and Abbreviations

The following defines common symbols and abbreviations used in reporting technical data:

RL	Reporting Limit	**BMQL**	Below Minimum Quantitation Level
N.D.	none detected	**MPN**	Most Probable Number
TNTC	Too Numerous To Count	**CP Units**	cobalt-chloroplatinate units
IU	International Units	**NTU**	nephelometric turbidity units
umhos/cm	micromhos/cm		
C	degrees Celsius	**F**	degrees Fahrenheit
meq	milliequivalents	**lb.**	pound(s)
g	gram(s)	**kg**	kilogram(s)
ug	microgram(s)	**mg**	milligram(s)
ml	milliliter(s)	**l**	liter(s)
m3	cubic meter(s)	**ul**	microliter(s)

< less than - The number following the sign is the limit of quantitation, the smallest amount of analyte which can be reliably determined using this specific test.

> greater than

J estimated value – The result is ≥ the Method Detection Limit (MDL) and < the Limit of Quantitation (LOQ).

ppm parts per million - One ppm is equivalent to one milligram per kilogram (mg/kg), or one gram per million grams. For aqueous liquids, ppm is usually taken to be equivalent to milligrams per liter (mg/l), because one liter of water has a weight very close to a kilogram. For gases or vapors, one ppm is equivalent to one microliter of gas per liter of gas.

ppb parts per billion

Dry weight basis Results printed under this heading have been adjusted for moisture content. This increases the analyte weight concentration to approximate the value present in a similar sample without moisture. All other results are reported on an as-received basis.

U.S. EPA CLP Data Qualifiers:

Organic Qualifiers

A	TIC is a possible aldol-condensation product
B	Analyte was also detected in the blank
C	Pesticide result confirmed by GC/MS
D	Compound quantitated on a diluted sample
E	Concentration exceeds the calibration range of the instrument
N	Presumptive evidence of a compound (TICs only)
P	Concentration difference between primary and confirmation columns >25%
U	Compound was not detected
X,Y,Z	Defined in case narrative

Inorganic Qualifiers

B	Value is <CRDL, but ≥IDL
E	Estimated due to interference
M	Duplicate injection precision not met
N	Spike sample not within control limits
S	Method of standard additions (MSA) used for calculation
U	Compound was not detected
W	Post digestion spike out of control limits
*****	Duplicate analysis not within control limits
+	Correlation coefficient for MSA <0.995

Analytical test results for methods listed on the laboratories' accreditation scope meet all requirements of NELAC unless otherwise noted under the individual analysis.

Measurement uncertainty values, as applicable, are available upon request.

Tests results relate only to the sample tested. Clients should be aware that a critical step in a chemical or microbiological analysis is the collection of the sample. Unless the sample analyzed is truly representative of the bulk of material involved, the test results will be meaningless. If you have questions regarding the proper techniques of collecting samples, please contact us. We cannot be held responsible for sample integrity, however, unless sampling has been performed by a member of our staff. This report shall not be reproduced except in full, without the written approval of the laboratory.

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VOC ANALYSIS RESULTS FOR PILOT STUDY WITH CURRENT M18 SMOKE

Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4670121

19193002 TOX M18 RAT #30689-0497 [redacted] Air
5866 #02-D-0037
Pick-Up Order #032 Delivery Order # 04 Air
Collected:12/14/2005

Account Number: 04694

Submitted: 12/14/2005 18:50
Reported: 12/25/2005 at 20:47
Discard: 03/06/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

93002 SDG#: TXM01-02*

CAT No.	Analysis Name	CAS Number	As Received Result	As Received Limit of Quantitation	Units	Dilution Factor
07199	11 Volatiles in air by TO-14					
02076	tert-Butyl Alcohol	75-65-0	12.	10.	ppb(v)	10
07201	Propene	115-07-1	600.	10.	ppb(v)	10
07202	Dichlorodifluoromethane	75-71-8	N.D.	10.	ppb(v)	10
07203	Chlorodifluoromethane	75-45-6	N.D.	10.	ppb(v)	10
07204	Freon 114	76-14-2	N.D.	10.	ppb(v)	10
07205	Chloromethane	74-87-3	110.	10.	ppb(v)	10
07206	Vinyl Chloride	75-01-4	41.	10.	ppb(v)	10
07207	1,3-Butadiene	106-99-0	78.	10.	ppb(v)	10
07208	Bromomethane	74-83-9	N.D.	10.	ppb(v)	10
07209	Chloroethane	75-00-3	N.D.	10.	ppb(v)	10
07210	Dichlorofluoromethane	75-43-4	N.D.	10.	ppb(v)	10
07212	Trichlorofluoromethane	75-69-4	N.D.	10.	ppb(v)	10
07213	Pentane	109-66-0	17.	10.	ppb(v)	10
07214	Acrolein	107-02-8	N.D.	10.	ppb(v)	10
07215	1,1-Dichloroethene	75-35-4	N.D.	10.	ppb(v)	10
07216	Freon 113	76-13-1	N.D.	10.	ppb(v)	10
07217	Acetone	67-64-1	960.	20.	ppb(v)	10
07218	Methyl Iodide	74-88-4	N.D.	10.	ppb(v)	10
07219	Carbon Disulfide	75-15-0	44,000.	1,000.	ppb(v)	1000
07220	Acetonitrile	75-05-8	200.	10.	ppb(v)	10
07221	3-Chloropropene	107-05-1	N.D.	10.	ppb(v)	10
07222	Methylene Chloride	75-09-2	16.	10.	ppb(v)	10
07223	Acrylonitrile	107-13-1	290.	10.	ppb(v)	10
07224	trans-1,2-Dichloroethene	156-60-5	N.D.	10.	ppb(v)	10
07225	Methyl t-Butyl Ether	1634-04-4	9.0 J	10.	ppb(v)	10
07226	Hexane	110-54-3	16.	10.	ppb(v)	10
07227	1,1-Dichloroethane	75-34-3	N.D.	10.	ppb(v)	10
07228	Vinyl Acetate	108-05-4	17.	10.	ppb(v)	10
07230	cis-1,2-Dichloroethene	156-59-2	N.D.	10.	ppb(v)	10
07231	2-Butanone	78-93-3	20.	10.	ppb(v)	10
07232	Ethyl Acetate	141-78-6	N.D.	10.	ppb(v)	10
07233	Methyl Acrylate	96-33-3	N.D.	10.	ppb(v)	10
07234	Chloroform	67-66-3	29.	10.	ppb(v)	10
07235	1,1,1-Trichloroethane	71-55-6	N.D.	10.	ppb(v)	10
07236	Carbon Tetrachloride	56-23-5	N.D.	10.	ppb(v)	10

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PO Box 12425
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Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4670121

19193002 TOX M18 RAT #30689-0497 [redacted] Air
5866 #02-D-0037
Pick-Up Order #032 Delivery Order # 04 Air
Collected:12/14/2005

Account Number: 04694

Submitted: 12/14/2005 18:50
Reported: 12/25/2005 at 20:47
Discard: 03/06/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

93002 SDG#: TXM01-02*

CAT No.	Analysis Name	CAS Number	As Received Result		As Received Limit of Quantitation	Units	Dilution Factor
07237	1,2-Dichloroethane	107-06-2	8.0	J	10.	ppb(v)	10
07238	Benzene	71-43-2	500.		10.	ppb(v)	10
07239	Isooctane	540-84-1	N.D.		10.	ppb(v)	10
07240	Heptane	142-82-5	N.D.		10.	ppb(v)	10
07241	Trichloroethene	79-01-6	N.D.		10.	ppb(v)	10
07242	Ethyl Acrylate	140-88-5	N.D.		10.	ppb(v)	10
07243	1,2-Dichloropropane	78-87-5	N.D.		10.	ppb(v)	10
07244	Methyl Methacrylate	80-62-6	N.D.		10.	ppb(v)	10
07245	Dibromomethane	74-95-3	N.D.		10.	ppb(v)	10
07246	1,4-Dioxane	123-91-1	N.D.		10.	ppb(v)	10
07247	Bromodichloromethane	75-27-4	N.D.		10.	ppb(v)	10
07248	cis-1,3-Dichloropropene	10061-01-5	N.D.		10.	ppb(v)	10
07249	4-Methyl-2-Pentanone	108-10-1	N.D.		10.	ppb(v)	10
07250	Toluene	108-88-3	59.		10.	ppb(v)	10
07251	Octane	111-65-9	19.		10.	ppb(v)	10
07252	trans-1,3-Dichloropropene	10061-02-6	N.D.		10.	ppb(v)	10
07253	Ethyl Methacrylate	97-63-2	N.D.		10.	ppb(v)	10
07254	1,1,2-Trichloroethane	79-00-5	N.D.		10.	ppb(v)	10
07255	Tetrachloroethene	127-18-4	N.D.		10.	ppb(v)	10
07256	2-Hexanone	591-78-6	N.D.		10.	ppb(v)	10
07257	Dibromochloromethane	124-48-1	N.D.		10.	ppb(v)	10
07258	1,2-Dibromoethane	106-93-4	N.D.		10.	ppb(v)	10
07259	Chlorobenzene	108-90-7	17.		10.	ppb(v)	10
07260	1,1,1,2-Tetrachloroethane	630-20-6	N.D.		10.	ppb(v)	10
07261	Ethylbenzene	100-41-4	16.		10.	ppb(v)	10
07262	m/p-Xylene	1330-20-7	33.		10.	ppb(v)	10
07263	o-Xylene	95-47-6	18.		10.	ppb(v)	10
07264	Styrene	100-42-5	5.0	J	10.	ppb(v)	10
07265	Bromoform	75-25-2	N.D.		10.	ppb(v)	10
07266	Cumene	98-82-8	N.D.		10.	ppb(v)	10
07267	1,1,2,2-Tetrachloroethane	79-34-5	N.D.		10.	ppb(v)	10
07268	1,2,3-Trichloropropane	96-18-4	N.D.		10.	ppb(v)	10
07269	Bromobenzene	108-86-1	N.D.		10.	ppb(v)	10
07270	4-Ethyltoluene	622-96-8	N.D.		10.	ppb(v)	10
07271	1,3,5-Trimethylbenzene	108-67-8	N.D.		10.	ppb(v)	10
07272	Alpha Methyl Styrene	98-83-9	N.D.		10.	ppb(v)	10
07273	1,2,4-Trimethylbenzene	95-63-6	N.D.		10.	ppb(v)	10
07274	1,3-Dichlorobenzene	541-73-1	N.D.		10.	ppb(v)	10
07275	1,4-Dichlorobenzene	106-46-7	N.D.		10.	ppb(v)	10

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Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4670121

19193002 TOX M18 RAT #30689-0497 [redacted] Air
5866 #02-D-0037
Pick-Up Order #032 Delivery Order # 04 Air
Collected:12/14/2005

Account Number: 04694

Submitted: 12/14/2005 18:50
Reported: 12/25/2005 at 20:47
Discard: 03/06/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

93002 SDG#: TXM01-02*

CAT No.	Analysis Name	CAS Number	As Received Result	As Received Limit of Quantitation	Units	Dilution Factor
07277	1,2-Dichlorobenzene	95-50-1	N.D.	10.	ppb(v)	10
07278	Hexachloroethane	67-72-1	N.D.	10.	ppb(v)	10
07279	1,2,4-Trichlorobenzene	120-82-1	N.D.	10.	ppb(v)	10
07280	Hexachlorobutadiene	87-68-3	N.D.	10.	ppb(v)	10

The reporting limits for the GC/MS volatile compounds were raised because sample dilution was necessary to bring target compounds into the calibration range of the system.

Laboratory Chronicle

CAT No.	Analysis Name	Method	Trial#	Analysis Date and Time	Analyst	Dilution Factor
07199	11 Volatiles in air by TO-14	EPA TO14A	1	12/19/2005 19:17	Douglas Graham	10
07199	11 Volatiles in air by TO-14	EPA TO14A	1	12/20/2005 14:24	Douglas Graham	1000

0027

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VOC ANALYSIS RESULTS FOR CONTROL EXPOSURE WITH CURRENT M18 SMOKE (10 MINUTE EXPOSURE)

Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4697814

19588001 TOX M18 Rat St #30807-0497 [redacted] Water
0497-024-CV #02-D-0037
Pick-Up Order #042 Delivery Order # 04 Air
Collected:01/24/2006

Account Number: 04694

Submitted: 01/27/2006 15:00
Reported: 02/10/2006 at 18:08
Discard: 04/22/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

-24CV SDG#: TXM02-01

CAT No.	Analysis Name	CAS Number	As Received Result		As Received Limit of Quantitation	Units	Dilution Factor
07199	11 Volatiles in air by TO-14						
02076	tert-Butyl Alcohol	75-65-0	N.D.		1.0	ppb(v)	1
07201	Propene	115-07-1	2.0		1.0	ppb(v)	1
07202	Dichlorodifluoromethane	75-71-8	0.70	J	1.0	ppb(v)	1
07203	Chlorodifluoromethane	75-45-6	N.D.		1.0	ppb(v)	1
07204	Freon 114	76-14-2	N.D.		1.0	ppb(v)	1
07205	Chloromethane	74-87-3	N.D.		1.0	ppb(v)	1
07206	Vinyl Chloride	75-01-4	N.D.		1.0	ppb(v)	1
07207	1,3-Butadiene	106-99-0	N.D.		1.0	ppb(v)	1
07208	Bromomethane	74-83-9	N.D.		1.0	ppb(v)	1
07209	Chloroethane	75-00-3	N.D.		1.0	ppb(v)	1
07210	Dichlorofluoromethane	75-43-4	N.D.		1.0	ppb(v)	1
07212	Trichlorofluoromethane	75-69-4	0.30	J	1.0	ppb(v)	1
07213	Pentane	109-66-0	3.0		1.0	ppb(v)	1
07214	Acrolein	107-02-8	N.D.		1.0	ppb(v)	1
07215	1,1-Dichloroethene	75-35-4	N.D.		1.0	ppb(v)	1
07216	Freon 113	76-13-1	N.D.		1.0	ppb(v)	1
07217	Acetone	67-64-1	48.		2.0	ppb(v)	1
07218	Methyl Iodide	74-88-4	N.D.		1.0	ppb(v)	1
07219	Carbon Disulfide	75-15-0	2.0		1.0	ppb(v)	1
07220	Acetonitrile	75-05-8	N.D.		1.0	ppb(v)	1
07221	3-Chloropropene	107-05-1	N.D.		1.0	ppb(v)	1
07222	Methylene Chloride	75-09-2	N.D.		1.0	ppb(v)	1
07223	Acrylonitrile	107-13-1	N.D.		1.0	ppb(v)	1
07224	trans-1,2-Dichloroethene	156-60-5	N.D.		1.0	ppb(v)	1
07225	Methyl t-Butyl Ether	1634-04-4	2.0		1.0	ppb(v)	1
07226	Hexane	110-54-3	0.70	J	1.0	ppb(v)	1
07227	1,1-Dichloroethane	75-34-3	N.D.		1.0	ppb(v)	1
07228	Vinyl Acetate	108-05-4	N.D.		1.0	ppb(v)	1
07230	cis-1,2-Dichloroethene	156-59-2	N.D.		1.0	ppb(v)	1
07231	2-Butanone	78-93-3	N.D.		1.0	ppb(v)	1
07232	Ethyl Acetate	141-78-6	N.D.		1.0	ppb(v)	1
07233	Methyl Acrylate	96-33-3	N.D.		1.0	ppb(v)	1
07234	Chloroform	67-66-3	N.D.		1.0	ppb(v)	1
07235	1,1,1-Trichloroethane	71-55-6	N.D.		1.0	ppb(v)	1
07236	Carbon Tetrachloride	56-23-5	N.D.		1.0	ppb(v)	1

0822

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Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4697814

19588001 TOX M18 Rat St #30807-0497 [redacted] Water
0497-024-CV #02-D-0037
Pick-Up Order #042 Delivery Order # 04 Air
Collected:01/24/2006

Account Number: 04694

Submitted: 01/27/2006 15:00
Reported: 02/10/2006 at 18:08
Discard: 04/22/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

-24CV SDG#: TXM02-01

CAT No.	Analysis Name	CAS Number	As Received Result		As Received Limit of Quantitation	Units	Dilution Factor
07237	1,2-Dichloroethane	107-06-2	N.D.		1.0	ppb(v)	1
07238	Benzene	71-43-2	0.70	J	1.0	ppb(v)	1
07239	Isooctane	540-84-1	N.D.		1.0	ppb(v)	1
07240	Heptane	142-82-5	N.D.		1.0	ppb(v)	1
07241	Trichloroethene	79-01-6	N.D.		1.0	ppb(v)	1
07242	Ethyl Acrylate	140-88-5	N.D.		1.0	ppb(v)	1
07243	1,2-Dichloropropane	78-87-5	N.D.		1.0	ppb(v)	1
07244	Methyl Methacrylate	80-62-6	N.D.		1.0	ppb(v)	1
07245	Dibromomethane	74-95-3	N.D.		1.0	ppb(v)	1
07246	1,4-Dioxane	123-91-1	N.D.		1.0	ppb(v)	1
07247	Bromodichloromethane	75-27-4	N.D.		1.0	ppb(v)	1
07248	cis-1,3-Dichloropropene	10061-01-5	N.D.		1.0	ppb(v)	1
07249	4-Methyl-2-Pentanone	108-10-1	N.D.		1.0	ppb(v)	1
07250	Toluene	108-88-3	1.0		1.0	ppb(v)	1
07251	Octane	111-65-9	N.D.		1.0	ppb(v)	1
07252	trans-1,3-Dichloropropene	10061-02-6	N.D.		1.0	ppb(v)	1
07253	Ethyl Methacrylate	97-63-2	N.D.		1.0	ppb(v)	1
07254	1,1,2-Trichloroethane	79-00-5	N.D.		1.0	ppb(v)	1
07255	Tetrachloroethene	127-18-4	N.D.		1.0	ppb(v)	1
07256	2-Hexanone	591-78-6	N.D.		1.0	ppb(v)	1
07257	Dibromochloromethane	124-48-1	N.D.		1.0	ppb(v)	1
07258	1,2-Dibromoethane	106-93-4	N.D.		1.0	ppb(v)	1
07259	Chlorobenzene	108-90-7	N.D.		1.0	ppb(v)	1
07260	1,1,1,2-Tetrachloroethane	630-20-6	N.D.		1.0	ppb(v)	1
07261	Ethylbenzene	100-41-4	N.D.		1.0	ppb(v)	1
07262	m/p-Xylene	1330-20-7	0.90	J	1.0	ppb(v)	1
07263	o-Xylene	95-47-6	0.30	J	1.0	ppb(v)	1
07264	Styrene	100-42-5	0.30	J	1.0	ppb(v)	1
07265	Bromoform	75-25-2	N.D.		1.0	ppb(v)	1
07266	Cumene	98-82-8	N.D.		1.0	ppb(v)	1
07267	1,1,2,2-Tetrachloroethane	79-34-5	N.D.		1.0	ppb(v)	1
07268	1,2,3-Trichloropropane	96-18-4	N.D.		1.0	ppb(v)	1
07269	Bromobenzene	108-86-1	N.D.		1.0	ppb(v)	1
07270	4-Ethyltoluene	622-96-8	N.D.		1.0	ppb(v)	1
07271	1,3,5-Trimethylbenzene	108-67-8	N.D.		1.0	ppb(v)	1
07272	Alpha Methyl Styrene	98-83-9	N.D.		1.0	ppb(v)	1
07273	1,2,4-Trimethylbenzene	95-63-6	0.30	J	1.0	ppb(v)	1
07274	1,3-Dichlorobenzene	541-73-1	N.D.		1.0	ppb(v)	1
07275	1,4-Dichlorobenzene	106-46-7	N.D.		1.0	ppb(v)	1

0823

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2425 New Holland Pike
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717-656-2300 Fax: 717-656-2681

Analysis Report

Lancaster Laboratories

10 min High

Lancaster Laboratories Sample No. AQ 4697814

19588001 TOX M18 Rat St #30807-0497 [redacted] Water
0497-024-CV HV **#02-D-0037**
Pick-Up Order #042 Delivery Order # 04 Air
Collected:01/24/2006

Account Number: 04694

Submitted: 01/27/2006 15:00
Reported: 02/10/2006 at 18:08
Discard: 04/22/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

-24CV SDG#: TXM02-01

CAT No.	Analysis Name	CAS Number	As Received Result	As Received Limit of Quantitation	Units	Dilution Factor
07277	1,2-Dichlorobenzene	95-50-1	N.D.	1.0	ppb(v)	1
07278	Hexachloroethane	67-72-1	N.D.	1.0	ppb(v)	1
07279	1,2,4-Trichlorobenzene	120-82-1	N.D.	1.0	ppb(v)	1
07280	Hexachlorobutadiene	87-68-3	N.D.	1.0	ppb(v)	1

The initial calibration did not meet the Method TO-14 percent RSD criteria for 1,4-dioxane. The value reported for 1,4-dioxane should be considered estimated.

All QC is compliant unless otherwise noted. Please refer to the Quality Control Summary for overall QC performance data and associated samples.

Laboratory Chronicle

CAT No.	Analysis Name	Method	Trial#	Analysis Date and Time	Analyst	Dilution Factor
07199	11 Volatiles in air by TO-14	EPA TO14A	1	02/07/2006 21:05	Douglas Graham	1

8824

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VOC ANALYSIS RESULTS FOR HIGH EXPOSURE WITH CURRENT M18 SMOKE (10 MINUTE EXPOSURE)

Analysis Report

Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4697815

19588002 TOX M18 Rat St #30807-0497 [redacted] Water
0497-024-HV #02-D-0037
Pick-Up Order #042 Delivery Order # 04 Air
Collected:01/24/2006

Account Number: 04694

Submitted: 01/27/2006 15:00
Reported: 02/10/2006 at 18:08
Discard: 04/22/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

-24HV SDG#: TXM02-02*

CAT No.	Analysis Name	CAS Number	As Received Result		As Received Limit of Quantitation	Units	Dilution Factor
07199	11 Volatiles in air by TO-14						
02076	tert-Butyl Alcohol	75-65-0	N.D.		10.	ppb(v)	10
07201	Propene	115-07-1	410.	J	1,000.	ppb(v)	1000
07202	Dichlorodifluoromethane	75-71-8	N.D.		10.	ppb(v)	10
07203	Chlorodifluoromethane	75-45-6	N.D.		10.	ppb(v)	10
07204	Freon 114	76-14-2	N.D.		10.	ppb(v)	10
07205	Chloromethane	74-87-3	120.		10.	ppb(v)	10
07206	Vinyl Chloride	75-01-4	60.		10.	ppb(v)	10
07207	1,3-Butadiene	106-99-0	130.		10.	ppb(v)	10
07208	Bromomethane	74-83-9	N.D.		10.	ppb(v)	10
07209	Chloroethane	75-00-3	N.D.		10.	ppb(v)	10
07210	Dichlorofluoromethane	75-43-4	N.D.		10.	ppb(v)	10
07212	Trichlorofluoromethane	75-69-4	N.D.		10.	ppb(v)	10
07213	Pentane	109-66-0	10.		10.	ppb(v)	10
07214	Acrolein	107-02-8	N.D.		10.	ppb(v)	10
07215	1,1-Dichloroethene	75-35-4	N.D.		10.	ppb(v)	10
07216	Freon 113	76-13-1	N.D.		10.	ppb(v)	10
07217	Acetone	67-64-1	1,800.	J	2,000.	ppb(v)	1000
07218	Methyl Iodide	74-88-4	N.D.		10.	ppb(v)	10
07219	Carbon Disulfide	75-15-0	54,000.		1,000.	ppb(v)	1000
07220	Acetonitrile	75-05-8	480.		10.	ppb(v)	10
07221	3-Chloropropene	107-05-1	N.D.		10.	ppb(v)	10
07222	Methylene Chloride	75-09-2	12.		10.	ppb(v)	10
07223	Acrylonitrile	107-13-1	810.		10.	ppb(v)	10
07224	trans-1,2-Dichloroethene	156-60-5	N.D.		10.	ppb(v)	10
07225	Methyl t-Butyl Ether	1634-04-4	N.D.		10.	ppb(v)	10
07226	Hexane	110-54-3	N.D.		10.	ppb(v)	10
07227	1,1-Dichloroethane	75-34-3	N.D.		10.	ppb(v)	10
07228	Vinyl Acetate	108-05-4	N.D.		10.	ppb(v)	10
07230	cis-1,2-Dichloroethene	156-59-2	N.D.		10.	ppb(v)	10
07231	2-Butanone	78-93-3	28.		10.	ppb(v)	10
07232	Ethyl Acetate	141-78-6	N.D.		10.	ppb(v)	10
07233	Methyl Acrylate	96-33-3	N.D.		10.	ppb(v)	10
07234	Chloroform	67-66-3	20.		10.	ppb(v)	10
07235	1,1,1-Trichloroethane	71-55-6	N.D.		10.	ppb(v)	10
07236	Carbon Tetrachloride	56-23-5	N.D.		10.	ppb(v)	10

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Lancaster Laboratories Sample No. AQ 4697815

19588002 TOX M18 Rat St #30807-0497 [redacted] Water
0497-024-HV #02-D-0037
Pick-Up Order #042 Delivery Order # 04 Air
Collected:01/24/2006

Account Number: 04694

Submitted: 01/27/2006 15:00
Reported: 02/10/2006 at 18:08
Discard: 04/22/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

-24HV SDG#: TXM02-02*

CAT No.	Analysis Name	CAS Number	As Received Result		As Received Limit of Quantitation	Units	Dilution Factor
07237	1,2-Dichloroethane	107-06-2	15.		10.	ppb(v)	10
07238	Benzene	71-43-2	820.		10.	ppb(v)	10
07239	Isooctane	540-84-1	N.D.		10.	ppb(v)	10
07240	Heptane	142-82-5	N.D.		10.	ppb(v)	10
07241	Trichloroethene	79-01-6	N.D.		10.	ppb(v)	10
07242	Ethyl Acrylate	140-88-5	N.D.		10.	ppb(v)	10
07243	1,2-Dichloropropane	78-87-5	N.D.		10.	ppb(v)	10
07244	Methyl Methacrylate	80-62-6	N.D.		10.	ppb(v)	10
07245	Dibromomethane	74-95-3	N.D.		10.	ppb(v)	10
07246	1,4-Dioxane	123-91-1	N.D.		10.	ppb(v)	10
07247	Bromodichloromethane	75-27-4	N.D.		10.	ppb(v)	10
07248	cis-1,3-Dichloropropene	10061-01-5	N.D.		10.	ppb(v)	10
07249	4-Methyl-2-Pentanone	108-10-1	N.D.		10.	ppb(v)	10
07250	Toluene	108-88-3	83.		10.	ppb(v)	10
07251	Octane	111-65-9	N.D.		10.	ppb(v)	10
07252	trans-1,3-Dichloropropene	10061-02-6	N.D.		10.	ppb(v)	10
07253	Ethyl Methacrylate	97-63-2	N.D.		10.	ppb(v)	10
07254	1,1,2-Trichloroethane	79-00-5	N.D.		10.	ppb(v)	10
07255	Tetrachloroethene	127-18-4	N.D.		10.	ppb(v)	10
07256	2-Hexanone	591-78-6	N.D.		10.	ppb(v)	10
07257	Dibromochloromethane	124-48-1	N.D.		10.	ppb(v)	10
07258	1,2-Dibromoethane	106-93-4	N.D.		10.	ppb(v)	10
07259	Chlorobenzene	108-90-7	30.		10.	ppb(v)	10
07260	1,1,1,2-Tetrachloroethane	630-20-6	N.D.		10.	ppb(v)	10
07261	Ethylbenzene	100-41-4	5.0	J	10.	ppb(v)	10
07262	m/p-Xylene	1330-20-7	9.0	J	10.	ppb(v)	10
07263	o-Xylene	95-47-6	5.0	J	10.	ppb(v)	10
07264	Styrene	100-42-5	13.		10.	ppb(v)	10
07265	Bromoform	75-25-2	N.D.		10.	ppb(v)	10
07266	Cumene	98-82-8	N.D.		10.	ppb(v)	10
07267	1,1,2,2-Tetrachloroethane	79-34-5	N.D.		10.	ppb(v)	10
07268	1,2,3-Trichloropropane	96-18-4	N.D.		10.	ppb(v)	10
07269	Bromobenzene	108-86-1	N.D.		10.	ppb(v)	10
07270	4-Ethyltoluene	622-96-8	N.D.		10.	ppb(v)	10
07271	1,3,5-Trimethylbenzene	108-67-8	N.D.		10.	ppb(v)	10
07272	Alpha Methyl Styrene	98-83-9	N.D.		10.	ppb(v)	10
07273	1,2,4-Trimethylbenzene	95-63-6	N.D.		10.	ppb(v)	10
07274	1,3-Dichlorobenzene	541-73-1	N.D.		10.	ppb(v)	10
07275	1,4-Dichlorobenzene	106-46-7	N.D.		10.	ppb(v)	10

0026

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717-656-2300 Fax: 717-656-2681

Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4697815

19588002 TOX M18 Rat St #30807-0497 [redacted] Water
0497-024-HV #02-D-0037
Pick-Up Order #042 Delivery Order # 04 Air
Collected:01/24/2006

Account Number: 04694

Submitted: 01/27/2006 15:00
Reported: 02/10/2006 at 18:08
Discard: 04/22/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

-24HV SDG#: TXM02-02*

CAT No.	Analysis Name	CAS Number	As Received Result	As Received Limit of Quantitation	Units	Dilution Factor
07277	1,2-Dichlorobenzene	95-50-1	N.D.	10.	ppb(v)	10
07278	Hexachloroethane	67-72-1	N.D.	10.	ppb(v)	10
07279	1,2,4-Trichlorobenzene	120-82-1	N.D.	10.	ppb(v)	10
07280	Hexachlorobutadiene	87-68-3	N.D.	10.	ppb(v)	10

The initial calibration did not meet the Method TO-14 percent RSD criteria for 1,4-dioxane. The value reported for 1,4-dioxane should be considered estimated.

All QC is compliant unless otherwise noted. Please refer to the Quality Control Summary for overall QC performance data and associated samples.

Laboratory Chronicle

CAT No.	Analysis Name	Method	Trial#	Analysis Date and Time	Analyst	Dilution Factor
07199	11 Volatiles in air by TO-14	EPA TO14A	1	02/07/2006 21:47	Douglas Graham	10
07199	11 Volatiles in air by TO-14	EPA TO14A	1	02/08/2006 09:46	Douglas Graham	1000

0027

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VOC ANALYSIS RESULTS FOR LOW EXPOSURE WITH CURRENT M18 SMOKE (10 MINUTE EXPOSURE)

Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4697884

19620001 TOX M18 Rat St. #30817-0497 [redacted] Air
0497-026-HV #02-D-0037
Pick-Up Order #047 Delivery Order # 04 Air
Collected:01/26/2006

Account Number: 04694

Submitted: 01/27/2006 15:00
Reported: 02/10/2006 at 18:01
Discard: 04/22/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

20001 SDG#: TXM03-01*

CAT No.	Analysis Name	CAS Number	As Received Result	As Received Limit of Quantitation	Units	Dilution Factor
07199	11 Volatiles in air by TO-14					
02076	tert-Butyl Alcohol	75-65-0	N.D.	10.	ppb(v)	10
07201	Propene	115-07-1	140.	10.	ppb(v)	10
07202	Dichlorodifluoromethane	75-71-8	N.D.	10.	ppb(v)	10
07203	Chlorodifluoromethane	75-45-6	N.D.	10.	ppb(v)	10
07204	Freon 114	76-14-2	N.D.	10.	ppb(v)	10
07205	Chloromethane	74-87-3	23.	10.	ppb(v)	10
07206	Vinyl Chloride	75-01-4	10.	10.	ppb(v)	10
07207	1,3-Butadiene	106-99-0	25.	10.	ppb(v)	10
07208	Bromomethane	74-83-9	N.D.	10.	ppb(v)	10
07209	Chloroethane	75-00-3	N.D.	10.	ppb(v)	10
07210	Dichlorofluoromethane	75-43-4	N.D.	10.	ppb(v)	10
07212	Trichlorofluoromethane	75-69-4	N.D.	10.	ppb(v)	10
07213	Pentane	109-66-0	N.D.	10.	ppb(v)	10
07214	Acrolein	107-02-8	N.D.	10.	ppb(v)	10
07215	1,1-Dichloroethene	75-35-4	N.D.	10.	ppb(v)	10
07216	Freon 113	76-13-1	N.D.	10.	ppb(v)	10
07217	Acetone	67-64-1	270.	20.	ppb(v)	10
07218	Methyl Iodide	74-88-4	N.D.	10.	ppb(v)	10
07219	Carbon Disulfide	75-15-0	13,000.	1,000.	ppb(v)	1000
07220	Acetonitrile	75-05-8	50.	10.	ppb(v)	10
07221	3-Chloropropene	107-05-1	N.D.	10.	ppb(v)	10
07222	Methylene Chloride	75-09-2	N.D.	10.	ppb(v)	10
07223	Acrylonitrile	107-13-1	81.	10.	ppb(v)	10
07224	trans-1,2-Dichloroethene	156-60-5	N.D.	10.	ppb(v)	10
07225	Methyl t-Butyl Ether	1634-04-4	N.D.	10.	ppb(v)	10
07226	Hexane	110-54-3	N.D.	10.	ppb(v)	10
07227	1,1-Dichloroethane	75-34-3	N.D.	10.	ppb(v)	10
07228	Vinyl Acetate	108-05-4	N.D.	10.	ppb(v)	10
07230	cis-1,2-Dichloroethene	156-59-2	N.D.	10.	ppb(v)	10
07231	2-Butanone	78-93-3	N.D.	10.	ppb(v)	10
07232	Ethyl Acetate	141-78-6	N.D.	10.	ppb(v)	10
07233	Methyl Acrylate	96-33-3	N.D.	10.	ppb(v)	10
07234	Chloroform	67-66-3	2.0 J	10.	ppb(v)	10
07235	1,1,1-Trichloroethane	71-55-6	N.D.	10.	ppb(v)	10
07236	Carbon Tetrachloride	56-23-5	N.D.	10.	ppb(v)	10

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Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4697884

19620001 TOX M18 Rat St. #30817-0497 [redacted] Air
0497-026-HV #02-D-0037
Pick-Up Order #047 Delivery Order # 04 Air
Collected:01/26/2006

Account Number: 04694

Submitted: 01/27/2006 15:00
Reported: 02/10/2006 at 18:01
Discard: 04/22/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

20001 SDG#: TXM03-01*

CAT No.	Analysis Name	CAS Number	As Received Result		As Received Limit of Quantitation	Units	Dilution Factor
07237	1,2-Dichloroethane	107-06-2	N.D.		10.	ppb(v)	10
07238	Benzene	71-43-2	230.		10.	ppb(v)	10
07239	Isooctane	540-84-1	N.D.		10.	ppb(v)	10
07240	Heptane	142-82-5	N.D.		10.	ppb(v)	10
07241	Trichloroethene	79-01-6	N.D.		10.	ppb(v)	10
07242	Ethyl Acrylate	140-88-5	N.D.		10.	ppb(v)	10
07243	1,2-Dichloropropane	78-87-5	N.D.		10.	ppb(v)	10
07244	Methyl Methacrylate	80-62-6	N.D.		10.	ppb(v)	10
07245	Dibromomethane	74-95-3	N.D.		10.	ppb(v)	10
07246	1,4-Dioxane	123-91-1	N.D.		10.	ppb(v)	10
07247	Bromodichloromethane	75-27-4	N.D.		10.	ppb(v)	10
07248	cis-1,3-Dichloropropene	10061-01-5	N.D.		10.	ppb(v)	10
07249	4-Methyl-2-Pentanone	108-10-1	N.D.		10.	ppb(v)	10
07250	Toluene	108-88-3	22.		10.	ppb(v)	10
07251	Octane	111-65-9	N.D.		10.	ppb(v)	10
07252	trans-1,3-Dichloropropene	10061-02-6	N.D.		10.	ppb(v)	10
07253	Ethyl Methacrylate	97-63-2	N.D.		10.	ppb(v)	10
07254	1,1,2-Trichloroethane	79-00-5	N.D.		10.	ppb(v)	10
07255	Tetrachloroethene	127-18-4	5.0	J	10.	ppb(v)	10
07256	2-Hexanone	591-78-6	N.D.		10.	ppb(v)	10
07257	Dibromochloromethane	124-48-1	N.D.		10.	ppb(v)	10
07258	1,2-Dibromoethane	106-93-4	N.D.		10.	ppb(v)	10
07259	Chlorobenzene	108-90-7	6.0	J	10.	ppb(v)	10
07260	1,1,1,2-Tetrachloroethane	630-20-6	N.D.		10.	ppb(v)	10
07261	Ethylbenzene	100-41-4	N.D.		10.	ppb(v)	10
07262	m/p-Xylene	1330-20-7	3.0	J	10.	ppb(v)	10
07263	o-Xylene	95-47-6	N.D.		10.	ppb(v)	10
07264	Styrene	100-42-5	N.D.		10.	ppb(v)	10
07265	Bromoform	75-25-2	N.D.		10.	ppb(v)	10
07266	Cumene	98-82-8	N.D.		10.	ppb(v)	10
07267	1,1,2,2-Tetrachloroethane	79-34-5	N.D.		10.	ppb(v)	10
07268	1,2,3-Trichloropropane	96-18-4	N.D.		10.	ppb(v)	10
07269	Bromobenzene	108-86-1	N.D.		10.	ppb(v)	10
07270	4-Ethyltoluene	622-96-8	N.D.		10.	ppb(v)	10
07271	1,3,5-Trimethylbenzene	108-67-8	N.D.		10.	ppb(v)	10
07272	Alpha Methyl Styrene	98-83-9	N.D.		10.	ppb(v)	10
07273	1,2,4-Trimethylbenzene	95-63-6	N.D.		10.	ppb(v)	10
07274	1,3-Dichlorobenzene	541-73-1	N.D.		10.	ppb(v)	10
07275	1,4-Dichlorobenzene	106-46-7	N.D.		10.	ppb(v)	10

0020

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Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4697884

19620001 TOX M18 Rat St. #30817-0497 [redacted] Air
0497-026-HV #02-D-0037
Pick-Up Order #047 Delivery Order # 04 Air
Collected:01/26/2006

Account Number: 04694

Submitted: 01/27/2006 15:00
Reported: 02/10/2006 at 18:01
Discard: 04/22/2006

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

20001 SDG#: TXM03-01*

CAT No.	Analysis Name	CAS Number	As Received Result	As Received Limit of Quantitation	Units	Dilution Factor
07277	1,2-Dichlorobenzene	95-50-1	N.D.	10.	ppb(v)	10
07278	Hexachloroethane	67-72-1	N.D.	10.	ppb(v)	10
07279	1,2,4-Trichlorobenzene	120-82-1	N.D.	10.	ppb(v)	10
07280	Hexachlorobutadiene	87-68-3	N.D.	10.	ppb(v)	10

The initial calibration did not meet the Method TO-14 percent RSD criteria for 1,4-dioxane. The value reported for 1,4-dioxane should be considered estimated.

All QC is compliant unless otherwise noted. Please refer to the Quality Control Summary for overall QC performance data and associated samples.

Laboratory Chronicle

CAT No.	Analysis Name	Method	Trial#	Analysis Date and Time	Analyst	Dilution Factor
07199	11 Volatiles in air by TO-14	EPA TO14A	1	02/07/2006 23:26	Douglas Graham	10
07199	11 Volatiles in air by TO-14	EPA TO14A	1	02/08/2006 10:28	Douglas Graham	1000

0021

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VOC ANALYSIS RESULTS FOR HIGH EXPOSURE WITH PROTOTYPE M18 SMOKE (10 MINUTE EXPOSURE)

Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4924781

23200002 APG #32240-063B[redacted]Air
0497-325 #02-D-0037
Pick-Up Order #046 Delivery Order # 05 Air

Collected:11/21/2006 09:20

Submitted: 11/28/2006 17:30
Reported: 12/12/2006 at 17:07
Discard: 02/21/2007

Account Number: 04694

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

00002 SDG#: TXM07-01*

CAT No.	Analysis Name	CAS Number	As Received Result		As Received Limit of Quantitation*	As Received Method Detection Limit	Units	Dilution Factor
07199	11 Volatiles in air by TO-14							
02076	tert-Butyl Alcohol	75-65-0	N.D.		10.	4.0	ppb(v)	10
07201	Propene	115-07-1	N.D.		10.	2.0	ppb(v)	10
07202	Dichlorodifluoromethane	75-71-8	N.D.		10.	2.0	ppb(v)	10
07203	Chlorodifluoromethane	75-45-6	N.D.		10.	2.0	ppb(v)	10
07204	Freon 114	76-14-2	N.D.		10.	2.0	ppb(v)	10
07205	Chloromethane	74-87-3	47,000.		1,000.	200.	ppb(v)	1000
07206	Vinyl Chloride	75-01-4	18.		10.	2.0	ppb(v)	10
07207	1,3-Butadiene	106-99-0	38.		10.	2.0	ppb(v)	10
07208	Bromomethane	74-83-9	110.		10.	2.0	ppb(v)	10
07209	Chloroethane	75-00-3	11.		10.	2.0	ppb(v)	10
07210	Dichlorofluoromethane	75-43-4	N.D.		10.	2.0	ppb(v)	10
07212	Trichlorofluoromethane	75-69-4	N.D.		10.	2.0	ppb(v)	10
07213	Pentane	109-66-0	11.		10.	2.0	ppb(v)	10
07214	Acrolein	107-02-8	1,300.		100.	50.	ppb(v)	100
07215	1,1-Dichloroethene	75-35-4	N.D.		10.	2.0	ppb(v)	10
07216	Freon 113	76-13-1	N.D.		10.	5.0	ppb(v)	10
07217	Acetone	67-64-1	3,700.		200.	50.	ppb(v)	100
07218	Methyl Iodide	74-88-4	N.D.		10.	2.0	ppb(v)	10
07219	Carbon Disulfide	75-15-0	5.4	J	10.	5.0	ppb(v)	10
07220	Acetonitrile	75-05-8	1,900.		100.	50.	ppb(v)	100
07221	3-Chloropropene	107-05-1	40.		10.	5.0	ppb(v)	10
07222	Methylene Chloride	75-09-2	35.		10.	5.0	ppb(v)	10
07223	Acrylonitrile	107-13-1	33.		10.	5.0	ppb(v)	10
07224	trans-1,2-Dichloroethene	156-60-5	N.D.		10.	2.0	ppb(v)	10
07225	Methyl t-Butyl Ether	1634-04-4	N.D.		10.	2.0	ppb(v)	10
07226	Hexane	110-54-3	5.0	J	10.	2.0	ppb(v)	10
07227	1,1-Dichloroethane	75-34-3	N.D.		10.	2.0	ppb(v)	10
07228	Vinyl Acetate	108-05-4	N.D.		10.	2.0	ppb(v)	10
07230	cis-1,2-Dichloroethene	156-59-2	2.6	J	10.	2.0	ppb(v)	10
07231	2-Butanone	78-93-3	41.		10.	5.0	ppb(v)	10
07232	Ethyl Acetate	141-78-6	140.		10.	5.0	ppb(v)	10
07233	Methyl Acrylate	96-33-3	18.		10.	2.0	ppb(v)	10
07234	Chloroform	67-66-3	51.		10.	2.0	ppb(v)	10
07235	1,1,1-Trichloroethane	71-55-6	N.D.		10.	2.0	ppb(v)	10
07236	Carbon Tetrachloride	56-23-5	N.D.		10.	2.0	ppb(v)	10
07237	1,2-Dichloroethane	107-06-2	N.D.		10.	2.0	ppb(v)	10

*=This limit was used in the evaluation of the final result

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Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4924781

23200002 APG #32240-063B [redacted] Air
0497-325 #02-D-0037
Pick-Up Order #046 Delivery Order # 05 Air

Collected:11/21/2006 09:20

Account Number: 04694

Submitted: 11/28/2006 17:30
Reported: 12/12/2006 at 17:07
Discard: 02/21/2007

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

00002 SDG#: TXM07-01*

CAT No.	Analysis Name	CAS Number	As Received Result		As Received Limit of Quantitation*	As Received Method Detection Limit	Units	Dilution Factor
07238	Benzene	71-43-2	1,400.		100.	20.	ppb(v)	100
07239	Isooctane	540-84-1	N.D.		10.	2.0	ppb(v)	10
07240	Heptane	142-82-5	N.D.		10.	2.0	ppb(v)	10
07241	Trichloroethene	79-01-6	N.D.		10.	2.0	ppb(v)	10
07242	Ethyl Acrylate	140-88-5	N.D.		10.	2.0	ppb(v)	10
07243	1,2-Dichloropropane	78-87-5	N.D.		10.	2.0	ppb(v)	10
07244	Methyl Methacrylate	80-62-6	N.D.		10.	2.0	ppb(v)	10
07245	Dibromomethane	74-95-3	N.D.		10.	2.0	ppb(v)	10
07246	1,4-Dioxane	123-91-1	N.D.		10.	10.	ppb(v)	10
07247	Bromodichloromethane	75-27-4	N.D.		10.	2.0	ppb(v)	10
07248	cis-1,3-Dichloropropene	10061-01-5	N.D.		10.	2.0	ppb(v)	10
07249	4-Methyl-2-Pentanone	108-10-1	26.		10.	5.0	ppb(v)	10
07250	Toluene	108-88-3	150.		10.	2.0	ppb(v)	10
07251	Octane	111-65-9	N.D.		10.	2.0	ppb(v)	10
07252	trans-1,3-Dichloropropene	10061-02-6	N.D.		10.	2.0	ppb(v)	10
07253	Ethyl Methacrylate	97-63-2	N.D.		10.	2.0	ppb(v)	10
07254	1,1,2-Trichloroethane	79-00-5	N.D.		10.	2.0	ppb(v)	10
07255	Tetrachloroethene	127-18-4	N.D.		10.	2.0	ppb(v)	10
07256	2-Hexanone	591-78-6	N.D.		10.	5.0	ppb(v)	10
07257	Dibromochloromethane	124-48-1	N.D.		10.	2.0	ppb(v)	10
07258	1,2-Dibromoethane	106-93-4	N.D.		10.	2.0	ppb(v)	10
07259	Chlorobenzene	108-90-7	12.		10.	2.0	ppb(v)	10
07260	1,1,1,2-Tetrachloroethane	630-20-6	N.D.		10.	2.0	ppb(v)	10
07261	Ethylbenzene	100-41-4	19.		10.	2.0	ppb(v)	10
07262	m/p-Xylene	1330-20-7	32.		10.	2.0	ppb(v)	10
07263	o-Xylene	95-47-6	15.		10.	2.0	ppb(v)	10
07264	Styrene	100-42-5	23.		10.	2.0	ppb(v)	10
07265	Bromoform	75-25-2	N.D.		10.	2.0	ppb(v)	10
07266	Cumene	98-82-8	N.D.		10.	3.0	ppb(v)	10
07267	1,1,2,2-Tetrachloroethane	79-34-5	N.D.		10.	2.0	ppb(v)	10
07268	1,2,3-Trichloropropane	96-18-4	N.D.		10.	2.0	ppb(v)	10
07269	Bromobenzene	108-86-1	N.D.		10.	2.0	ppb(v)	10
07270	4-Ethyltoluene	622-96-8	N.D.		10.	2.0	ppb(v)	10
07271	1,3,5-Trimethylbenzene	108-67-8	N.D.		10.	2.0	ppb(v)	10
07272	Alpha Methyl Styrene	98-83-9	N.D.		10.	2.0	ppb(v)	10
07273	1,2,4-Trimethylbenzene	95-63-6	9.9	J	10.	2.0	ppb(v)	10
07274	1,3-Dichlorobenzene	541-73-1	N.D.		10.	2.0	ppb(v)	10
07275	1,4-Dichlorobenzene	106-46-7	N.D.		10.	2.0	ppb(v)	10
07277	1,2-Dichlorobenzene	95-50-1	N.D.		10.	2.0	ppb(v)	10
07278	Hexachloroethane	67-72-1	N.D.		10.	3.0	ppb(v)	10

*=This limit was used in the evaluation of the final result

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Lancaster Laboratories

Lancaster Laboratories Sample No. AQ 4924781

23200002 APG #32240-063B [redacted] Air
0497-325 #02-D-0037
Pick-Up Order #046 Delivery Order # 05 Air

Collected:11/21/2006 09:20

Account Number: 04694

Submitted: 11/28/2006 17:30
Reported: 12/12/2006 at 17:07
Discard: 02/21/2007

U.S. Army CHPPM
ATTN: DFAS-RI-FPV BLDG. 68
Rock Island Operating Location
Rock Island IL 61299-8401

00002 SDG#: TXM07-01*

CAT No.	Analysis Name	CAS Number	As Received Result	As Received Limit of Quantitation*	As Received Method Detection Limit	Units	Dilution Factor
07279	1,2,4-Trichlorobenzene	120-82-1	N.D.	10.	7.0	ppb(v)	10
07280	Hexachlorobutadiene	87-68-3	N.D.	10.	7.0	ppb(v)	10

The initial calibration for acetonitrile did not meet the percent RSD criteria as listed in Method TO-14. The result reported for acetonitrile should be considered estimated.

All QC is compliant unless otherwise noted. Please refer to the Quality Control Summary for overall QC performance data and associated samples.

Laboratory Chronicle

CAT No.	Analysis Name	Method	Trial#	Analysis Date and Time	Analyst	Dilution Factor
07199	11 Volatiles in air by TO-14	EPA TO14A	1	12/07/2006 03:05	Gregory K Fisher	10
07199	11 Volatiles in air by TO-14	EPA TO14A	1	12/07/2006 19:07	Gregory K Fisher	1000
07199	11 Volatiles in air by TO-14	EPA TO14A	1	12/07/2006 19:48	Gregory K Fisher	100

0021

*=This limit was used in the evaluation of the final result

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APPENDIX G

SUMMARY OF BODY AND ORGAN WEIGHTS AND INDIVIDUAL DATA

Table G-1
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of Body Weights
10 Minute Exposure

		1 Day Hold			7 Day Hold			90 Day Hold		
Period		**Control**	**High**	**Low**	**Control**	**High**	**Low**	**Control**	**High**	**Low**
Exposure	Mean	209.7	212.0	213.9	213.2	209.9	220.1	205.7	215.0	217.3
	S.D.	6.13	11.38	7.3	5.34	5.67	9.51	6.31	8.51	8.33
	N	6	8	8	6	8	8	6	8	8
Day 1	Mean	214.0	206.0	215.8						
	S.D.	6.58	13.76	7.44						
	N	6	4	8						
Day 7	Mean				237.8	230.8	233.3	225.5	229.0	227.8
	S.D.				8.16	14.75	8.89	10.60	9.97	9.60
	N				6	4	8	6	4	8
Day 14	Mean							243.0	252.3	246.6
	S.D.							9.36	8.42	9.80
	N							6	4	8
Day 21	Mean							252.3	260.8	256.3
	S.D.							11.41	11.87	13.68
	N							6	4	8
Day 28	Mean							259.8	272.5	262.4
	S.D.							10.50	11.96	12.48
	N							6	4	8
Day 35	Mean							268.7	278.5	268.5
	S.D.							11.34	13.70	12.74
	N							6	4	8
Day 42	Mean							277.0	294.3	276.9
	S.D.							13.62	13.60	12.14
	N							6	4	8
Day 49	Mean							280.7	294.3	283.3
	S.D.							12.04	13.60	13.31
	N							6	4	8
Day 56	Mean							290.7	308.0	288.5
	S.D.							12.26	16.43	16.98
	N							6	4	8
Day 63	Mean							296.3	310.8	299.9
	S.D.							11.50	16.50	18.51
	N							6	4	8
Day 70	Mean							301.5	322.3	302.6
	S.D.							11.06	20.92	18.11
	N							6	4	8
Day 77	Mean							319.0	317.3	307.6
	S.D.							40.41	24.17	18.95
	N							6	4	8
Day 84	Mean							306.3	324.0	307.4
	S.D.							14.02	22.76	23.85
	N							6	4	8
Day 90	Mean							315.2	334.0	313.9
	S.D.							14.30	27.95	17.25
	N							6	4	8

Table G-2
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of Body Weights
2 Minute Exposure

		1 Day Hold			7 Day Hold			90 Day Hold		
Period		**Control**	**High**	**Low**	**Control**	**High**	**Low**	**Control**	**High**	**Low**
Exposure	Mean	218.2	219.8	223.5	214.8	218.9	222.6	213.2	213.9	223.5
	S.D.	9.97	6.07	9.23	8.61	11.33	6.12	9.81	5.03	9.37
	N	6	8	8	6	8	8	6	8	8
Day 1	Mean	222.8	218.1	220.1						
	S.D.	10.96	8.39	8.29						
	N	6	8	8						
Day 7	Mean				237.5	239.9	238.5	226.7	228.1	237.4
	S.D.				10.46	17.49	10.03	13.37	9.78	9.94
	N				6	8	8	6	8	8
Day 14	Mean							243.2	245.6	252.8
	S.D.							15.72	12.89	10.87
	N							6	8	8
Day 21	Mean							250.2	257.6	259.3
	S.D.							17.85	13.82	13.00
	N							6	8	8
Day 28	Mean							262.8	270.0	269.6
	S.D.							16.81	16.84	13.70
	N							6	8	8
Day 35	Mean							273.0	277.1	285.1
	S.D.							17.63	17.21	14.82
	N							6	8	8
Day 42	Mean							280.2	285.4	287.3
	S.D.							18.30	20.62	15.48
	N							6	8	8
Day 49	Mean							283.3	288.5	296.5
	S.D.							18.20	19.45	17.25
	N							6	8	8
Day 56	Mean							290.0	300.3	303.5
	S.D.							20.42	23.58	16.68
	N							6	8	8
Day 63	Mean							295.2	306.1	308.8
	S.D.							20.82	26.90	16.07
	N							6	8	8
Day 70	Mean							300.2	309.1	308.3
	S.D.							20.72	26.34	16.28
	N							6	8	8
Day 77	Mean							302.0	312.6	310.4
	S.D.							21.10	27.03	16.84
	N							6	8	8
Day 84	Mean							306.0	321.6	319.1
	S.D.							20.36	27.58	18.57
	N							6	8	8
Day 90	Mean							312.7	331.1	327.0
	S.D.							20.83	30.76	17.82
	N							6	8	8

Table G-3
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions
from the Violet Colored M18 Smoke Grenade in Rats

1-Day Hold Individual Body Weights (grams)

	Animal ID	Exposure	Terminal
10 min Exposure			
Control	52	219	216
	55	211	211
	56	198	201
	57	210	219
	59	210	221
	62	210	216
	Mean	**209.7**	**214.0**
	SD	**6.13**	**6.58**
High	50	203	dead
Concentration	54	204	198
	60	234	dead
	61	222	226
	63	215	dead
	70	201	dead
	77	220	dead
	79	205	204
	80	204	196
	Mean	**212.0**	**206.0**
	SD	**11.38**	**13.76**
Low	51	210	211
Concentration	53	216	223
	58	219	225
	64	222	218
	66	218	218
	67	200	202
	68	218	218
	72	208	211
	Mean	**213.9**	**215.8**
	SD	**7.30**	**7.44**
2 min Exposure			
Control	123	209	205
	125	229	232
	134	213	216
	136	208	222
	137	219	228
	138	231	234
	Mean	**218.2**	**222.8**
	SD	**9.97**	**10.96**
High	120	218	223
Concentration	121	212	205
	124	215	219
	128	230	228
	131	224	225
	133	223	219
	135	222	220
	146	214	206
	Mean	**219.8**	**218.1**
	SD	**6.07**	**8.39**
Low	122	220	218
Concentration	126	216	211
	127	227	224
	129	240	235
	130	222	217
	140	210	209
	141	231	223
	142	222	224
	Mean	**223.5**	**220.1**
	SD	**9.23**	**8.29**

7-Day Hold Individual Body Weights (grams)

	Animal ID	Exposure	Terminal
10 min Exposure			
Control	65	218	235
	69	207	226
	71	211	235
	76	220	245
	93	215	237
	98	208	249
	Mean	**213.2**	**237.8**
	SD	**5.34**	**8.16**
High	85	205	dead
Concentration	86	217	dead
	88	203	dead
	89	207	dead
	90	210	236
	91	219	252
	92	212	222
	95	204	213
	101	212	231
	Mean	**209.9**	**230.8**
	SD	**5.67**	**14.75**
Low	73	233	246
Concentration	74	219	236
	75	210	232
	78	208	223
	81	225	234
	82	213	224
	83	221	226
	84	232	245
	Mean	**220.1**	**233.3**
	SD	**9.51**	**8.89**
2 min Exposure			
Control	139	219	244
	144	224	234
	145	222	253
	151	210	222
	152	213	234
	166	201	238
	Mean	**214.8**	**237.5**
	SD	**8.61**	**10.46**
High	150	229	250
Concentration	153	232	269
	154	226	250
	155	204	212
	158	210	230
	163	226	246
	169	204	228
	172	220	234
	Mean	**218.9**	**239.9**
	SD	**11.33**	**17.49**
Low	147	221	241
Concentration	148	237	257
	149	221	233
	156	219	237
	160	219	233
	161	224	249
	162	222	228
	164	218	230
	Mean	**222.6**	**238.5**
	SD	**6.12**	**10.03**

Table G-4
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

90-Day Hold Individual Body Weights (grams)

	Animal ID	Exposure	1 week	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks	9 weeks	10 weeks	11 weeks	12 weeks	Terminal
10 min Exposure															
Control	99	205	230	244	253	259	270	274	278	284	290	290	290	294	298
	102	201	227	245	249	258	270	283	287	299	305	307	311	305	324
	104	205	212	235	241	251	256	260	267	277	282	291	287	297	309
	117	204	221	239	251	259	266	276	279	292	296	305	307	308	311
	118	201	220	235	246	252	261	269	272	282	291	297	397	301	310
	119	218	243	260	274	280	289	300	301	310	314	319	322	333	339
	Mean	**205.7**	**225.5**	**243.0**	**252.3**	**259.8**	**268.7**	**277.0**	**280.7**	**290.7**	**296.3**	**301.5**	**319.0**	**306.3**	**315.2**
	SD	**6.31**	**10.60**	**9.36**	**11.41**	**10.50**	**11.34**	**13.62**	**12.04**	**12.26**	**11.50**	**11.06**	**40.41**	**14.02**	**14.30**
High	105	219	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
Concentration	107	216	234	259	272	277	284	301	301	317	314	327	325	324	330
	109	206	216	240	244	255	258	275	275	284	287	292	282	293	300
	111	207	227	254	263	282	286	306	306	320	325	340	337	347	368
	114	213	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	115	229	239	256	264	276	286	295	295	311	317	330	325	332	338
	Mean	**215.0**	**229.0**	**252.3**	**260.8**	**272.5**	**278.5**	**294.3**	**294.3**	**308.0**	**310.8**	**322.3**	**317.3**	**324.0**	**334.0**
	SD	**8.51**	**9.97**	**8.42**	**11.87**	**11.96**	**13.70**	**13.60**	**13.60**	**16.43**	**16.50**	**20.92**	**24.17**	**22.76**	**27.95**
	87	209	218	244	254	260	276	285	293	295	307	310	318	315	317
	94	217	222	243	246	260	264	273	277	281	295	291	298	307	300
Low	96	210	219	230	233	236	268	251	256	255	263	266	268	273	282
Concentration	97	211	225	247	264	266	242	279	284	290	296	304	314	273	318
	100	229	240	252	262	273	279	291	297	306	316	315	326	334	325
	103	223	230	248	256	268	280	282	286	297	310	312	315	325	327
	106	228	244	265	280	277	277	282	295	306	322	325	323	330	336
	108	211	224	244	255	259	262	272	278	278	290	298	299	302	306
	Mean	**217.3**	**227.8**	**246.6**	**256.3**	**262.4**	**268.5**	**276.9**	**283.3**	**288.5**	**299.9**	**302.6**	**307.6**	**307.4**	**313.9**
	SD	**8.33**	**9.60**	**9.80**	**13.68**	**12.48**	**12.74**	**12.14**	**13.31**	**16.98**	**18.51**	**18.11**	**18.95**	**23.85**	**17.25**
	174	203	222	239	251	268	278	279	281	289	296	301	299	306	314
2 min Exposure	175	226	249	268	280	290	301	312	316	325	331	338	340	342	350
Control	177	216	227	241	250	260	269	278	270	283	287	291	290	292	301
	178	200	209	222	226	243	251	259	270	268	272	278	277	282	289
	179	218	232	253	254	268	280	286	292	300	304	304	304	308	317
	181	216	221	236	240	248	259	267	271	275	281	289	302	306	305
	Mean	**213.2**	**226.7**	**243.2**	**250.2**	**262.8**	**273.0**	**280.2**	**283.3**	**290.0**	**295.2**	**300.2**	**302.0**	**306.0**	**312.7**
	SD	**9.81**	**13.37**	**15.72**	**17.85**	**16.81**	**17.63**	**18.30**	**18.20**	**20.42**	**20.82**	**20.72**	**21.10**	**20.36**	**20.83**
	173	207	227	257	256	262	275	279	283	297	290	300	306	320	336
	182	217	238	243	270	270	283	289	290	297	299	312	308	317	336
High	183	218	239	256	265	281	292	310	302	334	335	343	350	365	376
Concentration	184	212	221	231	250	263	266	264	274	287	293	292	300	309	310
	185	215	228	248	259	278	280	300	306	310	325	325	328	337	342
	186	206	219	243	256	268	270	281	286	288	290	296	300	303	310
	187	217	214	225	230	240	247	252	253	261	269	265	266	276	279
	188	219	239	262	275	298	304	308	314	328	348	340	343	346	360
	Mean	**213.9**	**228.1**	**245.6**	**257.6**	**270.0**	**277.1**	**285.4**	**288.5**	**300.3**	**306.1**	**309.1**	**312.6**	**321.6**	**331.1**
	SD	**5.03**	**9.78**	**12.89**	**13.82**	**16.84**	**17.21**	**20.62**	**19.45**	**23.58**	**26.90**	**26.34**	**27.03**	**27.58**	**30.76**
	165	226	237	250	245	255	269	275	284	286	294	294	292	299	316
	167	234	250	268	270	283	300	309	308	314	320	318	319	325	340
Low	168	225	233	245	253	271	287	286	296	307	316	318	316	330	330
Concentration	170	221	234	257	261	265	282	283	289	292	297	295	293	303	312
	171	233	244	261	275	289	306	304	320	330	334	333	337	348	300
	176	206	217	232	238	248	261	261	265	280	285	283	290	294	356
	180	215	242	256	262	269	286	285	300	304	307	312	318	329	338
	189	228	242	253	270	277	290	295	310	315	317	313	318	325	324
	Mean	**223.5**	**237.4**	**252.8**	**259.3**	**269.6**	**285.1**	**287.3**	**296.5**	**303.5**	**308.8**	**308.3**	**310.4**	**319.1**	**327.0**
	SD	**9.37**	**9.94**	**10.87**	**13.00**	**13.70**	**14.82**	**15.48**	**17.25**	**16.68**	**16.07**	**16.28**	**16.84**	**18.57**	**17.82**

Table G-5
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Prototype Grenade 7-Day Hold Individual Body Weights (grams)

	Animal ID	Exposure	Terminal
10 min Exposure			
High	109	220	234
Concentration	110	226	236
	111	235	252
	112	230	240
	113	225	230
	114	222	231
	115	210	225
	116	225	226
	117	222	219
	118	255	266
	119	220	222
	120	242	250
	Mean	**227.7**	**235.9**
	SD	**11.77**	**13.94**

Table G-6
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of Organ Weights
10 Minute Exposure

Absolute Organ Weight (grams)

Period		1 Day Hold			7 Day Hold			90 Day Hold		
		Control	High	Low	Control	High	Low	Control	High	Low
Body Weight	Mean	214.0	209.3	215.8	237.8	230.8	233.3	315.2	334.0	313.9
	S.D.	7.21	14.74	7.44	8.16	17.04	8.89	14.3	27.95	17.25
	N	6	4	8	6	5	8	6	4	8
Adrenals	Mean	0.070	0.072	0.086	0.087	0.086	0.092	0.091	0.105	0.095
	S.D.	0.0096	0.0117	0.0201	0.0050	0.0183	0.0123	0.0246	0.0282	0.0163
	N	6	4	7	6	5	8	6	4	8
Brain	Mean	1.806	1.873	1.859	1.840	1.814	1.872	2.044	2.104	2.024
	S.D.	0.0867	0.1327	0.1073	0.1328	0.0739	0.0533	0.0981	0.0797	0.0984
	N	6	4	8	6	5	8	6	4	8
Heart	Mean	0.776	0.628	0.871	0.975	0.937	0.965	1.100	1.126	1.528
	S.D.	0.0826	0.3689	0.1107	0.0789	0.1399	0.0706	0.0658	0.0659	1.0706
	N	6	4	8	6	5	8	6	4	8
Kidneys	Mean	1.750	1.718	1.731	2.015	1.865	1.899	2.282	2.277	2.229
	S.D.	0.1484	0.2083	0.1061	0.1711	0.1823	0.1354	0.2979	0.1898	0.3495
	N	6	4	8	6	5	8	6	4	8
Liver	Mean	10.137	9.360	10.472	11.085	10.447	10.409	11.827	13.034	12.159
	S.D.	0.6333	1.6667	0.7767	0.9963	0.9489	0.6639	1.3336	1.2466	0.8997
	N	6	4	8	6	5	8	6	4	8
Lungs	Mean	1.311	1.350	1.378	1.487	1.346	1.422	1.668	1.749	1.596
	S.D.	0.0970	0.1271	0.1367	0.1482	0.1681	0.0406	0.1542	0.3306	0.1108
	N	5	4	8	6	5	8	6	4	8
Ovaries	Mean	0.147	0.146	0.172	0.257	0.182	0.179	0.211	0.189	0.188
	S.D.	0.0118	0.0209	0.0217	0.1621	0.0290	0.0121	0.0416	0.0150	0.0397
	N	6	4	8	6	5	8	6	4	8
Spleen	Mean	0.559	0.540	0.539	0.548	0.645	0.594	0.586	0.664	0.698
	S.D.	0.0657	0.0778	0.0440	0.0691	0.0879	0.0832	0.0304	0.0238	0.0510
	N	6	4	8	6	5	8	6	4	8
Thymus	Mean	0.569	0.619	0.566	0.605	0.612	0.551	0.378	0.333	0.381
	S.D.	0.1181	0.1392	0.0550	0.1075	0.0751	0.0650	0.0481	0.0694	0.0628
	N	6	4	8	6	5	8	6	4	8
Uterus	Mean	0.451	0.514	0.420	0.493	0.413	0.657	0.683	0.784	0.749
	S.D.	0.0706	0.1166	0.0662	0.0929	0.0493	0.1963	0.2424	0.3405	0.2595
	N	6	4	8	6	5	8	6	4	8

Table G-7
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of Organ Weights
2 Minute Exposure

Absolute Organ Weight (grams)

Period		1 Day Hold			7 Day Hold			90 Day Hold		
		Control	High	Low	Control	High	Low	Control	High	Low
Body Weight	Mean	222.8	218.1	220.1	234.2	239.9	238.5	312.7	331.1	327.0
	S.D.	10.96	8.39	8.29	11.14	17.49	10.03	20.83	30.76	17.82
	N	6	8	8	6	8	8	6	8	8
Adrenals	Mean	0.085	0.078	0.081	0.085	0.093	0.086	0.087	0.086	0.088
	S.D.	0.0185	0.0082	0.0076	0.0145	0.0177	0.0087	0.0139	0.0111	0.0143
	N	6	8	8	6	8	8	6	8	8
Brain	Mean	1.851	1.806	1.893	1.838	1.837	1.876	2.036	1.803	1.996
	S.D.	0.0441	0.0665	0.0761	0.1193	0.0924	0.0616	0.0914	0.3933	0.1256
	N	6	8	8	6	8	8	6	8	8
Heart	Mean	0.946	0.945	0.931	0.927	0.975	0.956	1.148	1.206	1.195
	S.D.	0.1238	0.0918	0.0440	0.1287	0.1306	0.1136	0.1690	0.0775	0.1344
	N	6	8	8	6	8	8	6	8	8
Kidneys	Mean	1.745	1.787	1.849	1.853	1.993	1.907	2.132	2.173	2.165
	S.D.	0.0872	0.0989	0.1457	0.1595	0.1808	0.1479	0.3141	0.1376	0.2253
	N	6	8	8	6	8	8	6	8	8
Liver	Mean	11.049	10.566	10.503	10.961	11.665	11.154	12.024	13.079	13.476
	S.D.	0.7847	0.9939	1.1575	1.2676	0.9801	0.7705	1.3523	1.4627	1.4374
	N	6	8	8	6	8	8	6	8	8
Lungs	Mean	1.294	1.416	1.427	1.382	1.411	1.549	1.717	1.674	1.661
	S.D.	0.0987	0.1165	0.1336	0.1655	0.0644	0.1610	0.2315	0.2139	0.2794
	N	6	8	8	6	8	8	6	8	8
Ovaries	Mean	0.167	0.162	0.173	0.157	0.190	0.176	0.210	0.200	0.159
	S.D.	0.0218	0.0291	0.0285	0.0296	0.0279	0.0245	0.0326	0.0363	0.0411
	N	6	8	8	6	8	8	6	8	8
Spleen	Mean	0.575	0.597	0.600	0.661	0.620	0.570	0.702	0.732	0.614
	S.D.	0.0808	0.0774	0.0662	0.0927	0.1015	0.0455	0.1360	0.1795	0.0820
	N	6	8	8	6	8	8	6	8	8
Thymus	Mean	0.596	0.610	0.621	0.584	0.622	0.616	0.464	0.509	0.362
	S.D.	0.0816	0.1148	0.1270	0.0890	0.1192	0.0723	0.1304	0.3414	0.0890
	N	6	8	8	6	8	8	6	8	8
Uterus	Mean	0.453	0.449	0.492	0.629	0.425	0.523	0.818	0.810	0.858
	S.D.	0.0463	0.1134	0.1133	0.1244	0.0423	0.2252	0.2479	0.1868	0.5099
	N	6	8	8	6	8	8	6	8	8

Table G-8
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

1, 7, and 90-Day Hold Individual Absolute Organ Weights (grams)
10 Minute Exposure

	Animal ID	Body Weight	Adrenals	Brain	Heart	Kidneys	Liver	Lungs	Ovaries	Spleen	Thymus	Uterus
1 Day Hold												
Control	52	216	0.07	1.72	0.76	1.58	9.76	1.26	0.14	0.56	0.55	0.38
	55	211	0.09	1.94	0.74	1.74	10.14		0.14	0.47	0.44	0.49
	56	201	0.07	1.87	0.70	1.61	9.49	1.21	0.15	0.51	0.47	0.35
	57	219	0.07	1.83	0.74	1.89	10.71	1.33	0.15	0.64	0.77	0.48
	59	221	0.06	1.72	0.93	1.95	11.08	1.47	0.17	0.61	0.55	0.53
	62	216	0.07	1.76	0.79	1.73	9.66	1.29	0.14	0.56	0.62	0.47
	Mean	**214.0**	**0.070**	**1.806**	**0.776**	**1.750**	**10.137**	**1.311**	**0.147**	**0.559**	**0.569**	**0.451**
	SD	**7.21**	**0.0096**	**0.0867**	**0.0826**	**0.1484**	**0.6333**	**0.0970**	**0.0118**	**0.0657**	**0.1181**	**0.0706**
High	50	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
Concentration	54	198	0.06	1.75	0.78	1.48	7.61	1.26	0.13	0.54	0.69	0.57
	60	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	61	226	0.09	1.98	0.92	1.88	11.18	1.44	0.15	0.65	0.65	0.52
	63	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	70	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	77	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	79	204	0.08	1.77	0.72	1.91	10.31	1.48	0.18	0.48	0.73	0.62
	80	196	0.06	1.99	0.09	1.62	8.34	1.22	0.13	0.48	0.42	0.35
	Mean	**209.3**	**0.072**	**1.873**	**0.628**	**1.718**	**9.360**	**1.350**	**0.146**	**0.540**	**0.619**	**0.514**
	SD	**14.74**	**0.0117**	**0.1327**	**0.3689**	**0.2083**	**1.6667**	**0.1271**	**0.0209**	**0.0778**	**0.1392**	**0.1166**
Low	51	211	0.08	1.74	0.82	1.60	9.50	1.32	0.17	0.51	0.56	0.40
Concentration	53	223		1.90	0.82	1.66	10.62	1.23	0.20	0.61	0.58	0.38
	58	225	0.08	1.97	0.95	1.92	10.67	1.21	0.17	0.57	0.57	0.45
	64	218	0.09	1.75	1.10	1.72	10.63	1.47	0.20	0.54	0.61	0.52
	66	218	0.08	2.00	0.85	1.81	10.80	1.50	0.18	0.53	0.63	0.48
	67	202	0.13	1.73	0.73	1.66	9.28	1.52	0.14	0.50	0.46	0.43
	68	218	0.08	1.93	0.87	1.81	11.77	1.52	0.15	0.57	0.60	0.30
	72	211	0.07	1.85	0.84	1.68	10.50	1.26	0.19	0.48	0.52	0.40
	Mean	**215.8**	**0.086**	**1.859**	**0.871**	**1.731**	**10.472**	**1.378**	**0.172**	**0.539**	**0.566**	**0.420**
	SD	**7.44**	**0.0201**	**0.1073**	**0.1107**	**0.1061**	**0.7767**	**0.1367**	**0.0217**	**0.0440**	**0.0550**	**0.0662**
7-Day Hold												
Control	65	235	0.09	1.84	1.02	2.03	11.17	1.30	0.16	0.49	0.68	0.40
	69	226	0.08	1.87	0.88	1.82	10.31	1.36	0.17	0.57	0.50	0.42
	71	235	0.09	1.59	1.01	1.82	11.10	1.42	0.58	0.46	0.66	0.42
	76	245	0.09	1.85	0.88	2.10	11.43	1.58	0.18	0.58	0.56	0.53
	93	237	0.09	1.90	0.98	2.06	9.80	1.67	0.21	0.54	0.48	0.62
	98	249	0.09	1.98	1.08	2.27	12.69	1.59	0.24	0.65	0.75	0.57
	Mean	**237.8**	**0.087**	**1.840**	**0.975**	**2.015**	**11.085**	**1.487**	**0.257**	**0.548**	**0.605**	**0.493**
	SD	**8.16**	**0.0050**	**0.1328**	**0.0789**	**0.1711**	**0.9963**	**0.1482**	**0.1621**	**0.0691**	**0.1075**	**0.0929**
High	85	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
Concentration	86	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	88	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	89	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	90	236	0.07	1.73	0.95	1.87	10.87	1.26	0.21	0.72	0.65	0.47
	91	252	0.07	1.91	1.13	2.15	11.90	1.47	0.18	0.72	0.73	0.43
	92	222	0.08	1.80	0.75	1.75	9.86	1.21	0.18	0.53	0.56	0.43
	95	213	0.10	1.87	0.87	1.67	9.56	1.22	0.14	0.68	0.55	0.34
	101	231	0.11	1.77	0.98	1.88	10.04	1.58	0.20	0.58	0.57	0.40
	Mean	**230.8**	**0.086**	**1.814**	**0.937**	**1.865**	**10.447**	**1.346**	**0.182**	**0.645**	**0.612**	**0.413**
	SD	**17.04**	**0.0183**	**0.0739**	**0.1399**	**0.1823**	**0.9489**	**0.1681**	**0.0290**	**0.0879**	**0.0751**	**0.0493**
Low	73	246	0.12	1.82	1.05	2.01	10.31	1.48	0.18	0.45	0.52	0.53
Concentration	74	236	0.09	1.84	0.99	1.86	10.54	1.43	0.18	0.72	0.51	0.42
	75	232	0.09	1.82	1.00	2.03	11.23	1.44	0.18	0.65	0.55	0.70
	78	223	0.08	1.93	0.89	1.79	10.05	1.41	0.19	0.64	0.46	0.61
	81	234	0.08	1.96	0.94	1.93	10.49	1.43	0.17	0.59	0.53	1.07
	82	224	0.08	1.89	1.02	1.80	9.75	1.34	0.20	0.59	0.62	0.73
	83	226	0.09	1.84	0.84	1.69	9.50	1.41	0.16	0.51	0.56	0.68
	84	245	0.10	1.88	1.00	2.07	11.40	1.44	0.18	0.61	0.66	0.52
	Mean	**233.3**	**0.092**	**1.872**	**0.965**	**1.899**	**10.409**	**1.422**	**0.179**	**0.594**	**0.551**	**0.657**
	SD	**8.89**	**0.0123**	**0.0533**	**0.0706**	**0.1354**	**0.6639**	**0.0406**	**0.0121**	**0.0832**	**0.0650**	**0.1963**
90-Day Hold												
Control	99	298	0.08	2.04	1.08	2.43	10.81	1.49	0.18	0.55	0.41	0.62
	102	324	0.14	2.18	1.06	2.80	13.73	1.95	0.27	0.61	0.36	0.96
	104	309	0.10	2.06	1.05	2.06	12.06	1.68	0.18	0.60	0.39	0.49
	117	311	0.09	1.88	1.16	2.07	10.14	1.60	0.20	0.56	0.34	1.01
	118	310	0.06	2.07	1.21	2.04	11.35	1.62	0.26	0.57	0.32	0.43
	119	339	0.09	2.03	1.05	2.30	12.88	1.67	0.17	0.63	0.45	0.60
	Mean	**315.2**	**0.091**	**2.044**	**1.100**	**2.282**	**11.827**	**1.668**	**0.211**	**0.586**	**0.378**	**0.683**
	SD	**14.30**	**0.0246**	**0.0981**	**0.0658**	**0.2979**	**1.3336**	**0.1542**	**0.0416**	**0.0304**	**0.0481**	**0.2424**
High	105	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
Concentration	107	330	0.14	2.20	1.06	2.21	12.47	1.67	0.21	0.65	0.25	1.29
	109	300	0.10	2.00	1.09	2.28	11.94	1.51	0.18	0.70	0.36	0.67
	111	368	0.08	2.12	1.20	2.53	14.81	2.24	0.19	0.66	0.42	0.56
	114	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	115	338	0.10	2.10	1.17	2.08	12.92	1.59	0.17	0.65	0.31	0.61
	Mean	**334.0**	**0.105**	**2.104**	**1.126**	**2.277**	**13.034**	**1.749**	**0.189**	**0.664**	**0.333**	**0.784**
	SD	**27.95**	**0.0282**	**0.0797**	**0.0659**	**0.1898**	**1.2466**	**0.3306**	**0.0150**	**0.0238**	**0.0694**	**0.3405**
Low	87	317	0.08	1.80	4.17	1.61	10.95	1.47	0.15	0.63	0.30	0.92
Concentration	94	300	0.10	2.04	1.07	1.97	12.44	1.62	0.18	0.65	0.34	0.48
	96	282	0.09	2.03	1.06	2.25	10.93	1.45	0.20	0.77	0.33	0.68
	97	318	0.09	2.02	1.24	2.25	12.42	1.51	0.16	0.75	0.37	1.17
	100	325	0.13	2.04	1.06	2.42	12.25	1.64	0.24	0.68	0.43	0.60
	103	327	0.10	2.06	1.22	2.61	13.23	1.60	0.20	0.73	0.48	0.60
	106	336	0.10	2.14	1.25	2.67	13.28	1.74	0.14	0.66	0.37	0.51
	108	306	0.09	2.07	1.15	2.06	11.79	1.73	0.24	0.70	0.44	1.04
	Mean	**313.9**	**0.095**	**2.024**	**1.528**	**2.229**	**12.159**	**1.596**	**0.188**	**0.698**	**0.381**	**0.749**
	SD	**17.25**	**0.0163**	**0.0984**	**1.0706**	**0.3495**	**0.8997**	**0.1108**	**0.0397**	**0.0510**	**0.0628**	**0.2595**

= no data

Table G-9
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

1, 7, and 90-Day Hold Individual Absolute Organ Weights (grams)
2 Minute Exposure

	Animal ID	Body Weight	Adrenals	Brain	Heart	Kidneys	Liver	Lungs	Ovaries	Spleen	Thymus	Uterus
1 Day Hold												
Control	123	205	0.07	1.78	0.87	1.73	10.42	1.38	0.17	0.60	0.53	0.50
	125	232	0.07	1.90	1.11	1.79	11.96	1.30	0.14	0.61	0.60	0.36
	134	216	0.08	1.84	0.85	1.71	10.15	1.20	0.16	0.41	0.57	0.45
	136	222	0.08	1.87	0.81	1.61	10.71	1.18	0.16	0.63	0.58	0.47
	137	228	0.09	1.90	0.98	1.76	11.03	1.43	0.21	0.58	0.76	0.46
	138	234	0.12	1.83	1.07	1.87	12.02	1.27	0.18	0.62	0.55	0.47
	Mean	**222.8**	**0.085**	**1.851**	**0.946**	**1.745**	**11.049**	**1.294**	**0.167**	**0.575**	**0.596**	**0.453**
	SD	**10.96**	**0.0185**	**0.0441**	**0.1238**	**0.0872**	**0.7847**	**0.0587**	**0.0218**	**0.0808**	**0.0816**	**0.0463**
High	120	223	0.09	1.71	0.99	1.73	10.01	1.40	0.11	0.59	0.53	0.38
Concentration	121	205	0.07	1.89	0.78	1.89	11.16	1.49	0.14	0.62	0.70	0.64
	124	219	0.07	1.80	0.84	1.59	8.60	1.21	0.14	0.53	0.41	0.59
	128	228	0.08	1.92	0.99	1.89	11.25	1.57	0.20	0.62	0.74	0.42
	131	225	0.09	1.77	0.98	1.79	10.41	1.51	0.18	0.50	0.52	0.42
	133	219	0.08	1.79	1.03	1.76	10.47	1.44	0.17	0.56	0.70	0.30
	135	220	0.073	1.784	1.027	1.818	11.936	1.435	0.19	0.757	0.669	0.387
	146	206	0.08	1.78	0.93	1.84	10.69	1.29	0.16	0.60	0.61	0.46
	Mean	**218.1**	**0.078**	**1.806**	**0.945**	**1.787**	**10.566**	**1.416**	**0.162**	**0.597**	**0.610**	**0.449**
	SD	**8.39**	**0.0082**	**0.0665**	**0.0918**	**0.0989**	**0.9939**	**0.1165**	**0.0291**	**0.0774**	**0.1148**	**0.1134**
Low	122	218	0.08	1.92	0.91	1.86	9.93	1.34	0.17	0.68	0.62	0.45
Concentration	126	211	0.08	1.82	0.98	1.77	10.25	1.39	0.15	0.60	0.67	0.48
	127	224	0.08	1.86	0.91	2.07	10.71	1.48	0.17	0.54	0.58	0.31
	129	235	0.09	1.92	0.98	1.86	11.14	1.37	0.23	0.63	0.83	0.60
	130	217	0.07	1.78	0.89	1.59	9.40	1.50	0.19	0.51	0.52	0.69
	140	209	0.09	1.96	0.86	1.78	9.40	1.20	0.16	0.54	0.45	0.44
	141	223	0.08	2.02	0.96	1.99	10.24	1.48	0.14	0.68	0.55	0.53
	142	224	0.07	1.87	0.96	1.88	12.96	1.65	0.16	0.62	0.75	0.45
	Mean	**220.1**	**0.081**	**1.893**	**0.931**	**1.849**	**10.503**	**1.427**	**0.173**	**0.600**	**0.621**	**0.492**
	SD	**8.29**	**0.0076**	**0.0761**	**0.0440**	**0.1457**	**1.1575**	**0.1336**	**0.0285**	**0.0662**	**0.1270**	**0.1133**
7-Day Hold												
Control	139	224	0.08	1.93	0.98	1.79	10.27	1.39	0.15	0.64	0.45	0.53
	144	234	0.07	1.88	0.89	1.71	10.62	1.36	0.18	0.57	0.64	0.57
	145	253	0.08	1.91	0.92	1.89	12.50	1.57	0.16	0.75	0.70	0.86
	151	222	0.09	1.62	0.77	1.70	9.09	1.08	0.15	0.79	0.59	0.64
	152	234	0.11	1.90	0.87	1.90	11.08	1.40	0.11	0.64	0.60	0.65
	166	238	0.09	1.79	1.15	2.13	12.20	1.50	0.20	0.57	0.52	0.53
	Mean	**234.2**	**0.085**	**1.838**	**0.927**	**1.853**	**10.961**	**1.382**	**0.157**	**0.661**	**0.584**	**0.629**
	SD	**11.14**	**0.0145**	**0.1193**	**0.1287**	**0.1595**	**1.2676**	**0.1655**	**0.0296**	**0.0927**	**0.0890**	**0.1244**
High	150	250	0.10	1.93	0.99	2.10	13.05	1.43	0.18	0.75	0.59	0.41
Concentration	153	269	0.08	1.80	1.12	2.34	12.39	1.52	0.23	0.63	0.78	0.43
	154	250	0.09	1.98	1.09	2.07	12.28	1.46	0.16	0.81	0.82	0.38
	155	212	0.07	1.78	0.89	1.73	9.81	1.34	0.18	0.58	0.65	0.44
	158	230	0.09	1.73	0.78	1.93	11.72	1.33	0.19	0.54	0.59	0.37
	163	246	0.09	1.87	1.14	1.98	11.63	1.43	0.15	0.53	0.50	0.43
	169	228	0.09	1.74	0.92	1.90	11.10	1.41	0.22	0.57	0.53	0.45
	172	234	0.13	1.87	0.87	1.89	11.34	1.37	0.21	0.56	0.52	0.50
	Mean	**239.9**	**0.093**	**1.837**	**0.975**	**1.993**	**11.665**	**1.411**	**0.190**	**0.620**	**0.622**	**0.425**
	SD	**17.49**	**0.0177**	**0.0924**	**0.1306**	**0.1808**	**0.9801**	**0.0644**	**0.0279**	**0.1015**	**0.1192**	**0.0423**
Low	147	241	0.09	1.85	1.11	1.92	12.02	1.30	0.18	0.58	0.63	0.67
Concentration	148	257	0.09	1.99	1.01	2.02	11.91	1.55	0.15	0.61	0.60	0.36
	149	233	0.09	1.90	0.93	2.03	10.70	1.58	0.19	0.66	0.56	0.51
	156	237	0.08	1.88	1.00	2.09	11.62	1.51	0.16	0.56	0.57	0.44
	160	233	0.08	1.88	0.81	1.67	10.08	1.86	0.16	0.54	0.78	0.41
	161	249	0.10	1.80	1.08	1.94	11.81	1.63	0.16	0.53	0.63	1.02
	162	228	0.08	1.91	0.89	1.77	10.36	1.42	0.23	0.55	0.54	0.41
	164	230	0.09	1.81	0.82	1.81	10.72	1.53	0.19	0.53	0.62	0.36
	Mean	**238.5**	**0.086**	**1.876**	**0.956**	**1.907**	**11.154**	**1.549**	**0.176**	**0.570**	**0.616**	**0.523**
	SD	**10.03**	**0.0087**	**0.0616**	**0.1136**	**0.1479**	**0.7705**	**0.1610**	**0.0245**	**0.0455**	**0.0723**	**0.2252**
90-Day Hold	174	314	0.08	2.02	1.43	2.17	13.42	1.70	0.21	0.73	0.52	0.55
Control	175	350	0.10	2.19	1.26	2.71	13.81	2.09	0.27	0.93	0.71	0.75
	177	301	0.09	1.95	1.07	2.10	11.41	1.77	0.20	0.76	0.37	1.20
	178	289	0.08	2.11	1.05	2.00	10.51	1.37	0.18	0.57	0.39	0.74
	179	317	0.11	1.98	1.13	2.03	12.12	1.70	0.19	0.65	0.42	1.03
	181	305	0.07	1.97	0.96	1.78	10.88	1.67	0.21	0.58	0.38	0.63
	Mean	**312.7**	**0.087**	**2.036**	**1.148**	**2.132**	**12.024**	**1.717**	**0.210**	**0.702**	**0.464**	**0.818**
	SD	**20.83**	**0.0139**	**0.0914**	**0.1690**	**0.3141**	**1.3523**	**0.2315**	**0.0326**	**0.1360**	**0.1304**	**0.2479**
	173	336	0.07	2.02	1.18	2.08	12.68	1.44	0.18	1.16	0.28	0.95
High	182	336	0.10	1.94	1.18	2.40	15.04	1.63	0.26	0.72	0.47	0.58
Concentration	183	376	0.09	1.70	1.27	2.24	14.58	1.59	0.23	0.67	1.32	0.83
	184	310	0.09	2.02	1.25	2.00	12.21	1.74	0.16	0.76	0.41	0.84
	185	342	0.08	0.87	1.34	2.31	12.66	1.67	0.20	0.61	0.53	1.00
	186	310	0.08	2.06	1.10	2.15	11.69	2.16	0.16	0.61	0.33	1.06
	187	279	0.09	1.84	1.13	2.05	11.18	1.55	0.23	0.65	0.26	0.60
	188	360	0.09	1.97	1.21	2.16	14.58	1.61	0.18	0.69	0.47	0.63
	Mean	**331.1**	**0.086**	**1.803**	**1.206**	**2.173**	**13.079**	**1.674**	**0.200**	**0.732**	**0.509**	**0.810**
	SD	**30.76**	**0.0111**	**0.3933**	**0.0775**	**0.1376**	**1.4627**	**0.2139**	**0.0363**	**0.1795**	**0.3414**	**0.1868**
	165	316	0.07	1.96	1.07	1.99	12.24	1.52	0.14	0.51	0.35	0.49
Low	167	340	0.10	2.02	1.19	2.31	15.82	1.61	0.14	0.61	0.27	0.79
Concentration	168	330	0.11	1.92	1.28	1.98	12.73	1.65	0.17	0.59	0.44	1.24
	170	312	0.07	2.08	1.01	2.00	12.04	1.98	0.18	0.72	0.33	0.55
	171	356	0.08	2.19	1.27	2.38	13.97	1.17	0.16	0.74	0.40	1.97
	176	300	0.08	1.81	1.44	1.87	12.19	1.65	0.09	0.64	0.34	0.59
	180	338	0.10	2.11	1.17	2.46	15.18	1.61	0.17	0.54	0.52	0.67
	189	324	0.10	1.89	1.15	2.33	13.65	2.08	0.23	0.57	0.26	0.57
	Mean	**327.0**	**0.088**	**1.996**	**1.195**	**2.165**	**13.476**	**1.661**	**0.159**	**0.614**	**0.362**	**0.858**
	SD	**17.82**	**0.0143**	**0.1256**	**0.1344**	**0.2253**	**1.4374**	**0.2794**	**0.0411**	**0.0820**	**0.0890**	**0.5099**

APPENDIX H

SUMMARY OF ORGAN TO BODY WEIGHT RATIOS AND INDIVIDUAL DATA

Table H-1
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of % Body Weight Organ Weights
10 Minute Exposure

		1 Day Hold			7 Day Hold			90 Day Hold		
Period		**Control**	**High**	**Low**	**Control**	**High**	**Low**	**Control**	**High**	**Low**
Adrenals	Mean	0.0325	0.0361	0.0412	0.0364	0.0376	0.0377	0.0289	0.0317	0.0309
	S.D.	0.00482	0.00347	0.01173	0.00155	0.00945	0.00236	0.00735	0.00950	0.00481
	N	6	4	7	6	5	8	6	4	8
Brain	Mean	0.8456	0.9208	0.8687	0.7736	0.7885	0.8188	0.6493	0.6324	0.6542
	S.D.	0.06297	0.08244	0.03787	0.05318	0.05741	0.03765	0.03778	0.04335	0.03619
	N	6	4	8	6	5	8	6	4	8
Heart	Mean	0.3622	0.2685	0.4117	0.4097	0.4045	0.4104	0.3500	0.3379	0.3691
	S.D.	0.03091	0.19502	0.04928	0.02972	0.04058	0.02857	0.02967	0.01926	0.02209
	N	6	4	8	6	5	8	6	4	8
Kidneys	Mean	0.8171	0.8629	0.8191	0.8464	0.8067	0.8172	0.7243	0.6838	0.7524
	S.D.	0.05397	0.06150	0.02417	0.04830	0.02864	0.04386	0.09087	0.06009	0.05417
	N	6	4	8	6	5	8	6	4	8
Liver	Mean	4.7356	4.7528	4.9234	4.6565	4.5211	4.5069	3.7478	3.9010	3.8995
	S.D.	0.21132	0.43355	0.27265	0.31299	0.14725	0.22311	0.32448	0.11931	0.09366
	N	6	4	8	6	5	8	6	4	8
Lungs	Mean	0.6104	0.6612	0.6579	0.6245	0.5828	0.6122	0.5291	0.5210	0.5144
	S.D.	0.03062	0.05481	0.07654	0.05144	0.05935	0.01644	0.03997	0.05965	0.03078
	N	5	4	8	6	5	8	6	4	8
Ovaries	Mean	0.0688	0.0728	0.0784	0.1082	0.0787	0.0777	0.0669	0.0566	0.0627
	S.D.	0.00514	0.01147	0.00993	0.06919	0.01064	0.00783	0.01318	0.00542	0.01444
	N	6	4	8	6	5	8	6	4	8
Spleen	Mean	0.2610	0.2571	0.2474	0.2302	0.2795	0.2590	0.1860	0.2001	0.2284*
	S.D.	0.02482	0.02647	0.01175	0.02513	0.03571	0.02292	0.00446	0.02324	0.02626
	N	6	4	8	6	5	8	6	4	8
Thymus	Mean	0.2649	0.2849	0.2614	0.2540	0.2643	0.2441	0.1199	0.0999	0.1272
	S.D.	0.04981	0.07187	0.02354	0.04122	0.01699	0.02729	0.01401	0.01944	0.01565
	N	6	4	8	6	5	8	6	4	8
Uterus	Mean	0.2100	0.2367	0.1997	0.2069	0.1789	0.3115	0.2166	0.2372	0.2444
	S.D.	0.02857	0.06221	0.03444	0.03531	0.01658	0.08116	0.07605	0.10671	0.08962
	N	6	4	8	6	5	8	6	4	8

* significantly greater than controls
p less than or equal to 0.05

Table H-2
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of % Body Weight Organ Weights
2 Minute Exposure

		1 Day Hold			7 Day Hold			90 Day Hold		
Period		**Control**	**High**	**Low**	**Control**	**High**	**Low**	**Control**	**High**	**Low**
Adrenals	Mean	0.0381	0.0358	0.0370	0.0362	0.0387	0.0361	0.0278	0.0263	0.0270
	S.D.	0.00696	0.00334	0.00350	0.00650	0.00788	0.00318	0.00360	0.00419	0.00396
	N	6	8	8	6	8	8	6	8	8
Brain	Mean	0.8318	0.8293	0.8608	0.7853	0.7683	0.7876	0.6526	0.5510	0.6107
	S.D.	0.03064	0.04736	0.04366	0.04989	0.04983	0.03447	0.03863	0.13864	0.02709
	N	6	8	8	6	8	8	6	8	8
Heart	Mean	0.4265	0.4330	0.4231	0.3960	0.4059	0.4000	0.3669	0.3659	0.3665
	S.D.	0.04115	0.03491	0.01786	0.05252	0.03818	0.03820	0.04636	0.02883	0.04888
	N	6	8	8	6	8	8	6	8	8
Kidneys	Mean	0.7840	0.8209	0.8401	0.7915	0.8300	0.7995	0.6799	0.6596	0.6610
	S.D.	0.03966	0.06260	0.05880	0.05930	0.02089	0.05457	0.06424	0.05289	0.04522
	N	6	8	8	6	8	8	6	8	8
Liver	Mean	4.9562	4.8522	4.7675	4.6701	4.8626	4.6743	3.8393	3.9499	4.1164
	S.D.	0.19249	0.51335	0.44476	0.35883	0.21572	0.20779	0.25288	0.24514	0.30924
	N	6	8	8	6	8	8	6	8	8
Lungs	Mean	0.5820	0.6496	0.6480	0.5892	0.5895	0.6504	0.5476	0.5107	0.5113
	S.D.	0.05569	0.05080	0.05516	0.05247	0.02333	0.07345	0.04448	0.09130	0.10083
	N	6	8	8	6	8	8	6	8	8
Ovaries	Mean	0.0752	0.0742	0.0785	0.0668	0.0794	0.0740	0.0670	0.0606	0.0484
	S.D.	0.00972	0.01246	0.01111	0.01198	0.01219	0.01277	0.00629	0.01209	0.01246
	N	6	8	8	6	8	8	6	8	8
Spleen	Mean	0.2580	0.2743	0.2724	0.2830	0.2585	0.2390	0.2234	0.2223	0.1879
	S.D.	0.03519	0.03809	0.02866	0.04323	0.03634	0.01988	0.03161	0.05496	0.02595
	N	6	8	8	6	8	8	6	8	8
Thymus	Mean	0.2675	0.2804	0.2812	0.2488	0.2590	0.2585	0.1470	0.1489	0.1106
	S.D.	0.03294	0.05514	0.05051	0.03161	0.04391	0.03234	0.03096	0.08510	0.02551
	N	6	8	8	6	8	8	6	8	8
Uterus	Mean	0.2042	0.2073	0.2237	0.2678	0.1781	0.2182	0.2629	0.2460	0.2576
	S.D.	0.02781	0.05791	0.05072	0.04340	0.02408	0.08828	0.08419	0.05969	0.13843
	N	6	8	8	6	8	8	6	8	8

Table H-3
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

1, 7, and 90-Day Hold Individual % Body Weight Organ Weights (grams)
10 Minute Exposure

	Animal ID	Adrenals	Brain	Heart	Kidneys	Liver	Lungs	Ovaries	Spleen	Thymus	Uterus
1 Day Hold											
Control	52	0.031	0.798	0.352	0.730	4.517	0.585	0.063	0.260	0.255	0.178
	55	0.041	0.918	0.350	0.823	4.806		0.067	0.220	0.210	0.232
	56	0.032	0.928	0.348	0.801	4.720	0.601	0.073	0.253	0.234	0.172
	57	0.031	0.837	0.336	0.862	4.888	0.605	0.070	0.294	0.352	0.217
	59	0.026	0.778	0.422	0.884	5.012	0.663	0.076	0.277	0.250	0.241
	62	0.034	0.815	0.366	0.802	4.470	0.597	0.063	0.261	0.288	0.219
	Mean	**0.0325**	**0.8456**	**0.3622**	**0.8171**	**4.7356**	**0.6104**	**0.0688**	**0.2610**	**0.2649**	**0.2100**
	SD	**0.00482**	**0.06297**	**0.03091**	**0.05397**	**0.21132**	**0.03062**	**0.00514**	**0.02482**	**0.04981**	**0.02857**
High	50	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
Concentration	54	0.031	0.881	0.396	0.745	3.841	0.637	0.065	0.274	0.346	0.288
	60	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	61	0.038	0.878	0.407	0.831	4.947	0.637	0.064	0.287	0.288	0.230
	63	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	70	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	77	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	79	0.038	0.869	0.353	0.934	5.055	0.724	0.086	0.237	0.355	0.302
	80	0.032	1.016	0.045	0.824	4.256	0.623	0.068	0.247	0.212	0.178
	Mean	**0.0361**	**0.9208**	**0.2685**	**0.8629**	**4.7528**	**0.6612**	**0.0728**	**0.2571**	**0.2849**	**0.2367**
	SD	**0.00347**	**0.08244**	**0.19502**	**0.06150**	**0.43355**	**0.05481**	**0.01147**	**0.02647**	**0.07187**	**0.06221**
Low	51	0.036	0.827	0.390	0.756	4.504	0.623	0.080	0.239	0.267	0.188
Concentration	53		0.853	0.366	0.746	4.764	0.549	0.089	0.274	0.259	0.171
	58	0.034	0.877	0.423	0.852	4.740	0.539	0.073	0.255	0.254	0.201
	64	0.042	0.802	0.503	0.787	4.878	0.674	0.091	0.246	0.278	0.237
	66	0.038	0.916	0.389	0.832	4.953	0.688	0.081	0.245	0.288	0.220
	67	0.064	0.856	0.359	0.820	4.595	0.752	0.069	0.247	0.226	0.214
	68	0.035	0.883	0.400	0.828	5.397	0.696	0.067	0.263	0.277	0.138
	72	0.035	0.878	0.396	0.795	4.977	0.599	0.089	0.228	0.246	0.190
	Mean	**0.0412**	**0.8687**	**0.4117**	**0.8191**	**4.9234**	**0.6579**	**0.0784**	**0.2474**	**0.2614**	**0.1997**
	SD	**0.01173**	**0.03787**	**0.04928**	**0.02417**	**0.27265**	**0.07654**	**0.00993**	**0.01175**	**0.02354**	**0.03444**
7-Day Hold											
Control	65	0.037	0.784	0.435	0.866	4.755	0.551	0.069	0.210	0.289	0.171
	69	0.035	0.827	0.390	0.806	4.562	0.603	0.075	0.250	0.223	0.186
	71	0.039	0.676	0.429	0.774	4.724	0.604	0.248	0.195	0.281	0.177
	76	0.037	0.756	0.360	0.856	4.666	0.645	0.072	0.238	0.227	0.216
	93	0.036	0.802	0.412	0.867	4.135	0.704	0.087	0.226	0.203	0.262
	98	0.036	0.796	0.432	0.910	5.097	0.640	0.098	0.263	0.302	0.229
	Mean	**0.0364**	**0.7736**	**0.4097**	**0.8464**	**4.6565**	**0.6245**	**0.1082**	**0.2302**	**0.2540**	**0.2069**
	SD	**0.00155**	**0.05318**	**0.02972**	**0.04830**	**0.31299**	**0.05144**	**0.06919**	**0.02513**	**0.04122**	**0.03531**
High	85	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
Concentration	86	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	88	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	89	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	90	0.030	0.731	0.404	0.793	4.608	0.532	0.090	0.306	0.275	0.199
	91	0.027	0.757	0.448	0.854	4.723	0.585	0.072	0.284	0.288	0.172
	92	0.037	0.812	0.339	0.788	4.440	0.544	0.080	0.238	0.253	0.193
	95	0.046	0.877	0.407	0.785	4.489	0.571	0.064	0.321	0.258	0.159
	101	0.048	0.766	0.424	0.813	4.346	0.682	0.087	0.249	0.247	0.171
	Mean	**0.0376**	**0.7885**	**0.4045**	**0.8067**	**4.5211**	**0.5828**	**0.0787**	**0.2795**	**0.2643**	**0.1789**
	SD	**0.00945**	**0.05741**	**0.04058**	**0.02864**	**0.14725**	**0.05935**	**0.01064**	**0.03571**	**0.01699**	**0.01658**
Low	73	0.048	0.740	0.427	0.819	4.189	0.603	0.072	0.183	0.211	0.215
Concentration	74	0.039	0.778	0.418	0.789	4.468	0.605	0.077	0.304	0.216	0.179
	75	0.038	0.784	0.432	0.876	4.841	0.619	0.077	0.280	0.236	0.300
	78	0.038	0.865	0.400	0.804	4.505	0.633	0.083	0.288	0.205	0.273
	81	0.035	0.839	0.400	0.826	4.484	0.610	0.071	0.251	0.227	0.457
	82	0.036	0.843	0.453	0.804	4.352	0.598	0.091	0.263	0.277	0.325
	83	0.041	0.814	0.371	0.747	4.205	0.623	0.073	0.226	0.249	0.302
	84	0.040	0.767	0.406	0.845	4.654	0.589	0.071	0.247	0.271	0.212
	Mean	**0.0377**	**0.8188**	**0.4104**	**0.8172**	**4.5069**	**0.6122**	**0.0777**	**0.2590**	**0.2441**	**0.3115**
	SD	**0.00236**	**0.03765**	**0.02857**	**0.04386**	**0.22311**	**0.01644**	**0.00783**	**0.02292**	**0.02729**	**0.08116**
90-Day Hold											
Control	99	0.027	0.686	0.363	0.816	3.628	0.500	0.062	0.185	0.136	0.208
	102	0.042	0.673	0.328	0.863	4.237	0.602	0.083	0.188	0.110	0.296
	104	0.031	0.667	0.339	0.665	3.902	0.544	0.058	0.193	0.127	0.157
	117	0.028	0.603	0.371	0.665	3.259	0.514	0.065	0.180	0.110	0.323
	118	0.021	0.668	0.389	0.657	3.662	0.523	0.083	0.185	0.103	0.140
	119	0.025	0.600	0.310	0.678	3.799	0.493	0.051	0.185	0.133	0.176
	Mean	**0.0289**	**0.6493**	**0.3500**	**0.7243**	**3.7478**	**0.5291**	**0.0669**	**0.1860**	**0.1199**	**0.2166**
	SD	**0.00735**	**0.03778**	**0.02967**	**0.09087**	**0.32448**	**0.03997**	**0.01318**	**0.00446**	**0.01401**	**0.07605**
High	105	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
Concentration	107	0.043	0.665	0.320	0.670	3.778	0.505	0.063	0.197	0.076	0.391
	109	0.033	0.667	0.362	0.761	3.981	0.502	0.060	0.233	0.118	0.225
	111	0.020	0.575	0.325	0.688	4.023	0.607	0.053	0.179	0.113	0.152
	114	dead	dead	dead	dead	dead	dead	dead	dead	dead	dead
	115	0.030	0.622	0.345	0.616	3.822	0.470	0.051	0.192	0.092	0.181
	Mean	**0.0317**	**0.6324**	**0.3379**	**0.6838**	**3.9010**	**0.5210**	**0.0566**	**0.2001**	**0.0999**	**0.2372**
	SD	**0.00950**	**0.04335**	**0.01926**	**0.06009**	**0.11931**	**0.05965**	**0.00542**	**0.02324**	**0.01944**	**0.10671**
Low	87	0.024	0.567	1.315	0.509	3.453	0.465	0.046	0.199	0.093	0.291
Concentration	94	0.033	0.679	0.356	0.656	4.147	0.540	0.058	0.216	0.113	0.159
	96	0.031	0.719	0.376	0.799	3.875	0.515	0.070	0.273	0.116	0.242
	97	0.027	0.635	0.391	0.707	3.906	0.474	0.051	0.237	0.115	0.367
	100	0.040	0.629	0.326	0.744	3.768	0.506	0.075	0.210	0.131	0.184
	103	0.030	0.631	0.373	0.797	4.044	0.490	0.060	0.224	0.146	0.184
	106	0.028	0.636	0.373	0.796	3.952	0.519	0.042	0.197	0.111	0.150
	108	0.029	0.675	0.375	0.672	3.852	0.564	0.079	0.229	0.145	0.339
	Mean	**0.0309**	**0.6542**	**0.3691**	**0.7524**	**3.8995**	**0.5114**	**0.0627**	**0.2284**	**0.1272**	**0.2444**
	SD	**0.00481**	**0.03619**	**0.02209**	**0.05417**	**0.09366**	**0.03078**	**0.01444**	**0.02626**	**0.01565**	**0.08962**

= no data

Table H-4
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

1, 7, and 90-Day Hold Individual % Body Weight Organ Weights (grams)
2 Minute Exposure

	Animal ID	Adrenals	Brain	Heart	Kidneys	Liver	Lungs	Ovaries	Spleen	Thymus	Uterus
1 Day Hold											
Control	123	0.033	0.870	0.422	0.845	5.085	0.672	0.080	0.290	0.259	0.243
	125	0.031	0.817	0.478	0.772	5.154	0.561	0.061	0.264	0.257	0.157
	134	0.036	0.850	0.393	0.791	4.698	0.556	0.072	0.191	0.263	0.210
	136	0.037	0.841	0.364	0.725	4.826	0.532	0.072	0.283	0.260	0.211
	137	0.041	0.832	0.428	0.770	4.839	0.629	0.090	0.256	0.332	0.202
	138	0.050	0.781	0.456	0.800	5.135	0.542	0.075	0.263	0.235	0.202
	Mean	**0.0381**	**0.8318**	**0.4235**	**0.7840**	**4.9562**	**0.5820**	**0.0752**	**0.2580**	**0.2675**	**0.2042**
	SD	**0.00696**	**0.03064**	**0.04115**	**0.03966**	**0.19249**	**0.05569**	**0.00972**	**0.03519**	**0.03294**	**0.02781**
High	120	0.041	0.768	0.445	0.776	4.488	0.626	0.051	0.263	0.236	0.168
Concentration	121	0.036	0.920	0.380	0.921	5.445	0.724	0.068	0.304	0.342	0.310
	124	0.032	0.824	0.381	0.724	3.928	0.552	0.064	0.244	0.187	0.271
	128	0.033	0.843	0.435	0.828	4.934	0.686	0.088	0.272	0.325	0.185
	131	0.040	0.788	0.434	0.796	4.625	0.669	0.080	0.222	0.232	0.188
	133	0.034	0.816	0.469	0.805	4.780	0.659	0.076	0.256	0.320	0.135
	135	0.033	0.811	0.467	0.826	5.425	0.652	0.086	0.344	0.304	0.176
	146	0.036	0.865	0.453	0.891	5.191	0.627	0.080	0.290	0.298	0.225
	Mean	**0.0358**	**0.8293**	**0.4330**	**0.8209**	**4.8522**	**0.6496**	**0.0742**	**0.2743**	**0.2804**	**0.2073**
	SD	**0.00334**	**0.04736**	**0.03491**	**0.06260**	**0.51335**	**0.05080**	**0.01246**	**0.03809**	**0.05514**	**0.05791**
Low	122	0.039	0.880	0.418	0.854	4.555	0.615	0.080	0.312	0.283	0.205
Concentration	126	0.037	0.864	0.463	0.839	4.855	0.660	0.073	0.285	0.319	0.227
	127	0.034	0.832	0.408	0.923	4.780	0.662	0.076	0.239	0.258	0.138
	129	0.040	0.817	0.418	0.791	4.740	0.582	0.099	0.266	0.355	0.254
	130	0.033	0.820	0.408	0.731	4.332	0.693	0.089	0.233	0.237	0.316
	140	0.043	0.937	0.412	0.852	4.500	0.574	0.078	0.259	0.214	0.212
	141	0.038	0.905	0.430	0.891	4.592	0.663	0.064	0.306	0.248	0.238
	142	0.033	0.833	0.427	0.840	5.787	0.736	0.069	0.278	0.335	0.200
	Mean	**0.0370**	**0.8608**	**0.4231**	**0.8401**	**4.7675**	**0.6480**	**0.0785**	**0.2724**	**0.2812**	**0.2237**
	SD	**0.00350**	**0.04366**	**0.01786**	**0.05880**	**0.44476**	**0.05516**	**0.01111**	**0.02866**	**0.05051**	**0.05072**
7-Day Hold											
Control	139	0.034	0.862	0.438	0.800	4.585	0.620	0.066	0.287	0.201	0.235
	144	0.028	0.803	0.378	0.729	4.538	0.581	0.075	0.243	0.274	0.243
	145	0.031	0.754	0.363	0.746	4.942	0.619	0.064	0.296	0.278	0.340
	151	0.040	0.728	0.345	0.766	4.094	0.488	0.065	0.358	0.265	0.290
	152	0.046	0.813	0.371	0.812	4.735	0.599	0.047	0.275	0.257	0.277
	166	0.038	0.751	0.482	0.894	5.127	0.628	0.083	0.239	0.218	0.223
	Mean	**0.0362**	**0.7853**	**0.3960**	**0.7915**	**4.6701**	**0.5892**	**0.0668**	**0.2830**	**0.2488**	**0.2678**
	SD	**0.00650**	**0.04989**	**0.05252**	**0.05930**	**0.35883**	**0.05247**	**0.01198**	**0.04323**	**0.03161**	**0.04340**
High	150	0.038	0.773	0.397	0.842	5.221	0.571	0.073	0.298	0.235	0.162
Concentration	153	0.029	0.668	0.414	0.868	4.606	0.567	0.086	0.233	0.288	0.160
	154	0.037	0.794	0.436	0.826	4.913	0.584	0.064	0.323	0.328	0.151
	155	0.035	0.841	0.421	0.814	4.625	0.633	0.085	0.272	0.305	0.205
	158	0.039	0.751	0.341	0.840	5.095	0.577	0.082	0.236	0.258	0.160
	163	0.038	0.761	0.465	0.806	4.726	0.580	0.061	0.216	0.203	0.174
	169	0.038	0.761	0.402	0.835	4.866	0.618	0.095	0.251	0.231	0.196
	172	0.056	0.798	0.371	0.809	4.847	0.586	0.089	0.240	0.223	0.215
	Mean	**0.0387**	**0.7683**	**0.4059**	**0.8300**	**4.8626**	**0.5895**	**0.0794**	**0.2585**	**0.2590**	**0.1781**
	SD	**0.00788**	**0.04983**	**0.03818**	**0.02089**	**0.21572**	**0.02333**	**0.01219**	**0.03634**	**0.04391**	**0.02408**
Low	147	0.037	0.766	0.460	0.796	4.989	0.540	0.074	0.240	0.260	0.277
Concentration	148	0.034	0.776	0.393	0.788	4.635	0.603	0.058	0.238	0.235	0.140
	149	0.038	0.813	0.399	0.873	4.593	0.678	0.080	0.283	0.242	0.219
	156	0.032	0.792	0.424	0.883	4.904	0.638	0.067	0.235	0.242	0.187
	160	0.033	0.805	0.348	0.715	4.327	0.797	0.070	0.232	0.333	0.175
	161	0.041	0.723	0.433	0.780	4.744	0.656	0.063	0.212	0.252	0.410
	162	0.035	0.839	0.388	0.774	4.545	0.624	0.099	0.241	0.236	0.181
	164	0.039	0.787	0.355	0.788	4.659	0.667	0.082	0.230	0.270	0.157
	Mean	**0.0361**	**0.7876**	**0.4000**	**0.7995**	**4.6743**	**0.6504**	**0.0740**	**0.2390**	**0.2585**	**0.2182**
	SD	**0.00318**	**0.03447**	**0.03820**	**0.05457**	**0.20779**	**0.07345**	**0.01277**	**0.01988**	**0.03234**	**0.08828**
90-Day Hold	174	0.025	0.644	0.454	0.691	4.275	0.542	0.067	0.231	0.165	0.175
Control	175	0.029	0.624	0.361	0.775	3.945	0.598	0.077	0.265	0.202	0.215
	177	0.030	0.649	0.355	0.698	3.791	0.589	0.067	0.253	0.123	0.399
	178	0.027	0.728	0.364	0.692	3.636	0.474	0.061	0.197	0.136	0.256
	179	0.033	0.625	0.355	0.640	3.822	0.535	0.060	0.205	0.133	0.325
	181	0.023	0.646	0.313	0.583	3.566	0.547	0.070	0.189	0.123	0.208
	Mean	**0.0278**	**0.6526**	**0.3669**	**0.6799**	**3.8393**	**0.5476**	**0.0670**	**0.2234**	**0.1470**	**0.2629**
	SD	**0.00360**	**0.03863**	**0.04636**	**0.06424**	**0.25288**	**0.04448**	**0.00629**	**0.03161**	**0.03096**	**0.08419**
	173	0.020	0.602	0.350	0.619	3.773	0.428	0.054	0.344	0.083	0.281
High	182	0.031	0.578	0.352	0.715	4.477	0.485	0.077	0.215	0.139	0.172
Concentration	183	0.023	0.453	0.338	0.594	3.878	0.422	0.061	0.178	0.351	0.220
	184	0.030	0.651	0.403	0.645	3.944	0.562	0.052	0.245	0.134	0.269
	185	0.023	0.255	0.390	0.677	3.703	0.489	0.058	0.177	0.154	0.292
	186	0.027	0.665	0.354	0.694	3.770	0.695	0.051	0.197	0.105	0.342
	187	0.031	0.658	0.405	0.733	4.006	0.555	0.081	0.232	0.095	0.216
	188	0.026	0.547	0.335	0.600	4.049	0.448	0.050	0.191	0.131	0.176
	Mean	**0.0263**	**0.5510**	**0.3659**	**0.6596**	**3.9499**	**0.5107**	**0.0606**	**0.2223**	**0.1489**	**0.2460**
	SD	**0.00419**	**0.13864**	**0.02883**	**0.05289**	**0.24514**	**0.09130**	**0.01209**	**0.05496**	**0.08510**	**0.05969**
	165	0.022	0.619	0.337	0.631	3.874	0.481	0.043	0.160	0.111	0.155
Low	167	0.030	0.593	0.350	0.680	4.651	0.474	0.041	0.179	0.078	0.231
Concentration	168	0.032	0.582	0.387	0.601	3.858	0.500	0.052	0.180	0.133	0.376
	170	0.023	0.665	0.322	0.642	3.858	0.636	0.059	0.230	0.105	0.175
	171	0.023	0.615	0.358	0.668	3.923	0.328	0.045	0.207	0.111	0.554
	176	0.026	0.603	0.478	0.622	4.063	0.551	0.029	0.213	0.113	0.197
	180	0.028	0.625	0.345	0.727	4.491	0.478	0.049	0.160	0.155	0.197
	189	0.031	0.584	0.355	0.718	4.213	0.642	0.070	0.174	0.079	0.175
	Mean	**0.0270**	**0.6107**	**0.3665**	**0.6610**	**4.1164**	**0.5113**	**0.0484**	**0.1879**	**0.1106**	**0.2576**
	SD	**0.00396**	**0.02709**	**0.04888**	**0.04522**	**0.30924**	**0.10083**	**0.01246**	**0.02595**	**0.02551**	**0.13843**

APPENDIX I

SUMMARY OF ORGAN TO BRAIN WEIGHT RATIOS AND INDIVIDUAL DATA

Table I-1
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of % Brain Weight Organ Weights
10 Minute Exposure

		1 Day Hold			7 Day Hold			90 Day Hold		
Period		**Control**	**High**	**Low**	**Control**	**High**	**Low**	**Control**	**High**	**Low**
Adrenals	Mean	3.8409	3.9669	4.7616	4.7415	4.7503	4.6187	4.4531	4.9525	4.7437
	S.D.	0.41786	0.69594	1.44139	0.56226	1.05053	0.44423	1.05512	1.22054	0.83854
	N	6	4	7	6	5	8	6	4	8
Heart	Mean	43.1620	30.4931	47.6274	53.2293	51.6148	50.2112	53.9966	53.5680	56.5204
	S.D.	6.22751	22.71178	7.72967	6.07058	7.24633	4.18794	4.91192	3.75151	3.91862
	N	6	4	8	6	5	8	6	4	8
Kidneys	Mean	97.0908	94.4260	94.3767	109.6485	102.8180	100.0822	111.4976	108.3695	115.2757
	S.D.	10.10594	13.19683	3.18798	6.47231	9.37760	8.77083	11.40798	10.12307	10.12489
	N	6	4	8	6	5	8	6	4	8
Liver	Mean	562.5172	521.4971	567.3887	604.9038	576.1107	551.9887	577.7357	619.6195	597.6811
	S.D.	48.45257	89.25775	34.44290	64.87820	50.68757	47.21733	45.79772	56.48979	37.24048
	N	6	4	8	6	5	8	6	4	8
Lungs	Mean	73.7880	72.4028	75.9081	80.9904	74.2471	74.8605	81.5881	83.0623	78.2625
	S.D.	7.32749	11.01364	9.87869	7.94358	9.57631	3.04383	5.70006	15.00969	4.53638
	N	5	4	8	6	5	8	6	4	8
Ovaries	Mean	8.1670	7.9715	9.0546	14.5350	10.0811	9.4839	10.2803	8.9535	9.5650
	S.D.	0.83163	1.67433	1.39192	10.90126	1.91618	0.77743	1.79551	0.49455	2.06870
	N	6	4	8	6	5	8	6	4	8
Spleen	Mean	31.1135	28.1116	28.5227	29.7445	35.5490	31.6573	28.7172	31.6106	34.8614*
	S.D.	4.59138	4.25759	1.81665	2.27524	4.80622	2.76542	1.46712	2.31200	2.63238
	N	6	4	8	6	5	8	6	4	8
Thymus	Mean	31.6100	31.5067	30.1345	33.0900	33.7170	29.9259	18.5192	15.9033	19.5106
	S.D.	6.94275	10.09393	2.93011	6.56896	3.92139	4.12271	2.46290	3.57445	2.71155
	N	6	4	8	6	5	8	6	4	8
Uterus	Mean	25.0043	26.1672	23.0943	26.7487	22.8442	37.9268	33.6172	37.0017	37.2876
	S.D.	4.23441	8.61713	4.56308	4.12729	3.26090	9.18188	12.65223	14.81632	13.54484
	N	6	4	8	6	5	8	6	4	8

* significantly greater than controls
p less than or equal to 0.05

Table I-2
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of % Brain Weight Organ Weights
2 Minute Exposure

		1 Day Hold			7 Day Hold			90 Day Hold		
Period		**Control**	**High**	**Low**	**Control**	**High**	**Low**	**Control**	**High**	**Low**
Adrenals	Mean	4.6013	4.3381	4.2945	4.6331	5.0302	4.6041	4.2826	5.0961	4.4476
	S.D.	1.00621	0.56463	0.30138	0.88609	0.89800	0.55359	0.66813	1.68157	0.80730
	N	6	8	8	6	8	8	6	8	8
Heart	Mean	51.0625	52.4493	49.2446	50.5108	53.0309	50.9777	56.3769	73.0705	60.2369
	S.D.	6.29356	6.00797	2.92371	6.89311	6.12683	6.42286	7.81369	32.81776	9.32953
	N	6	8	8	6	8	8	6	8	8
Kidneys	Mean	94.3336	98.9811	97.6793	101.1376	108.5837	101.6689	104.4841	130.9246	108.4178
	S.D.	5.36920	4.75349	6.64527	10.18090	9.95878	7.79750	11.84038	55.26793	8.84383
	N	6	8	8	6	8	8	6	8	8
Liver	Mean	596.8545	585.0674	555.7147	596.5718	635.0720	595.0081	590.6107	778.7890	675.6705
	S.D.	39.22964	52.15337	66.16429	59.03846	46.32832	45.46696	58.88853	289.13738	64.27570
	N	6	8	8	6	8	8	6	8	8
Lungs	Mean	69.9272	78.4185	75.5625	75.1070	76.9131	82.6297	84.3760	99.6491	83.8066
	S.D.	5.51092	5.80817	8.63945	6.43553	4.08512	9.12029	10.45487	38.37830	16.53157
	N	6	8	8	6	8	8	6	8	8
Ovaries	Mean	9.0412	8.9499	9.1629	8.5579	10.3858	9.3639	10.3094	11.9809	7.9414
	S.D.	1.14531	1.50945	1.60401	1.74890	1.83328	1.32850	1.32883	4.97106	2.10338
	N	6	8	8	6	8	8	6	8	8
Spleen	Mean	31.0548	33.0736	31.6401	36.2645	33.6548	30.3412	34.4262	42.5488	30.7541
	S.D.	4.33125	4.29469	2.91148	7.00455	4.18738	2.00684	5.90606	13.48857	3.71955
	N	6	8	8	6	8	8	6	8	8
Thymus	Mean	32.1594	33.7113	32.8823	31.8851	33.8255	32.8736	22.6583	31.2978	18.0996
	S.D.	3.82169	5.72308	6.89887	5.11759	6.08187	4.21134	5.41146	24.00658	4.11870
	N	6	8	8	6	8	8	6	8	8
Uterus	Mean	24.5188	24.8181	26.0842	34.3394	23.1784	28.0870	40.4092	49.6440	42.4113
	S.D.	2.91181	5.86207	6.47930	6.83176	2.62953	12.86320	13.30710	27.33945	23.01846
	N	6	8	8	6	8	8	6	8	8

Table I-3
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

1, 7, and 90-Day Hold Individual % Brain Weight Organ Weights (grams)
10 Minute Exposure

	Animal ID	Adrenals	Heart	Kidneys	Liver	Lungs	Ovaries	Spleen	Thymus	Uterus
1 Day Hold										
Control	52	3.886	44.142	91.473	565.893	73.260	7.947	32.599	31.903	22.274
	55	4.440	38.100	89.675	523.542		7.331	24.006	22.922	25.297
	56	3.485	37.480	86.381	508.686	64.772	7.882	27.239	25.201	18.552
	57	3.657	40.120	103.002	584.334	72.380	8.406	35.153	42.085	25.983
	59	3.372	54.244	113.605	644.012	85.233	9.709	35.640	32.151	30.988
	62	4.205	44.886	98.409	548.636	73.295	7.727	32.045	35.398	26.932
	Mean	**3.8409**	**43.1620**	**97.0908**	**562.5172**	**73.7880**	**8.1670**	**31.1135**	**31.6100**	**25.0043**
	SD	**0.41786**	**6.22751**	**10.10594**	**48.45257**	**7.32749**	**0.83163**	**4.59138**	**6.94275**	**4.23441**
High	50	dead	dead	dead	dead	dead	dead	dead	dead	dead
Concentration	54	3.553	44.928	84.527	435.874	72.321	7.335	31.060	39.255	32.665
	60	dead	dead	dead	dead	dead	dead	dead	dead	dead
	61	4.335	46.321	94.657	563.508	72.530	7.308	32.712	32.762	26.210
	63	dead	dead	dead	dead	dead	dead	dead	dead	dead
	70	dead	dead	dead	dead	dead	dead	dead	dead	dead
	77	dead	dead	dead	dead	dead	dead	dead	dead	dead
	79	4.402	40.688	107.506	581.998	83.352	9.876	27.314	40.914	34.763
	80	3.164	4.470	81.115	418.985	61.326	6.730	24.309	20.844	17.529
	Mean	**3.9669**	**30.4931**	**94.4260**	**521.4971**	**72.4028**	**7.9715**	**28.1116**	**31.5067**	**26.1672**
	SD	**0.69594**	**22.71178**	**13.19683**	**89.25775**	**11.01364**	**1.67433**	**4.25759**	**10.09393**	**8.61713**
Low	51	4.415	47.133	91.456	544.897	75.401	9.633	28.956	32.282	22.764
Concentration	53		42.880	87.388	558.224	64.372	10.405	32.055	30.373	20.074
	58	3.852	48.201	97.162	540.598	61.429	8.363	29.042	28.941	22.909
	64	5.203	62.722	98.113	607.947	83.991	11.321	30.703	34.591	29.503
	66	4.106	42.414	90.836	540.661	75.063	8.813	26.740	31.447	23.986
	67	7.519	41.990	95.778	536.842	87.912	8.097	28.861	26.374	24.986
	68	3.948	45.299	93.766	611.221	78.857	7.636	29.818	31.377	15.584
	72	3.942	45.140	90.605	567.063	68.197	10.097	25.972	28.078	21.598
	Mean	**4.7616**	**47.6274**	**94.3767**	**567.3887**	**75.9081**	**9.0546**	**28.5227**	**30.1345**	**23.0943**
	SD	**1.44139**	**7.72967**	**3.18798**	**34.44290**	**9.87869**	**1.39192**	**1.81665**	**2.93011**	**4.56308**
7-Day Hold										
Control	65	4.669	55.537	110.423	606.623	70.304	8.849	26.764	36.808	21.878
	69	4.171	47.112	97.433	551.390	72.834	9.037	30.214	26.952	22.460
	71	5.790	63.499	114.537	698.678	89.364	36.627	28.886	41.536	26.180
	76	4.860	47.624	113.175	617.225	85.313	9.503	31.479	29.968	28.510
	93	4.471	51.341	108.101	515.466	87.743	10.889	28.143	25.355	32.720
	98	4.488	54.261	114.221	640.040	80.383	12.305	32.980	37.922	28.744
	Mean	**4.7415**	**53.2293**	**109.6485**	**604.9038**	**80.9904**	**14.5350**	**29.7445**	**33.0900**	**26.7487**
	SD	**0.56226**	**6.07058**	**6.47231**	**64.87820**	**7.94358**	**10.90126**	**2.27524**	**6.56896**	**4.12729**
High	85	dead	dead	dead	dead	dead	dead	dead	dead	dead
Concentration	86	dead	dead	dead	dead	dead	dead	dead	dead	dead
	88	dead	dead	dead	dead	dead	dead	dead	dead	dead
	89	dead	dead	dead	dead	dead	dead	dead	dead	dead
	90	4.116	55.304	108.464	630.377	72.812	12.348	41.797	37.681	27.246
	91	3.512	59.224	112.788	623.847	77.201	9.539	37.526	38.050	22.746
	92	4.606	41.787	97.059	547.003	67.037	9.822	29.301	31.132	23.751
	95	5.300	46.360	89.561	511.831	65.096	7.334	36.617	29.443	18.148
	101	6.218	55.399	106.218	567.496	89.090	11.362	32.504	32.278	22.329
	Mean	**4.7503**	**51.6148**	**102.8180**	**576.1107**	**74.2471**	**10.0811**	**35.5490**	**33.7170**	**22.8442**
	SD	**1.05053**	**7.24633**	**9.37760**	**50.68757**	**9.57631**	**1.91618**	**4.80622**	**3.92139**	**3.26090**
Low	73	6.484	57.747	110.659	566.209	81.538	9.725	24.780	28.571	29.121
Concentration	74	5.008	53.674	101.306	573.979	77.681	9.907	39.085	27.708	22.972
	75	4.785	55.116	111.826	617.822	78.988	9.791	35.699	30.088	38.284
	78	4.352	46.218	92.953	520.518	73.161	9.637	33.316	23.679	31.554
	81	4.126	47.733	98.421	534.488	72.746	8.507	29.903	27.050	54.457
	82	4.235	53.732	95.394	516.093	70.937	10.746	31.128	32.875	38.539
	83	5.000	45.543	91.739	516.522	76.576	8.913	27.717	30.598	37.120
	84	5.213	52.926	110.160	606.489	76.755	9.309	32.181	35.266	27.606
	Mean	**4.6187**	**50.2112**	**100.0822**	**551.9887**	**74.8605**	**9.4839**	**31.6573**	**29.9259**	**37.9268**
	SD	**0.44423**	**4.18794**	**8.77083**	**47.21733**	**3.04383**	**0.77743**	**2.76542**	**4.12271**	**9.18188**
90-Day Hold										
Control	99	3.965	52.912	119.090	529.173	72.883	9.006	26.921	19.873	30.299
	102	6.284	48.761	128.257	629.725	89.450	12.294	27.982	16.284	44.037
	104	4.612	50.777	99.806	585.340	81.602	8.689	28.981	19.078	23.544
	117	4.587	61.600	110.293	540.587	85.227	10.773	29.813	18.293	53.600
	118	3.090	58.281	98.407	548.093	78.223	12.409	27.716	15.403	20.908
	119	4.181	51.648	113.133	633.497	82.145	8.510	30.890	22.184	29.316
	Mean	**4.4531**	**53.9966**	**111.4976**	**577.7357**	**81.5881**	**10.2803**	**28.7172**	**18.5192**	**33.6172**
	SD	**1.05512**	**4.91192**	**11.40798**	**45.79772**	**5.70006**	**1.79551**	**1.46712**	**2.46290**	**12.65223**
High	105	dead	dead	dead	dead	dead	dead	dead	dead	dead
Concentration	107	6.515	48.109	100.683	567.927	75.854	9.431	29.567	11.481	58.770
	109	4.998	54.223	114.143	596.852	75.262	8.946	34.933	17.741	33.683
	111	3.543	56.448	119.650	699.339	105.574	9.164	31.034	19.650	26.453
	114	dead	dead	dead	dead	dead	dead	dead	dead	dead
	115	4.755	55.492	99.001	614.360	75.559	8.274	30.908	14.741	29.101
	Mean	**4.9525**	**53.5680**	**108.3695**	**619.6195**	**83.0623**	**8.9535**	**31.6106**	**15.9033**	**37.0017**
	SD	**1.22054**	**3.75151**	**10.12307**	**56.48979**	**15.00969**	**0.49455**	**2.31200**	**3.57445**	**14.81632**
Low	87	4.227	231.924	89.711	608.843	81.924	8.065	35.095	16.463	51.390
Concentration	94	4.858	52.453	96.565	610.451	79.490	8.587	31.796	16.585	23.405
	96	4.290	52.318	111.045	538.856	71.548	9.665	38.018	16.075	33.629
	97	4.208	61.535	111.287	614.851	74.653	7.970	37.327	18.119	57.772
	100	6.412	51.884	118.404	599.413	80.470	11.894	33.480	20.803	29.222
	103	4.750	59.186	126.321	641.057	77.702	9.549	35.482	23.170	29.229
	106	4.445	58.634	125.129	621.338	81.610	6.598	30.931	17.454	23.631
	108	4.356	55.566	99.468	570.571	83.591	11.713	33.930	21.442	50.242
	Mean	**4.7437**	**56.5204**	**115.2757**	**597.6811**	**78.2625**	**9.5650**	**34.8614**	**19.5106**	**37.2876**
	SD	**0.83854**	**3.91862**	**10.12489**	**37.24048**	**4.53638**	**2.06870**	**2.63238**	**2.71155**	**13.54484**

= no data

Table 1-4
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

1, 7, and 90-Day Hold Individual % Brain Weight Organ Weights (grams)
2 Minute Exposure

	Animal ID	Adrenals	Heart	Kidneys	Liver	Lungs	Ovaries	Spleen	Thymus	Uterus
1 Day Hold										
Control	123	3.756	48.543	97.141	584.305	77.242	9.249	33.352	29.709	27.971
	125	3.850	58.492	94.462	630.643	68.671	7.489	32.331	31.487	19.198
	134	4.196	46.213	93.134	552.970	65.395	8.501	22.507	30.899	24.687
	136	4.392	43.332	86.235	573.808	63.257	8.570	33.637	30.905	25.121
	137	4.955	51.450	92.567	581.655	75.540	10.859	30.785	39.852	24.302
	138	6.459	58.347	102.463	657.745	69.458	9.579	33.716	30.104	25.835
	Mean	**4.6013**	**51.0625**	**94.3336**	**596.8545**	**69.9272**	**9.0412**	**31.0548**	**32.1594**	**24.5188**
	SD	**1.00621**	**6.29356**	**5.36920**	**39.22964**	**5.51092**	**1.14531**	**4.33125**	**3.82169**	**2.91181**
High	120	5.371	57.910	100.992	584.238	81.553	6.597	34.209	30.706	21.891
Concentration	121	3.922	41.229	100.106	591.574	78.696	7.419	33.015	37.202	33.651
	124	3.880	46.286	87.860	476.885	66.962	7.816	29.601	22.727	32.927
	128	3.956	51.640	98.282	585.580	81.468	10.411	32.327	38.574	21.968
	131	5.073	55.017	100.902	586.640	84.837	10.203	28.129	29.369	23.844
	133	4.199	57.503	98.768	586.170	80.851	9.295	31.355	39.194	16.573
	135	4.092	57.567	101.906	669.058	80.437	10.650	42.433	37.500	21.693
	146	4.211	52.442	103.032	600.393	72.544	9.208	33.520	34.419	25.997
	Mean	**4.3381**	**52.4493**	**98.9811**	**585.0674**	**78.4185**	**8.9499**	**33.0736**	**33.7113**	**24.8181**
	SD	**0.56463**	**6.00797**	**4.75349**	**52.15337**	**5.80817**	**1.50945**	**4.29469**	**5.72308**	**5.86207**
Low	122	4.380	47.550	97.028	517.675	69.864	9.072	35.454	32.169	23.253
Concentration	126	4.279	53.538	97.148	561.986	76.413	8.393	33.022	36.917	26.221
	127	4.079	49.061	111.004	574.772	79.603	9.179	28.771	31.079	16.640
	129	4.846	51.172	96.873	580.406	71.287	12.090	32.569	43.460	31.110
	130	4.045	49.775	89.101	528.146	84.438	10.899	28.427	28.933	38.539
	140	4.597	44.025	90.909	480.286	61.236	8.274	27.681	22.829	22.625
	141	4.163	47.522	98.513	507.433	73.241	7.086	33.845	27.403	26.264
	142	3.968	51.314	100.858	695.013	88.418	8.311	33.351	40.268	24.021
	Mean	**4.2945**	**49.2446**	**97.6793**	**555.7147**	**75.5625**	**9.1629**	**31.6401**	**32.8823**	**26.0842**
	SD	**0.30138**	**2.92371**	**6.64527**	**66.16429**	**8.63945**	**1.60401**	**2.91148**	**6.89887**	**6.47930**
7-Day Hold										
Control	139	3.988	50.751	92.853	531.901	71.880	7.664	33.299	23.356	27.240
	144	3.511	47.074	90.798	564.787	72.340	9.309	30.266	34.096	30.213
	145	4.090	48.138	99.004	655.637	82.119	8.495	39.276	36.864	45.045
	151	5.446	47.339	105.260	562.376	67.017	8.973	49.134	36.386	39.790
	152	5.675	45.612	99.895	582.291	73.673	5.833	33.789	31.582	34.051
	166	5.089	64.150	119.016	682.438	83.613	11.074	31.823	29.027	29.698
	Mean	**4.6331**	**50.5108**	**101.1376**	**596.5718**	**75.1070**	**8.5579**	**36.2645**	**31.8851**	**34.3394**
	SD	**0.88609**	**6.89311**	**10.18090**	**59.03846**	**6.43553**	**1.74890**	**7.00455**	**5.11759**	**6.83176**
High	150	4.917	51.398	108.903	675.621	73.861	9.420	38.561	30.435	20.963
Concentration	153	4.287	62.082	130.067	689.922	84.855	12.918	34.855	43.151	23.998
	154	4.688	54.940	104.133	619.103	73.589	8.014	40.675	41.381	19.052
	155	4.150	50.084	96.747	549.972	75.210	10.151	32.305	36.231	24.397
	158	5.211	45.397	111.928	678.518	76.896	10.886	31.384	34.395	21.367
	163	4.968	61.058	105.929	621.100	76.282	8.066	28.419	26.709	22.917
	169	4.954	52.823	109.677	639.113	81.164	12.442	33.007	30.357	25.806
	172	7.066	46.467	101.285	607.227	73.448	11.188	30.032	27.944	26.927
	Mean	**5.0302**	**53.0309**	**108.5837**	**635.0720**	**76.9131**	**10.3858**	**33.6548**	**33.8255**	**23.1784**
	SD	**0.89800**	**6.12683**	**9.95878**	**46.32832**	**4.08512**	**1.83328**	**4.18738**	**6.08187**	**2.62953**
Low	147	4.821	60.076	103.954	651.300	70.531	9.642	31.365	33.965	36.132
Concentration	148	4.413	50.702	101.505	597.392	77.683	7.523	30.692	30.241	18.054
	149	4.675	49.024	107.282	564.697	83.325	9.815	34.776	29.710	26.966
	156	3.994	53.461	111.448	618.850	80.564	8.413	29.659	30.511	23.642
	160	4.107	43.253	88.800	537.707	99.040	8.640	28.853	41.333	21.707
	161	5.664	59.911	107.829	655.858	90.727	8.717	29.373	34.870	56.746
	162	4.184	46.287	92.312	541.946	74.425	11.768	28.713	28.086	21.548
	164	4.975	45.108	100.221	592.316	84.743	10.392	29.298	34.273	19.900
	Mean	**4.6041**	**50.9777**	**101.6689**	**595.0081**	**82.6297**	**9.3639**	**30.3412**	**32.8736**	**28.0870**
	SD	**0.55359**	**6.42286**	**7.79750**	**45.46696**	**9.12029**	**1.32850**	**2.00684**	**4.21134**	**12.86320**
90-Day Hold	174	3.806	70.440	107.266	663.569	84.132	10.331	35.887	25.655	27.187
Control	175	4.668	57.757	124.165	631.991	95.789	12.403	42.517	32.311	34.371
	177	4.559	54.764	107.684	584.631	90.881	10.348	39.088	18.955	61.527
	178	3.753	49.929	94.964	499.192	65.083	8.361	26.983	18.670	35.202
	179	5.303	56.818	102.525	611.869	85.606	9.646	32.879	21.263	51.970
	181	3.606	48.553	90.300	552.412	84.764	10.767	29.203	19.096	32.199
	Mean	**4.2826**	**56.3769**	**104.4841**	**590.6107**	**84.3760**	**10.3094**	**34.4262**	**22.6583**	**40.4092**
	SD	**0.66813**	**7.81369**	**11.84038**	**58.88853**	**10.45487**	**1.32883**	**5.90606**	**5.41146**	**13.30710**
	173	3.264	58.111	102.868	627.003	71.167	8.902	57.221	13.749	46.736
High	182	5.355	60.917	123.738	774.614	83.934	13.388	37.178	24.047	29.763
Concentration	183	5.164	74.648	131.162	855.692	93.134	13.556	39.319	77.406	48.650
	184	4.561	61.973	99.108	606.098	86.415	8.032	37.581	20.526	41.398
	185	8.935	152.921	265.063	1450.630	191.638	22.795	69.301	60.481	114.204
	186	4.078	53.301	104.369	567.330	104.612	7.670	29.612	15.777	51.408
	187	4.741	61.526	111.444	609.046	84.414	12.316	35.204	14.387	32.861
	188	4.670	61.168	109.645	739.898	81.878	9.188	34.975	24.010	32.132
	Mean	**5.0961**	**73.0705**	**130.9246**	**778.7890**	**99.6491**	**11.9809**	**42.5488**	**31.2978**	**49.6440**
	SD	**1.68157**	**32.81776**	**55.26793**	**289.13738**	**38.37830**	**4.97106**	**13.48857**	**24.00658**	**27.33945**
	165	3.579	54.448	101.892	625.818	77.761	6.902	25.869	17.945	25.051
Low	167	5.007	58.949	114.675	784.085	79.970	6.842	30.144	13.188	39.018
Concentration	168	5.521	66.563	103.333	663.021	85.938	8.906	30.885	22.865	64.583
	170	3.470	48.482	96.482	580.048	95.566	8.867	34.651	15.759	26.313
	171	3.746	58.200	108.588	638.008	53.403	7.355	33.714	18.045	90.132
	176	4.369	79.369	103.208	674.115	91.427	4.757	35.343	18.750	32.743
	180	4.500	55.187	116.343	719.138	76.457	7.911	25.580	24.775	31.549
	189	5.388	60.697	122.821	721.130	109.931	11.992	29.847	13.471	29.900
	Mean	**4.4476**	**60.2369**	**108.4178**	**675.6705**	**83.8066**	**7.9414**	**30.7541**	**18.0996**	**42.4113**
	SD	**0.80730**	**9.32953**	**8.84383**	**64.27570**	**16.53157**	**2.10338**	**3.71955**	**4.11870**	**23.01846**

APPENDIX J

SUMMARY OF HEMATOLOGY AND INDIVIDUAL DATA

Table J-1
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of Hematology
10 Minute Exposure

		1 Day Hold			7 Day Hold			90 Day Hold		
Period		Control	High	Low	Control	High	Low	Control	High	Low
WBC	Mean	9.903	7.015	5.437	9.880	12.322	11.096	11.285	9.448	10.044
	S.D.	1.3640	3.9811	2.0931	1.8143	5.8459	2.4218	4.1802	2.1250	2.7641
	N	6	4	6	6	5	8	6	4	8
NEU	Mean	1.0130	0.5300	0.8070	0.7425	1.1178	0.9116	0.8055	0.7865	0.6696
	S.D.	0.22968	0.31939	0.40139	0.34834	0.56499	0.34994	0.52563	0.32077	0.26082
	N	6	4	6	6	5	8	6	4	8
% NEU	Mean	10.3250	7.0325	15.1983	7.7783	9.1140	8.1488	6.9050	8.6575	6.7475
	S.D.	1.47955	3.69854	8.08446	4.30933	2.23805	2.14892	4.07405	4.46133	1.88655
	N	6	4	6	6	5	8	6	4	8
LYM	Mean	8.2000	6.1375	4.1967	8.4367	10.2280	9.4250	9.6767	8.0900	8.7475
	S.D.	1.20966	3.47727	1.75090	1.94345	5.00018	1.96749	3.56462	2.05786	2.32899
	N	6	4	6	6	5	8	6	4	8
%LYM	Mean	83.8167	88.4500	76.6500[A]	84.9667	82.6600	85.1875	86.0667	85.1500	87.2750
	S.D.	2.33188	3.51805	9.04892	7.57197	2.29848	2.72891	5.76183	5.33198	2.14326
	N	6	4	6	6	5	8	6	4	8
MONO	Mean	0.3968	0.2670	0.2697	0.4157	0.5528	0.3949	0.5635	0.3775	0.3299
	S.D.	0.05899	0.23648	0.14455	0.14153	0.17729	0.17384	0.32022	0.14775	0.17013
	N	6	4	6	6	5	8	6	4	8
% MONO	Mean	4.1000	3.3125	4.9783	4.3750	4.8300	3.5113	4.8100	4.0450	3.1825
	S.D.	0.73675	2.02329	1.46038	1.90903	1.78645	1.09111	1.34338	1.38700	1.08856
	N	6	4	6	6	5	8	6	4	8
EOS	Mean	0.0635	0.0425	0.0693	0.0715	0.1460	0.0993	0.0683	0.0595	0.0834
	S.D.	0.03742	0.03317	0.03495	0.03784	0.09336	0.04892	0.03763	0.03313	0.03820
	N	6	4	6	6	5	8	6	4	8
% EOS	Mean	0.6535	0.7008	1.3402[C]	0.7120	1.1386	0.9045[C]	0.6088	0.6585	0.846[C]
	S.D.	0.34568	0.44711	0.74149	0.36043	0.38595	0.45758	0.37605	0.39773	0.33055
	N	6	4	6	6	5	8	6	4	8
BASO	Mean	0.1068	0.0323	0.0925	0.2142	0.2700	0.2539	0.1800	0.1431	0.2086
	S.D.	0.07250	0.02254	0.02990	0.12590	0.13832	0.12011	0.10326	0.08237	0.15615
	N	6	4	6	6	5	8	6	4	8
% BASO	Mean	1.1050	0.4983	1.8423	2.1883	2.2400	2.2588	1.6007	1.4995	1.9444
	S.D.	0.77498	0.24338	0.63494	1.33359	0.89830	0.88690	0.90566	0.97654	1.08329
	N	6	4	6	6	5	8	6	4	8
RBC	Mean	6.610	6.168	6.660	6.938	6.890	7.016	7.683	7.830	7.573
	S.D.	0.4264	0.8475	0.2065	0.1597	0.3924	0.2907	0.4236	0.3574	0.3883
	N	6	4	6	6	5	8	6	4	8
HGB	Mean	13.67	12.50	13.25	13.87	13.70	13.49	14.33	14.38	14.19
	S.D.	0.873	1.627	0.362	0.258	0.854	0.587	0.403	1.044	0.795
	N	6	4	6	6	5	8	6	4	8
HCT	Mean	38.70	36.68	37.92	39.88	39.68	39.61	41.70	41.05	40.91
	S.D.	2.212	4.355	1.235	0.813	1.564	1.931	1.200	2.876	1.796
	N	6	4	6	6	5	8	6	4	8
MCV	Mean	58.60	59.65	56.95	57.50	57.66	56.44	54.33	52.45	54.08
	S.D.	0.883	3.214	1.638	0.486	1.827	1.108	1.841	2.512	1.307
	N	6	4	6	6	5	8	6	4	8
MCH	Mean	20.70	20.33	19.88	19.97	19.92	19.26	18.73	18.35	18.75
	S.D.	0.529	0.785	0.538	0.505	0.779	0.607	0.742	0.810	0.769
	N	6	4	6	6	5	8	6	4	8
MCHC	Mean	35.33	34.08	34.92	34.72	34.54	34.10	34.43	35.05	34.68
	S.D.	1.316	0.964	0.523	0.900	0.942	0.748	0.480	0.404	1.046
	N	6	4	6	6	5	8	6	4	8
RDW	Mean	14.88	14.80	14.40	14.00	15.74	14.53[B]	15.73	14.85	15.16
	S.D.	0.615	0.716	0.684	0.899	0.971	0.555	0.532	0.603	0.961
	N	6	4	6	6	5	8	6	4	8
PLT	Mean	947.00	676.18	607.60[D]	854.50	782.80	634.18[D]	821.83	806.75	595.36[D]
	S.D.	129.769	556.080	429.369	194.135	340.851	374.055	130.128	97.247	343.600
	N	6	4	6	6	5	8	6	4	8
MPV	Mean	5.695	5.773	6.105	5.412	5.778	5.247	5.682	5.623	5.709
	S.D.	0.6146	0.4500	0.7886	0.4601	0.5192	0.4383	0.3518	0.4020	0.5247
	N	6	4	6	6	5	8	6	4	8

[A] significantly different from high dose group
[B] significantly different from high dose group
[C] significantly different from controls
[D] significantly different from controls
[ABCD] p less than or equal to 0.05

Table J-2
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of Hematology
2 Minute Exposure

Period		1 Day Hold			7 Day Hold			90 Day Hold		
		Control	High	Low	Control	High	Low	Control	High	Low
WBC	Mean	6.902	9.026	10.355	8.827	10.444	10.579	8.438	9.798	6.964
	S.D.	1.9560	2.5497	2.5106	3.7891	2.5307	3.3242	3.0504	4.2838	2.7751
	N	5	7	8	6	8	7	4	8	7
NEU	Mean	2.1762	0.8087	0.9976	0.6775	0.7561	0.7226	0.5998	1.8190	0.5863
	S.D.	3.35195	0.42095	0.43550	0.24279	0.38080	0.23974	0.28520	3.39231	0.37347
	N	5	7	8	6	8	7	4	8	7
%NEU	Mean	10.5820	9.1271	9.8088	9.6867	7.4175	7.2729	7.4600	12.8800	8.1800
	S.D.	1.82960	4.24055	3.95562	7.83450	3.46984	2.77439	3.34174	15.74325	2.17305
	N	5	7	8	6	8	7	4	8	7
LYM	Mean	5.6880	6.4267	8.7213	7.6050	9.0463	9.1486	7.4150	7.1750	5.8586
	S.D.	1.77833	3.27698	2.47690	3.58527	2.35091	3.16889	2.78123	1.21910	2.16949
	N	5	7	8	6	8	7	4	8	7
%LYM	Mean	81.8000	84.1571	83.4500	83.4000	86.3750	85.4857	87.2750	79.4750	84.8000
	S.D.	3.17096	5.56563	6.08722	11.25184	4.67447	4.84232	4.31770	17.21708	1.98830
	N	5	7	8	6	8	7	4	8	7
MONO	Mean	0.2398	0.3123	0.2956	0.2937	0.3586	0.3689	0.2185	0.4170	0.2530
	S.D.	0.05865	0.12279	0.09513	0.11585	0.14336	0.12387	0.07567	0.23005	0.12627
	N	5	7	8	6	8	7	4	8	7
% MONO	Mean	3.5200	3.4871	3.1950	3.8883	3.3900	3.7514	2.6200	4.1388	3.5657
	S.D.	0.38852	1.31644	1.86910	2.22670	0.97901	1.69724	0.22760	0.65984	0.99483
	N	5	7	8	6	8	7	4	8	7
EOS	Mean	0.0820	0.0804	0.0958	0.0573	0.0968	0.0927	0.0813	0.0900	0.0501
	S.D.	0.02623	0.01452	0.03342	0.02106	0.02744	0.06074	0.02317	0.03050	0.03177
	N	5	7	8	6	8	7	4	8	7
% EOS	Mean	1.2960	0.9346	1.0773	0.9495	0.9649	0.9339	1.0548	0.9800	0.7084
	S.D.	0.57950	0.23459	0.76608	1.04549	0.33388	0.66500	0.45232	0.38391	0.33206
	N	5	7	8	6	8	7	4	8	7
BASO	Mean	0.1864	0.2104	0.2408	0.1738	0.1924	0.2574	0.1248	0.3020	0.2073
	S.D.	0.08855	0.09370	0.09488	0.06426	0.07666	0.11179	0.04219	0.37360	0.14159
	N	5	7	8	6	8	7	4	8	7
% BASO	Mean	2.7720	2.3014	2.4813	2.0550	1.8450	2.5500	1.5850	2.5261	2.7671
	S.D.	1.30854	0.60513	1.19466	0.36861	0.52337	1.04677	0.59763	1.67612	1.18737
	N	5	7	8	6	8	7	4	8	7
RBC	Mean	6.364	6.549	6.728	6.737	6.914	6.890	7.320	7.451	7.167
	S.D.	0.3610	0.5681	0.3922	0.3878	0.4071	0.4545	0.2821	0.3964	0.3263
	N	5	7	8	6	8	7	4	8	7
HGB	Mean	13.120	13.157	13.463	13.400	13.638	13.543	13.675	13.488	13.400
	S.D.	0.7328	0.8162	0.7070	0.4817	0.6823	0.9537	0.2872	0.5817	0.6218
	N	5	7	8	6	8	7	4	8	7
HCT	Mean	37.90	38.04	37.98	38.68	39.34	39.03	39.23	39.89	38.57
	S.D.	1.979	2.089	1.711	1.477	1.968	2.765	1.801	1.908	2.271
	N	5	7	8	6	8	7	4	8	7
MCV	Mean	59.60	58.23	56.51	57.48	56.94	56.64	53.58	53.56	53.79
	S.D.	0.957	2.168	1.642	1.450	1.308	1.864	2.082	0.980	1.301
	N	5	7	8	6	8	7	4	8	7
MCH	Mean	20.62	20.16	20.01	19.95	19.76	19.69	18.70	18.08	18.69
	S.D.	0.567	0.990	0.579	0.817	0.793	1.096	0.424	0.557	0.385
	N	5	7	8	6	8	7	4	8	7
MCHC	Mean	34.58	34.60	35.43	34.72	34.71	34.73	34.93	33.80	34.73
	S.D.	0.563	0.968	0.607	0.783	0.960	0.934	1.406	0.668	0.695
	N	5	7	8	6	8	7	4	8	7
RDW	Mean	14.56	13.96	14.83*	13.72	14.56	13.64*	15.13	15.15	14.69
	S.D.	0.439	0.493	0.688	0.655	0.670	0.718	0.403	0.674	0.573
	N	5	7	8	6	8	7	4	8	7
PLT	Mean	392.392	429.010	600.850	470.378	648.750	600.216	797.000	663.000	828.429
	S.D.	373.4849	406.6127	388.4760	450.4295	307.8356	433.3615	243.1940	243.2342	139.4619
	N	5	7	8	6	8	7	4	8	7
MPV	Mean	5.663	5.550	5.683	5.330	5.336	5.292	5.505	5.714	5.580
	S.D.	0.6518	0.4089	0.6032	0.1807	0.3898	0.3848	0.5415	0.5917	0.1690
	N	5	7	8	6	8	7	4	8	7

* signficantly different than the high dose group
p less than or equal to 0.05

Table J-3
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

1, 7, and 90-Day Hold Individual Hematology
10 Minute Exposure

	Animal ID	WBC	NEU	% NEU	LYM	% LYM	MONO	% MONO	EOS	% EOS	BASO	% BASO	RBC	HGB	HCT	MCV	MCH	MCHC	RDW	PLT	MPV	Description
1 Day Hold Control	52	9.02	0.809	8.980	7.770	86.200	0.350	3.880	0.054	0.601	0.035	0.388	6.28	12.7	37.3	59.5	20.3	34.1	14.2	969.0	5.17	
	55	8.29	0.996	12.000	6.710	80.900	0.461	5.560	0.081	0.983	0.045	0.546	6.24	12.7	37.1	59.5	20.4	34.3	15.2	1002.0	5.27	
	56	11.60	1.100	9.510	9.960	86.200	0.422	3.650	0.024	0.208	0.048	0.416	7.34	14.7	42.9	58.4	20.0	34.2	14.9	887.0	5.54	
	57	9.80	0.885	9.750	7.680	84.500	0.323	3.550	0.034	0.372	0.167	1.840	6.34	13.4	37.4	59.0	21.1	35.7	15.0	726.0	5.68	
	59	9.21	0.858	9.310	7.730	83.900	0.365	3.970	0.060	0.647	0.200	2.170	6.61	14.0	38.2	57.8	21.2	36.7	14.2	988.0	6.88	
	62	11.50	1.430	12.400	9.350	81.200	0.460	3.990	0.128	1.110	0.146	1.270	6.85	14.5	39.3	57.4	21.2	37.0	15.8	1110.0	5.63	
	Mean	**9.903**	**1.0130**	**10.3250**	**8.2000**	**83.8167**	**0.3968**	**4.1000**	**0.0635**	**0.6535**	**0.1068**	**1.1050**	**6.610**	**13.67**	**38.70**	**58.60**	**20.70**	**35.33**	**14.88**	**947.00**	**5.695**	
	SD	**1.3640**	**0.22968**	**1.47955**	**1.20966**	**2.33188**	**0.05899**	**0.73675**	**0.03742**	**0.34568**	**0.07250**	**0.77498**	**0.4264**	**0.873**	**2.212**	**0.883**	**0.529**	**1.316**	**0.615**	**129.769**	**0.6146**	
High Concentration	50	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	
	54	6.34	0.737	11.600	5.490	86.500	0.086	1.350	0.018	0.281	0.012	0.194	7.07	13.6	38.9	55.1	19.3	35.0	15.2	380.0	6.28	
	60	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	
	61	8.25	0.650	7.870	7.030	85.200	0.482	5.840	0.036	0.440	0.056	0.673	6.09	12.5	38.1	62.5	20.5	32.8	14.3	1232.0	5.42	
	63	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	
	70	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	
	77	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	
	79	11.50	0.679	5.890	10.200	88.900	0.460	4.000	0.091	0.792	0.047	0.411	6.46	13.7	39.5	61.1	21.2	34.6	15.6	1045.0	5.62	
	80	1.97	0.054	2.770	1.830	93.200	0.040	2.060	0.025	1.290	0.014	0.715	5.05	10.2	30.2	59.9	20.3	33.9	14.1	47.7	ND	hemolyzed
	Mean	**7.015**	**0.5300**	**7.0325**	**6.1375**	**88.4500**	**0.2670**	**3.3125**	**0.0425**	**0.7008**	**0.0323**	**0.4983**	**6.168**	**12.50**	**36.68**	**59.65**	**20.33**	**34.08**	**14.80**	**676.18**	**5.773**	
	SD	**3.9811**	**0.31939**	**3.69854**	**3.47727**	**3.51805**	**0.23648**	**2.02329**	**0.03317**	**0.44711**	**0.02254**	**0.24338**	**0.8475**	**1.627**	**4.355**	**3.214**	**0.785**	**0.964**	**0.716**	**556.080**	**0.4500**	
Low Concentration	51	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	hemolyzed
	53	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
	58	7.50	1.400	18.700	5.330	71.000	0.542	7.220	0.104	1.380	0.130	1.730	7.01	13.3	38.1	54.4	18.9	34.8	15.7	951.0	3.61	
	64	7.80	0.855	11.000	6.470	83.000	0.267	3.420	0.101	1.300	0.105	1.340	6.81	13.8	40.2	59.1	20.2	34.2	14.2	970.0	5.65	hemolyzed
	66	6.06	0.669	11.000	4.980	82.300	0.288	4.750	0.062	1.020	0.036	0.924	6.52	13.2	37.9	58.1	20.2	34.8	14.0	824.0	5.37	
	67	2.73	0.180	6.590	2.290	83.900	0.171	6.260	0.029	1.070	0.060	2.190	6.51	12.7	36.6	56.2	19.6	34.8	14.6	777.0	6.22	hemolyzed
	68	5.16	0.743	14.400	4.060	78.800	0.209	4.050	0.028	0.541	0.115	2.230	6.51	13.1	37.4	57.4	20.2	35.1	13.9	37.2	6.23	
	72	3.37	0.995	29.500	2.050	60.900	0.141	4.170	0.092	2.730	0.089	2.640	6.60	13.4	37.3	56.5	20.2	35.8	14.0	86.4	7.55	
	Mean	**5.437**	**0.8070**	**15.1983**	**4.1967**	**76.6500**	**0.2697**	**4.9783**	**0.0693**	**1.3402**	**0.0925**	**1.8423**	**6.660**	**13.25**	**37.92**	**56.95**	**19.08**	**34.92**	**14.40**	**607.60**	**6.105**	
	SD	**2.0931**	**0.40139**	**8.08446**	**1.75090**	**9.04892**	**0.14455**	**1.46038**	**0.03495**	**0.74149**	**0.02990**	**0.63494**	**0.2065**	**0.362**	**1.235**	**1.638**	**0.538**	**0.523**	**0.684**	**429.369**	**0.7886**	
7-Day Hold Control	65	9.18	0.618	6.730	8.100	88.200	0.281	3.060	0.049	0.539	0.133	1.440	6.97	14.1	40.2	57.7	20.2	35.0	13.0	533.0	5.58	
	69	13.10	0.726	5.540	11.500	88.100	0.379	2.890	0.116	0.886	0.332	2.540	6.84	14.1	38.9	56.9	20.7	36.3	13.3	855.0	5.07	
	71	8.75	1.440	16.500	6.100	69.700	0.687	7.850	0.116	1.320	0.413	4.710	6.89	13.9	39.8	57.8	20.1	34.8	14.3	930.0	5.09	
	76	9.11	0.570	6.250	7.990	87.700	0.360	3.950	0.061	0.668	0.134	1.470	6.79	13.6	39.5	58.2	20.0	34.4	13.5	808.0	5.06	
	93	8.24	0.529	6.420	7.100	86.200	0.432	5.250	0.021	0.259	0.156	1.900	7.24	14.0	41.3	57.1	19.3	33.8	14.5	869.0	6.24	
	98	10.90	0.572	5.230	9.830	89.900	0.355	3.250	0.066	0.600	0.117	1.070	6.90	13.5	39.6	57.3	19.5	34.0	15.4	1132.0	5.43	
	Mean	**9.880**	**0.7425**	**7.7783**	**8.4367**	**84.9667**	**0.4157**	**4.3750**	**0.0715**	**0.7120**	**0.2142**	**2.1883**	**6.938**	**13.87**	**39.88**	**57.50**	**19.97**	**34.72**	**14.00**	**854.50**	**5.412**	
	SD	**1.8143**	**0.34834**	**4.30933**	**1.94345**	**7.57197**	**0.14153**	**1.90903**	**0.03784**	**0.36043**	**0.12598**	**1.33359**	**0.1597**	**0.258**	**0.813**	**0.486**	**0.505**	**0.900**	**0.899**	**194.135**	**0.4601**	
High Concentration	85	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	
	86	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	
	88	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	
	89	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	
	90	22.50	2.060	9.150	18.900	84.100	0.750	3.330	0.299	1.330	0.473	2.100	6.83	13.6	39.9	58.4	19.9	34.1	15.5	180.0	6.24	
	91	11.80	1.120	9.500	9.770	82.900	0.529	4.500	0.120	1.020	0.242	2.050	6.33	13.0	38.2	60.4	20.6	34.0	14.4	870.0	6.32	
	92	8.97	0.623	6.940	7.160	79.800	0.711	7.920	0.139	1.540	0.339	3.780	7.28	14.0	40.7	55.9	19.2	34.4	16.0	992.0	5.15	
	95	8.24	1.040	12.600	6.670	81.000	0.331	4.020	0.044	0.533	0.150	1.820	7.25	15.0	41.6	57.4	20.8	36.2	13.7	897.0	5.82	
	101	10.10	0.746	7.380	8.640	85.500	0.443	4.380	0.128	1.270	0.146	1.450	6.76	12.9	38.0	56.2	19.1	34.0	17.1	975.0	5.36	
	Mean	**12.322**	**1.1178**	**9.1140**	**10.2280**	**82.6600**	**0.5528**	**4.8300**	**0.1460**	**1.1386**	**0.2700**	**2.2400**	**6.890**	**13.70**	**39.68**	**57.66**	**19.92**	**34.54**	**15.74**	**782.80**	**5.778**	
	SD	**5.8459**	**0.56499**	**2.23805**	**5.00818**	**2.29848**	**0.17729**	**1.78645**	**0.09336**	**0.38595**	**0.13832**	**0.89830**	**0.3924**	**0.854**	**1.564**	**1.827**	**0.779**	**0.942**	**0.971**	**340.851**	**0.5192**	
Low Concentration	73	13.60	1.360	9.990	11.000	81.100	0.753	5.540	0.120	0.882	0.340	2.500	6.96	13.9	40.5	58.1	20.0	34.4	13.7	763.0	5.66	
	74	8.89	0.856	9.630	7.390	83.200	0.337	3.800	0.055	0.616	0.247	2.780	6.51	12.8	36.8	56.5	19.7	34.8	14.9	738.0	4.99	
	75	11.00	0.592	5.380	9.580	87.100	0.461	4.190	0.064	0.582	0.305	2.780	7.12	14.1	40.4	56.8	19.7	34.8	14.1	64.5	ND	
	78	9.81	0.475	4.840	8.870	90.400	0.228	2.320	0.079	0.805	0.164	1.670	6.99	12.6	38.2	54.5	18.1	33.1	15.1	8.97	ND	
	81	12.30	0.828	6.750	10.400	84.800	0.487	3.970	0.067	0.548	0.476	3.880	7.51	14.2	43.1	57.4	18.9	32.9	14.8	917.0	5.54	
	82	13.20	1.480	9.730	12.900	85.100	0.382	2.520	0.154	1.020	0.249	1.640	7.22	13.6	40.2	55.7	18.9	33.9	14.4	903.0	4.50	
	83	8.26	0.744	9.010	7.050	85.300	0.266	3.230	0.068	0.820	0.136	1.640	6.83	13.2	38.1	55.8	19.4	34.7	14.0	845.0	5.53	
	84	9.71	0.958	9.860	8.210	84.500	0.245	2.520	0.187	1.963	0.114	1.180	6.99	13.5	39.6	56.7	19.4	34.2	15.2	834.0	5.26	
	Mean	**11.096**	**0.9116**	**8.1488**	**9.4250**	**85.1875**	**0.3949**	**3.5113**	**0.0993**	**0.9045**	**0.2539**	**2.2588**	**7.016**	**13.49**	**39.61**	**56.44**	**19.26**	**34.10**	**14.53**	**634.18**	**5.247**	
	SD	**2.4218**	**0.34994**	**2.14892**	**1.96749**	**2.72891**	**0.17384**	**1.09111**	**0.04892**	**0.45758**	**0.12011**	**0.88690**	**0.2907**	**0.587**	**1.931**	**1.108**	**0.607**	**0.748**	**0.555**	**374.055**	**0.4383**	
90-Day Hold Control	99	12.50	0.564	4.510	11.300	90.200	0.504	4.030	0.062	0.493	0.092	0.735	8.04	14.70	43.4	54.0	18.3	33.9	15.9	898.00	5.75	
	102	5.41	0.190	3.510	4.950	91.500	0.219	4.060	0.007	0.135	0.043	0.799	8.07	14.80	42.7	52.9	18.4	34.8	16.6	987.00	5.81	
	104	18.30	1.260	6.880	15.600	85.400	1.130	6.200	0.054	0.295	0.227	1.240	7.80	14.30	41.8	53.5	18.4	34.3	15.6	718.00	5.26	
	117	10.50	0.535	5.080	9.470	89.800	0.311	2.950	0.078	0.736	0.146	1.390	7.87	14.10	41.2	52.4	18.0	34.3	15.3	887.00	5.24	
	118	10.90	1.610	14.800	8.290	76.200	0.579	5.330	0.091	0.834	0.308	2.840	7.05	13.70	40.1	56.8	19.4	34.1	15.9	631.00	6.05	
	119	10.10	0.674	6.650	8.450	83.300	0.638	6.290	0.118	1.160	0.264	2.600	7.27	14.4	41.0	56.4	19.9	35.2	15.1	810.0	5.98	
	Mean	**11.285**	**0.8055**	**6.9050**	**9.6767**	**86.0667**	**0.5635**	**4.8100**	**0.0683**	**0.6088**	**0.1800**	**1.6007**	**7.683**	**14.33**	**41.70**	**54.33**	**18.73**	**34.43**	**15.73**	**821.83**	**5.682**	
	SD	**4.1802**	**0.52563**	**4.07405**	**3.56462**	**5.76183**	**0.32022**	**1.34338**	**0.03763**	**0.37605**	**0.10326**	**0.90566**	**0.4236**	**0.403**	**1.200**	**1.841**	**0.742**	**0.480**	**0.532**	**130.128**	**0.3518**	
High Concentration	105	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	
	107	7.32	1.100	15.000	5.700	77.900	0.404	5.520	0.079	1.080	0.047	0.569	7.79	13.40	37.9	48.7	17.2	35.4	14.3	872.00	5.82	
	109	8.07	0.457	5.670	7.080	87.800	0.271	3.350	0.029	0.355	0.227	2.810	7.93	14.70	42.3	53.4	18.5	34.7	14.6	846.00	5.10	serum lipemic - 1:1 Dilution; TRIG
	111	11.90	1.020	8.550	10.100	84.700	0.576	4.840	0.034	0.285	0.194	1.630	8.23	15.70	44.4	54.0	19.1	35.4	15.7	847.00	5.54	slightly lipemic
	114	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	
	115	10.50	0.569	5.410	9.480	90.200	0.259	2.470	0.096	0.914	0.104	0.989	7.37	13.7	39.6	53.7	18.6	34.7	14.8	662.0	6.03	
	Mean	**9.448**	**0.7865**	**8.6575**	**8.0900**	**85.1500**	**0.3775**	**4.0450**	**0.0595**	**0.6585**	**0.1431**	**1.4995**	**7.830**	**14.38**	**41.05**	**52.45**	**18.35**	**35.05**	**14.85**	**806.75**	**5.623**	
	SD	**2.1250**	**0.32077**	**4.46133**	**2.05786**	**5.33198**	**0.14775**	**1.38700**	**0.03313**	**0.39773**	**0.08237**	**0.97654**	**0.3574**	**1.044**	**2.876**	**2.512**	**0.810**	**0.404**	**0.603**	**97.247**	**0.4020**	
Low Concentration	87	7.23	0.343	4.750	6.560	90.700	0.166	2.300	0.062	0.854	0.100	1.380	6.98	13.60	39.0	55.9	19.5	34.8	13.6	636.00	5.29	
	94	10.40	0.549	5.280	9.180	88.300	0.300	2.890	0.155	1.490	0.214	2.060	7.50	13.50	39.4	52.5	18.0	34.3	16.5	856.00	5.37	
	96	12.80	1.140	8.950	10.900	85.200	0.454	3.550	0.093	0.727	0.203	1.590	7.63	15.40	41.6	54.6	20.2	37.1	15.0	622.00	5.78	
	97	8.47	0.643	7.600	7.570	89.400	0.096	1.140	0.067	0.793	0.087	1.030	7.17	13.10	38.7	54.0	18.3	33.9	14.4	66.50	5.09	serum slightly hemolyzed
	100	12.30	0.753	6.150	10.400	84.900	0.479	3.910	0.108	0.881	0.504	4.120	7.50	13.80	40.4	53.8	18.4	34.2	14.5	809.00	5.25	
	103	10.70	0.926	8.640	9.330	87.000	0.333	3.110	0.032	0.298	0.097	0.905	7.84	14.70	41.9	53.5	18.7	34.9	15.7	679.00	6.33	
	106	13.00	0.545	4.200	11.400	87.600	0.594	4.580	0.096	0.738	0.379	2.920	8.23	14.80	43.2	52.5	18.0	34.3	16.0	1005.00	6.29	
	108	5.45	0.458	8.410	4.640	85.100	0.217	3.980	0.054	0.987	0.085	1.550	7.73	14.6	43.1	55.8	18.9	33.9	15.6	89.4	6.27	
	Mean	**10.044**	**0.6696**	**6.7475**	**8.7475**	**87.2750**	**0.3299**	**3.1825**	**0.0834**	**0.8460**	**0.2086**	**1.9444**	**7.573**	**14.19**	**40.91**	**54.08**	**18.75**	**34.68**	**15.16**	**595.36**	**5.709**	
	SD	**2.7641**	**0.26082**	**1.88655**	**2.32899**	**2.14326**	**0.17013**	**1.08856**	**0.03820**	**0.33055**	**0.15615**	**1.08329**	**0.3883**	**0.795**	**1.796**	**1.307**	**0.769**	**1.046**	**0.961**	**343.600**	**0.5247**	

NS = No Sample
ND = No Data

Table J-4
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

1, 7, and 90-Day Hold Individual Hematology
2 Minute Exposure

	Animal ID	WBC	NEU	% NEU	LYM	% LYM	MONO	% MONO	EOS	%EOS	BASO	% BASO	RBC	HGB	HCT	MCV	MCH	MCHC	RDW	PLT	MPV	Description
1 Day Hold Control	123	8.68	0.779	8.980	7.400	85.200	0.304	3.500	0.060	0.687	0.139	1.600	6.53	13.10	38.3	58.6	20.0	34.1	15.0	897.00	5.25	
	125	8.61	8.170	9.480	7.260	84.300	0.258	2.990	0.059	0.683	0.217	2.520	6.32	13.60	38.6	61.1	21.5	35.3	14.6	372.00	5.15	
	134	ss	ss	ss	ss	ss	ss	ss	ss	ss	ss	ss	ss	ss	ss	ss	ss	ss	ss	ss	ss	short sample
	136	4.60	0.627	13.600	3.550	77.200	0.157	3.420	0.073	1.580	0.191	4.160	6.15	12.80	36.5	59.5	20.8	35.0	14.9	3.76	ND	
	137	7.58	0.755	9.950	6.120	80.700	0.275	3.620	0.119	1.570	0.311	4.110	6.88	14.00	40.6	59.0	20.4	34.5	14.4	73.20	6.58	slide error - electrolytes only
	138	5.04	0.550	10.900	4.110	81.600	0.205	4.070	0.099	1.960	0.074	1.470	5.94	12.10	35.5	59.8	20.4	34.0	13.9	616.00	5.67	
	Mean	**6.902**	**2.1762**	**10.5820**	**5.6880**	**81.8000**	**0.2398**	**3.5200**	**0.0820**	**1.2960**	**0.1864**	**2.7720**	**6.364**	**13.120**	**37.90**	**59.60**	**20.62**	**34.58**	**14.56**	**392.392**	**5.663**	
	SD	**1.9560**	**3.35195**	**1.82960**	**1.77833**	**3.17096**	**0.05865**	**0.38852**	**0.02623**	**0.57950**	**0.08855**	**1.30854**	**0.3610**	**0.7328**	**1.979**	**0.957**	**0.567**	**0.563**	**0.439**	**373.4849**	**0.6518**	
High Concentration	120	6.00	0.295	4.920	5.380	89.700	0.110	1.830	0.061	1.020	0.154	2.570	6.32	12.50	36.6	57.9	19.8	34.2	14.2	2.37	ND	
	121	ND	ND	ND	ND	ND	ND	ND	NO	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	hemolyzed
	124	8.74	0.680	7.790	7.480	85.600	0.299	3.430	0.070	0.804	0.209	2.390	6.45	13.10	38.6	59.9	20.3	33.9	13.8	47.60	5.43	
	128	12.50	0.576	4.600	11.200	89.200	0.315	2.520	0.107	0.857	0.350	2.800	6.14	13.60	37.2	60.6	22.1	36.5	14.7	378.00	5.58	
	131	6.28	0.790	12.600	5.060	80.600	0.235	3.740	0.086	1.370	0.109	1.740	7.25	14.10	40.1	55.3	19.5	35.2	14.2	737.00	6.25	
	133	11.50	1.600	13.800	9.090	78.700	0.463	4.010	0.075	0.649	0.323	2.790	7.22	13.70	40.4	55.9	19.0	34.0	13.8	737.00	5.10	
	135	7.66	1.080	14.100	5.840	76.300	0.456	5.950	0.080	1.040	0.201	2.620	5.70	11.70	34.5	60.5	20.5	33.8	13.1	80.10	5.71	
	146	10.50	0.640	6.080	0.937	89.000	0.308	2.930	0.084	0.802	0.127	1.200	6.76	13.40	38.9	57.5	19.9	34.6	13.9	1021.00	5.23	
	Mean	**9.026**	**0.8087**	**9.1271**	**6.4267**	**84.1571**	**0.3123**	**3.4871**	**0.0804**	**0.9346**	**0.2134**	**2.3014**	**6.549**	**13.157**	**38.04**	**58.23**	**20.16**	**34.60**	**13.96**	**429.010**	**5.550**	
	SD	**2.5497**	**0.42095**	**4.24055**	**3.27698**	**5.56563**	**0.12279**	**1.31644**	**0.01452**	**0.23459**	**0.09370**	**0.60513**	**0.5681**	**0.8162**	**2.089**	**2.168**	**0.990**	**0.968**	**0.493**	**406.6127**	**0.4089**	
Low Concentration	122	12.20	0.692	5.660	11.100	91.200	0.172	1.410	0.052	0.425	0.166	1.360	6.82	13.20	37.9	55.6	19.3	34.7	14.7	200.00	6.63	slide error - electrolytes only
	126	10.30	0.730	7.070	9.200	89.100	0.191	1.850	0.083	0.801	0.124	1.200	6.77	13.00	37.3	55.1	19.2	34.9	14.6	74.80	ND	
	127	10.70	0.875	8.180	9.100	85.100	0.383	3.580	0.102	0.952	0.233	2.180	6.55	13.20	37.0	56.5	20.2	35.7	14.2	810.00	5.21	
	129	12.70	0.816	6.420	11.300	89.100	0.240	1.890	0.100	0.789	0.224	1.760	6.77	13.60	38.1	56.3	20.1	35.7	14.4	959.00	5.04	
	130	11.00	1.680	15.300	8.380	76.400	0.400	3.650	0.079	0.719	0.439	4.000	7.36	14.40	39.7	54.0	19.6	36.3	16.4	911.00	5.61	
	140	12.70	1.590	12.500	10.500	82.600	0.275	2.150	0.069	0.542	0.282	2.210	6.63	13.60	39.1	59.0	20.4	34.7	14.5	140.00	6.37	
	141	5.82	0.468	8.040	4.510	77.500	0.418	7.180	0.159	2.740	0.262	4.500	6.95	14.40	40.0	57.5	20.7	36.0	13.1	792.00	5.65	
	142	7.42	1.130	15.300	5.680	76.600	0.286	3.850	0.122	1.650	0.196	2.640	5.97	12.30	34.7	58.1	20.6	35.4	14.7	920.00	5.27	
	Mean	**10.355**	**0.9976**	**9.8088**	**8.7213**	**83.4500**	**0.2956**	**3.1950**	**0.0958**	**1.0773**	**0.2408**	**2.4813**	**6.728**	**13.463**	**37.98**	**56.51**	**20.01**	**35.43**	**14.83**	**600.850**	**5.683**	
	SD	**2.5106**	**0.43550**	**3.95562**	**2.47690**	**6.08722**	**0.09513**	**1.86910**	**0.03342**	**0.76608**	**0.09488**	**1.19466**	**0.3922**	**0.7070**	**1.711**	**1.642**	**0.579**	**0.607**	**0.688**	**388.4760**	**0.6032**	
7-Day Hold Control	139	9.53	0.540	5.670	8.600	90.200	0.193	2.030	0.036	0.377	0.161	1.680	6.83	13.50	39.4	57.8	19.8	34.4	13.5	870.00	5.45	
	144	3.16	0.805	25.500	1.920	60.800	0.259	8.190	0.097	3.060	0.077	2.420	6.55	12.90	37.4	57.1	19.7	34.5	12.8	6.07	ND	
	145	12.80	0.667	5.200	11.500	90.000	0.310	2.410	0.055	0.430	0.253	1.970	6.35	13.20	38.0	59.8	20.9	34.9	14.2	79.30	5.40	
	151	13.00	1.100	8.480	11.000	85.300	0.517	3.990	0.052	0.400	0.237	1.830	7.46	14.00	41.3	55.3	18.8	34.0	14.7	829.00	5.01	
	152	6.56	0.468	7.130	5.640	86.000	0.232	3.540	0.045	0.688	0.170	2.600	6.67	13.90	38.5	57.7	20.9	36.2	13.5	939.00	5.38	
	166	7.91	0.485	6.140	6.970	88.100	0.251	3.170	0.059	0.742	0.145	1.830	6.56	12.90	37.5	57.2	19.6	34.3	13.6	98.90	5.41	
	Mean	**8.827**	**0.6775**	**9.6867**	**7.6050**	**83.4000**	**0.2937**	**3.8883**	**0.0573**	**0.9495**	**0.1738**	**2.0550**	**6.737**	**13.400**	**38.68**	**57.48**	**19.95**	**34.72**	**13.72**	**470.378**	**5.330**	
	SD	**3.7891**	**0.24279**	**7.83450**	**3.58527**	**11.25184**	**0.11585**	**2.22670**	**0.02106**	**1.04549**	**0.06426**	**0.36861**	**0.3878**	**0.4817**	**1.477**	**1.450**	**0.817**	**0.783**	**0.655**	**450.4295**	**0.1807**	
High Concentration	150	13.10	0.476	3.630	11.800	89.700	0.449	3.420	0.100	0.765	0.321	2.450	7.42	14.50	42.6	57.4	19.5	34.0	13.9	604.00	5.78	
	153	11.20	1.610	14.400	8.550	76.500	0.612	5.480	0.141	1.260	0.263	2.350	6.18	12.60	36.7	59.3	20.5	34.5	14.3	891.00	4.94	
	154	11.50	0.658	5.750	10.200	88.600	0.424	3.700	0.067	0.586	0.153	1.340	7.14	14.00	40.4	56.6	19.6	34.6	14.7	963.00	5.51	
	155	12.70	0.729	5.730	11.400	89.900	0.321	2.520	0.107	0.844	0.128	1.000	7.31	13.20	40.0	54.7	18.1	33.1	14.7	278.00	4.81	
	158	7.63	0.459	6.020	6.670	87.400	0.233	3.050	0.122	1.600	0.146	1.910	6.88	14.00	39.3	57.1	20.4	35.7	13.7	429.00	5.22	
	163	12.60	0.881	7.000	11.000	87.900	0.409	3.250	0.097	0.771	0.256	2.030	7.01	14.10	40.4	57.6	20.1	35.0	14.8	866.00	5.01	
	169	7.30	0.784	10.800	6.020	82.400	0.253	3.470	0.081	1.110	0.162	2.220	6.54	12.80	36.9	56.5	19.5	34.6	14.5	218.00	5.67	
	172	7.52	0.452	6.010	6.730	89.500	0.168	2.230	0.059	0.783	0.110	1.460	6.83	13.90	38.4	56.3	20.4	36.2	15.9	941.00	5.75	
	Mean	**10.444**	**0.7561**	**7.4175**	**9.0463**	**86.3750**	**0.3586**	**3.3900**	**0.0968**	**0.9649**	**0.1924**	**1.8450**	**6.914**	**13.638**	**39.338**	**56.94**	**19.76**	**34.713**	**14.563**	**648.750**	**5.336**	
	SD	**2.5307**	**0.38080**	**3.46984**	**2.35091**	**4.67447**	**0.14336**	**0.97901**	**0.02744**	**0.33388**	**0.07666**	**0.52337**	**0.4071**	**0.6823**	**1.9683**	**1.308**	**0.793**	**0.9598**	**0.6696**	**307.8356**	**0.3898**	
Low Concentration	147	5.10	0.443	8.690	3.980	78.100	0.360	7.060	0.111	2.170	0.203	3.990	6.92	12.90	38.0	54.9	18.7	34.1	14.6	301.00	ND	
	148	14.20	0.700	4.920	12.800	89.700	0.464	3.260	0.075	0.524	0.223	1.560	6.69	14.50	40.0	59.8	21.7	36.3	13.8	1041.00	5.35	
	149	14.70	0.670	4.560	13.100	89.200	0.386	2.630	0.200	1.360	0.331	2.250	7.32	13.50	39.7	54.2	18.4	34.1	14.0	193.00	5.88	
	156	9.08	0.799	8.810	7.870	86.700	0.209	2.300	0.039	0.425	0.158	1.740	6.42	13.00	36.2	56.4	20.2	35.8	13.1	1103.00	5.34	
	160	ND	ND	NO	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	hemolyzed
	161	9.44	1.130	12.000	7.660	81.100	0.363	3.840	0.036	0.385	0.255	2.700	6.61	13.10	37.7	57.0	19.8	34.6	13.3	853.00	4.95	
	162	11.90	0.862	7.220	9.900	82.900	0.566	4.740	0.138	1.150	0.472	3.950	7.68	15.20	44.5	57.9	19.8	34.2	14.2	702.00	4.94	
	164	9.63	0.454	4.710	8.730	90.700	0.234	2.430	0.050	0.523	0.160	1.660	6.59	12.60	37.1	56.3	19.2	34.0	12.5	8.51	ND	hemolyzed
	Mean	**10.579**	**0.7226**	**7.2729**	**9.1486**	**85.4857**	**0.3689**	**3.7514**	**0.0927**	**0.9339**	**0.2574**	**2.5500**	**6.890**	**13.543**	**39.03**	**56.64**	**19.69**	**34.73**	**13.64**	**600.216**	**5.293**	
	SD	**3.3242**	**0.23974**	**2.77439**	**3.16889**	**4.84232**	**0.12387**	**1.69724**	**0.06074**	**0.66500**	**0.11179**	**1.04677**	**0.4545**	**0.9537**	**1.765**	**1.064**	**1.096**	**0.934**	**0.718**	**433.3615**	**0.3848**	
90-Day Hold Control	174	9.02	0.558	6.180	7.930	87.900	0.241	2.670	0.110	1.220	0.183	2.030	7.03	13.50	39.5	56.1	19.2	34.2	14.9	451.00	6.13	
	175	12.10	0.988	8.160	10.600	87.500	0.312	2.580	0.085	0.698	0.127	1.050	7.65	14.10	40.4	52.8	18.4	34.9	15.1	1020.00	4.82	
	177	7.92	0.301	3.800	7.290	92.100	0.185	2.340	0.054	0.681	0.087	1.090	7.15	13.50	36.6	51.2	18.9	36.9	14.8	873.00	5.44	
	178	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	slightly hemolyzed
	179	4.71	0.552	11.700	3.840	81.600	0.136	2.890	0.076	1.620	0.102	2.170	7.45	13.60	40.4	54.2	18.3	33.7	15.7	844.00	5.63	slightly hemolyzed
	181	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
	Mean	**8.438**	**0.5998**	**7.4600**	**7.4150**	**87.2750**	**0.2185**	**2.6200**	**0.0813**	**1.0548**	**0.1248**	**1.5850**	**7.320**	**13.675**	**39.23**	**53.58**	**18.70**	**34.93**	**15.13**	**797.000**	**5.505**	
	SD	**3.0504**	**0.28520**	**3.34174**	**2.78123**	**4.31770**	**0.07567**	**0.22760**	**0.02317**	**0.45232**	**0.04219**	**0.59763**	**0.2821**	**0.2872**	**1.801**	**2.082**	**0.424**	**1.406**	**0.403**	**243.1940**	**0.5415**	
High Concentration	173	19.70	10.200	51.600	7.280	37.000	0.939	4.780	0.102	0.521	1.190	6.060	6.93	13.20	38.4	55.5	19.0	34.3	16.5	834.00	5.74	
	182	9.38	0.648	6.910	8.070	86.100	0.425	4.540	0.105	1.120	0.127	1.360	7.86	14.10	42.5	54.1	17.9	33.1	15.5	660.00	5.40	
	183	11.40	0.982	8.580	9.470	82.800	0.476	4.160	0.098	0.854	0.412	3.610	8.02	14.40	42.5	53.0	17.9	33.8	15.5	207.00	5.96	
	184	7.41	0.791	10.700	6.260	84.400	0.236	3.180	0.061	0.818	0.067	0.909	7.03	12.50	37.5	53.3	17.8	33.5	14.8	885.00	5.11	
	185	8.97	0.599	6.670	7.670	85.500	0.413	4.600	0.119	1.330	0.172	1.920	7.52	13.20	39.2	52.1	17.5	33.6	14.6	931.00	5.26	
	186	6.55	0.389	5.940	5.660	86.300	0.277	4.240	0.036	0.547	0.192	2.940	7.55	13.40	40.2	53.3	17.7	33.3	14.8	662.00	5.82	
	187	7.60	0.372	4.900	6.600	86.900	0.345	4.550	0.125	1.650	0.150	1.970	7.10	13.50	38.2	53.8	18.9	35.2	14.4	696.00	5.43	
	188	7.37	0.571	7.740	6.390	86.800	0.225	3.060	0.074	1.000	0.106	1.440	7.60	13.60	40.6	53.4	17.9	33.6	15.1	429.00	6.99	
	Mean	**9.798**	**1.8196**	**12.8800**	**7.1750**	**79.4750**	**0.4170**	**4.1388**	**0.0900**	**0.9800**	**0.3020**	**2.5261**	**7.451**	**13.488**	**39.89**	**53.56**	**18.08**	**33.80**	**15.15**	**663.000**	**5.714**	
	SD	**4.2838**	**3.39231**	**15.74325**	**1.21910**	**17.21708**	**0.23005**	**0.65984**	**0.03050**	**0.38391**	**0.37360**	**1.67612**	**0.3964**	**0.5817**	**1.908**	**0.980**	**0.557**	**0.668**	**0.674**	**243.2342**	**0.5917**	
Low Concentration	165	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
	167	7.86	0.395	5.020	6.590	83.900	0.414	5.270	0.056	0.718	0.404	5.140	7.44	13.70	40.3	54.1	18.4	33.9	15.4	912.00	5.68	
	168	12.60	1.400	11.100	10.200	81.400	0.432	3.440	0.103	0.816	0.409	3.260	7.72	14.60	42.5	55.1	18.9	34.3	14.7	727.00	5.73	
	170	5.10	0.471	9.230	4.420	86.700	0.096	1.870	0.026	0.501	0.087	1.700	6.98	12.70	35.9	51.4	18.2	35.5	14.0	772.00	5.70	
	171	6.38	0.368	5.770	5.550	87.100	0.239	3.750	0.080	1.260	0.137	2.140	6.74	13.10	36.9	54.7	19.4	35.5	15.4	913.00	5.32	
	176	4.01	0.356	8.870	3.390	84.700	0.153	3.810	0.036	0.904	0.070	1.750	7.21	13.50	38.5	53.4	18.7	35.0	14.7	808.00	5.36	
	180	6.88	0.663	9.640	5.770	83.800	0.234	3.400	0.037	0.536	0.181	2.630	6.98	13.00	37.0	53.0	18.6	35.0	14.6	1044.00	5.60	
	189	5.92	0.451	7.630	5.090	86.000	0.203	3.420	0.013	0.224	0.163	2.750	7.10	13.20	38.9	54.8	18.6	33.9	14.0	623.00	5.67	
	Mean	**6.964**	**0.5863**	**8.1800**	**5.8586**	**84.8000**	**0.2530**	**3.5657**	**0.0501**	**0.7084**	**0.2073**	**2.7671**	**7.167**	**13.400**	**38.57**	**53.79**	**18.69**	**34.73**	**14.69**	**828.429**	**5.580**	
	SD	**2.7751**	**0.37347**	**2.17305**	**2.16949**	**1.98830**	**0.12627**	**0.99483**	**0.03177**	**0.33206**	**0.14159**	**1.18737**	**0.3263**	**0.6218**	**2.271**	**1.301**	**0.385**	**0.695**	**0.573**	**139.4619**	**0.1690**	

ND = No Data
ss = Short Sample

APPENDIX K

SUMMARY OF CLINICAL CHEMISTRY AND INDIVIDUAL DATA

Table K-1
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of Clinical Chemistry
10 Minute Exposure

		1 Day Hold			7 Day Hold			90 Day Hold		
Period		**Control**	**High**	**Low**	**Control**	**High**	**Low**	**Control**	**High**	**Low**
ALB	Mean	2.93	2.95	2.94	2.95	2.88	3.10	3.48	3.35	3.33
	S.D.	0.280	0.100	0.220	0.152	0.148	0.169	0.445	0.443	0.116
	N	6	4	8	6	5	8	6	4	8
ALK P	Mean	275.7	210.8	235.1	269.0	254.0	244.0	166.7	211.5	128.3
	S.D.	69.76	58.62	48.94	56.22	66.74	47.45	63.45	52.40	47.64
	N	6	4	8	6	5	8	6	4	8
ALT	Mean	95.2	78.5	84.4	64.5	73.4	68.9	83.2	81.3	86.5
	S.D.	60.67	32.85	20.78	6.09	14.71	8.43	13.99	18.14	31.36
	N	6	4	8	6	5	8	6	4	8
AST	Mean	205.2	160.3	207.4	95.3	114.8	106.5	118.7	132.8	151.8
	S.D.	160.20	85.17	208.28	9.71	22.86	14.51	43.13	20.17	75.62
	N	6	4	8	6	5	8	6	4	8
BUN	Mean	22.5	17.8[A]	24.0	24.2	20.2	23.9	21.5	22.8	22.0
	S.D.	1.05	1.89	2.07	3.43	2.39	2.53	3.02	1.26	2.83
	N	6	4	8	6	5	8	6	4	8
CA	Mean	10.05	10.00	9.91	9.67	9.74	9.69	9.75	9.50	9.54
	S.D.	0.345	0.374	0.432	0.103	0.152	0.270	0.281	0.383	0.250
	N	6	4	8	6	5	8	6	4	8
CHOL	Mean	70.8	75.3	68.6	75.5	67.8	73.9	81.2	68.0	73.4
	S.D.	4.83	12.69	10.11	10.77	6.76	8.84	10.93	30.24	10.69
	N	6	4	8	6	5	8	6	4	8
CREA	Mean	0.45	0.43	0.44	0.43	0.40	0.45	0.48	0.43	0.46
	S.D.	0.055	0.050	0.052	0.082	0.000	0.053	0.041	0.050	0.052
	N	6	4	8	6	5	8	6	4	8
GLU	Mean	217.8	209.3	234.9	228.7	198.4	201.9	226.2	271.5[B]	214.1
	S.D.	19.27	18.03	43.99	49.55	9.29	21.09	20.96	30.71	26.45
	N	6	4	8	6	5	8	6	4	8
TBIL	Mean	0.158	0.225	0.313	0.100	0.050	0.125	0.100	0.088	0.050
	S.D.	0.0917	0.1258	0.1126	0.1000	0.0000	0.0964	0.0775	0.0750	0.0000
	N	6	4	8	6	5	8	6	4	8
TP	Mean	5.75	5.85	5.84	5.90	5.90	6.18	6.90	6.68	6.51
	S.D.	0.351	0.191	0.245	0.261	0.158	0.249	0.696	0.608	0.189
	N	6	4	8	6	5	8	6	4	8
TRIG	Mean	48.3	46.5	84.8	75.0	75.2	76.8	202.5	269.0	143.3
	S.D.	19.71	23.06	29.08	34.61	16.30	32.71	95.81	171.92	54.97
	N	6	4	8	6	5	8	6	4	8
GLOB	Mean	2.85	2.93	2.93	2.93	3.02	3.05	3.42	3.35	3.19
	S.D.	0.084	0.096	0.128	0.121	0.084	0.151	0.279	0.191	0.083
	N	6	4	8	6	5	8	6	4	8
Na	Mean	145.3	146.5	145.4	145.3	146.0	147.4[C]	150.3[D]	146.0	147.4
	S.D.	2.58	1.73	1.30	0.82	1.00	1.60	2.07	2.58	1.69
	N	6	4	8	6	5	8	6	4	8
K	Mean	4.82	5.10	5.16	4.70	4.68	4.44	5.08	4.68	4.58
	S.D.	0.512	0.837	0.555	0.518	0.444	0.573	0.741	1.018	1.173
	N	6	4	8	6	5	8	6	4	8
Cl	Mean	104.8	106.0	105.1	105.0	104.8	105.4	101.8	103.8	104.3
	S.D.	0.41	0.82	1.64	0.89	1.30	1.19	3.06	2.63	1.83
	N	6	4	8	6	5	8	6	4	8

[A] significantly different than control and low dose group
[B] significantly different than control and low dose group
[C] significantly different than high dose group
[D] significantly different than high and low dose group
[ABCD] p less than or equal to 0.05

Table K-2
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation of Emissions from the Violet Colored M18 Smoke Grenade in Rats

Summary of Clinical Chemistry
2 Minute Exposure

		1 Day Hold			7 Day Hold			90 Day Hold		
Period		Control	High	Low	Control	High	Low	Control	High	Low
ALB	Mean	2.80	2.78	2.91	2.88	2.94	2.99	3.05	3.40	3.43
	S.D.	0.122	0.149	0.234	0.248	0.074	0.230	0.404	0.346	0.620
	N	5	8	7	6	8	8	6	8	8
ALK P	Mean	243.6	202.0[A]	284.4	242.5	216.8	225.1	155.7	138.0	106.0
	S.D.	39.18	40.27	34.53	53.39	44.03	73.97	75.56	38.55	24.60
	N	5	8	7	6	8	8	6	8	8
ALT	Mean	66.4	80.5	69.6	61.7	61.4	93.1	66.0	68.5	73.5
	S.D.	7.67	32.23	13.07	8.33	6.70	39.32	14.01	10.46	14.75
	N	5	8	7	6	8	8	6	8	8
AST	Mean	147.0	226.3	118.9	112.7	102.0	217.4	149.7	148.9	165.6
	S.D.	34.85	197.49	43.61	42.99	21.10	214.07	47.31	75.61	53.64
	N	5	8	7	6	8	8	6	8	8
BUN	Mean	23.2	21.8	18.4[B]	21.7	21.1	21.4	22.5	24.3	24.8
	S.D.	1.92	1.58	1.99	2.34	1.46	2.26	2.59	4.30	2.71
	N	5	8	7	6	8	8	6	8	8
CA	Mean	7.96	9.69	9.74	9.65	10.01	9.75	9.58	9.71	9.63
	S.D.	4.453	0.217	0.264	0.383	0.304	0.581	0.492	0.242	0.406
	N	5	8	7	6	8	8	6	8	8
CHOL	Mean	65.2	75.9	79.6	77.3	71.8	71.3	70.8	72.9	77.5
	S.D.	5.22	4.39	9.71	9.91	10.57	9.79	13.50	15.20	15.36
	N	5	8	7	6	8	8	6	8	8
CREA	Mean	0.42	0.43	0.43	0.40	0.41	0.46	0.45	0.49	0.46
	S.D.	0.045	0.046	0.049	0.000	0.035	0.074	0.055	0.113	0.074
	N	5	8	7	6	8	8	6	8	8
GLU	Mean	215.2	222.0	214.3	220.7	231.0	227.9	237.2	212.4	194.5
	S.D.	19.31	18.56	9.62	0.050	20.72	39.51	45.77	31.96	16.04
	N	5	8	7	6	8	8	6	8	8
TBIL	Mean	0.050	0.088	0.050	18.91	0.050	0.156	0.100	0.106	0.088
	S.D.	0.0000	0.0876	0.0000	0.0000	0.0000	0.3005	0.1000	0.0776	0.0876
	N	5	8	7	6	8	8	6	8	8
TP	Mean	5.66	5.65	5.80	5.83	5.86	5.91	6.00	6.48	6.51
	S.D.	0.167	0.227	0.342	0.314	0.177	0.247	0.443	0.518	0.820
	N	5	8	7	6	8	8	6	8	8
TRIG	Mean	63.8	65.5	40.4	69.5	95.0	92.0	105.2	173.6	179.5
	S.D.	39.86	39.27	28.09	28.81	43.47	29.83	15.74	80.14	73.18
	N	5	8	7	6	8	8	6	8	8
GLOB	Mean	2.84	2.86	2.86	2.93	2.94	2.96	2.97	3.09	3.09
	S.D.	0.089	0.119	0.172	0.082	0.092	0.160	0.082	0.327	0.236
	N	5	8	7	6	8	8	6	8	8
Na	Mean	143.7	145.0	145.4	146.5	145.5	146.3	148.7	148.8	149.4
	S.D.	3.27	1.51	2.39	1.05	0.93	2.12	3.01	2.19	3.74
	N	5	8	7	6	8	8	6	8	8
K	Mean	4.58	4.80	4.46	4.42	4.36	5.39	4.73	4.94	5.00
	S.D.	0.248	0.363	0.444	0.479	0.256	1.233	0.635	0.883	0.393
	N	5	8	7	6	8	8	6	8	8
Cl	Mean	104.8	104.0	104.4	105.7	104.6	104.5	106.8	105.1	103.5
	S.D.	1.17	1.77	1.60	0.82	0.92	2.20	1.60	3.48	3.51
	N	5	8	7	6	8	8	6	8	8

[A] signficantly different than low dose group
[B] significantly different than control and high dose group
[AB] p less than or equal to 0.05

Table K-3
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

1, 7, and 90-Day Hold Individual Clinical Chemistry
2 Minute Exposure

	Animal ID	ALB	ALKP	ALT	AST	BUN	CA	CHOL	CREA	GLU	TBIL	TP	TRIG	GLOB	Na	K	Cl
1 Day Hold Control	52	2.8	274	76	96	22	10.2	75	0.4	219	0.20	5.5	31	2.7	145	4.0	105
	55	3.1	357	54	113	23	9.6	63	0.4	227	0.05	5.8	17	2.8	145	5.1	105
	56	2.9	248	215	360	22	10.1	67	0.4	239	0.10	5.7	56	2.9	148	5.5	105
	57	2.6	171	96	455	24	10.0	75	0.5	193	0.20	5.4	63	2.9	141	5.0	105
	59	3.4	350	56	83	23	10.6	73	0.5	196	0.30	6.4	57	2.9	148	4.6	104
	62	2.8	254	74	124	21	9.8	72	0.5	233	0.10	5.7	66	2.9	145	4.7	105
	Mean	**2.93**	**275.7**	**95.2**	**205.2**	**22.5**	**10.05**	**70.8**	**0.45**	**217.8**	**0.158**	**5.75**	**48.3**	**2.85**	**145.3**	**4.82**	**104.8**
	SD	**0.280**	**69.76**	**60.67**	**160.20**	**1.05**	**0.345**	**4.83**	**0.055**	**19.27**	**0.0917**	**0.351**	**19.71**	**0.084**	**2.58**	**0.512**	**0.41**
High Concentration	50	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	54	2.9	185	75	141	19	9.6	66	0.4	222	0.20	5.9	21	3.0	146	4.4	106
	60	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	61	2.9	276	57	96	19	10.5	80	0.5	190	0.10	5.7	57	2.8	149	5.3	105
	63	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	70	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	77	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	79	3.1	239	56	119	18	10.0	91	0.4	198	0.20	6.1	73	3.0	146	4.5	106
	80	2.9	143	126	285	15	9.9	64	0.4	227	0.40	5.7	35	2.9	145	6.2	107
	Mean	**2.95**	**210.8**	**78.5**	**160.3**	**17.8**	**10.00**	**75.3**	**0.43**	**209.3**	**0.225**	**5.85**	**46.5**	**2.93**	**146.5**	**5.10**	**106.0**
	SD	**0.100**	**58.62**	**32.85**	**85.17**	**1.89**	**0.374**	**12.69**	**0.050**	**18.03**	**0.1258**	**0.191**	**23.06**	**0.096**	**1.73**	**0.837**	**0.82**
Low Concentration	51	3.0	154	79	147	28	9.7	65	0.4	200	0.50	6.1	114	3.1	144	5.5	106
	53	2.7	267	82	132	23	9.6	63	0.4	251	0.20	5.6	33	3.0	146	4.4	105
	58	3.3	250	63	100	26	10.1	85	0.5	224	0.30	6.1	96	2.9	146	4.9	102
	64	2.8	181	66	111	24	9.6	73	0.4	188	0.40	5.6	111	2.8	146	5.1	107
	66	3.2	306	67	106	24	10.3	79	0.4	208	0.20	6.0	63	2.8	147	4.4	107
	67	2.9	221	116	716	23	9.4	53	0.5	211	0.40	6.0	83	3.1	146	5.8	105
	68	2.9	263	114	207	22	10.7	63	0.5	285	0.30	5.8	112	2.8	145	5.7	104
	72	2.7	239	88	140	22	9.9	68	0.4	312	0.20	5.5	66	2.9	143	5.5	105
	Mean	**2.94**	**235.1**	**84.4**	**207.4**	**24.0**	**9.91**	**68.6**	**0.44**	**234.9**	**0.313**	**5.84**	**84.8**	**2.93**	**145.4**	**5.16**	**105.1**
	SD	**0.220**	**48.94**	**20.78**	**208.28**	**2.07**	**0.432**	**10.11**	**0.052**	**43.99**	**0.1126**	**0.245**	**29.08**	**0.128**	**1.30**	**0.555**	**1.64**
7-Day Hold Control	65	3.1	326	73	110	28	9.7	76	0.5	214	0.30	6.3	138	3.1	146	5.4	104
	69	2.7	240	64	99	28	9.6	76	0.5	189	0.10	5.6	63	2.9	146	4.9	105
	71	2.9	335	59	93	25	9.7	72	0.4	185	0.05	5.9	76	3.0	145	5.1	106
	76	3.1	230	60	86	23	9.7	80	0.5	204	0.05	6.1	39	3.0	146	4.2	106
	93	3.0	195	60	84	21	9.5	58	0.4	275	0.05	5.8	52	2.8	144	4.5	105
	98	2.9	288	71	100	20	9.8	91	0.3	305	0.05	5.7	82	2.8	145	4.1	104
	Mean	**2.95**	**269.0**	**64.5**	**95.3**	**24.2**	**9.67**	**75.5**	**0.43**	**228.7**	**0.100**	**5.90**	**75.0**	**2.93**	**145.3**	**4.70**	**105.0**
	SD	**0.152**	**56.22**	**6.09**	**9.71**	**3.43**	**0.103**	**10.77**	**0.082**	**49.55**	**0.1000**	**0.261**	**34.61**	**0.121**	**0.82**	**0.518**	**0.89**
High Concentration	85	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	86	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	88	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	89	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	90	2.9	279	68	146	22	9.9	61	0.4	192	0.05	5.9	87	3.0	145	5.4	106
	91	2.8	343	63	96	20	9.5	71	0.4	209	0.05	5.8	49	2.9	147	4.5	106
	92	3.1	268	99	127	23	9.8	78	0.4	208	0.05	6.1	70	3.1	146	4.2	105
	95	2.9	211	72	90	17	9.7	64	0.4	190	0.05	6.0	88	3.1	147	4.7	103
	101	2.7	169	65	115	19	9.8	65	0.4	193	0.05	5.7	82	3	145	4.6	104
	Mean	**2.88**	**254.0**	**73.4**	**114.8**	**20.2**	**9.74**	**67.8**	**0.40**	**198.4**	**0.050**	**5.90**	**75.2**	**3.02**	**146.0**	**4.68**	**104.8**
	SD	**0.148**	**66.74**	**14.71**	**22.86**	**2.39**	**0.152**	**6.76**	**0.000**	**9.29**	**0.0000**	**0.158**	**16.30**	**0.084**	**1.00**	**0.444**	**1.30**
Low Concentration	73	3.1	307	56	89	21	9.7	58	0.4	197	0.05	6.0	107	2.9	148	4.6	107
	74	3.2	181	67	115	23	9.4	78	0.4	212	0.05	5.9	118	2.8	145	4.1	105
	75	3.4	229	68	120	23	10.2	81	0.4	185	0.10	6.6	84	3.2	147	4.7	105
	78	2.9	317	70	102	22	9.5	79	0.5	193	0.05	6.1	88	3.2	147	4.2	104
	81	3.2	226	62	107	23	9.9	64	0.5	179	0.30	6.5	98	3.2	149	5.7	104
	82	3.0	233	67	84	26	9.7	80	0.5	191	0.20	6.1	48	3.0	150	4.2	105
	83	3.1	203	82	126	29	9.4	70	0.5	213	0.20	6.2	38	3.1	147	4.0	106
	84	2.9	256	79	109	24	9.7	81	0.4	245	0.05	6	33	3	146	4	107
	Mean	**3.10**	**244.0**	**68.9**	**106.5**	**23.9**	**9.69**	**73.9**	**0.45**	**201.9**	**0.125**	**6.18**	**76.8**	**3.05**	**147.4**	**4.44**	**105.4**
	SD	**0.169**	**47.45**	**8.43**	**14.51**	**2.53**	**0.270**	**8.84**	**0.053**	**21.09**	**0.0964**	**0.249**	**32.71**	**0.151**	**1.68**	**0.573**	**1.19**
90-Day Hold Control	99	3.1	136	87	195	23	9.4	73	0.5	234	0.05	6.3	137	3.2	150	4.9	104
	102	4.3	235	98	122	21	10.0	81	0.5	226	0.20	8.2	323	3.9	154	5.2	98
	104	3.6	250	87	108	25	9.8	69	0.5	192	0.20	7.1	186	3.5	151	5.4	99
	117	3.5	165	95	127	16	9.4	88	0.4	222	0.05	6.7	92	3.2	148	3.7	106
	118	3.2	122	66	92	22	9.9	77	0.5	226	0.05	6.4	161	3.2	150	5.5	103
	119	3.2	92	66	68	22	10	99	0.5	257	0.05	6.7	316	3.5	149	5.8	101
	Mean	**3.48**	**166.7**	**83.2**	**118.7**	**21.5**	**9.75**	**81.2**	**0.48**	**226.2**	**0.100**	**6.90**	**202.5**	**3.42**	**150.3**	**5.08**	**101.8**
	SD	**0.445**	**63.45**	**13.99**	**43.13**	**3.02**	**0.281**	**10.93**	**0.041**	**20.96**	**0.0775**	**0.696**	**95.81**	**0.279**	**2.07**	**0.741**	**3.06**
High Concentration	105	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	107	2.9	189	70	147	21	9.0	26	0.4	280	0.05	6.0	128	3.1	143	4.2	105
	109	3.9	239	77	103	23	9.8	96	0.4	226	0.20	7.4	505	3.5	149	4.2	106
	111	3.5	268	108	138	24	9.8	68	0.5	291	0.05	6.9	287	3.5	147	6.2	100
	114	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead	Dead
	115	3.1	150	70	143	23	9.4	82	0.4	289	0.05	6.4	156	3.3	145	4.1	104
	Mean	**3.35**	**211.5**	**81.3**	**132.8**	**22.8**	**9.50**	**68.0**	**0.43**	**271.5**	**0.088**	**6.68**	**269.0**	**3.35**	**146.0**	**4.68**	**103.8**
	SD	**0.443**	**52.40**	**18.14**	**20.17**	**1.26**	**0.383**	**30.24**	**0.050**	**30.71**	**0.0750**	**0.608**	**171.92**	**0.191**	**2.58**	**1.018**	**2.63**
Low Concentration	87	3.2	212	135	260	22	9.2	83	0.5	199	0.05	6.3	105	3.1	148	3.6	108
	94	3.5	98	95	116	20	9.8	93	0.4	232	0.05	6.7	133	3.2	145	3.7	104
	96	3.3	98	68	135	23	9.5	69	0.4	184	0.05	6.3	151	3.1	146	4.1	104
	97	3.3	83	64	253	23	9.4	79	0.4	256	0.05	6.4	123	3.1	146	4.8	105
	100	3.5	98	58	65	21	10.0	68	0.5	208	0.05	6.8	101	3.2	147	7.1	102
	103	3.2	140	133	193	28	9.5	69	0.5	233	0.05	6.4	188	3.2	148	4.2	105
	106	3.3	109	64	73	19	9.5	61	0.5	179	0.05	6.6	255	3.3	150	5.3	103
	108	3.3	188	75	119	20	9.4	65	0.5	222	0.05	6.6	90	3.3	149	3.8	103
	Mean	**3.33**	**128.3**	**86.5**	**151.8**	**22.0**	**9.54**	**73.4**	**0.46**	**214.1**	**0.050**	**6.51**	**143.3**	**3.19**	**147.4**	**4.58**	**104.3**
	SD	**0.116**	**47.64**	**31.36**	**75.62**	**2.83**	**0.250**	**10.69**	**0.052**	**26.45**	**0.0000**	**0.189**	**54.97**	**0.083**	**1.69**	**1.173**	**1.83**

Table K-4
Protocol No. 0497-24-05-08-01
Toxicity of Acute Inhalation Exposure of Emissions from the Violet Colored M18 Smoke Grenade in Rats

1, 7, and 90-Day Hold Individual Clinical Chemistry
2 Minute Exposure

	Animal ID	ALB	ALKP	ALT	AST	BUN	CA	CHOL	CREA	GLU	TBIL	TP	TRIG	GLOB	Na	K	Cl
1 Day Hold Control	123	2.8	278	75	125	24	10.2	61	0.4	204	0.05	5.8	14	2.9	146	4.5	103
	125	2.7	218	69	104	26	10.0	67	0.4	226	0.05	5.6	43	2.9	144	4.6	104
	134	2.8	294	63	187	22	9.8	73	0.4	188	0.05	5.7	107	2.9	147	4.8	106
	136	2.7	216	70	177	21	0.0	60	0.4	237	0.05	5.4	53	2.7	138	4.9	106
	137	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	142	4.2	105
	138	3.0	212	55	142	23	9.8	65	0.5	221	0.05	5.8	102	2.8	145	4.5	105
	Mean	**2.80**	**243.6**	**66.4**	**147.0**	**23.2**	**7.96**	**65.2**	**0.42**	**215.2**	**0.050**	**5.66**	**63.8**	**2.84**	**143.7**	**4.58**	**104.8**
	SD	**0.122**	**39.18**	**7.67**	**34.85**	**1.92**	**4.453**	**5.22**	**0.045**	**19.31**	**0.0000**	**0.167**	**39.86**	**0.089**	**3.27**	**0.248**	**1.17**
High Concentration	120	2.7	169	81	311	24	9.7	75	0.4	209	0.10	5.5	30	2.8	144	4.7	101
	121	3.0	122	155	676	24	9.4	69	0.4	203	0.30	5.8	67	2.8	145	4.8	104
	124	2.8	244	68	132	22	9.9	77	0.4	245	0.05	5.8	36	3.0	148	4.2	106
	128	2.5	224	56	130	22	9.4	80	0.4	208	0.05	5.2	55	2.7	143	5.1	106
	131	2.8	187	71	124	21	9.6	73	0.4	207	0.05	5.6	102	2.8	146	4.9	105
	133	2.9	220	62	82	20	9.7	77	0.5	220	0.05	5.9	74	3.0	145	4.8	104
	135	2.7	227	91	246	20	10.0	83	0.5	234	0.05	5.6	138	2.8	145	5.4	102
	146	2.8	223	60	109	21	9.8	73	0.4	250	0.05	5.8	22	3.0	144	4.5	104
	Mean	**2.78**	**202.0**	**80.5**	**226.3**	**21.8**	**9.69**	**75.9**	**0.43**	**222.0**	**0.088**	**5.65**	**65.5**	**2.86**	**145.0**	**4.80**	**104.0**
	SD	**0.149**	**40.27**	**32.23**	**197.49**	**1.58**	**0.217**	**4.39**	**0.046**	**18.56**	**0.0876**	**0.227**	**39.27**	**0.119**	**1.51**	**0.363**	**1.77**
Low Concentration	122	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	142	5.1	106
	126	2.6	256	62	216	19	9.4	70	0.4	225	0.05	5.4	81	2.8	144	4.4	106
	127	2.6	237	70	99	16	9.7	90	0.4	224	0.05	5.6	25	2.9	146	3.9	105
	129	3.0	302	64	95	19	9.4	79	0.5	203	0.05	5.9	35	2.9	144	4.5	102
	130	3.2	316	65	98	19	9.9	96	0.5	222	0.05	6.4	66	3.2	150	5.1	102
	140	3.1	321	97	118	22	9.8	73	0.4	207	0.05	6.0	56	2.8	147	4.0	105
	141	3.0	306	57	97	17	10.1	75	0.4	204	0.05	5.8	4	2.7	145	4.3	105
	142	2.9	253	72	109	17	9.9	74	0.4	215	0.05	5.5	16	2.7	145	4.4	104
	Mean	**2.91**	**284.4**	**69.6**	**118.9**	**18.4**	**9.74**	**79.6**	**0.43**	**214.3**	**0.050**	**5.80**	**40.4**	**2.86**	**145.4**	**4.46**	**104.4**
	SD	**0.234**	**34.53**	**13.07**	**43.61**	**1.99**	**0.264**	**9.71**	**0.049**	**9.62**	**0.0000**	**0.342**	**28.09**	**0.172**	**2.39**	**0.444**	**1.60**
7-Day Hold Control	139	3.3	229	54	86	22	9.6	81	0.4	193	0.05	6.4	74	3.1	147	4.6	106
	144	2.7	152	72	196	24	10.1	73	0.4	246	0.05	5.6	12	2.9	146	4.0	107
	145	2.6	297	58	122	22	9.0	85	0.4	208	0.05	5.5	90	2.9	145	4.9	105
	151	3.0	282	64	87	18	9.8	83	0.4	217	0.05	5.9	76	2.9	148	5.0	105
	152	2.8	273	70	89	24	9.9	83	0.4	226	0.05	5.8	86	2.9	147	4.1	105
	166	2.9	222	52	96	20	9.5	59	0.4	234	0.05	5.8	79	2.9	146	3.9	106
	Mean	**2.88**	**242.5**	**61.7**	**112.7**	**21.7**	**9.65**	**77.3**	**0.40**	**220.7**	**0.050**	**5.83**	**69.5**	**2.93**	**146.5**	**4.42**	**105.7**
	SD	**0.248**	**53.39**	**8.33**	**42.99**	**2.34**	**0.383**	**9.91**	**0.000**	**18.91**	**0.0000**	**0.314**	**28.81**	**0.082**	**1.05**	**0.479**	**0.82**
High Concentration	150	3.0	239	71	114	23	10.0	94	0.5	240	0.05	6.1	140	3.1	147	4.5	105
	153	3.0	239	61	101	22	10.2	67	0.4	200	0.05	5.9	118	2.9	145	4.8	103
	154	2.9	268	62	77	21	10.3	74	0.4	213	0.05	5.8	170	2.9	146	4.3	104
	155	2.9	160	59	84	22	9.7	68	0.4	221	0.05	5.9	47	3.0	144	4.2	105
	158	3.0	186	52	89	21	10.1	78	0.4	219	0.05	6.0	66	3.0	146	4.4	105
	163	2.8	276	68	97	18	9.9	60	0.4	243	0.05	5.5	58	2.8	146	4.4	106
	169	2.9	184	65	110	21	10.4	64	0.4	255	0.05	5.8	73	2.9	145	3.9	105
	172	3.0	182	53	144	21	9.5	69	0.4	257	0.05	5.9	88	2.9	145	4.4	104
	Mean	**2.94**	**216.8**	**61.4**	**102.0**	**21.1**	**10.01**	**71.8**	**0.41**	**231.0**	**0.050**	**5.86**	**95.0**	**2.94**	**145.5**	**4.36**	**104.6**
	SD	**0.074**	**44.03**	**6.70**	**21.10**	**1.46**	**0.304**	**10.57**	**0.035**	**20.72**	**0.0000**	**0.177**	**43.47**	**0.092**	**0.93**	**0.256**	**0.92**
Low Concentration	147	2.9	265	85	132	24	9.8	88	0.5	238	0.05	6.0	88	3.1	146	5.0	103
	148	3.2	286	85	100	20	9.9	74	0.5	211	0.05	6.1	98	3.0	148	4.5	104
	149	3.0	178	70	94	21	9.9	76	0.4	200	0.05	5.9	97	3.0	147	4.1	108
	156	3.2	323	58	88	20	9.2	73	0.4	219	0.05	6.2	131	3.0	145	4.6	106
	160	2.7	112	180	584	24	9.2	55	0.4	159	0.90	5.9	49	3.2	147	7.3	105
	161	2.9	236	69	109	19	9.6	62	0.5	244	0.05	5.6	134	2.7	146	5.2	106
	162	3.3	260	80	90	19	11.0	69	0.6	281	0.05	6.1	68	2.9	149	7.3	103
	164	2.7	141	118	542	24	9.4	73	0.4	271	0.05	5.5	71	2.8	142	5.1	101
	Mean	**2.99**	**225.1**	**93.1**	**217.4**	**21.4**	**9.75**	**71.3**	**0.46**	**227.9**	**0.156**	**5.91**	**92.0**	**2.96**	**146.3**	**5.39**	**104.5**
	SD	**0.230**	**73.97**	**39.32**	**214.07**	**2.26**	**0.581**	**9.79**	**0.074**	**39.51**	**0.3005**	**0.247**	**29.83**	**0.160**	**2.12**	**1.233**	**2.30**
90-Day Hold Control	174	3.8	118	51	210	27	10.5	93	0.5	228	0.10	6.8	80	2.9	150	4.8	106
	175	2.8	224	65	94	19	9.5	66	0.4	294	0.05	5.8	102	3.0	146	4.3	107
	177	2.8	82	55	103	22	9.1	67	0.4	295	0.05	5.7	99	2.9	148	3.9	108
	178	3.1	258	91	189	22	9.4	80	0.5	196	0.30	6.2	112	3.1	154	5.3	104
	179	2.7	77	65	170	22	9.3	64	0.4	200	0.05	5.6	127	3.0	146	5.6	108
	181	3.1	175	69	132	23	9.7	55	0.5	210	0.05	5.9	111	2.9	148	4.5	108
	Mean	**3.05**	**155.7**	**66.0**	**149.7**	**22.5**	**9.58**	**70.8**	**0.45**	**237.2**	**0.100**	**6.00**	**105.2**	**2.97**	**148.7**	**4.73**	**106.8**
	SD	**0.404**	**75.56**	**14.01**	**47.31**	**2.59**	**0.492**	**13.50**	**0.055**	**45.77**	**0.1000**	**0.443**	**15.74**	**0.082**	**3.01**	**0.635**	**1.60**
High Concentration	173	2.9	171	86	121	27	9.9	102	0.6	186	0.05	5.3	87	2.4	151	5.5	106
	182	3.0	113	76	118	32	9.4	48	0.6	201	0.05	6.5	276	3.5	148	6.8	103
	183	3.7	118	61	133	28	10.0	81	0.5	191	0.05	6.9	277	3.3	148	4.3	109
	184	3.8	104	59	164	22	9.9	73	0.5	190	0.05	6.9	114	3.1	147	5.0	107
	185	3.8	101	54	110	22	9.8	74	0.4	231	0.20	6.8	138	3.0	147	4.5	104
	186	3.3	119	75	330	22	9.4	67	0.6	253	0.20	6.6	89	3.3	153	4.9	98
	187	3.4	179	67	113	19	9.5	72	0.3	184	0.20	6.4	169	3.0	149	4.5	108
	188	3.3	199	70	102	22	9.8	66	0.4	263	0.05	6.4	239	3.1	147	4.0	106
	Mean	**3.40**	**138.0**	**68.5**	**148.9**	**24.3**	**9.71**	**72.9**	**0.49**	**212.4**	**0.106**	**6.48**	**173.6**	**3.09**	**148.8**	**4.94**	**105.1**
	SD	**0.346**	**38.55**	**10.46**	**75.61**	**4.30**	**0.242**	**15.20**	**0.113**	**31.96**	**0.0776**	**0.518**	**80.14**	**0.327**	**2.19**	**0.883**	**3.48**
Low Concentration	165	3.6	85	100	270	25	9.8	78	0.4	194	0.05	6.6	196	3.0	151	4.9	104
	167	3.9	92	72	138	27	9.9	72	0.5	196	0.10	7.4	335	3.5	153	5.6	98
	168	3.5	97	74	133	28	9.3	73	0.5	174	0.05	6.3	160	2.9	149	4.4	105
	170	2.4	90	61	113	24	8.9	52	0.4	228	0.05	5.3	100	2.9	144	4.7	107
	171	3.1	131	58	123	25	9.8	90	0.4	201	0.05	5.9	149	2.8	147	4.9	105
	176	3.1	156	67	191	22	9.4	82	0.4	187	0.05	6.2	116	3.1	145	5.0	108
	180	4.5	102	91	209	20	10.2	104	0.5	182	0.30	7.9	214	3.3	154	5.0	100
	189	3.3	95	65	148	27	9.7	69	0.6	194	0.05	6.5	166	3.2	152	5.5	101
	Mean	**3.43**	**106.0**	**73.5**	**165.6**	**24.8**	**9.63**	**77.5**	**0.46**	**194.5**	**0.088**	**6.51**	**179.5**	**3.09**	**149.4**	**5.00**	**103.5**
	SD	**0.620**	**24.60**	**14.75**	**53.64**	**2.71**	**0.406**	**15.36**	**0.074**	**16.04**	**0.0876**	**0.820**	**73.18**	**0.236**	**3.74**	**0.393**	**3.51**

ND = No Data

APPENDIX L

HISTOPATHOLOGY REPORT

BIOTECHNICS
FOCUSED EXPERTISE

U. S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE

TOXICITY OF ACUTE INHALATION EXPOSURE OF EMISSIONS FROM THE VIOLET COLORED M18 SMOKE GRENADE IN RATS

STUDY NO. 0497-24-05-08-01

REPORT DATE: 06 October 2006

SUBMITTED BY:

[redacted] DVM, PhD
Dipl. ACVP, ACLAM

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U. S. ARMY CENTER FOR HEALTH PROMOTION AND PREVENTIVE MEDICINE

PATHOLOGY REPORT

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INTRODUCTION:

This acute inhalation toxicity study was designed to assess and evaluate the toxic characteristics of a single dose exposure to emissions from the Violet Colored M18 Smoke Grenade in the rat. The protocol was designed to provide comparisons of emissions from "old" and "new" violet colored M18 smoke grenades, however this report addresses only the findings from Experiment 2 (Main Study) rats exposed to the "old" violet colored smoke grenades

METHODOLOGY:

We received untrimmed, formalin-fixed tissues that were labeled with Pathology Branch accession numbers. Following routine histologic processing, paraffin-embedded tissues were sectioned at 5 µm, stained with hematoxylin and eosin, and examined by routine light microscopy. Groups of female rats were exposed for either 10 (Study V-OLD-10) or 2 minutes (Study V-OLD-2) to either high (Group 2) or low (Group 3) concentrations of "Old" Violet Colored M18, with and appropriate control group (Group 1) and with scheduled sacrifices on Days 1, 7, and 90 post-exposure. The study design for the data included in this report is summarized in the following table.

Study V-OLD-10 (10 Minute Exposure)				
		Scheduled Sacrifices		
		Day 1	Day 7	Day 90
Group	Exposure	# of Rats	# of Rats	# of Rats
1	0 mg/mg^3	6	6	6
2	1136 mg/mg^3	8	8	8
3	419 mg/mg^3	8	8	8

Study V-OLD-2 (2 Minute Exposure)				
		Scheduled Sacrifices		
		Day 1	Day 7	Day 90
Group	Exposure	# of Rats	# of Rats	# of Rats
1	0 mg/mg^3	6	6	6
2	2150 mg/mg^3	8	8	8
3	1375 mg/mg^3	8	8	8

A record of tissues examined and histopathologic findings were entered in a computer-assisted data retrieval system (StarTox, Graham Laboratories, New Braunfels, TX) at the time of histopathologic examination and serve as the basis for this narrative summary. To allow separate tabulation of the V-OLD-10 and V-OLD-2 treatments within the StarTox software program, the V-OLD-2 Groups 1, 2 and 3 were renamed Groups 4, 5, and 6, respectively. The microscopic sections were of adequate size and

quality to allow critical histopathologic evaluation. Histologic sections from a small number of tissues were not available for examination, or the sections were considered to be inadequate for histologic evaluation, thus the number of tissues examined per group in the attached StarTox tables does not necessarily match the total number of animals initially included in the study. The mandibular lymph nodes and uterus of Group 1 V-OLD-10 Rat Number 06-117 were processed and evaluated. Since there were no macroscopic findings noted for these two non-protocol tissues, this was a protocol deviation. This deviation did not impact on the overall integrity of the study.

RESULTS:

The Summary Incidence Table and Individual Animal Data Tables present, in sequence, the histopathology findings for the Unscheduled Deaths and the Day 1, Day 7 and Day 90 scheduled sacrifices for the V-OLD-10 animals Followed by the V-OLD-2 data.

MORTALITY:

Eleven of the 24 V-OLD-10 rats exposed to 1136 mg/m^3 for 10 minutes were found dead at the end of the exposure period on Day 0. There were no specific alterations evident in the protocol-specified tissue sections to account for the deaths of these animals, nor were there any test substance-related specific alterations noted in the tissue sections.

The gross alterations noted in these animal included purple discolorations/masses associated with fur and feet, external nares, oral or buccal cavity, and/or anterior trachea. These alterations were not evident in the tissue sections and were presumed to represent particulate material associated with the test substance that was not recognizable following the processing to tissue sections. The congestion that was commonly noted in the sections of liver and/or lung was considered secondary to agonal death, rather than representing a test substance-specific alteration.

SCHEDULED SACRIFICES:

Study V-OLD-10:

The findings for the unscheduled deaths (Found Dead animals) associated with 10 minute exposure to 1136 mg/m^3 are discussed above.

Day 1 Scheduled Sacrifice:

Minimal degeneration was noted in the bronchioles of 1 of 4 rats exposed to 1136 mg/m^3 for 10 minutes.

This alteration was characterized by epithelial disorganization and occasional mitotic figures. Due to the small number of rats examined at this time point, it is unclear if this alteration represents a reproducible test substance-related finding.

Day 7 Scheduled Sacrifice:

No specific test substance-related findings were noted.

Day 90 Scheduled Sacrifice:

No specific test substance-related findings were noted.

Study V-OLD-2:

There were no unscheduled deaths noted in rats exposed for 2 minutes to either 1375 or 2150 mg/m^3.

Day 1 Scheduled Sacrifice:

Intraluminal alveolar infiltrates in the lungs, characterized by minimal very focal accumulations of macrophages, were noted in 3 of 8 rats exposed to 2150 mg/m^3 for 2 minutes and minimal degeneration in the trachea was evident in 1 of 8 rats at this exposure. Minimal focal alveolar infiltrates of macrophages are a common spontaneous alteration and these minimal alterations were not considered toxicologically significant. Because the tracheal degeneration was noted in only one rat dosed for 2 minutes and was not evident in the rats dosed for 10 minutes, this alteration also was not considered a significant test substance-related alteration.

Day 7 Scheduled Sacrifice:

No specific test substance-related findings were noted.

Day 90 Scheduled Sacrifice:

No clear, specific test substance-related findings were noted. However, the occurrence of a subcutaneous hemangiosarcoma with metastasis to the lung in 1 of 8 rats exposed to 2150 mg/m^3 for 2 minutes is problematic. Tumors of any type are very uncommon in young rats, and hemangiosarcomas associated with the skin are uncommon (< 2%) in older rats based on a review of preclinical safety carcinogenicity study databases provided by Charles River Laboratories. No other vascular alterations were noted in any protocol-specified tissue in the study.

All other alterations in this study were considered common spontaneous alterations.

HISTOPATHOLOGIC FINDINGS:

No clearly specific histologic evidence of toxicity related to the exposure to "old" violet colored M18 smoke grenade emissions were noted in this study.

Minimal degeneration was noted in the bronchioles of 1 of 4 rats exposed to 1136 mg/m^3 for 10 minutes. Due to the small number of rats examined at this time point, it is unclear if this alteration represents a reproducible test substance-related finding.

A hemangiosarcoma with metastasis to the lung was noted in 1 of 8 rats sacrificed 90 days after exposure to 2150 mg/m^3 for 2 minutes. While the specific induction of a hemangiosarcoma within 90 days would be quite unusual, it should be noted that spontaneous hemangiosarcomas are uncommon in Sprague Dawley rats. This study was not designed with sufficient power to assess possible carcinogenic effects, and thus, it cannot be concluded that there is a specific carcinogenic effect with respect to this tumor.

CONCLUSIONS:

No clearly specific histologic evidence of toxicity related to the exposure to "old" violet colored M18 smoke grenade emissions were noted in this study.

SUBMITTED BY:

[redacted] 06 Oct 2006
Date

Dipl. ACVP, DABT

Study Number: 0497-24-05-08-01
Overall Microscopic Incidence Table
Audited Histopathology Report
Date Printed: 08 Sep 2006 11:49 AM

Organs / *Diagnoses* / *Modifiers* — Group:	*Group 01*		*Group 02*		*Group 03*		*Group 04*	
Sacrifice:	*Dos*	*Sac*	*Dos*	*Sac*	*Dos*	*Sac*	*Dos*	*Sac*
Sex:	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*
Total Animals Selected:	[0]	[18]	[0]	[24]	[11]	[13]	[0]	[18]
Body as a Whole	(0)	(0)	(0)	(0)	(10)	(0)	(0)	(0)
Not examined, not found in wet tissues	0	0	0	0	11	0	0	0
Not examined, not in plane of section	0	0	0	0	1	0	0	0
Cavity, Abdominal	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Within Normal Limits	0	0	0	0	0	0	0	0
Cavity, Oral	(0)	(0)	(0)	(0)	(3)	(0)	(0)	(0)
Within Normal Limits	0	0	0	0	3	0	0	0
Eye	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Within Normal Limits	0	0	0	0	0	0	0	0
Intestine, Small	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Within Normal Limits	0	0	0	0	0	0	0	0
Liver	(0)	(18)	(0)	(23)	(11)	(10)	(0)	(17)
Congestion	0	0	0	0	9	0	0	0
minimal	0	0	0	0	5	0	0	0
mild	0	0	0	0	4	0	0	0
Within Normal Limits	0	18	0	23	2	10	0	17
Lungs with bronchi	(0)	(18)	(0)	(23)	(11)	(12)	(0)	(17)
Congestion	0	0	0	0	7	0	0	1
minimal	0	0	0	0	6	0	0	1
mild	0	0	0	0	1	0	0	0
Degeneration	0	0	0	0	0	1	0	0
minimal	0	0	0	0	0	1	0	0
Hemangiosarcoma	0	0	0	0	0	0	0	0
Metastatic	0	0	0	0	0	0	0	0
Hemorrhage	0	2	0	1	0	1	0	1
minimal	0	2	0	1	0	1	0	1
mild	0	0	0	0	0	0	0	0
Infiltrate	0	0	0	0	1	0	0	0
minimal	0	0	0	0	1	0	0	0
Within Normal Limits	0	16	0	22	3	10	0	15
Lymph Node, Bronchial	(0)	(18)	(0)	(23)	(11)	(12)	(0)	(18)
Hemorrhage	0	4	0	5	2	0	0	7
minimal	0	4	0	5	2	0	0	6
mild	0	0	0	0	0	0	0	1
Hyperplasia, lymphoid	0	1	0	0	0	0	0	0
minimal	0	1	0	0	0	0	0	0
Not examined, not in plane of section	0	1	0	5	5	3	0	2
Within Normal Limits	0	12	0	13	4	9	0	9
Lymph Node, Cervical	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Hemorrhage	0	0	0	0	0	0	0	0
mild	0	0	0	0	0	0	0	0
Within Normal Limits	0	0	0	0	0	0	0	0
Lymph Node, Mandibular	(0)	(12)	(0)	(7)	(3)	(9)	(0)	(12)
Edema	0	0	0	0	0	0	0	0
minimal	0	0	0	0	0	0	0	0
Hemorrhage	0	5	0	6	0	7	0	9
minimal	0	5	0	4	0	6	0	6
mild	0	0	0	2	0	1	0	3
Not examined, not in plane of section	0	0	0	0	0	0	0	1

Group 1=Control V-OLD- 10
Group 2=Low Dose V-OLD- 10
Group 3=High Dose V-OLD-10
Group 4=Control V-OLD-2
Group 5=Low Dose V-OLD-2
Group 6=High Dose V-OLD-2
Dos=Died on Study (FD) Found Dead
Sac=Scheduled Sacrifice (SK) Scheduled Kill

Organs Group:	*Group 01*		*Group 02*		*Group 03*		*Group 04*	
Diagnoses Sacrifice:	*Dos*	*Sac*	*Dos*	*Sac*	*Dos*	*Sac*	*Dos*	*Sac*
Modifiers Sex:	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*
Total Animals Selected:	[0]	[18]	[0]	[24]	[11]	[13]	[0]	[18]
Lymph Node, Mandibular (continued)								
Within Normal Limits	0	7	0	1	3	2	0	2
Lymph Node, Mesenteric	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Not examined, not found in wet tissues	0	0	0	0	0	0	0	0
Within Normal Limits	0	0	0	0	0	0	0	0
Nasal Tissues, Level 1	(0)	(18)	(0)	(23)	(11)	(11)	(0)	(17)
Not examined, not found in wet tissues	0	0	0	0	1	0	0	0
Within Normal Limits	0	18	0	23	10	11	0	17
Nasal Tissues, Level 2	(0)	(18)	(0)	(23)	(11)	(11)	(0)	(17)
Within Normal Limits	0	18	0	23	11	11	0	17
Nasal Tissues, Level 3	(0)	(18)	(0)	(23)	(11)	(11)	(0)	(17)
Congestion	0	0	0	1	0	0	0	0
mild	0	0	0	1	0	0	0	0
Within Normal Limits	0	18	0	22	11	11	0	17
Nasal Tissues, Level 4	(0)	(18)	(0)	(23)	(11)	(11)	(0)	(17)
Congestion	0	0	0	1	0	0	0	0
mild	0	0	0	1	0	0	0	0
Hemorrhage	0	0	0	0	0	0	0	0
mild	0	0	0	0	0	0	0	0
Within Normal Limits	0	18	0	22	11	11	0	17
Oral Tissues, Buccal Wall	(0)	(0)	(0)	(0)	(2)	(0)	(0)	(0)
Within Normal Limits	0	0	0	0	2	0	0	0
Oral Tissues, Tongue	(0)	(0)	(0)	(0)	(6)	(0)	(0)	(0)
Within Normal Limits	0	0	0	0	6	0	0	0
Ovary	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(1)
Congestion	0	0	0	0	0	0	0	1
minimal	0	0	0	0	0	0	0	1
Skin	(0)	(0)	(0)	(0)	(10)	(0)	(0)	(0)
Not examined, not found in wet tissues	0	0	0	0	4	0	0	0
Not examined, not present on slide	0	0	0	0	1	0	0	0
Within Normal Limits	0	0	0	0	5	0	0	0
Spinal Cord, Thorax	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(0)
Hemangiosarcoma	0	0	0	0	0	0	0	0
Spleen	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(1)
Within Normal Limits	0	0	0	0	0	0	0	1
Stomach	(0)	(0)	(0)	(0)	(3)	(0)	(0)	(0)
Within Normal Limits	0	0	0	0	3	0	0	0
Thymus	(0)	(3)	(0)	(1)	(0)	(1)	(0)	(1)
Hemorrhage	0	3	0	1	0	1	0	1
minimal	0	2	0	1	0	0	0	1
mild	0	1	0	0	0	1	0	0
Within Normal Limits	0	0	0	0	0	0	0	0
Trachea	(0)	(18)	(0)	(23)	(11)	(11)	(0)	(17)
Degeneration	0	0	0	0	0	0	0	0
minimal	0	0	0	0	0	0	0	0
Not examined, not found in wet tissues	0	0	0	0	0	0	0	0
Within Normal Limits	0	18	0	23	11	11	0	17
Uterus	(0)	(1)	(0)	(0)	(0)	(1)	(0)	(0)
Dilatation	0	1	0	0	0	1	0	0

Group 01=Control V-OLD- 10
Group 02=Low Dose V-OLD- 10
Group 03=High Dose V-OLD-10
Group 04=Control V-OLD-2
Group 05=Low Dose V-OLD-2
Group 06=High Dose V-OLD-2
Dos=Died on Study (FD) Found Dead
Sac=Scheduled Sacrifice (SK) Scheduled Kill

Study Number: 0497-24-05-08-01
Overall Microscopic Incidence Table
Audited Histopathology Report
Date Printed: 08 Sep 2006 11:49 AM

Organs / *Diagnoses* / *Modifiers*	Group:	*Group 01*		*Group 02*		*Group 03*		*Group 04*	
	Sacrifice:	*Dos*	*Sac*	*Dos*	*Sac*	*Dos*	*Sac*	*Dos*	*Sac*
	Sex:	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*	*M&F*
	Total Animals Selected:	[0]	[18]	[0]	[24]	[11]	[13]	[0]	[18]
Uterus (continued)									
Dilatation (continued)									
minimal		0	1	0	0	0	1	0	0

Group 01=Control V-OLD- 10
Group 02=Low Dose V-OLD- 10
Group 03=High Dose V-OLD-10
Group 04=Control V-OLD-2
Group 05=Low Dose V-OLD-2
Group 06=High Dose V-OLD-2
Dos=Died on Study (FD) Found Dead
Sac=Scheduled Sacrifice (SK) Scheduled Kill

Study Number: 0497-24-05-08-01
Overall Microscopic Incidence Table
Audited Histopathology Report
Date Printed: 08 Sep 2006 11:49 AM

Organs / *Diagnoses* / *Modifiers* — Group:	*Group 05*		*Group 06*	
Sacrifice:	*Dos*	*Sac*	*Dos*	*Sac*
Sex:	*M&F*	*M&F*	*M&F*	*M&F*
Total Animals Selected:	[0]	[24]	[0]	[24]
Body as a Whole	(0)	(0)	(0)	(0)
Not examined, not found in wet tissues	0	0	0	0
Not examined, not in plane of section	0	0	0	0
Cavity, Abdominal	(0)	(1)	(0)	(0)
Within Normal Limits	0	1	0	0
Cavity, Oral	(0)	(0)	(0)	(0)
Within Normal Limits	0	0	0	0
Eye	(0)	(1)	(0)	(0)
Within Normal Limits	0	1	0	0
Intestine, Small	(0)	(1)	(0)	(0)
Within Normal Limits	0	1	0	0
Liver	(0)	(20)	(0)	(24)
Congestion	0	0	0	0
minimal	0	0	0	0
mild	0	0	0	0
Within Normal Limits	0	20	0	24
Lungs with bronchi	(0)	(21)	(0)	(24)
Congestion	0	4	0	1
minimal	0	4	0	1
mild	0	0	0	0
Degeneration	0	0	0	0
minimal	0	0	0	0
Hemangiosarcoma	0	0	0	1
Metastatic	0	0	0	1
Hemorrhage	0	3	0	0
minimal	0	2	0	0
mild	0	1	0	0
Infiltrate	0	0	0	3
minimal	0	0	0	3
Within Normal Limits	0	14	0	19
Lymph Node, Bronchial	(0)	(22)	(0)	(24)
Hemorrhage	0	1	0	11
minimal	0	1	0	7
mild	0	0	0	4
Hyperplasia, lymphoid	0	0	0	0
minimal	0	0	0	0
Not examined, not in plane of section	0	4	0	3
Within Normal Limits	0	17	0	10
Lymph Node, Cervical	(0)	(4)	(0)	(0)
Hemorrhage	0	1	0	0
mild	0	1	0	0
Within Normal Limits	0	3	0	0
Lymph Node, Mandibular	(0)	(10)	(0)	(10)
Edema	0	1	0	0
minimal	0	1	0	0
Hemorrhage	0	7	0	10
minimal	0	6	0	5
mild	0	1	0	5
Not examined, not in plane of section	0	2	0	0

Group 1=Control V-OLD- 10
Group 2=Low Dose V-OLD- 10
Group 3=High Dose V-OLD-10
Group 4=Control V-OLD-2
Group 5=Low Dose V-OLD-2
Group 6=High Dose V-OLD-2
Dos=Died on Study (FD) Found Dead
Sac=Scheduled Sacrifice (SK) Scheduled Kill

Study Number: 0497-24-05-08-01
Overall Microscopic Incidence Table
Audited Histopathology Report
Date Printed: 08 Sep 2006 11:50 AM

Organs / *Diagnoses* / *Modifiers* — Group:	*Group 05*		*Group 06*	
Sacrifice:	*Dos*	*Sac*	*Dos*	*Sac*
Sex:	*M&F*	*M&F*	*M&F*	*M&F*
Total Animals Selected:	[0]	[24]	[0]	[24]
Lymph Node, Mandibular (continued)				
Within Normal Limits	0	0	0	0
Lymph Node, Mesenteric	(0)	(2)	(0)	(0)
Not examined, not found in wet tissues	0	1	0	0
Within Normal Limits	0	1	0	0
Nasal Tissues, Level 1	(0)	(21)	(0)	(24)
Not examined, not found in wet tissues	0	0	0	0
Within Normal Limits	0	21	0	24
Nasal Tissues, Level 2	(0)	(21)	(0)	(24)
Within Normal Limits	0	21	0	24
Nasal Tissues, Level 3	(0)	(21)	(0)	(24)
Congestion	0	0	0	0
mild	0	0	0	0
Within Normal Limits	0	21	0	24
Nasal Tissues, Level 4	(0)	(21)	(0)	(24)
Congestion	0	0	0	0
mild	0	0	0	0
Hemorrhage	0	0	0	1
mild	0	0	0	1
Within Normal Limits	0	21	0	23
Oral Tissues, Buccal Wall	(0)	(0)	(0)	(0)
Within Normal Limits	0	0	0	0
Oral Tissues, Tongue	(0)	(0)	(0)	(0)
Within Normal Limits	0	0	0	0
Ovary	(0)	(0)	(0)	(0)
Congestion	0	0	0	0
minimal	0	0	0	0
Skin	(0)	(0)	(0)	(1)
Not examined, not found in wet tissues	0	0	0	0
Not examined, not present on slide	0	0	0	0
Within Normal Limits	0	0	0	1
Spinal Cord, Thorax	(0)	(0)	(0)	(1)
Hemangiosarcoma	0	0	0	1
Spleen	(0)	(0)	(0)	(0)
Within Normal Limits	0	0	0	0
Stomach	(0)	(1)	(0)	(0)
Within Normal Limits	0	1	0	0
Thymus	(0)	(6)	(0)	(3)
Hemorrhage	0	5	0	3
minimal	0	5	0	3
mild	0	0	0	0
Within Normal Limits	0	1	0	0
Trachea	(0)	(21)	(0)	(24)
Degeneration	0	0	0	1
minimal	0	0	0	1
Not examined, not found in wet tissues	0	0	0	1
Within Normal Limits	0	21	0	22
Uterus	(0)	(0)	(0)	(0)
Dilatation	0	0	0	0

Group 01=Control V-OLD- 10
Group 02=Low Dose V-OLD- 10
Group 03=High Dose V-OLD-10
Group 04=Control V-OLD-2
Group 05=Low Dose V-OLD-2
Group 06=High Dose V-OLD-2
Dos=Died on Study (FD) Found Dead
Sac=Scheduled Sacrifice (SK) Scheduled Kill

Organs	Group:	*Group 05*		*Group 06*	
Diagnoses	Sacrifice:	*Dos*	*Sac*	*Dos*	*Sac*
Modifiers	Sex:	*M&F*	*M&F*	*M&F*	*M&F*
	Total Animals Selected:	[0]	[24]	[0]	[24]
Uterus (continued)					
Dilatation (continued)					
minimal		0	0	0	0

Group 01=Control V-OLD- 10
Group 02=Low Dose V-OLD- 10
Group 03=High Dose V-OLD-10
Group 04=Control V-OLD-2
Group 05=Low Dose V-OLD-2
Group 06=High Dose V-OLD-2
Dos=Died on Study (FD) Found Dead
Sac=Scheduled Sacrifice (SK) Scheduled Kill

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-052
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

·Lymph Node, Bronchial	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-055
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-056
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-057
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal
Thymus	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-059
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Hyperplasia, lymphoid, minimal
Thymus	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-062
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

•Thymus	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-065
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-069
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-071
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-076
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-093
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-098
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-099
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lungs with bronchi	Hemorrhage, minimal
Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-102
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-104
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-117
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal
Uterus	Dilatation, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-118
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lungs with bronchi	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Bronchial, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (01) Control V-OLD- 10 Sex: Female Animal Number: 06-119
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-051
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, mild

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-053
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Thymus	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-058
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-064
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal
Lymph Node, Mandibular	Hemorrhage, mild
Nasal Tissues, Level 3	Congestion, mild
Nasal Tissues, Level 4	Congestion, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-066
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-067
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lungs with bronchi	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-068
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-072
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-073
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-074
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-075
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-078
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-081
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-081
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results (continued)

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-082
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-083
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-084
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-087
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-094
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-096
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-097
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-100
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-103
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-106
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-106
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results (continued)

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (02) Low Dose V-OLD- 10 Sex: Female Animal Number: 06-108
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-050
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results

Body as a Whole	Not examined, not found in wet tissues *Feet*
Lymph Node, Bronchial	Not examined, not in plane of section
Nasal Tissues, Level 1	Within Normal Limits *Nares*

The following organs were found to be Within Normal Limits:
Cavity, Oral, Liver, Lungs with bronchi, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Skin, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-054
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lungs with bronchi	Degeneration, minimal *Bronchioles*
Lymph Node, Bronchial	Not examined, not in plane of section

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-060
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results

Body as a Whole	Not examined, not found in wet tissues *Feet*
Lymph Node, Bronchial	Hemorrhage, minimal
Nasal Tissues, Level 1	Within Normal Limits *Nares*
Skin	Not examined, not present on slide *Fur*

The following organs were found to be Within Normal Limits:
Cavity, Oral, Liver, Lungs with bronchi, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-061
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-063
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results

Body as a Whole	Not examined, not in plane of section *Nares* Not examined, not found in wet tissues *Feet* Not examined, not found in wet tissues *Feet*
Liver	Congestion, minimal
Lungs with bronchi	Congestion, minimal
Lymph Node, Bronchial	Not examined, not in plane of section
Nasal Tissues, Level 1	Within Normal Limits *Nares*

The following organs were found to be Within Normal Limits:
Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Oral Tissues, Tongue, Skin, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-070
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results

Body as a Whole	Not examined, not found in wet tissues *Feet*
Liver	Congestion, minimal
Lungs with bronchi	Infiltrate, minimal *Alveolar*
Nasal Tissues, Level 1	Within Normal Limits *Nares*

The following organs were found to be Within Normal Limits:
Lymph Node, Bronchial, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Skin, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-077
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results

Body as a Whole	Not examined, not found in wet tissues *Feet*
Liver	Congestion, minimal
Lungs with bronchi	Congestion, minimal
Lymph Node, Bronchial	Not examined, not in plane of section

The following organs were found to be Within Normal Limits:
Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Oral Tissues, Buccal Wall, Oral Tissues, Tongue, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-079
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lungs with bronchi	Hemorrhage, minimal

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-080
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-085
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results

Body as a Whole	Not examined, not found in wet tissues
	Feet
Liver	Congestion, minimal
Nasal Tissues, Level 1	Within Normal Limits
	Nares

The following organs were found to be Within Normal Limits:
Lungs with bronchi, Lymph Node, Bronchial, Lymph Node, Mandibular, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Oral Tissues, Buccal Wall, Oral Tissues, Tongue, Skin, Stomach, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-086
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results

Body as a Whole	Not examined, not found in wet tissues
	Feet
Liver	Congestion, mild
Lungs with bronchi	Congestion, minimal
Nasal Tissues, Level 1	Not examined, not found in wet tissues
	Nares
Skin	Not examined, not found in wet tissues
	Fur

The following organs were found to be Within Normal Limits:
Cavity, Oral, Lymph Node, Bronchial, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Oral Tissues, Tongue, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-088
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results

Body as a Whole	*Feet*
Liver	Congestion, mild
Lungs with bronchi	Congestion, minimal
Nasal Tissues, Level 1	Within Normal Limits
	Nares

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-088
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results (continued)

The following organs were found to be Within Normal Limits:
Lymph Node, Bronchial, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Oral Tissues, Tongue, Skin, Stomach, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-089
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results

Body as a Whole	Not examined, not found in wet tissues *Feet*
Liver	Congestion, mild
Lungs with bronchi	Congestion, mild
Lymph Node, Bronchial	Not examined, not in plane of section
Skin	Not examined, not found in wet tissues *Fur*

The following organs were found to be Within Normal Limits:
Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Oral Tissues, Tongue, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-090
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-091
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-092
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Lymph Node, Mandibular	Hemorrhage, minimal
Thymus	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-095
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-101
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Lymph Node, Mandibular	Hemorrhage, minimal

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-105
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results

Body as a Whole	Not examined, not found in wet tissues *Feet*
Liver	Congestion, minimal
Lungs with bronchi	Congestion, minimal
Lymph Node, Bronchial	Not examined, not in plane of section
Nasal Tissues, Level 1	Within Normal Limits *Nares*
Skin	Not examined, not found in wet tissues *Fur*

The following organs were found to be Within Normal Limits:
Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-107
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal
Uterus	Dilatation, minimal *Luminal*

The following organs were found to be Within Normal Limits:
Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-109
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-111
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-114
Fate: (FD) Found Dead Species: Rat Days on Study: 0

Microscopic Results

Body as a Whole	Not examined, not found in wet tissues *Feet*
Liver	Congestion, mild
Lungs with bronchi	Congestion, minimal
Lymph Node, Bronchial	Hemorrhage, minimal
Nasal Tissues, Level 1	Within Normal Limits *Nares*
Skin	Not examined, not found in wet tissues *Fur*

The following organs were found to be Within Normal Limits:
Lymph Node, Mandibular, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Stomach, Trachea

Gp: (03) High Dose V-OLD-10 Sex: Female Animal Number: 06-115
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-123
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-125
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal
Lymph Node, Mandibular	Hemorrhage, minimal

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-134
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-136
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Ovary	Congestion, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-137
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Thymus	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-138
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lungs with bronchi	Congestion, minimal
Lymph Node, Bronchial	Hemorrhage, minimal
Lymph Node, Mandibular	Not examined, not in plane of section

The following organs were found to be Within Normal Limits:
Liver, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-139
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-144
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, mild
Lymph Node, Mandibular	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-145
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-151
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-152
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-166
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Spleen, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-174
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

•Lymph Node, Bronchial	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-175
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal
Lymph Node, Mandibular	Hemorrhage, minimal *The mandibular lymph node apparently was identified as "cervical lymph node" in some macroscopic findings*

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-177
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal
Lymph Node, Mandibular	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-178
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-179
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Lymph Node, Mandibular, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (04) Control V-OLD-2 Sex: Female Animal Number: 06-181
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lungs with bronchi	Hemorrhage, minimal
Lymph Node, Bronchial	Hemorrhage, minimal
Lymph Node, Mandibular	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-122
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lungs with bronchi	Congestion, minimal
Lymph Node, Bronchial	Not examined, not in plane of section
Lymph Node, Mandibular	Not examined, not in plane of section

The following organs were found to be Within Normal Limits:
Liver, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-126
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Mandibular	Not examined, not in plane of section
Thymus	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-127
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lungs with bronchi	Congestion, minimal
Lymph Node, Cervical	Hemorrhage, mild
Thymus	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-129
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Lymph Node, Mandibular	Hemorrhage, mild
Thymus	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Lungs with bronchi, Lymph Node, Cervical, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-130
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Uterus	*Normal estrus-phase*

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-140
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal
Lymph Node, Mesenteric	Not examined, not found in wet tissues
Thymus	Hemorrhage, minimal

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-141
Fate: (SK) Scheduled Kill Species: 06.0352 Days on Study: 1

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Lymph Node, Cervical, Lymph Node, Mesenteric, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Stomach, Thymus, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-142
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lungs with bronchi	Congestion, minimal
Lymph Node, Bronchial	Not examined, not in plane of section
Thymus	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Cavity, Abdominal, Intestine, Small, Liver, Lymph Node, Cervical, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-147
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-148
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-149
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-156
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-160
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lungs with bronchi	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-161
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Mandibular	Edema, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-162
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-162
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results (continued)

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-164
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lungs with bronchi	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-165
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lungs with bronchi	Hemorrhage, minimal
Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-167
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-168
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Eye

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-170
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lungs with bronchi	Congestion, minimal

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-170
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results (continued)

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-171
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-176
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-180
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (05) Low Dose V-OLD-2 Sex: Female Animal Number: 06-189
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-120
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lungs with bronchi	Infiltrate, minimal *Alveolar*
Lymph Node, Mandibular	Hemorrhage, minimal

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-120
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results (continued)

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-121
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lungs with bronchi	Infiltrate, minimal *Alveolar*

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-124
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-128
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lungs with bronchi	Infiltrate, minimal *Alveolar*
Lymph Node, Bronchial	Hemorrhage, minimal
Lymph Node, Mandibular	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-131
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-133
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-135
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Trachea	Degeneration, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-146
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 1

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Lymph Node, Mandibular	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-150
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Not examined, not in plane of section
Lymph Node, Mandibular	Hemorrhage, mild
Thymus	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-153
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Skin, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-154
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, mild
Lymph Node, Mandibular	Hemorrhage, minimal
Thymus	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-155
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal
Lymph Node, Mandibular	Hemorrhage, minimal
Thymus	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-158
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Trachea	Not examined, not found in wet tissues

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-163
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal
Lymph Node, Mandibular	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-169
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal
Lymph Node, Mandibular	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-172
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 7

Microscopic Results

Lungs with bronchi	Congestion, minimal
Lymph Node, Mandibular	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-173
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lungs with bronchi	Hemangiosarcoma, Metastatic
Lymph Node, Bronchial	Hemorrhage, mild
Spinal Cord, Thorax	Hemangiosarcoma
	Mass

The following organs were found to be Within Normal Limits:
Liver, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-182
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-183
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-184
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-185
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-186
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, minimal

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-187
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Lymph Node, Bronchial	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Nasal Tissues, Level 4, Trachea

Gp: (06) High Dose V-OLD-2 Sex: Female Animal Number: 06-188
Fate: (SK) Scheduled Kill Species: Rat Days on Study: 90

Microscopic Results

Nasal Tissues, Level 4	Hemorrhage, mild

The following organs were found to be Within Normal Limits:
Liver, Lungs with bronchi, Lymph Node, Bronchial, Nasal Tissues, Level 1, Nasal Tissues, Level 2, Nasal Tissues, Level 3, Trachea

End of Report