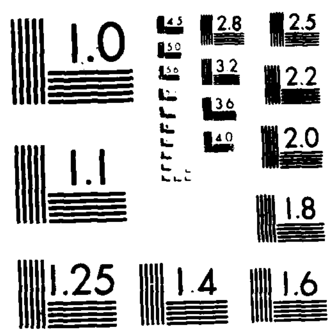
AD-A179 966   USA PYROTECHNICS OVERVIEW(U) NAVAL WEAPONS SUPPORT CENTER CRANE IN APPLIED SCIENCES DEPT B E DOUDA 23 FEB 87 NWSC/CR/RDTR-339   1/1

UNCLASSIFIED   F/G 19/1   NL


1.0
1.1
1.25
1.4
1.6
1.8
2.0
2.2
2.5
2.8
3.2
3.6
4.0

AD-A179 966

UNCLASSIFIED DTIC FILE COPY (2)

UNCLASSIFIED
NWSC/CR/RDTR-339

# U.S.A. PYROTECHNICS OVERVIEW (U)


BERNARD E. DOUDA

NAVAL WEAPONS SUPPORT CENTER
ORDNANCE DEVELOPMENT DEPARTMENT
CRANE, INDIANA 47522-5050





FEBRUARY 1987


Approved For Public Release; Distribution is Unlimited.

UNCLASSIFIED

Submitted by: 

B. E. DOUDA
Senior Scientist for Pyrotechnics
Ordnance Development Department

Approved by: 

C. D. ROBINSON
Director
Ordnance Development Department

SECURITY CLASSIFICATION OF THIS PAGE

# REPORT DOCUMENTATION PAGE

| | |
|---|---|
| 1a REPORT SECURITY CLASSIFICATION<br>UNCLASSIFIED | 1b RESTRICTIVE MARKINGS |
| 2a SECURITY CLASSIFICATION AUTHORITY<br>--<br>2b DECLASSIFICATION / DOWNGRADING SCHEDULE<br>-- | 3 DISTRIBUTION / AVAILABILITY OF REPORT<br>Approved for Public Release; Distribution is Unlimited. |
| 4 PERFORMING ORGANIZATION REPORT NUMBER(S)<br>NWSC/CR/RDTR-339 | 5 MONITORING ORGANIZATION REPORT NUMBER(S)<br>-- |
| 6a NAME OF PERFORMING ORGANIZATION<br>Ordnance Development Dept.<br>Naval Weapons Support Center<br>6b OFFICE SYMBOL (If applicable)<br>50C | 7a NAME OF MONITORING ORGANIZATION<br>-- |
| 6c ADDRESS (City, State, and ZIP Code)<br>Crane, IN 47522-5050 | 7b ADDRESS (City, State, and ZIP Code)<br>-- |
| 8a NAME OF FUNDING / SPONSORING ORGANIZATION<br>8b OFFICE SYMBOL (If applicable) | 9 PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER |
| 8c ADDRESS (City, State, and ZIP Code) | 10 SOURCE OF FUNDING NUMBERS<br>PROGRAM ELEMENT NO / PROJECT NO / TASK NO / WORK UNIT ACCESSION NO. |

11 TITLE (Include Security Classification)

U. S. A. Pyrotechnics Overview (U)

12 PERSONAL AUTHOR(S)

Bernard E. Douda

| 13a TYPE OF REPORT | 13b TIME COVERED | 14 DATE OF REPORT (Year, Month, Day) | 15 PAGE COUNT |
|---|---|---|---|
| Final | FROM ______ TO 02/87 | 87/02/23 | |

16 SUPPLEMENTARY NOTATION

| 17 COSATI CODES | | | 18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number) |
|---|---|---|---|
| FIELD | GROUP | SUB-GROUP | Infrared Decoy Flares. Smoke/Obscurants. Pyrotechnics. |

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

This paper addresses main pyrotechnic efforts relating to infrared decoys and smoke/obscurants for protection of aircraft, ships and tanks from threat devices and agencies which have substantial pyrotechnics interest.

This paper was presented at the Pyroteknikdagen Symposium 16 October 1986, at the University of Lund, Sweden.

| | |
|---|---|
| 20 DISTRIBUTION / AVAILABILITY OF ABSTRACT<br>☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS | 21 ABSTRACT SECURITY CLASSIFICATION<br>UNCLASSIFIED |
| 22a NAME OF RESPONSIBLE INDIVIDUAL<br>Bernard E. Douda | 22b TELEPHONE (Include Area Code) (812) 854-3420 — 22c OFFICE SYMBOL 50C |

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete

SECURITY CLASSIFICATION OF THIS PAGE

*U.S. Government Printing Office: 1985—507-047

RE: Report for Military Application
Distribution Statement A is correct for this report.
Per Dr. B. E. Douda, NWSC/Code 50

# U. S. A. PYROTECHNICS OVERVIEW

BERNARD E. DOUDA
ORDNANCE DEVELOPMENT DEPARTMENT
NAVAL WEAPONS SUPPORT CENTER
CRANE, IN 47522-5050 U.S.A.

We will present this overview in two parts. First we will discuss pyrotechnic interest areas to summarize their status. We are using the word pyrotechnics in the American sense; namely, it excludes propellants and explosives. Secondly, we will describe who the agencies are which have substantial pyrotechnics interests.

From a technology base standpoint, the main pyrotechnics effort relates to infrared decoys and smoke/obscurants for protection of aircraft, ships and tanks from threat devices. These efforts will not be discussed in this presentation.



## RESEARCH

Directed research currently addresses three areas: (a) modeling of infrared decoys and obscurants from first principles; (b) synthesis, characterization and evaluation of materials with special properties in various regions of the electromagnetic spectrum; and (c) synthesis and evaluation of high energy materials.

The modeling of the infrared decoy flare ignition, combustion and radiation from first principles is quite challenging. The problem couples thermodynamic, kinetic and ignition theory of inhomogeneous reactions with the physics of radiative transfer and fluid mechanics of the surrounding atmosphere, the latter ranging from sea level to very high altitude and with relative velocities of almost zero to more than Mach 1. Even though many of the fundamental equations can be written, some of the values for the input parameters do not exist and, in themselves, must be the object of further investigation. These include thermal conductivity, kinetic data, combustion products and chemical mechanisms. It is estimated that, given the models and the parametric values which feed them, the largest and fastest (Cray) computers will be required to solve the problem. We expect to use this model to perform sensitivity analyses on the parameters and thus determine their influence on the overall flare performance.

## INSENSITIVE PYROTECHNICS

The Tri-Services have embarked on a program to provide insensitive munitions to the operational forces. The impetus for this program stems from several catastrophic accidents involving munitions containing energetic materials. The program includes insensitive pyrotechnics. An insensitive pyrotechnic would be one which might burn but not deflagrate nor detonate. The program is applicable to all existing as well as future devices. All of this must be accomplished without sacrifice to performance.

A technological dilemma exists in many situations. On the one hand, we wish to formulate the material to deliver optimum and oftentimes maximum energy output, and on the other hand we need to severely degrade this energy release when we subject the material to unwanted stimuli, such as certain levels of heat or shock. When initiated unintentionally, the device must show the insensitive properties. When initiated intentionally, the device must perform with release of its required energy output.

The technological challenges are many and varied. They might range from (a) design engineering of venting systems to relieve unwanted pressure buildup to (b) the synthesis of special materials and their incorporation into future pyrotechnic formulae, such that the material will transform from a high energy material to an impotent material when subjected to an unwanted stimulus. One concept for the latter was presented by Dr. Chin at the Eleventh International Pyrotechnics Seminar.

## POLLUTION ABATEMENT

Occupational health, safety and pollution abatement are major concerns. Our current devices are being examined. Health and safety procedures are required during development and later production of a device. Ecologically acceptable demilitarization procedures are required for all devices. For the most part, such procedures have already been developed and evaluated.

A disposal procedure was developed and a one-tenth scale pilot plant was placed in operation to demonstrate the procedure for each of the following generic pyrotechnic areas.

a. Illuminating compositions: The magnesium is reclaimed for sale or reuse. The sodium nitrate-water solution is sprayed on hay fields for fertilizer or recovered as the salt and the residue (binder) is placed in a landfill.

b. Red phosphorus containing compositions: Complete incineration is accomplished. The effluent gases are scrubbed with water to form saleable fertilizer grade phosphoric acid. The residue is suitable for disposal in a landfill or could be used in the ceramic industry.

c. Photoflash compositions: The barium nitrate and potassium perchlorate are dissolved in hot water while the aluminum is filtered out. The mixed salts are recovered in a chilling stage. The salts can be separated if desired, but mixed salts are suitable as ingredients of green colored flame formulae.

d. Conventional infrared compositions: All ingredients, except small amounts of non-halogenated binders when present, can be reclaimed for sale or reuse. The non-halogenated binder residues are suitable for controlled incineration or can be placed in a landfill.

Pilot plants for the incineration of colored smoke, colored flares and dye markers are being designed. The material will be burned in an incinerator with complete efficient monitoring.

In the case of the colored smokes, chlorine salts are the only residue. For the colored flares, residues are still being evaluated. It is anticipated that the heavy metals (barium, strontium, and copper) will be removed by a wet scrubbing system. The oxalates are destroyed. The incineration of the dyes in dye markers will be complete, with no residue remaining.

Almost all of the dyestuffs in pre-1980 colored smoke compositions were either carcinogenic or suspected to be so. As a result, a major effort was put forth to find suitable replacement dyestuffs and to verify their suitability through extensive toxicological tests and examinations. Replacement dyestuffs have been found for all colors. As new devices are developed, or as old devices undergo product improvement projects, the toxicologically approved materials for replacement are introduced into the smoke compositions. The old materials and devices which contain them are being systematically removed from operational use. Subsequently, demilitarization takes place.

The established, and in some cases suspected, toxicity of the heavy metals is of some concern. These are often found in ignition, first fire and delay compositions. Lead is one example; hexavalent chromium in barium chromate is another. The latter is used with elemental boron to make ignition and delay compositions. Its widespread use, reliability and outstanding performance characteristics will increase the challenge to the pyrotechnician for finding a suitable replacement, where necessary.

## SOURCE MATERIALS

Despite all of the technological advances, we still occasionally are plagued with raw material variations. The supply of iron oxide still varies from lot to lot and by source. Oxide coatings and other trace impurities in magnesium fuel can cause performance degradation. Efforts are continuing to identify the source of the problem and to devise analytical techniques to assure that the material is suitable for use. Our methods and instruments to control material particle size are also imperfect. A related material effort is to find a replacement for one of our binders, vinyl alcohol acetate resin (VAAR). This is not because it is undesirable but rather because the producer no longer finds it economical to supply it in relatively small quantities.

## INSTRUMENTATION ADVANCES

The enormous advances in solid state physics, energy sensors, chips, and compact efficient computers have provided new tools to the pyrotechnician. The chromatography-mass spectrometer combination with computer analysis and species identification now allows one to conduct analysis more easily and in a shorter time frame. Better radiation detectors and computer data reduction make it much easier to develop and test new flares. Advances in spectroscopy allow the examination of flame species and thermal imagers help one to find these species as a function of position in the radiator. Electron optics assist in material analyses. Optical multichannel spectral analyzers and fast fourier transform spectroscopy further help to identify species, perhaps to track the reaction kinetics and ultimately to gain a better understanding of what is happening during the reaction. The main thought that I wish to leave with you concerning these instruments is that we are quickly learning how to apply them to our pyrotechnic studies. With these superior tools, we should expect continuing technological advances in, and a better understanding of, pyrotechnics.

Perhaps because these instruments have found their way into pyrotechnic laboratories, we already observe (a) an increased emphasis on obtaining microscopic information about our reactions, (b) an increase in modeling and simulation efforts, (c) attempts to control raw material properties more carefully, (d) computer aided pyrotechnic design, and (e) a rapidly increasing data base.

## AGENCIES

Next I wish to provide a brief idea of who the main Department of Defense (DOD) agencies are which are involved in pyrotechnics (American sense) technology. They are:

a. Naval Weapons Support Center (NAVWPNSUPPCEN), Crane, Indiana: All aspects of pyrotechnics research and development.

b. Naval Research Laboratory (NRL), Washington, DC: Pyrotechnics for ship self-protection decoys.

c. Naval Ordnance Station (NOS), Indian Head, Maryland: Delays, igniters and impulse cartridges.

d. Ballistic Research Laboratory (BRL), Aberdeen Proving Ground, Maryland: Black powder research.

e. Armament Research, Development and Engineering Center, (ARDEC) Dover, New Jersey: Pyrotechnics research and development but not smoke/obscurants.

f. Chemical Research, Development and Engineering Center, (CRDEC) Aberdeen Proving Ground, Maryland: Smoke/obscurants and colored smoke research and development.

g. Avionics Laboratory, Wright-Patterson Air Force Base, Ohio: Sponsor of contract research and development of infrared countermeasures.

[illegible] test [illegible] contractor locations and within DOD [illegible] are used by pyrotechnicians [illegible].

a. [illegible] Beach, Maryland, [illegible].

b. [illegible] tested at the Naval Surface Weapons Center, [illegible], [illegible] Proving Grounds, [illegible], Arizona and Jefferson Proving Grounds, Madison, Indiana.

c. [illegible] environment at the Naval Air Test Center, Patuxent River, Maryland.

d. Air-to-air testing of infrared decoys takes place at the Pacific Missile Test Center, Point Mugu, California and Eglin Air Force Base, Florida.

e. On the ground and ground-to-air testing takes place at the Naval Weapons Center (NWC) China Lake, California and the White Sands Missile Range, (WSMR) New Mexico. In addition, pyrotechnics are tested at Dugway Proving Grounds, Salt Lake City, Utah and Fort Huachuca, Sierra Vista, Arizona. Training with pyrotechnics and simulators takes place at Fort Benning, Columbus, Georgia and the National Training Center, Fort Irwin, Barstow, California.

f. Some special and unique facilities exist at CRDEC, ARDEC and NAVWPNSUPPCEN. Smoke/obscurants evaluation and characterization chambers are at CRDEC. Radiation measurement laboratories exist at ARDEC and NAVWPNSUPPCEN. ARDEC has a 227 cubic meter volume high altitude chamber, about 23 meters long, of a conical shape with 4.6 meters diameter at the fireplace tapering to 1.5 meters diameter at the measurement end. Rocket sleds are available at NWC and Holloman Air Force Base, Alamogordo, New Mexico. Air stream, blow-down equipment and wind tunnels are located in a variety of locations.

## TRI-SERVICE COORDINATION

Foreign pyrotechnicians are frequently overwhelmed by the number of different American organizations which are involved in military pyrotechnics. The effort at these organizations does not necessarily proceed independently. We share resources and special and unique facilities, undertake joint projects, and, in general, work together toward common goals. We achieve this coordination mainly through the efforts of two Tri-Service committees. These are the Joint Technical Coordinating Group for Munitions Development (JTCG/MD) and the Joint Directors of Laboratories (JDL) technical panels.

6402K/21G

DISTRIBUTION:

ADMINISTRATOR (two copies)
DEFENSE TECHNICAL INFORMATION CENTER
(DTI[illegible] HAR)
CAMERON STATION
ALEXANDRIA, VA 22304-6145

CDR C[illegible]NT EPLEY, OCNR-0215
OFFICE OF THE CHIEF OF NAVAL RESEARCH
800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5000

MR. [illegible] M. HOAG, OCNR-25
OFFICE OF THE CHIEF OF NAVAL RESEARCH
800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5000

MR. RICH LOW, SEA-62Y32
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, DC 20362-5101

MR. DOUG PAYNE, SEA-62Y13
NAVAL SEA SYSTEMS COMMAND
WASHINGTON, DC 20362-5101

COMMANDER
NAVAL SEA SYSTEMS COMMAND
(SEA-06R)
WASHINGTON, DC 20352-5010

COMMANDER
NAVAL SEA SYSTEMS COMMAND
(SEA-06R32)
WASHINGTON, DC 20362-5101

MR. W. MAZZA, AIR-54043F
NAVAL AIR SYSTEMS COMMAND
WASHINGTON, DC 20361-5404

MR. D. K. SANDERS, AIR-5402E1
NAVAL AIR SYSTEMS COMMAND
WASHINGTON, DC 20361-5402

MR. G. E. KOVALENKO, AIR-932E
NAVAL AIR SYSTEMS COMMAND
WASHINGTON, DC 20361-9320

DR. W. M. TOLLES, CODE 6100
NAVAL RESEARCH LABORATORY
WASHINGTON, DC 20375-5000

DR. H. D. LADOUCEUR, CODE 6170
NAVAL RESEARCH LABORATORY
WASHINGTON, DC 20375-5000

DR. JOHN A. MONTGOMERY, CODE 5700
NAVAL RESEARCH LABORATORY
WASHINGTON, DC 20375-5000

MR. W. E. HOWELL, CODE 5711
NAVAL RESEARCH LABORATORY
WASHINGTON, DC 20375-5000

DR. J. A. LAFFMINA, CODE 5711
NAVAL RESEARCH LABORATORY
WASHINGTON, DC 20375-5000

MR. FRANK VALENTA, CODE 5124
ORDNANCE DEVICES DEPARTMENT
NAVAL ORDNANCE STATION
INDIAN HEAD, MD 20640-5000

MR. DAN STOWELL, CODE 4033
PACIFIC MISSILE TEST CENTER
POINT MUGU, CA 93042-5000

MR. JOHN CRECELIUS, CODE 3893
NAVAL WEAPONS CENTER
CHINA LAKE, CA 93555-6001

MR. JOHN JOYNER
NAVAL WEAPONS CENTER
CHINA LAKE, CA 93555-6001

MR. LARRY MATHEWS, CODE 3893
RESEARCH DEPARTMENT, ENGINEERING SCIENCES DIVISION
NAVAL WEAPONS CENTER
CHINA LAKE, CA 93555-6001

LT GARRY GAGNON, FTD/SDEO
FOREIGN TECHNOLOGY DIVISION (AFSC)
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433

MR. FRANCIS D. LINTON, AFWAL/AAWW-3
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-6543

MR. STEVE WIRICK, AFWAL/AAWW-3
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-6543

MR. BRUCE NOREN, AFWAL/AAWD-2
AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
WRIGHT-PATTERSON AIR FORCE BASE, OH 45433-6543

DR. FRANCIS R. TAYLOR, SMCAR-AEE-P
U.S. ARMY POINT OF CONTACT,
TTCP WTP-1 PYROTECHNICS AND INCENDIARIES
ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
DOVER, NJ 07801-5001

MR. JOE DOMANICO, SMCCR-MUS-A
MUNITIONS DIRECTORATE
CHEMICAL RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ABERDEEN PROVING GROUND, MD 21010-5423

DR. HENRY L. MANUEL, AMCPM-SMK-E
OFFICE OF THE PROJECT MANAGER SMOKE/OBSCURANTS
U.S. ARMY POINT OF CONTACT FOR SMOKE/OBSCURANTS
TTCP WTP-1 PYROTECHNICS AND INCENDIARIES
U.S. ARMY ARMAMENT, MUNITIONS AND CHEMICAL COMMAND
ABERDEEN PROVING GROUND, MD 21005-5001

MR. MERLIN ERICKSON, SMCCR-MUS
CHIEF, SMOKE DIVISION
U.S. ARMY CHEMICAL RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ABERDEEN PROVING GROUND, MD 21010-5423

MR. DENNIS F. FLANIGAN, SMCCR-RSP-B
CHIEF, OBSCURATION SCIENCES
CHEMICAL RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ABERDEEN PROVING GROUND, MD 21010-5423

MR. RONALD A. SASSE', SLCBR-IB-I
BALLISTIC RESEARCH LABORATORY
ABERDEEN PROVING GROUND, MD 21005-5066

MR. A. L. TURETSKY, SMCCR-RSP-B
CHEMICAL RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ABERDEEN PROVING GROUND, MD 21010-5423

DR. ED STUEBING, SMCCR-RSP-B
CHEMICAL RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ABERDEEN PROVING GROUND, MD 21010-5423

MR. JOSEPH C. CALLAHAN, AMCPM-SMK-D
OFFICE OF THE PROJECT MANAGER FOR SMOKE/OBSCURANTS
U.S. ARMY ARMAMENT, MUNITIONS AND CHEMICAL COMMAND
ABERDEEN PROVING GROUND, MD 21005-5001

MR. GILBERT CHESNOV, SMCAR-AEE-P
ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
DOVER, NJ 07801-5001

MR. LEO FREY, SMCAR-AEE-P
ARMAMENT RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
DOVER, NJ 07801-5001

MR. WILLIAM DEE, SMCCR-MU(A)
CHEMICAL RESEARCH, DEVELOPMENT AND ENGINEERING CENTER
ABERDEEN PROVING GROUND, MD 21010-5423

MR. MICHAEL LAMB, DT-3B
DEFENSE INTELLIGENCE AGENCY
WASHINGTON, DC 20301

DR. DAVID WANG, NISC-10
NAVAL INTELLIGENCE SUPPORT CENTER
WASHINGTON, DC 20390

MR. NORM TAYLOR
U.S. ARMY FOREIGN SCIENCE AND TECHNOLOGY CENTER
220 7TH STREET NE
CHARLOTTESVILLE, VA 22901-5396

MR. HOWARD SHEINFELD, AIAST-RA-ST3
U.S. ARMY FOREIGN SCIENCE AND TECHNOLOGY CENTER
220 7TH STREET NE
CHARLOTTESVILLE, VA 22901-5396

IIT RESEARCH INSTITUTE
(GACIAC DOCUMENT LIBRARY)
10 WEST 35TH STREET
CHICAGO, IL 60616

ENVIRONMENTAL RESEARCH INSTITUTE OF MICHIGAN
(IRIA LIBRARY)
P.O. BOX 9718
ANN ARBOR, MI 48107

ELECTROMAGNETIC COMPATIBILITY ANALYSIS CENTER
NORTH SEVERN, ECAC BUILDING 120
ANNAPOLIS, MD 21402

END
5-87
DTIC