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Pyrotechnics 3 days 3 instructors

OVERALL OBJECTIVES:

The student shall achieve a broad understanding of a wide variety of pyrotechnic devices, smokes, riot control compositions, whistles, illuminants, flares, strobes, igniters, delays, incendiaries, training devices, destruct systems and MEMS-based pyrotechnic ignition devices as well as considerations for the design, development, and testing of the ignition trains required to initiate them. In addition, he will learn the details of illuminants and infrared decoy flares including their underlying theory of operation, their methods of manufacture and some additional safety aspects.

LEARNING OBJECTIVES:

This course will provide a comprehensive overview of a wide variety of pyrotechnic materials, and how they are formulated, produced, tested, and qualified for military use. The design, development, testing and production of pyrotechnic devices will be addressed as well. The student is expected to achieve a general understanding of the uses of a variety of pyrotechnic devices, ignition trains, and MEMS devices for both military and commercial pyrotechnic applications.

This course will provide a technical discussion of the evolution of illuminants and infrared decoy flares with details on unique aspects of compositions, flame plumes, and counterintuitive aspects of processing and handling of compositions. Military applications of illuminants and decoy flares will be the primary intended focus area of the discussions. The "whys" of many factors such as component composition, mixing procedures, production processes, advances in processing technology and safety considerations unique to these two pyrotechnic classes (illuminants and decoy flares) will be presented. The student will be informed of several significant problem areas that have been encountered and solved as these pyrotechnic items have undergone production development. The methodology used in some of this problem-solving will help the student gain some insight into recognizing and solving production problems which he encounters.

Students will learn the basics of radiative transfer theory underlying the functioning of IR and visible illuminants and flares and how the effects of flare size, formulation changes,

selection of ingredients, particle size effects and other phenomena affect flare output. Many of these effects are counter-intuitive but have been verified by experimental data. He will learn how to achieve optimum IR output and how to control the output through oxidizer/fuel ratio and physical shape of the flare to provide the profile needed to decoy a heat-seeking missile. He will become familiar with a wide variety of manufacturing methods including Muller mixers, coacervation, and twin-screw extruder compounding, and be conversant with relevant safety issues for their operation with energetic materials.

Methods for testing the safe-handling aspects of new, uncharacterized pyrotechnic formulations will be presented, with special emphasis on friction, impact, and electrostatic sensitivity characteristics. A session will be included which will review the methods for analysis, assessment, and mitigation of electrostatic hazards in pyrotechnic mixing, handling, and operating areas, and the effects of formulation variables, particle size, environmental conditions, and electric discharge parameters on the sensitivity of various types of pyrotechnic formulations. Students will learn the current test methods and procedures by which military pyrotechnics are qualified for use, and the genesis and evolution of these procedures. The properties and performance of a wide variety of pyrotechnic mixtures which have commonly been employed in military & commercial use for many years (first-fire mixtures, priming mixtures, delays, photoflash, thermites, thermal battery heat powders, and incendiaries) will be discussed, along with newer technology energetics which have evolved relatively recently (sol-gel thermites, nano-energetics, Metastable-Interstitial-Composite (MIC) materials, SHS reactions and materials). An overview of the formulations used as pyrotechnic delay materials will be presented, as well as the basic design guidelines for the incorporation of delay materials into safe and reliable pyrotechnic delay devices. The student will learn how various types of in-line and out-of-line ignition trains for pyrotechnics are designed, developed and tested (mechanical, electric and laser initiation) and how test protocols should be developed in order to quantitatively or qualitatively assess the safety and reliability of these ignition trains in accordance with MIL-STD-1901 & MIL-STD-1911. Although the emphasis of ignition train assessment will be on systems that are designed for pyrotechnic output effects (smokes, flares, sound, incendiaries), these methods can typically applied with equal validity to rocket motors, Propellant-Actuated-Devices (PADs) and Cartridge-Actuated-Devices (CADs). Some commercial special-effects applications of pyrotechnic materials and other less well-known applications will also be presented and discussed in order to provide the student with a balanced perspective on the modern uses of pyrotechnic materials & devices.

In the areas of smokes, whistles, obscurants, and training simulators, this course will provide a technical overview of a wide variety of pyrotechnic compositions and devices, their applications, and some historical background. The student will take away from the presentations a general understanding of the many complex relations present amongst pyrotechnic compositions, their reliability on the canisters that are used with those compositions and a grasp of several technical, performance, and safety factors which relate to their use. Military, civilian, and hobbyist use of these materials will also be discussed to highlight cross platform applications.

The relationship among many factors such as particle size, loading pressure, component characteristics, additives, binders, and the like will be presented along with the resultant effects on pyrotechnic composition and device behavior, including the rate of reaction, color output, spark production, and other desired applications. The student will be exposed to the many possible combinations of factors and some of their resulting behavior of the pyrotechnic compositions. A new world of questions, and a suggested path to follow, will be opened to the student to allow him to focus his future attention on pyrotechnics and their applications. These principles will be presented to the student in the form of theory, calculations, data, photographs, and video clips.

IMMEDIATE BENEFITS:

Class notes will provide students with awareness of appropriate applications use and design of pyrotechnic devices. Class exercises will acquaint students with the types of decisions a formulator or pyrotechnic systems engineer may be called upon to perform, and feedback from instructors on the exercises will provide useful experience concerning material formulation, device design, and testing and evaluation. Students will be familiarized with methodologies available for testing and evaluation of new pyrotechnic formulations and devices so that they may do so independently in the future. Such familiarity will also enable them to objectively evaluate the attributes of pyrotechnic devices and systems designed by others, to judge the suitability of the materials chosen, and to properly interpret data concerning the safety and effectiveness of pyrotechnic devices and systems produced within the laboratory, or elsewhere.

The student will receive a full set of notes, organized into specific subject area modules, which may act as a basis for a reference for his future studies. A copy of the videos shown will be provided on DVD for their future use. Any information included in the class presentation which was added after the initial publication will be included on a separate DVD which will be distributed during the class.

Active student participation and questions are encouraged during the lecture in lieu of individual problem solving. Students will participate with the instructor during class in working through a few of the calculations and problem solving situations.

INSTRUCTORS

Dr. David R. Dillehay has been working in the field of propellants, pyrotechnics and explosives for the past 52 years. The first 38 years were employed working for Thiokol Corporation (now ATK-Thiokol) at the Longhorn Army Ammunition Plant (an Army propellant, pyrotechnic and explosives manufacturing facility). During the course of his career in energetic materials, he has published over 53 papers in the field of pyrotechnics and energetic materials processing and is the holder of 11 patents, including patents covering manufacturing processes and formulations.

In 1980, he was a co-founder of the International Pyrotechnics Society (IPS) and served 4 years as Secretary, 2 years as Vice-President and 2 years as President. He is currently a Life Member of the IPS, and currently serves as Treasurer of the Steering Committee of

the International Pyrotechnic Seminars and Treasurer of IPSUSA Seminars, Inc. (International Pyrotechnics Seminars USA Seminars, Inc.) He was a guest speaker at Pyrochem International 1975 in the UK, at the Pyroteknikdagen Conference in Sweden, and was an invited speaker of the USSR Academy of Science at the 2nd International Symposium on Flame Structure in Alma-ata, Khazakstan. He also served on the Navy investigating team for the USS Iowa Gun Incident and is a co-author of *Pyrotechnic Chemistry*, published by the Journal of Pyrotechnics in 2004.

In the course of working with infrared decoy flares, Dr. Dillehay has developed new test methods and advanced manufacturing processes for flare compositions. He has also performed hazards analyses on flares and flare manufacturing procedures in order to define conditions that cause ignition of flare materials and to characterize the hazards of flare compositions.

Additionally, Dr. Dillehay has developed unique capabilities in modeling effects of deflagrations, explosions and detonations using advanced computer software including the ability to model secondary fragments. He is currently involved in the construction of a new facility to manufacture energetic materials using a totally remote process for safety, quality, cost, flexibility and environmental compliance.

Mr. Gerald Laib has over 34 years experience in energetic materials RDT&E including the development & qualification of new explosive materials, formulations and components, the formulation or primer, igniter, and other energetic mixtures, and the development and analysis of quantal shock sensitivity data (VARICOMP, VARIDRIVE, SSGT, SSSGT, LSGT, BWIGT) for many new experimental explosive formulations and devices. For 12 yrs, he chaired the NATO Explosives Working Group which developed NATO STANAG 4363/AOP-21 for sensitivity measurement of NATO-interoperable lead and booster explosive devices. He served as Archivist of the International Pyrotechnics Society (IPS) for 18 years, and is currently a life member. He has conducted many explosive post-accident investigations and failure analyses on military weapon systems and sub-systems throughout his career as a Navy employee, and has investigated several serious pyrotechnics manufacturing and fireworks display accidents as a private expert consultant. For 15 years, Mr. Laib served as the Manager of the Explosive Components Branch at NSWC, White Oak, MD during which he oversaw the development and fleet introduction of numerous new explosive, ignition, and pyrotechnic components, devices and trains, many of which remain in service. He has authored over 29 papers, presentations, and course lectures on a wide variety of subjects related to energetic materials and devices, and is the sole inventor or co-inventor on 13 US Patents, some of which are currently in-process. Since 1997, Mr. Laib has served as a Senior Energetics Applications Scientist at the Naval Surface Warfare Center, Indian Head Division, where his current projects include the development of a general-purpose miniature MEMS-based Ignition-Safety-Device (ISD), development of a MEMS based Safety & Arming Device and Micro-Detonator, development and implementation of thin-film magnetron-sputtered nanoenergetic materials for destruct and anti-tamper applications, qualification of reduced-toxicity primary explosive materials, and employing the use of shock interaction effects to develop efficient boostering systems for EIDS (Extremely-Insensitive-Detonating-Substances) materials for Hazard Class 1.6 Munitions. In the

private sector, Mr. Laib has held licenses for both proximate and outdoor pyrotechnics displays in Maryland for the past 32 years. He was formerly active in building pyrotechnic devices for special effects on stage, in proximate displays, and in outdoor fireworks displays, and has served as fireworks choreographer for the Baltimore Symphony Orchestra (BSO) for many years. He has designed and produced over 100 fireworks displays during his career, many of which were choreographed to live music played by the BSO. He has been an invited speaker on the subject of pyrotechnics art and science at many national and international forums, including the American Society of Mass Spectrometry, the Gordon Research Conference on Energetic Materials, the International Pyrotechnics Symposium, and the ADPA Symposium on Compatibility & Processing of Energetic Materials. Mr. Laib also served for several years as a technical member of the NFPA Pyrotechnics Committee, which produces the US safety standards for the transportation, storage, and use of civilian pyrotechnics, and the conduct of both proximate and outdoor pyrotechnic displays.

Mr. Joseph A. Domanico has been involved both day and night with pyrotechnics for over 36 years. He has held several positions of leadership in the pyrotechnic community to include Director, International Fireworks Society; Chairman, Pyrotechnics and Explosives Application Section, American Defense Preparedness Association; Chairman, Pyrotechnics Section, National Defense Industrial Association; Technical Representative, National Fire Prevention Association; East Coast and European Area Vice President for the Western Pyrotechnics Association; and Vice President for Publications, for the Crackerjacks East Coast Regional Fireworks Club. His memberships include the International Pyrotechnics Association, and The Pyrotechnics Guild International. He holds a current ATF Type 20 license as a Manufacturer of Fireworks, is PGI Class B Shooter certified, and holds state issued shooter certifications in Delaware and Maryland. He was a Lead Fireworks Display Operator with Fireworks Productions Incorporated for over 8 years and has personally fired many commercial fireworks displays as well as non-professional displays for educational purposes. His efforts in teaching include 26 years as the principle instructor for the hands-on laboratory portions of the Summer Pyrotechnic Chemistry Seminars taught by Dr. John Conkling; Principle Pyrotechnics Presenter for the Teens Needs Technology Program hosted by the Department of the Army, and many, many presentations at events attended by both professionals and serious hobbyists. He has taught non-credit courses in microcomputers by invitation of the night school dean at Harford Community College. His oral technical presentations are widely received at several national and international professional conferences to include the speeches for the American Chemical Society and the Army Science Conference held at the West Point Academy in New York. He has performed professional level research since 1975 in direct support of the Department of Defense.