

Control of Pyrotechnic Burn Rate

B. J. and K. L. Kosanke

ABSTRACT

There may be many times when a fireworks manufacturer will want to adjust the burn rate of pyrotechnic compositions. Sometimes this may be for matters of esthetics and other times for safety. For example, all of the following are unacceptable:

- *Strobe stars that flash with so low a frequency that they fall to the ground still burning.*
- *Color stars that burn so rapidly that they occasionally explode when a shell flowerpots.*
- *Rockets that fail to lift-off because their thrust is too low.*
- *Rockets that explode upon firing because internal pressures exceed the casing strength.*
- *Salmes that burn like fountains instead of exploding with violence.*
- *Flash powder that explodes when unconfined, even in small quantity.*

In each case, taking action to adjust burn rate should solve the problem.

Depending somewhat on how they are counted, there are at least 15 factors that control pyrotechnic burn rate. A manufacturer that understands how these factors act to affect burn rate may better anticipate when product performance difficulties will occur. Also, such a manufacturer will be better prepared to modify product formulations to correct any problems that do occur. Each of the burn rate control factors act by affecting one or more of the following: activation energy, heat of reaction, and efficiency of energy feedback. In this paper, the 15 factors are presented, explained and examples given.

Introduction

In the burning of most pyrotechnic compositions it is necessary to balance competing processes to achieve the maximum desired effect. For example, when flame temperature of a color star is too low, the result can be low light output be-

cause there are an insufficient number of electrons reaching excited states. However, conversely, when flame temperature is too high, the result can be bright but washed-out colors because the color producing molecules have thermally decomposed. In addition to aesthetic ramifications, safe performance can also require a balance between too little and too much output. For example, when the thrust produced by a fireworks rocket is too low, the result can be an explosion of the rocket at ground level because the rocket failed to fly into the air. Conversely, when the thrust is too high, the result can again be an explosion at ground level because the internal pressure exceeded the strength of the motor casing.

One mechanism, useful in adjusting pyrotechnic output, is the control of burn rate. Burn rate determines the rate of energy release, and thus to some extent the flame temperature of a star. More directly, burn rate determines the rate of gas production from a propellant, and thus the thrust from and internal pressure within a rocket motor. Accordingly, an understanding of the ways in which burn rate can be adjusted, can be useful in modifying pyrotechnic formulations to maximize their performance and safety. In this article, after a brief theoretical discussion, which forms the basis for understanding how each factor acts to modify burn rate, 15 factors that affect burn rate are presented, discussed and examples given.

Pyrotechnic Ignition

Pyrotechnic materials are said to exist in a "meta-stable" state. That is to say, under normal circumstances they are stable (they do not spontaneously ignite); however, once ignited, the combustion reaction is self-sustaining producing an excess of thermal energy. The reason pyrotechnic materials do not spontaneously ignite under normal conditions is that ignition requires the input of energy into the composition. Once ignited, however, the pyrotechnic material burns thus producing energy. This two step energy relationship is illustrated in Figure 1, which is an attempt to

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Julia Schneider



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Selected Pyrotechnic Publications of K. L. and B. J. Kosanke, Part 4 Kenneth L. Kosanke, Bonnie J. Kosanke, 1999-12 These are a collection of previously published technical papers on a variety of pyrotechnic topics The articles have been reformatted into a 2 column 81 2x11 format with medium print Only those articles that continue to be of interest and use to pyrotechnicians have been included

Chemistry of Pyrotechnics Chris Mocella, John A. Conkling, 2019-01-15 This book provides chemists with technical insight on pyrotechnics and explosives It emphasizes basic chemical principles and practical hands on knowledge in the preparation of energetic materials It examines the interactions between and adaptations of pyrotechnics to changing technology in areas such as obscuration science and low signature flame emission The updated third edition discusses chemical and pyrotechnic principles components of high energy materials elements of ignition propagation and sensitivity It offers heat compositions including ignition mixes delays thermites and propellants and investigates the production of smoke and sound as well as light and color

Military Pyrotechnics Ajoy K. Bose, 2021-12-13 This book covers military pyrotechnics characteristics sensitivity combustion performance parameters ingredients and their behaviour various pyrotechnic compositions and their manufacturing methods filling pressing and assembly of ammunition and so forth Divided into two broader sections namely military pyrotechnic compositions and military pyrotechnic ammunitions and devices it provides full spectrum of military pyrotechnics and a guide for all personnel involved with management of military pyrotechnic ammunitions and devices in design production inspection training and use Features Answers know what know why and know how of pyrotechnic compositions and pyrotechnic ammunitions and devices Explains various concepts and mechanisms of the military pyrotechnics Deliberates on role and characteristics of pyrotechnic compositions and its classification Discusses various factors affecting performance and some differences in military pyrotechnics Describes various methods of initiation of ignition in ammunition Elucidates basic requirements of pyrotechnic ammunitions its development and life cycle of ammunition lots Provides classification division shelf life compatibility and nomenclature of ammunitions and devices Reviews test proof requirements of ammunitions and devices deployment and functioning defect classification sampling plan and acceptance criteria Explores latest trends in green pyrotechnics for environment friendly military pyrotechnics

Encyclopedic Dictionary of Pyrotechnics K.L. Kosanke, Barry T. Sturman, Robert M. Winokur, B.J. Kosanke, 2012-10

Selected Pyrotechnic Publications of Dr. Takeo Shimizu Part 3 Takeo Shimizu, 1997 Papers translated from Japanese to English by Dr Shimizu includes autobiography of Topics include Theoretical Development of the Line Reversal Method for Temperature Measurement of Flames Temperature Measurement of Flames by Means of Line Reversal Method On Backgrounds of Color Flame Spectra On Flame Spectra of Red Yellow and Green Color Compositions On Flame Spectra of Blue Color Compositions On Flame Spectra of Metal Aluminum Composition On Composition Series for Practical Use

Burn Rates of TiH₂/KClO₄/Viton and Output Testing of NASA SKD26100098-301

Pressure Cartridges ,1993 **Defence Science Journal** ,2006 Explosives, Propellants and Pyrotechnics A. Bailey,S. G. Murray,2000 Fully revised and updated to take account of the most recent developments in the field this useful text explains today s explosives from simple theory to practical use and considers future developments **Pyrotechnics** Alexander Paul Hardt,2001 *Government Reports Announcements & Index* ,1995 **32nd AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit** ,1996 Energy Research Abstracts ,1990 Semiannual with semiannual and annual indexes
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41st AIAA Aerospace Sciences Meeting & Exhibit ,2003 **Papers Presented at the AIAA Thermophysics, Plasmadynamics and Lasers Conference** ,1988 **New Scientist** ,1959 *Government Reports Annual Index* ,1990
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