



Pyrotechnics in Defence



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Ministry of Defence, New Delhi - 110 011

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2026

DRDO MONOGRAPHS/SPECIAL PUBLICATIONS SERIES

PYROTECHNICS IN DEFENCE

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Pyrotechnics in Defence

DRDO Monographs/Special Publications Series

1. Pyrotechnics

2. Defence Uses

3. Infra-Red Smokes

4. Delay Compositions

I. Title

II. Series

623.4.083.3

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ISBN 978-93-94166-57-8

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Cover Design

Rajesh Kumar

Printing

Rajesh Kumar Singh

Marketing

Dipti Arora

Published by Director, DESIDOC, Metcalfe House, Delhi – 110 054.

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Preface

The monograph on 'Pyrotechnics in Defence' is primarily intended for dissemination of knowledge and information in pyrotechnics to scientists, officers and staff working on the field of High Energy Materials, Pyrotechnics and Armaments and those in the civil sector. The subject is a civil and military science but no university in India currently gives degree in this field. The monograph can serve as a quick guide and add to the understanding of pyrotechnics.

The monograph has been written in ten chapters. Chapter 1 provides an introduction in the field of pyrotechnics. It brings out the history, uses and chemical constituents of pyrotechnics along with few pyrotechnics compositions with nominal (or approximate) percentage of ingredients. Chapter 2 deals with the screening smokes, history, application in civil and defence, visual and infrared screening smokes, processing and testing of infrared screening smokes and factors affecting their performance as well as mechanics of action. Chapter 3 describes the methodology adopted in the evaluation of infra-red screening smokes, determination of particle size and evaluation for anti-laser role. Chapter 2 and 3 are part of my PhD (Chemistry) thesis on 'Studies in Infra-red Screening Smoke' submitted to University of Pune. Chapter 4 covers coloured signalling smokes, their history, defence uses, formulations, manufacture and typical compositions. Chapter 5 briefly touches on illuminating flares, their history, uses, formulations, evaluation and lists a few compositions. Chapter 6 deals with some pyrotechnic stores and compositions developed in High Energy Materials Research Laboratory, Pune. Chapter 7 describes Delay compositions, their history, uses, types, futuristic compositions, ingredients and a few typical compositions. Chapter 8 briefly describes manufacture and safety of pyrotechnic compositions. Chapter 9 gives the chemical testing/

quality assurance of pyrotechnic compositions. Chapter 10 describes few pyrotechnics stores which are useful in defence but not covered in chapters 1 to 9.

India has achieved self-reliance in the field of pyrotechnics. This is due to hardwork, dedication and scientific approach of the scientists and officers who toiled long hours to achieve success.

This monograph is a humble tribute to all of them.

Pune

Dr Amarjit Singh
Former Scientist 'G'

Acknowledgements

I am grateful to all my teachers like Father M Mascarenhas, Ex Principal, St Josephs Boys High School Kirkee; Prof SP Pathak, Ex Head, Chemistry Department, Fergusson College; Dr MS Wadia, Ex Head, Department of Chemistry, University of Pune; Dr Surjit Singh, Ex Controller, CQA (ME) Pune; Dr Haridwar Singh, Dr KRK Rao and Dr A Subhananda Rao, Former Directors, HEMRL who laid the foundation for writing this monograph.

I am thankful to Dr Gopal Bhusan, former Director, DESIDOC, who gave me this assignment. I am grateful to Dr (Mrs) Alka Suri then Director, DESIDOC and officers and staff of monograph division DESIDOC especially Ms Alka Bansal, Ms Kavita Narwal and Mr NK Chawla for the help and encouragement received from time to time.

I am indebted to Shri KPS Murthy, Director HEMRL for allowing me access to TIRC/Knowledge Centre (KC) and making available to me various photographs of pyrotechnics stores developed in HEMRL. I am grateful to Dr MB Talawar, Sc 'F' & GD, HRDKC division and Ms Patil and Ms Ashwani and all officers and staff of TIRC, HEMRL for guidance, help and encouragement. I am also grateful to Dr DB Sarwade, Sc 'G' (Retd.) and Dr Sushma Adhav, TO 'D' for assistance rendered.

I gratefully acknowledge the support given by Dr V Venkateswara Rao, Director, ARDE and Mrs SS Avachat, Sc 'G' (Retd.) as well as the facility at ICAT (Information Centre for Armament Technology). I am particularly indebted to Mrs SS Avachat for constant help, support, morale boosting and advice. I am also thankful to all other officers and staff of ICAT particularly Dr BB Padhy, Sc 'F', GD; Mr AK Pandey, Sc 'D'; Mrs VS Khadke, TO 'C' and Mr A Sarode, TO 'B'.

I take this opportunity to thank my spiritual teachers Sri Sri Ravi Shankar Jee, Art of Living Foundation, Bangaluru; Dr Sudhir Arora, Mind Control, Pune and Jayant Phadke, Bhramvidya, Pune.

I wish to express my appreciation for encouragement and support to my wife Mrs Manjeet Kaur, my sons Tejveer Singh Rana and Punit Singh Rana and their wives Ms Tanpreet Kaur Rana and Ms Kompal Kaur Rana.

Pune

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List of Abbreviations

APC	Armoured Personnel Carrier
BLO	Boiled Linseed Oil
CMT	Cadmium-Mercury-Telluride
CVF	Continuously Variable Filter
DSC	Differential Scanning Calorimetry
DST	Disodium Tartarate
DTA	Differential Thermal Analysis
F of I	Figure of Insensitivity
GAP	Glycidylazide Polymer
IBR	Inverse Burning Rate
IND/ME	Indian Military Explosive
IRCMs	Infra-Red Countermeasures
ISS	Indian Standard Specification
JSS	Joint Service Specification
LPS	Lightning Protection System
LV	Lithographic Varnish
MCE	Mixed Cellulose Ester
NVD	Night Vision Devices
QC	Quality Control
QCM-CI	Quartz Crystal Microbalance-Cascade Impactor
SD	Self Destruction
TG	Thermogravimetry

TOP	Total Obscuration Power
VAAR	Vinyl Acetate Alcohol Resins
VM	Volatile Matter

CHAPTER 1

Introduction

1.1 HISTORY

The word 'Pyrotechnics' is derived from the Greek words 'Pyr' meaning fire and 'Teche' meaning art. It is the art of making and using fireworks.¹ The art was known since ancient times. The Bible mentions about firebrands and action of water on naphtha and burnt lime to produce self igniting systems.² It is written in the Ramayana that Lord Rama used 'Brahma-Astra' (which emitted flames) to kill the Demon king Ravana.³ Kauravas and Pandavas fought each other in the Mahabharata and on the first day of battle arrows flew in air like burning meteors.⁴ Chinese, Indians, Greeks and Mughals used pyrotechnics for celebrations in time of peace and to terrify the enemies during war. The making of Black powder or Gun powder (consisting of a mixture of potassium nitrate, sulphur and charcoal) in China by Sung dynasty prior to AD 1000 led to its use as an incendiary in the initial stages. Subsequently it was used in rockets and in fire works. Black powder was introduced by Roger Bacon in Europe prior to 1242.⁵

With the invention of the Canon, Black powder was used as propellants and explosives by the British, French, Moghuls and Sikh Forces. Black powder was also used in rockets. Tipu Sultan used these rockets very effectively to inflict damage on the British Forces in Southern India in the battle of Seringapatam in 1792 and 1799. Sir William engrave improved on the rocket of Tipu Sultan, invented incendiary rockets which were used in British-American wars in 1812 and in other battles.⁶ In India, the cracker industry is a visible example of pyrotechnics and a large quantity of pyrotechnic items are produced for Diwali celebrations as well as for festive and religious functions where colour and visible effects are produced.

The match stick is another example of the application of pyrotechnics wherein incendiary composition based on red phosphorus is used in a match stick for ignition purposes. Fireworks are an integral culture of many nations like United States, USSR, UK, France, Germany, Japan, Switzerland, India, etc., and used to celebrate various occasions, since bright colours and sound produced give an aesthetic appeal and happiness to the people. Figure 1.1 shows celebrations using pyrotechnics.



Figure 1.1. Celebrations using pyrotechnics.

1.2 CURRENT PYROTECHNICS

In Defence, pyrotechnics covers a large variety of explosives that produce effects other than those produced by high explosives, initiators and propellants as well as produce special effects.⁷⁻¹⁰ Generally pyrotechnics are used:

- To produce light for: (a) Illumination in flares and photoflash cartridges for observations and identification of targets, (b) Signalling in signals, and (c) Tracing the trajectories of shells/shots in tracers.
- To produce smoke for: (a) Observation and signaling using various coloured smokes like orange, red, green, blue and white, (b) Screening or masking to prevent observation in visual or infrared regions of the electromagnetic spectrum, and (c) Training purposes for fire fighting training, NBCD training, etc.
- To produce delays, i.e., time intervals between two successive explosive events using: (a) Gasless delay composition, and (b) Gas emitting delay composition.

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About the Monograph

The monograph *Pyrotechnics in Defence* aims to create broad-based awareness of the field of defence pyrotechnics. It comprises ten chapters covering topics such as general introduction; screening smokes; evaluation of infrared screening smokes; coloured signalling smokes; illuminating flares; compositions and stores developed at HEMRL, Pune; delay compositions; manufacturing practices and safety aspects; quality assurance and chemical testing of pyrotechnic compositions; and miscellaneous items.

The monograph represents a modest yet meaningful effort to initiate structured documentation in the area of defence pyrotechnics. It is intended to serve as a quick guide and reference for Armaments and High Energy Materials scientists and technologists of DRDO, as well as officers and staff of the Directorate General of Ordnance Factories (DGOF) and the Directorate General of Quality Assurance (DGQA). It may also be useful to professionals in the civil sector engaged in the manufacture of pyrotechnic items for festivals such as Diwali and other celebrations. The readers will gain useful information and guidance from this monograph.

About the Author



Dr Amarjit Singh holds an MSc and PhD in Chemistry from the University of Pune. He has nearly four decades of professional experience spanning the Controllerate of Quality Assurance (Military Explosives), Pune; Defence Research and Development Laboratory (DRDL), Hyderabad; High Energy Materials Research Laboratory (HEMRL), Pune; and the private sector. A major portion of his career was spent at HEMRL, Pune, where he was actively involved in R&D in the areas of pyrotechnics, gun propellants, high energy materials, combustible cartridge cases, and other armament stores.

He has been invited to deliver lectures in several courses and has served as a guest lecturer at the Defence Institute of Advanced Technology (DIAT) in the areas of pyrotechnics and high energy materials, as well as at the Institute of Technology Management, Mussoorie. He has also guided doctoral research at the University of Pune. His scholarly contributions include 29 research papers published in technical journals and more than 100 technical papers presented at national and international seminars. He holds several patents and personally presented a paper on pyrotechnics at the 23rd International Pyrotechnics Seminar held in Tsukuba, Japan.

A recipient of several prestigious honours, he has been awarded the DRDO Scientist of the Year Award (2010), DRDO Technology Awards, and DRDO Cash Awards. Following his superannuation, he continues to contribute to the field as a member of the Institute of Defence Scientists and Technologists, Pune. He has served as an Expert Board Member of the Recruitment and Assessment Board (RAC) and as Chairperson of the DRTC Central Assessment Boards under the Centre for Personnel Talent Management (CEPTAM).

Price: ₹ 1800
US \$ 38
UK £ 28

978-93-94166-57-8



Defence Scientific Information & Documentation Centre
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Ministry of Defence, Metcalfe House, Delhi - 110 054