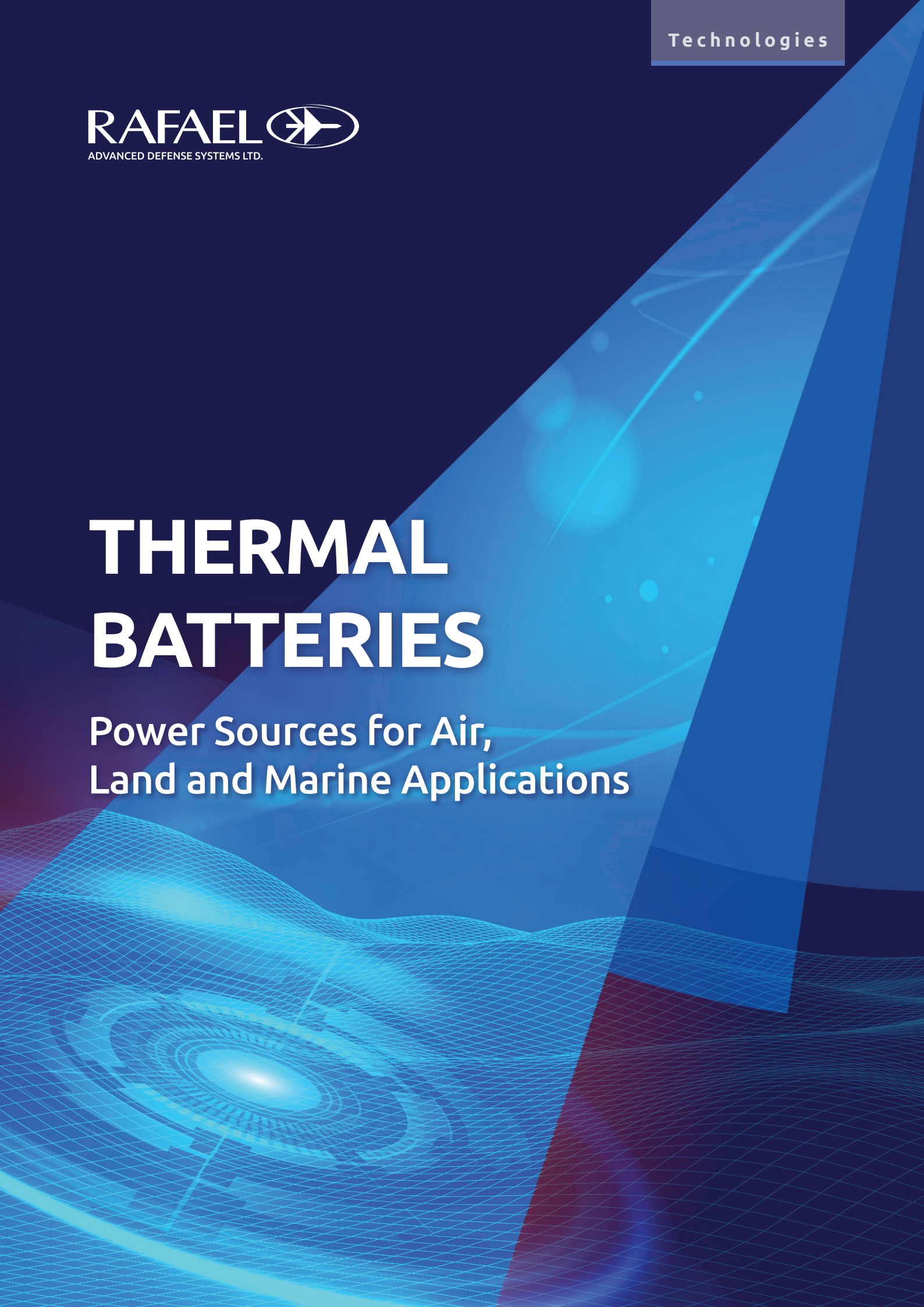
Technologies

RAFAEL
ADVANCED DEFENSE SYSTEMS LTD.

THERMAL BATTERIES

Power Sources for Air, Land and Marine Applications





Introduction

RAFAEL Advanced Defense Systems Ltd. – established as part of the Israeli Ministry of Defense more than 70 years ago – designs, develops, manufactures and supplies a wide range of high-tech systems for air, land, sea and space applications. .

The company has created partnerships with leading aerospace and defense companies in Israel and abroad, and has organized offset activities and industrial cooperation with over 20 countries worldwide. Over the last decade – based on the company's ability to accurately predict future aerospace and defense requirements and provide an ongoing stream of next-generation technologies and systems – international business activities have steadily expanded across the globe.

RAFAEL's highly skilled and dedicated workforce tackles complex projects – from initial development, through prototype, production, and acceptance tests. Providing a high level of customer service and support, the company upgrades existing systems and offers a wide range of turnkey projects from the transfer of basic technologies to the creation of complete production facilities.

RAFAEL is certified for AS9100, ISO 9001, ISO 17025, ISO 14001, and OHSAS 18001, and complies with CMM and CMMI (Level 3).



Overview

RAFAEL's thermal battery plant was established in 1985 to meet the company's demand for reliable high-end power sources for its many complex and exacting projects. Thermal batteries were selected for their high power bursts, instant activation, and long shelf life.

The company's thermal battery labs boast State-of-the-art equipment that enables the development of cutting-edge batteries of exceptionally high reliability that require no maintenance. Uniquely flexible production machinery provides any quantity required, from small batches to large-scale production.

The unique, in-depth knowledge and know-how developed at the plant have positioned RAFAEL as a global leader, supporting a wide range of advanced projects in Israel, the USA, Europe and the Far East.



Applications

RAFAEL develops and produces an extensive array of advanced thermal batteries, both off-the-shelf and custom-made, for a variety of applications that meet the needs of today's most critical missions. Applications include:

- Missiles
- Rockets
- Underwater and acoustic countermeasure systems
- Electronic warfare systems
- Proximity fuzes
- Sensors for dispersed submunitions
- Aircraft ejection seats
- Guided artillery rounds



Design and Development

RAFAEL has amassed extensive experience in the design and development of highly reliable thermal batteries, using computer-aided design including heat propagation, mass transfer, and mechanical simulations.

The company's thermal batteries deliver high power and instant activation, as well as a long shelf life and exceptional dependability.

Multi-disciplinary engineering and research teams create innovative new solutions, based on RAFAEL's proprietary novel materials and technologies. Electrical and physical interface solutions for customer platforms are provided, along with various battery initiation options including an electrical pulse to a squib, a mechanical apparatus based on a spring, gas pressure, inertial force, or other mechanisms.

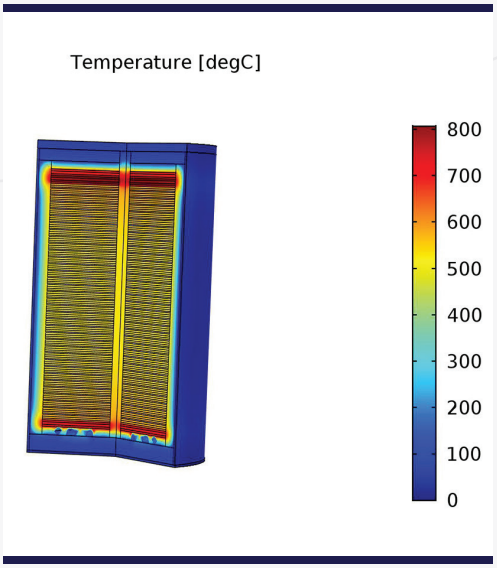
Rapid prototyping of engineering models enables customers to perform testing during the early stages of development.

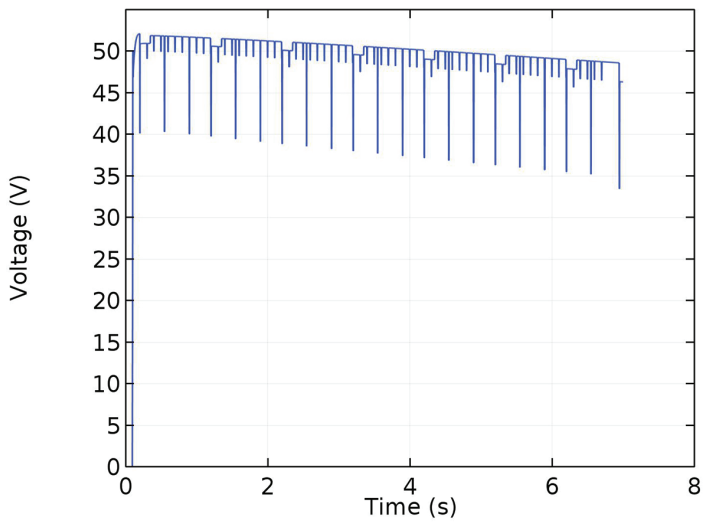
Energy Management Simulation

A full-scale simulation of the thermal-electric model of the design is created, significantly enhancing the fitting and development stages and facilitating process completion.

RAFAEL's comprehensive simulations provide numerous benefits including:

- Predicted voltage profile for a given load - power or current, constant or pulsed
- Case temperature profile throughout the battery's lifetime and beyond
- Real-time comparison between design alternatives
- Sensitivity analysis of key parameters of the battery's performance





Testing Facilities

RAFAEL's ultra-modern thermal battery testing facilities provide a unique range of capabilities that enable comprehensive testing. The facilities incorporate in-process testing, online X-ray radiography and analysis, an environmental testing center capable of testing under any conditions and combinations of conditions required by MIL-STD-810 and safety standards, a ballistics department and a metallurgical testing department. Computerized discharge testers are capable of discharging in any profile required by the customer under climatic and dynamic conditions.

Climatic & Dynamic Simulation Facilities

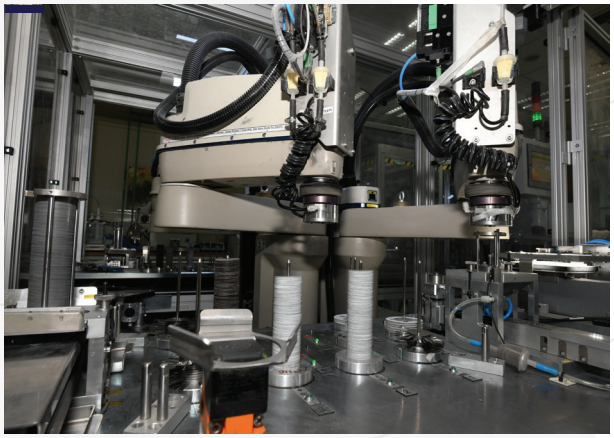
Enviromental testing capabilities:

Climatic	Dynamic	Combined Testing	Packaging
• Temperature, Cold & Heat • Thermal Shock • Humidity • Altitude • Salt Fog • Sand & Dust • Rain & Wind • Solar Radiation	• Sine Vibration • Random Vibration • Sine on Random - Gunfire & Helicopter Vibration • Narrowband on Broadband • Random - Propeller Aircraft • Tracked Vehicle Vibration • Mission Profile Simulation • Loose Cargo Simulation • Linear Acceleration • Shock Through Classical Waveform • Shock Spectrum Simulation • Time History Simulation (Measured Vibration and Shock) • Pyroshock • Drop Tests	• Vibration and Climatic Conditioning • Acceleration and Vibration • Dual Shaker Tests	• Vibration, Mechanical Shock & Drop Tests, Climatic Testing • Qualified by the Ministry Of Transportation for Testing Packaging for Hazardous Goods

Production

RAFAEL's modern, multifaceted thermal battery production plant is equipped with an automated state-of-the-art infrastructure including dry rooms, a pyrotechnics production facility, and a powder manufacturing facility. These versatile facilities enable fabrication of a broad range of products, from very simple to highly complex, from miniscule to extremely large, and in quantities from unique, one-of-a-kind items to high-volume production.

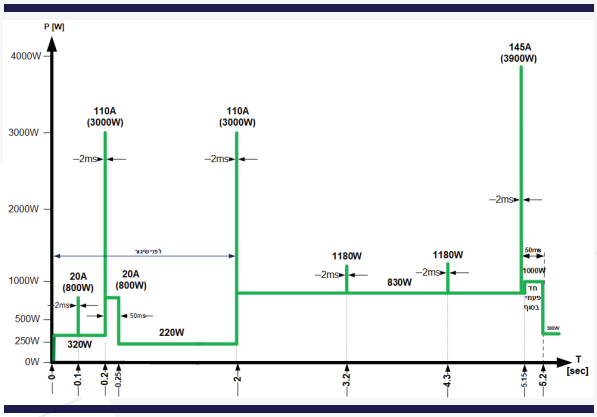






High power family

Power Density [KW/kg]	>10
Lifetime [s]	5 ≤ t ≤ 300
Diameter [mm]	30 ≤ D ≤ 90
Mass [gr]	150 ≤ m ≤ 5000
Length [mm]	65 ≤ h ≤ 330
Temperature [°C]	-40 ≤ T ≤ 85

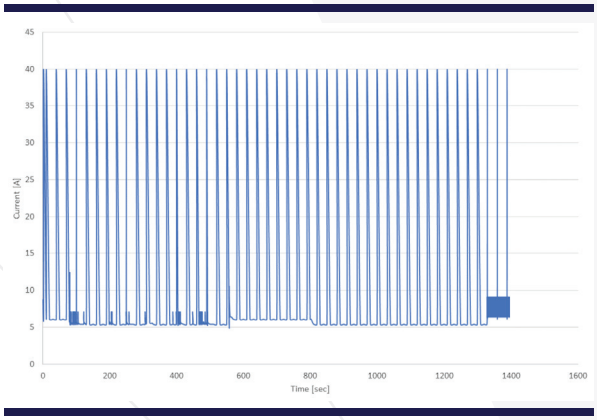






High energy family

Power Density [KW/kg]	>20
Lifetime [s]	720 ≤ t ≤ 1200
Diameter [mm]	86 ≤ D ≤ 108
Mass [gr]	2300 ≤ m ≤ 5800
Length [mm]	150 ≤ h ≤ 280
Temperature [°C]	-40 ≤ T ≤ 71





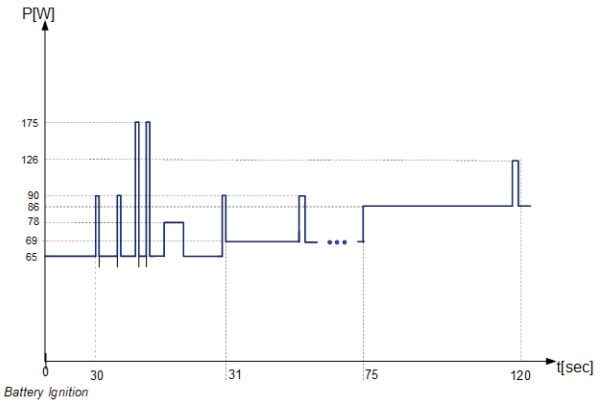


Small size family

Lifetime [s]	20 ≤ t ≤ 130
Diameter [mm]	19 ≤ D ≤ 32
Mass [gr]	40 ≤ m ≤ 160
Length [mm]	43 ≤ h ≤ 70
Temperature [°C]	-54 ≤ T ≤ 85



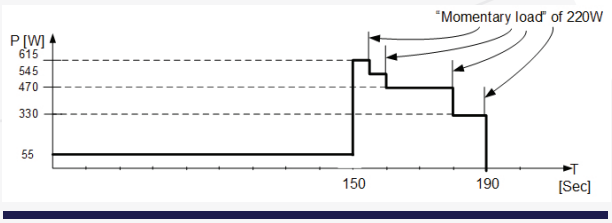


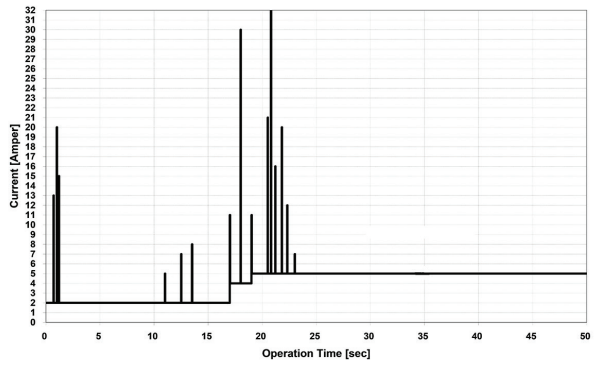




Mid size family

Lifetime [s]	35 ≤ t ≤ 310
Diameter [mm]	38 ≤ D ≤ 73
Mass [gr]	250 ≤ m ≤ 1600
Length [mm]	43 ≤ h ≤ 183
Temperature [°C]	-54 ≤ T ≤ 85











Additional Information

- Most designs are ignited electrically using an initiator or squib
- All designs can be modified for **mechanical ignition** and from mechanical to electrical ignition



Custom Spring & Hammer Mechanism



Spring & Hammer Mechanism



Inertial



Primer Only

Assembly Solutions

- A variety of solutions for electrical and mechanical integration are developed and assembled at RAFAEL's thermal battery plant





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