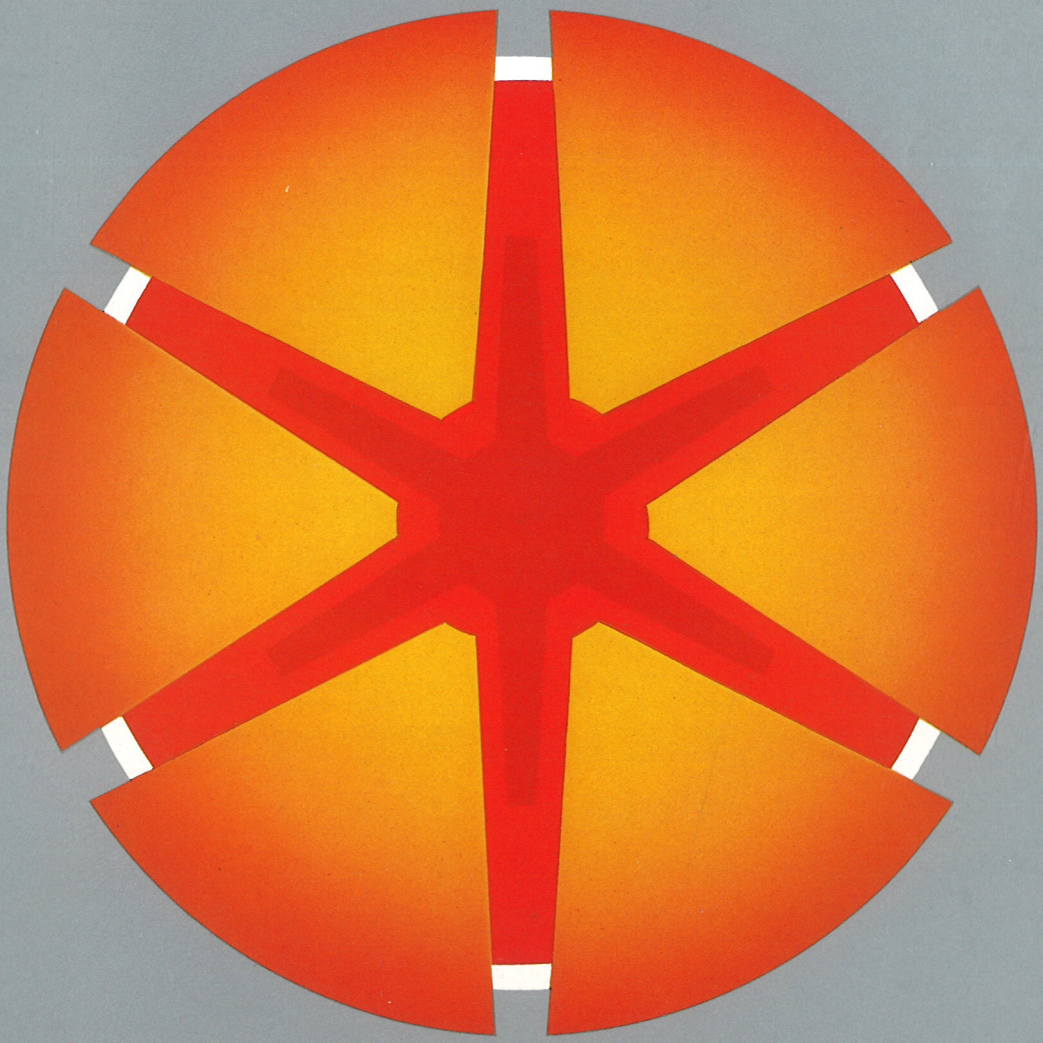
Rocket Motors
RO Explosives
Division
Bishopton

Rocket motors

A total capability in solid and liquid propulsion systems



ROYAL ORDNANCE

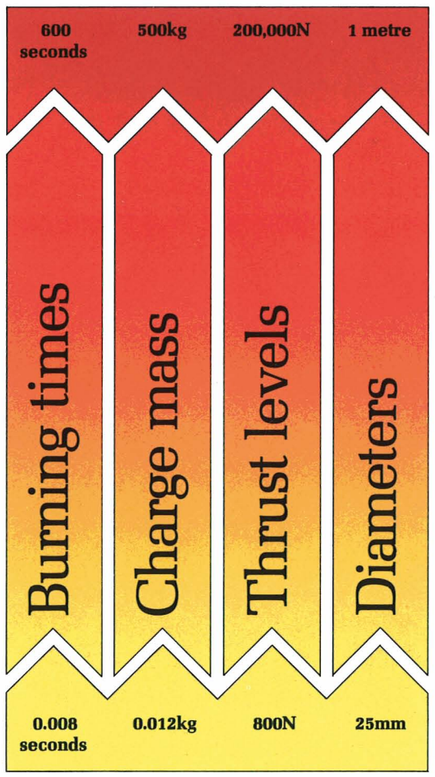
Defence systems, sub-systems and components

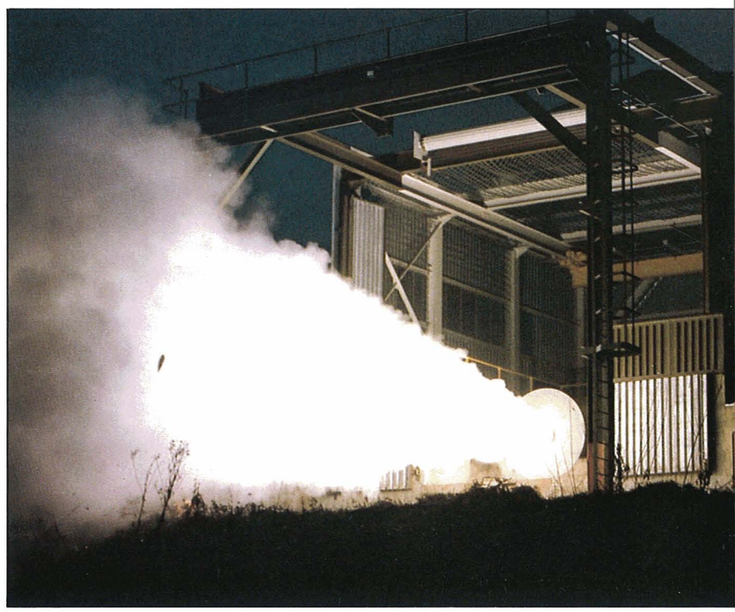
Explosives Division is totally integrated through five locations, each possessing resources appropriate to its particular expertise. Design and development responsibilities for solid rocket motors are held by Westcott and Summerfield sites, and for storable liquid motors by Westcott; production is carried out at Summerfield, Bishopton and Bridgwater.

Royal Ordnance rocket motor propulsion systems

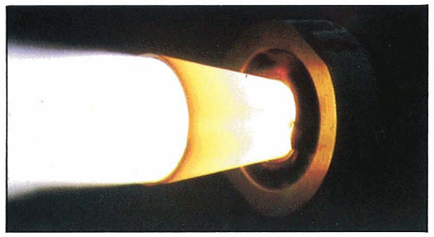
Royal Ordnance Explosives Division is the principal United Kingdom capability in the related fields of explosives, propellants and rocket motors. Propulsion systems for rocket motors include double base or composite solid propellants and mono- and bi-propellant liquid engines. A complete service is offered, starting with feasibility and assessment studies, through design, development and qualification to final manufacture.

Royal Ordnance rocket motor propellant systems are designed to suit world-wide environmental conditions. Present performance ranges from 0.008 seconds to 600 seconds burning time, 0.012kg to more than 500kg charge mass, and 800N to 200,000N thrust level. 25mm to 1 metre diameters are within our normal production and plant is available to manufacture much larger rocket motors if required.

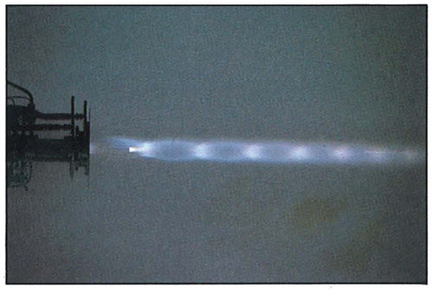




Test firing for evaluation of thrust vector control equipment



An advanced carbon/carbon composite nozzle structure being evaluated in the severe high temperature, erosive environment of a rocket motor efflux



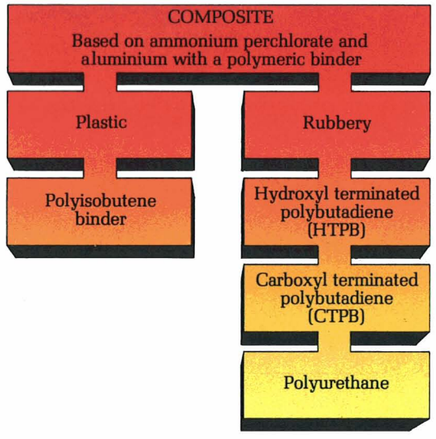
Liquid propulsion system under test

Solid rocket motors

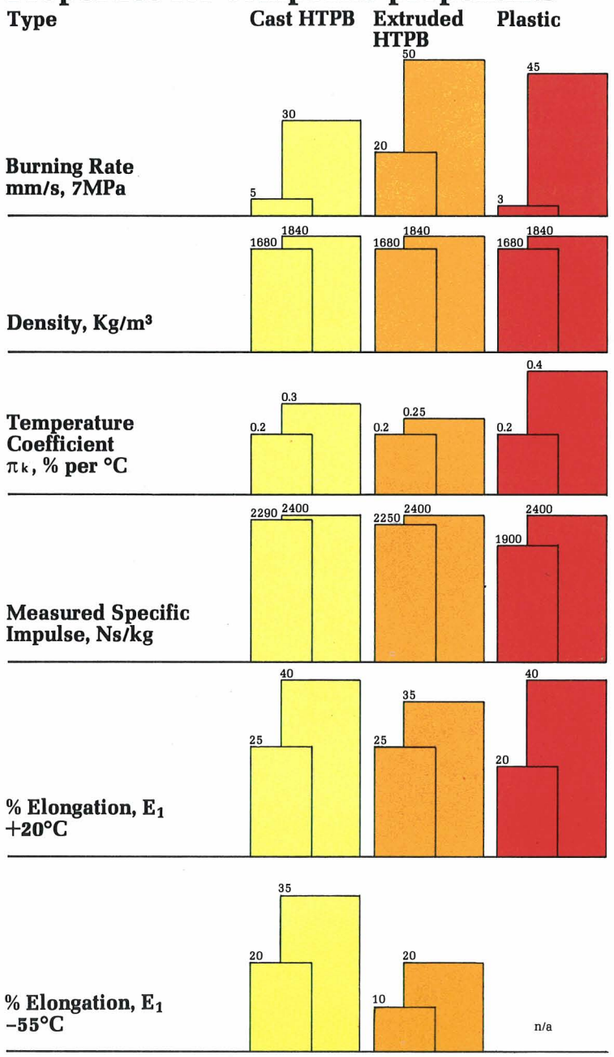
Royal Ordnance produces all types of composite propellants for solid rocket motors, offering a wide choice of configurations for new propulsion units.

Composite propellants

Composite propellants create no practical limit to charge design and are used in applications where high performance and resistance to extreme environments are required.

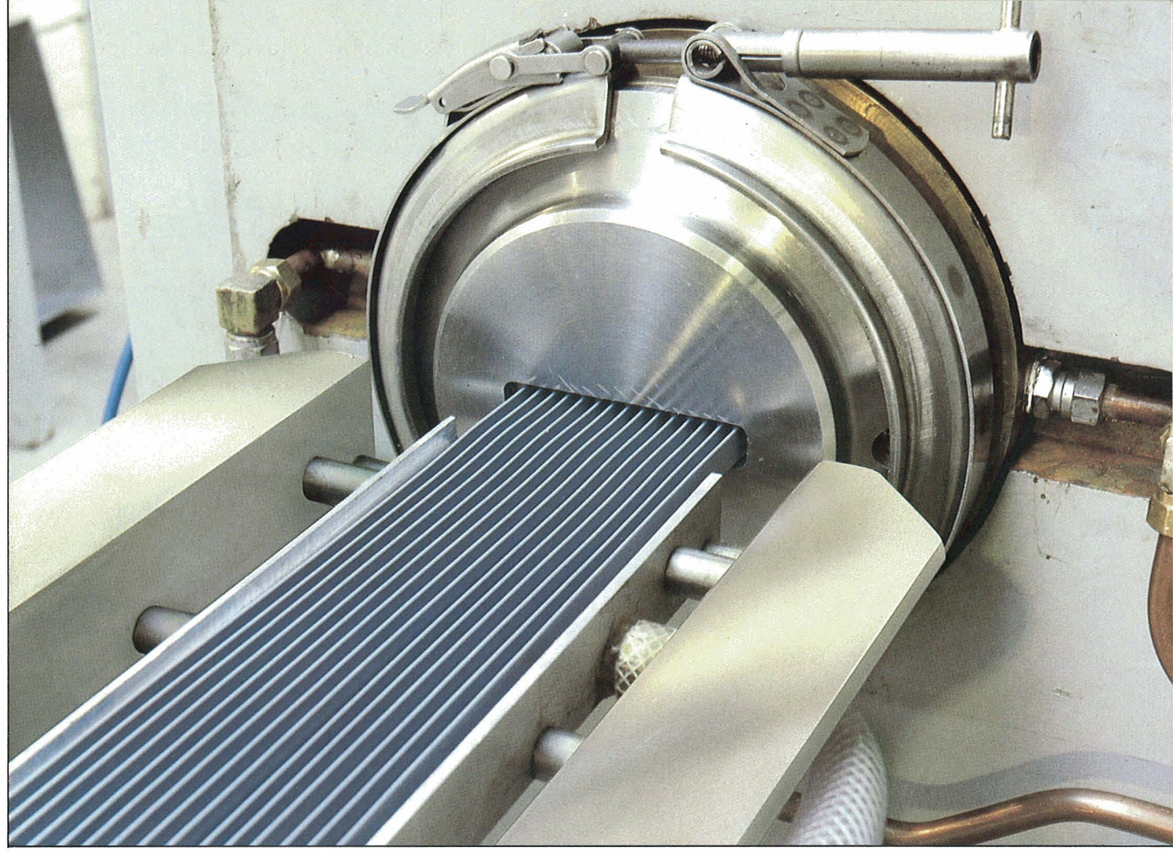


Properties for composite propellants



Royal Ordnance has unrivalled experience with the whole family of composite propellants but the major emphasis is now on HTPB compositions. They are produced in either cast or extruded forms in order to optimise production processes for specific motor designs. With a wide spectrum of ballistic and mechanical properties making them suitable for many different rocket motor applications, HTPB propellants also offer the advantages of:

- ability to withstand service environments from −55°C to + 70°C
- low cost
- extensive range of burning rates
- high density impulses
- ease of case-bonding with high loading density charges
- ease of casting complex charge shapes
- high extensibility at a range of temperatures
- safety in manufacture and handling



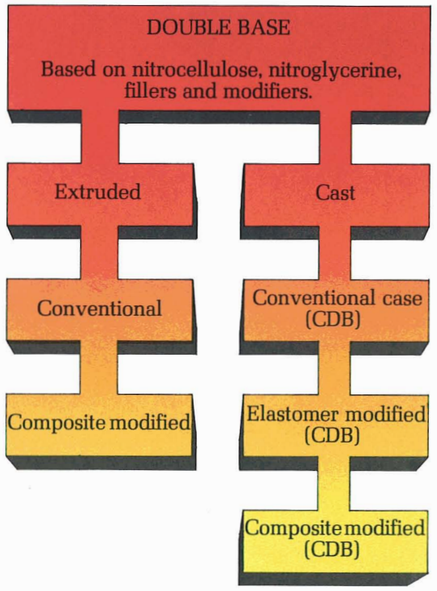
Planetary mixer for composite propellant production. Royal Ordnance has also recently installed a 420 gallon mixer — the largest available in the world today.

Extrusion of HTPB propellant is a unique Royal Ordnance capability

Micronizing mill for ammonium perchlorate

Double base propellants

Double base propellants may be selected for many applications, and their ability to give a smokeless, non-corrosive and flashless exhaust is of particular importance.

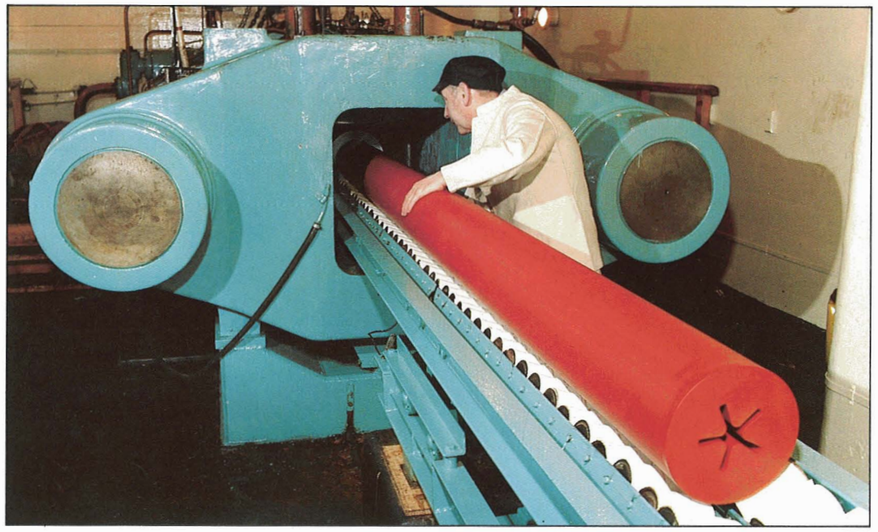


All conventional double base compositions may be platonised to give low temperature coefficients. Royal Ordnance uses nitramine fillers to produce significant increases in density impulse whilst retaining plateau burning characteristics. Additives may be used to suppress flash from motor exhausts up to nozzle exit temperatures above 1700°K+.

Extruded double base propellants are very suitable for many cost-effective applications and are particularly applicable for short burning times or high volume production.

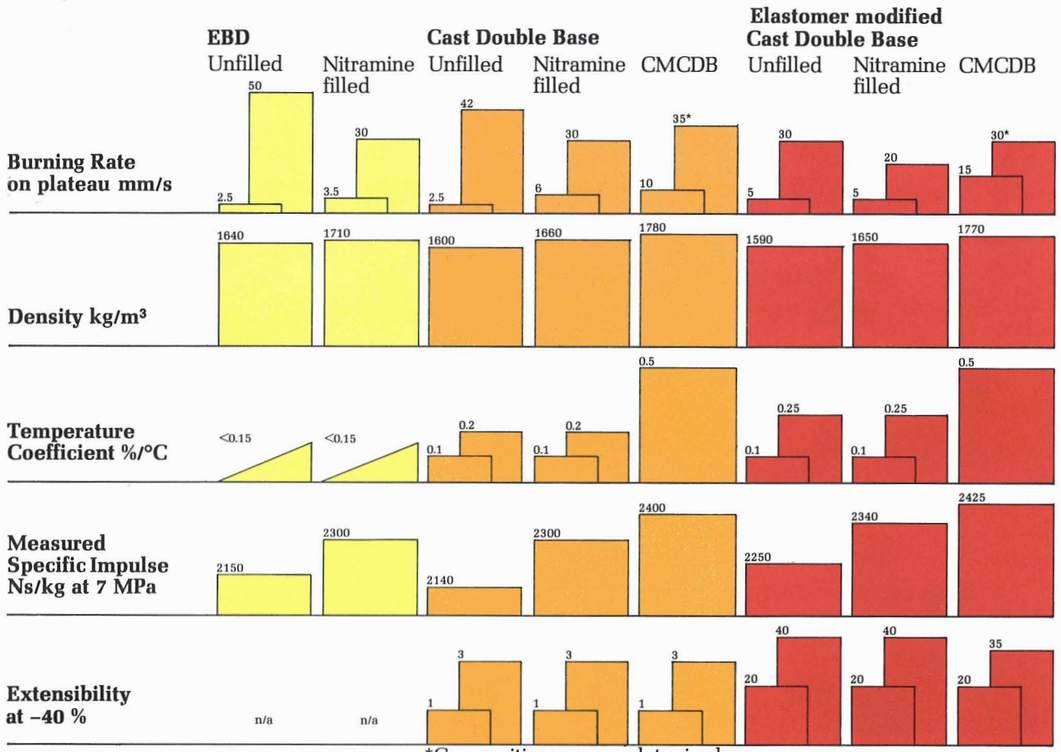
Cast double base propellants can be case-bonded to give optimum performance. Elastomer modified propellants have improved physical properties and may be applied over a wider range of temperatures.

The use of ammonium perchlorate and aluminium in composite modified propellants gives the desired density impulse for high performance applications.

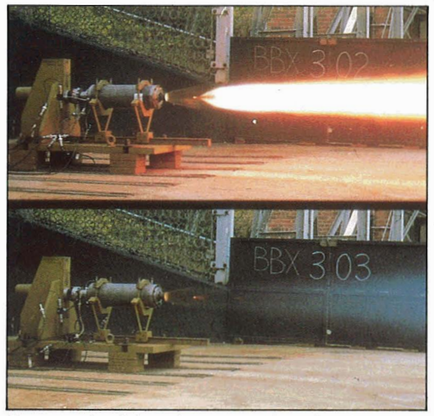


Extrusion of large rocket propellant charge

Properties for double base propellants



*Compositions are unplatonised



Comparative firing of motors with and without flame suppression additives

Part of the automated plant for casting propellant charges

Solid rocket motor applications

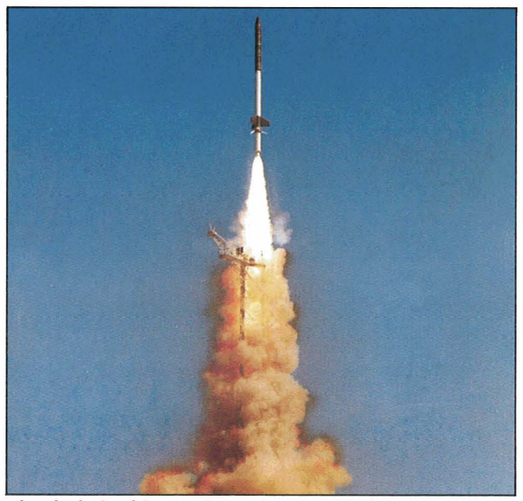
Royal Ordnance Explosives designs and produces solid propulsion systems for the complete range of military and civil requirements, including:

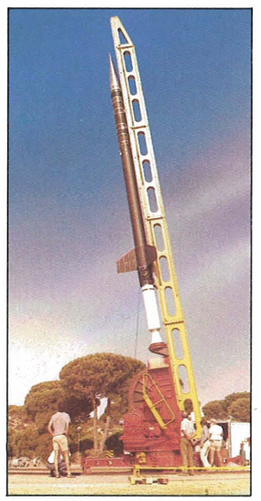
- **guided, strategic, artillery and shoulder-launched weapons**
- **Space and sounding rockets**

Designs

The variety of thrust profiles currently available includes conventional, boost/sustainer, second boost on demand, and pulsed. Optimum designs for all applications are made possible by the wide range of propellant types. Line-of-sight guided systems incorporate Royal Ordnance developments in smokeless and flashless rocket motors. Shoulder-launched systems have special requirements for safe and reliable operation: Royal Ordnance has produced designs with minimal effects on the firer — and proved them in both theory and practice. The Skylark Sounding Rocket system has been successfully fired at many different sites with various rocket motor configurations. Royal Ordnance has special ability in designing motors which give minimum hazard when exposed to fragment attack or fuel fires.

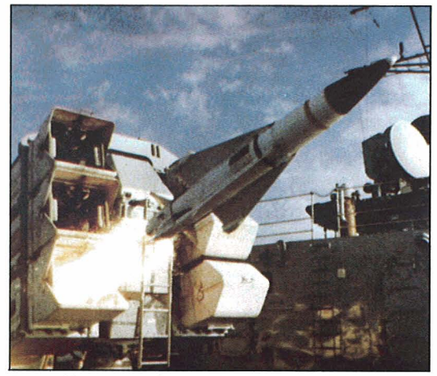
Bloodhound ground-to-air missile





Skylark upper atmosphere research vehicle fired from polar and equatorial sites

Launch of Seacat missile

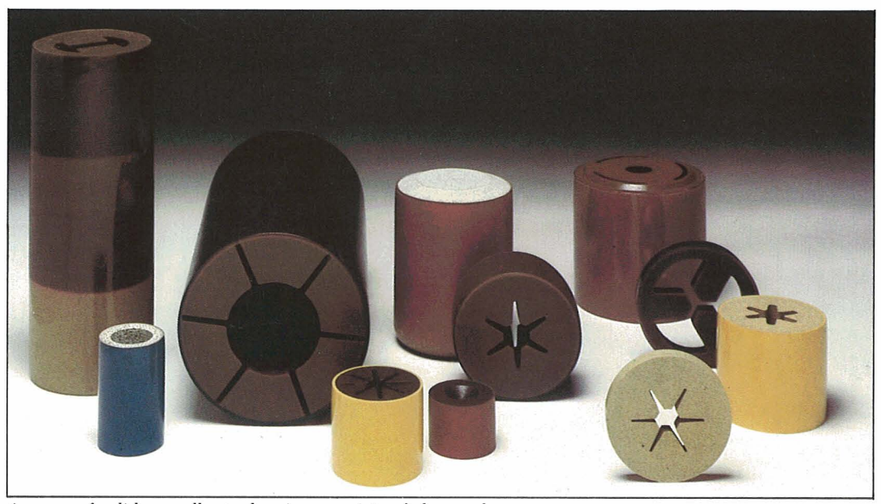


Seawolf anti-missile missile system is in operational service with the Royal Navy

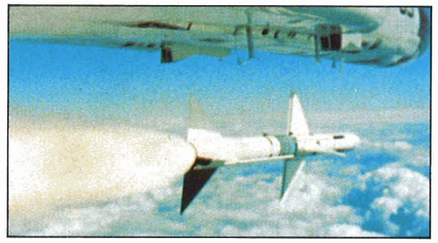
Materials

Comprehensive ranges of materials and processes are available for motor case manufacture, including: conventional and high strength steels; aluminium and titanium alloys; metal/composite constructions; carbon and Kevlar reinforced plastics; and metal strip laminates. Insulation materials are selected according to efficiency, requirements of low smoke, high erosion resistance, insulation properties, low plasticiser migration or good bonding strength. These features are combined with the mechanical properties necessary to meet specified environmental conditions. Materials for nozzle assemblies include graphite, molybdenum, tungsten, ceramic coatings, silicon carbide, carbon/carbon and filled phenolic resins as required by the duty cycle.

A typical selection of rocket motor cases



A range of solid propellants showing a variety of charge shapes



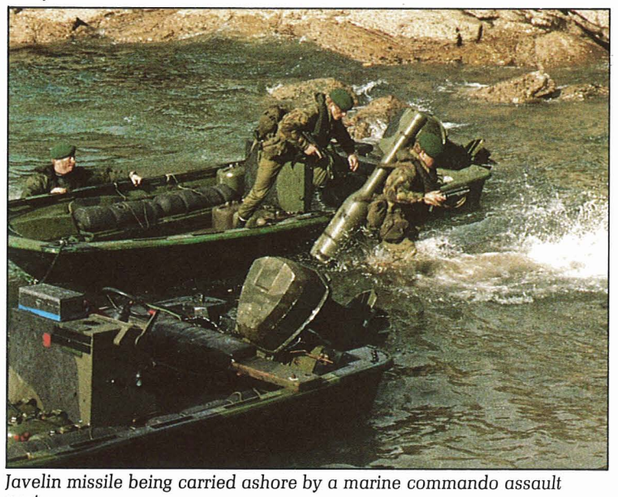
An improved boost/sustain motor is under development for the Skyflash missile, here shown launched from Phantom

Components

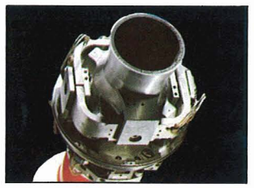
Royal Ordnance expertise in the development of propulsion system subcomponents provides its customers with the benefits of: cost effectiveness and high quality; lightweight and stiffness; integral wing attachment; low vulnerability. Current thrust vector control systems include spoilers, swivelling nozzles, jetavators and fluid or hot gas injection. Combinations of these can be applied to give 3-axis, pitch, roll and yaw control. A vertical launch capability has been demonstrated for VL Seawolf. Pyrotechnic or pyrogen ignition systems are available to meet any requirement. Non-electric initiation can be provided, or shuttered systems and electrical filter circuits are available, to guard against electro-magnetic pick-up or inadvertent ignition.

Thrust vector control operating on the Swingfire long-range wire-guided anti-tank weapon

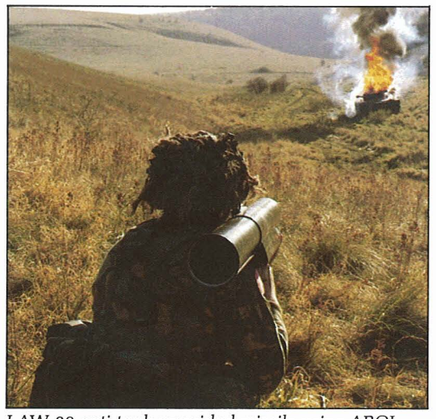
For the operator's safety, the shoulder-launched anti-aircraft Blowpipe missile is fitted with an 'All Burnt On Launch' (ABOL) boost motor, and a delayed-action sustainer



Javelin missile being carried ashore by a marine commando assault party



Thrust vector control systems use a variety of techniques for the control of the efflux from the propulsion unit, such as the single and multi-moving nozzles shown here

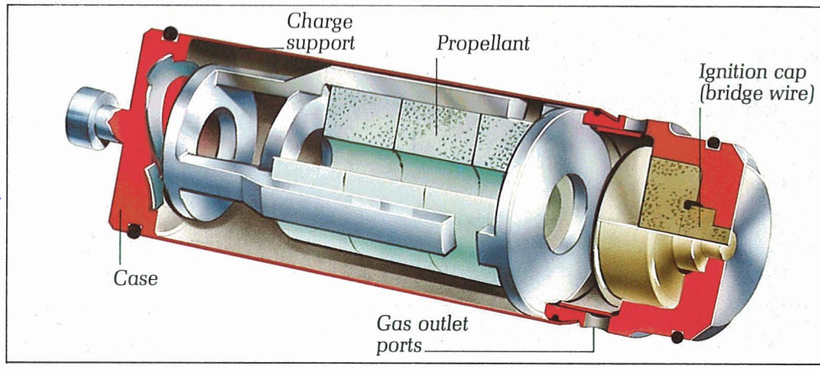


LAW 80 anti-tank unguided missile using ABOL motor

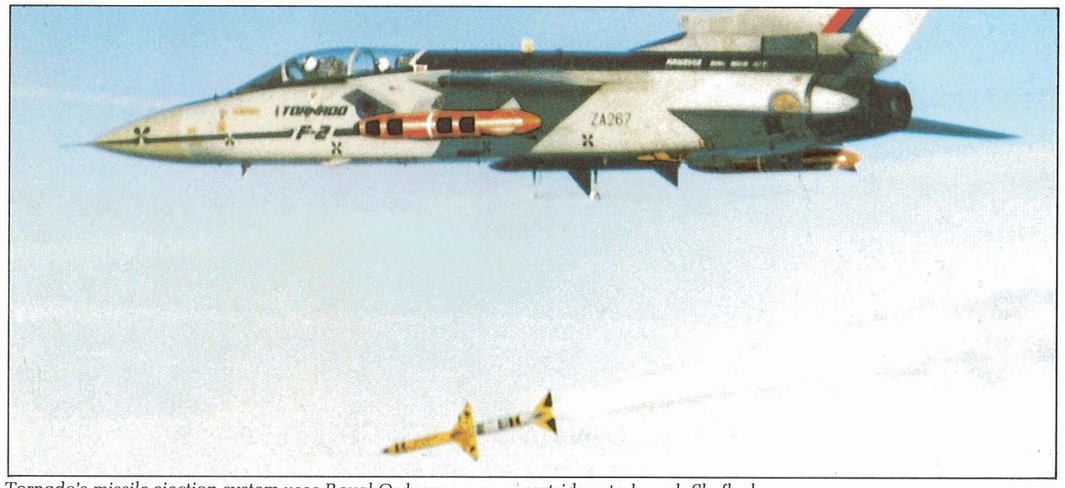
Power units

Power cartridges and gas generators provide instantaneous sources of energy for many military and civil systems. Application examples include: ejection of missiles and stores from aircraft, fighting vehicles or submarines; engine starters; control thrustors and actuator system power for guided weapons; Gyro power units; emergency battery electrolyte filling; and inflation of devices by cooled gas. These products are designed to suit the application requirements, using composite or double base propellants, and with energy release tailored accordingly. Correct choice of propellant is extremely important to minimise debris and ensure reliable operation.

A selection of charges for power cartridges and gas generators



Sectioned view of Skyflash launcher primary power cartridge

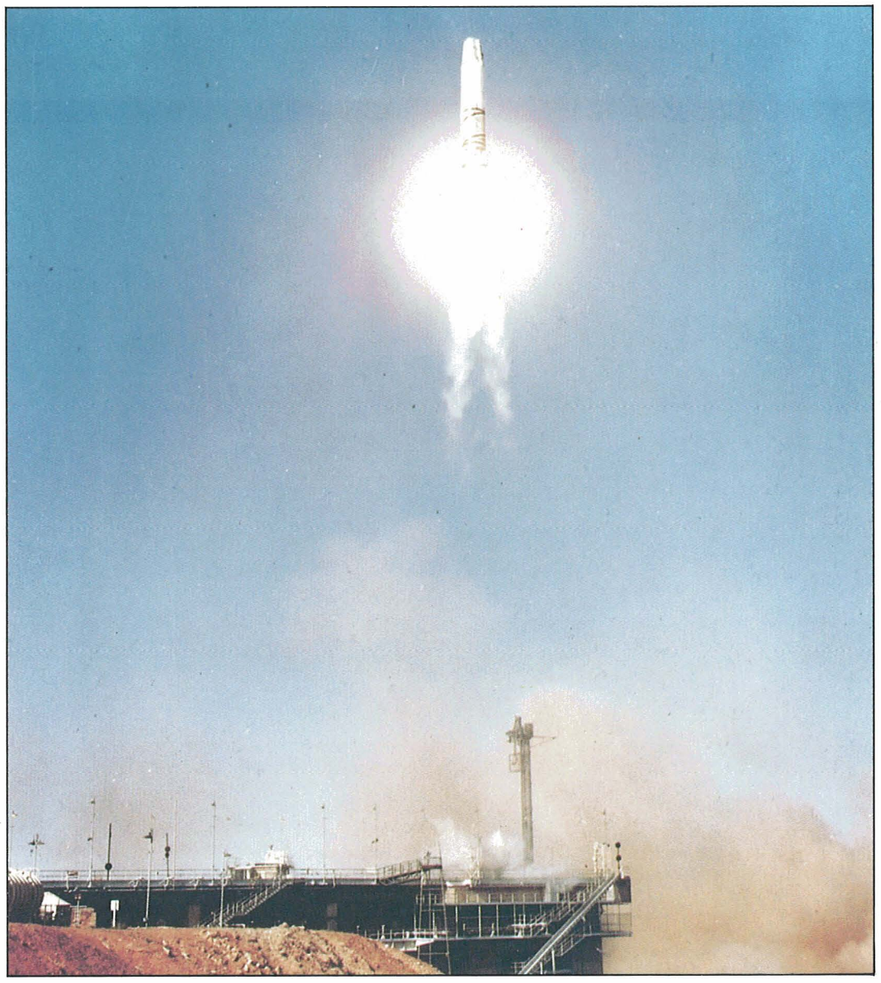


Tornado's missile ejection system uses Royal Ordnance power cartridges to launch Skyflash

Liquid rocket motor propellants

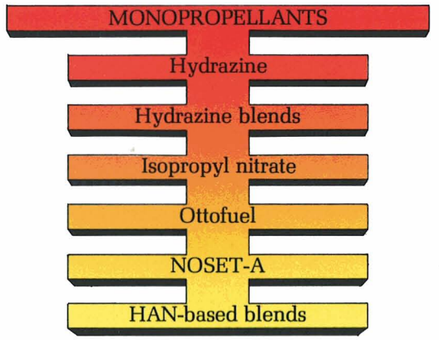
Royal Ordnance Explosives has successfully applied liquid propellant technology to tactical, strategic and space propulsion systems. It is particularly attractive for strategic post-boost propulsion and satellite attitude control systems, because they demand flexibility from controlled intermittent operation to continuous programmable thrust.

Liquid propulsion capabilities are based upon 40 years' experience, embracing the design, development and production of both propellant, components and systems. This has been supported by a strong background of research, including propellant compatibility, characterisation and analysis.

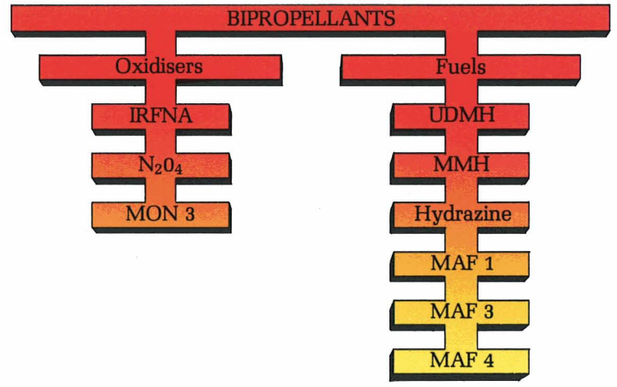


Although currently specialising in applications which require small packaged liquid propulsion systems, Royal Ordnance retains a proven large boost expertise, here illustrated by Blue Streak

In recent years and in the foreseeable future, propulsion activities will be concentrated upon the use of long term storable mono- and bi-propellants. Experience has been gained with propellants which have a wide range of potential applications, from auxiliary power units, gas generators, torpedoes and liquid propellant guns to tactical, strategic and space propulsion systems.



Experience with these propellants has included basic and applied research, technology demonstrator flight trials and the design, development and production of post-boost propulsion for the Royal Navy's Chevaline weapon system. The post-boost design comprises an axial bi-propellant system interfacing with monopropellant based pressurisation and attitude control systems. Royal Ordnance Explosives was directly responsible for the bipropellant system and, as Technical Authority for the attitude control system, was closely associated with design, development and production.



Components of development motor for space applications

Throttleable liquid propellant valves for research programme

In the Western world this is the first application of liquid propellants to a strategic submarine launched weapon system and the first application requiring long term unactivated storage of a monopropellant. Extremely high standards of quality, reliability and safety have been achieved and must be maintained for the proposed service life. To support the deployment of this system Royal Ordnance Explosives is conducting in-service surveillance and long term storage trials for all ordnance items in the Chevaline post-boost propulsion system.

Additional support for the Chevaline programme involves comprehensive research and development to evaluate the long term compatibility of bipropellants and hydrazine. Royal Ordnance Explosives is the acknowledged leader in the compatibility and long term storage characteristics of hydrazine, with unique facilities for processing and filling bipropellant and hydrazine tanks, and performing the final closure welds.

Royal Ordnance offers a unique combination of experience and expertise, from research to production, in liquid propellant systems and components, now and in the future.

Whatever your rocket motor requirement, talk to the people who can take it through every stage from concept to reality — Royal Ordnance Explosives Division.

Long term storage testing of satellite propellant storage systems

Further information may be obtained from:

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