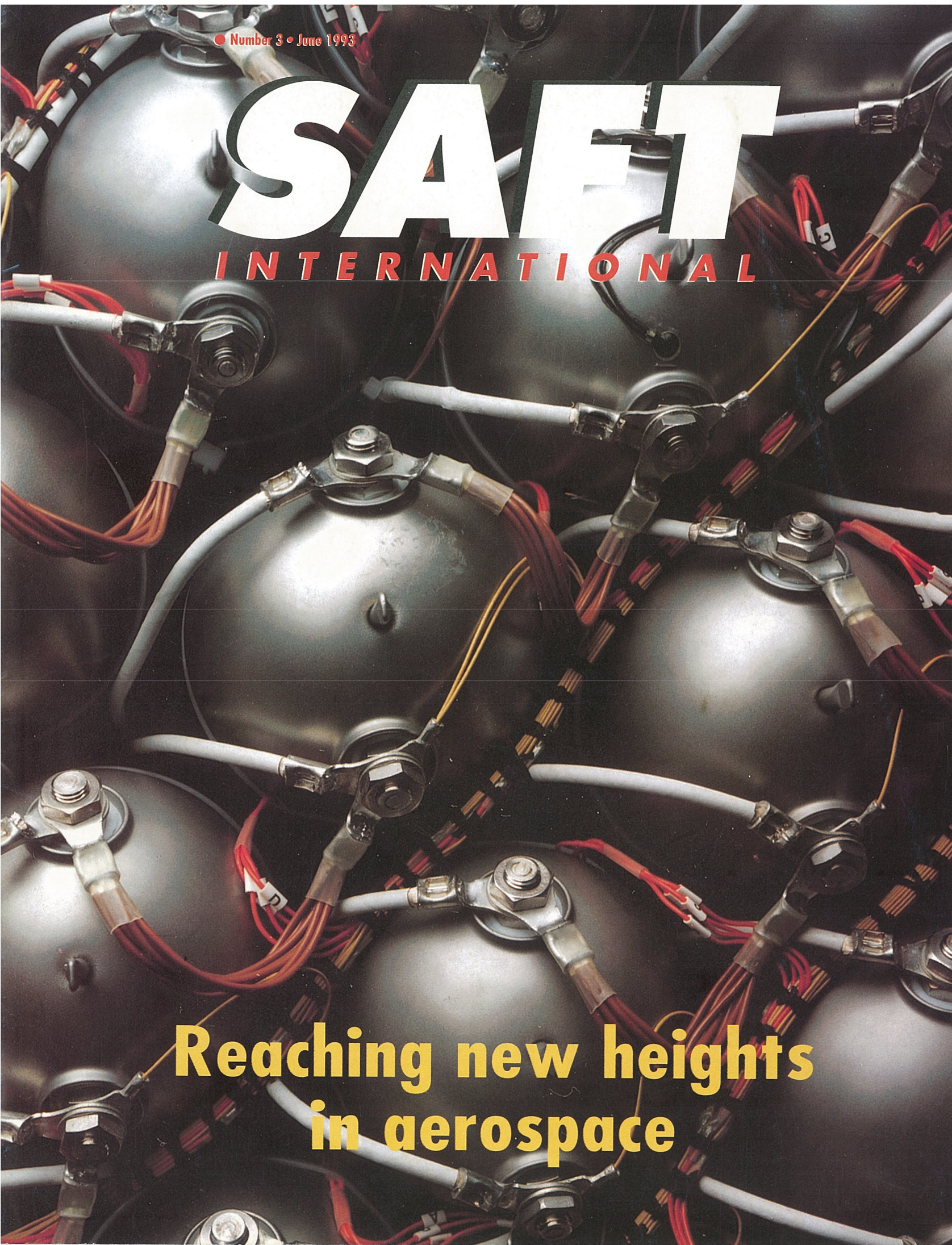
Number 3 • June 1993

SAFT
INTERNATIONAL



Reaching new heights in aerospace

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Number 3 • June 1993

SAFT

SAFT INTERNATIONAL
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EDITORIAL

REACHING NEW HEIGHTS IN AEROSPACE...

Over the years, Saft has built its name and business in diverse battery markets by focusing on the tandem of innovation and reliability. We know that our customers seek the cost and performance benefits of technological advances – but never at the expense of dependability.

The aerospace industry is a prime example. Batteries made for starting airplane engines or powering rocket launches must constantly keep up with the cutting edge of developing technology. But reliability must be built into the design equation: there are no service stations available for quick repairs at 39,000 feet – much less at 23,000 miles. A battery failure in these applications could mean the loss of priceless life and millions of dollars worth of equipment.


M. Bertrand

At Saft, we take pride in the exemplary performance our aerospace batteries have recorded – and continue to record. It's a story we tell in this issue of *Saft International*, and one that we will surely be retelling at the 1993 Paris Air Show at Le Bourget, where Saft's expertise in aerospace batteries is on display at Alcatel Alsthom's stand. In space, Saft batteries have powered the French and European space program for almost 30 years without one failure. This record of dependability – combined with the development of innovative lithium battery technology for rocket launchers in the late 1980s – won us the right to supply some of the most important American space programs. Building on this momentum, our new nickel-hydrogen battery will feature big weight savings and innovative modular architecture – the ideal power source for almost any space platform.

In aviation, Saft's reputation for quality and reliability stretches back to 1954, explaining our leading – and still growing – position in the global aviation market. Our batteries are now found on every major make of commercial aircraft, corporate jet and helicopter, as well in many military aviation programs. The ULM battery, which drastically reduces maintenance costs, is the latest in a long line of Saft aviation stars.

As Saft engineers and researchers work now to help power the aerospace technology of the future, we remain committed to ensuring that our batteries can ultimately be trusted to keep flying machines aloft and functioning properly – time after time after time.

BERNARD PIERRE
Chairman & Managing Director

Cover: Nickel-hydrogen battery for space applications (Photo: C. Jarlan)

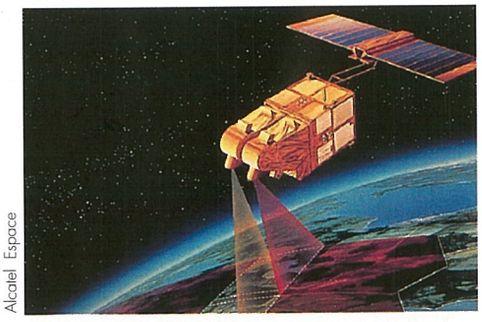
Perspectives in space

CNES/Arianespace

Batteries run vital systems in European launcher Ariane 4

Crafting batteries that stand up to the most rigorous environment known to man – an overview of Saft's space career.

For a battery, almost no application is more demanding than space travel. A space battery must withstand incredible accelerations and vibrations at launch. When used to power satellites, it must operate flawlessly – sometimes for 15 to 20 years – despite extreme variations in temperature and vacuum conditions, all the while maintaining an electrochemical equilibrium in a hermetically sealed box. It's a small but vital link in space missions. If it fails, the mission fails. Despite these challenging conditions, Saft has racked up some 52 million hours of cycling space cells and batteries without failure – a record of dependability that has made it the leading battery supplier for the European space industry and which is now helping



Alcatel Espace

Batteries power satellites at "night", when the earth blocks their solar power source

Saft

At work on technologies for 21st-century telecommunications

the company enter the U.S. market – 75% of the global space market.

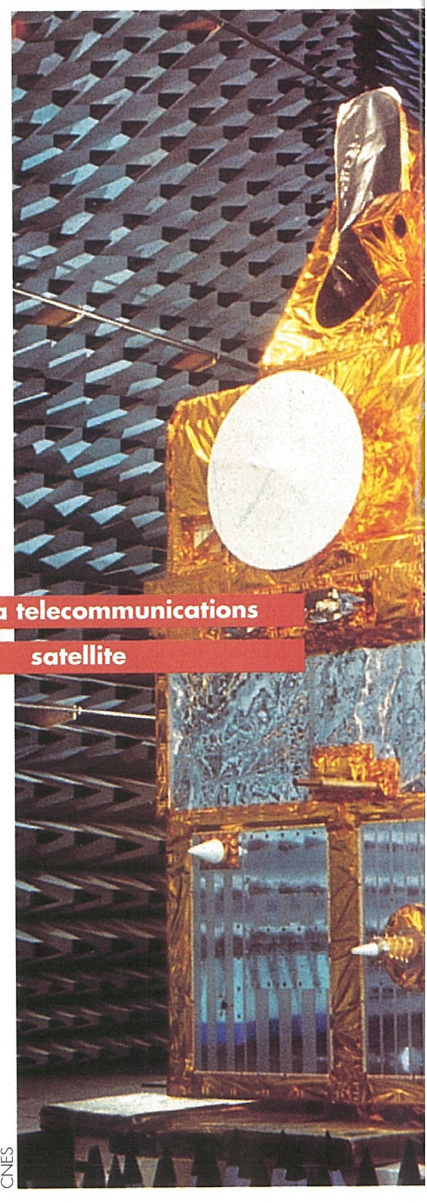
Saft is hoping to get an extra boost in the years ahead with its lithium-thionyl chloride battery – recently qualified by the U.S. Air Force for military rocket launches – and a new nickel-hydrogen battery that could extend the lifespan of satellites.

NO FAILURES

Saft has grown to achieve around a quarter of the estimated $60 million world market for batteries to power launch vehicles and satellites. There are currently approximately 100 launches a year in the Western world, a number that has stabilized recently following a satellite-launch boom through the 1980s. "While the industry is leveling off after expanding over the last 10 years, our market share is increasing regularly," said Philippe Vannier-Bertrand, director of Saft's Space Program. "We've grown 20% a year over the last four years, doubling our sales." He attributes the success to Saft's dependability. "We're one of the few battery suppliers that has never experienced a failure in space, in more than 25 years," Mr. Vannier-Bertrand said. "It is the result of the drastic quality controls that Saft puts into every step of the battery's design and fabrication."

The failure of a battery worth several hundred thousand dollars can doom a satellite costing $100 million or more. Batteries power satellite equipment – such as telecommunications gear, television transponders or remote sensing cameras – during the satellite's passage through "night," when the earth blocks the sun from reaching their solar electric panels. The batteries switch on automatically when "night" begins, and they switch off during the "day," while they are being charged by the solar cells.

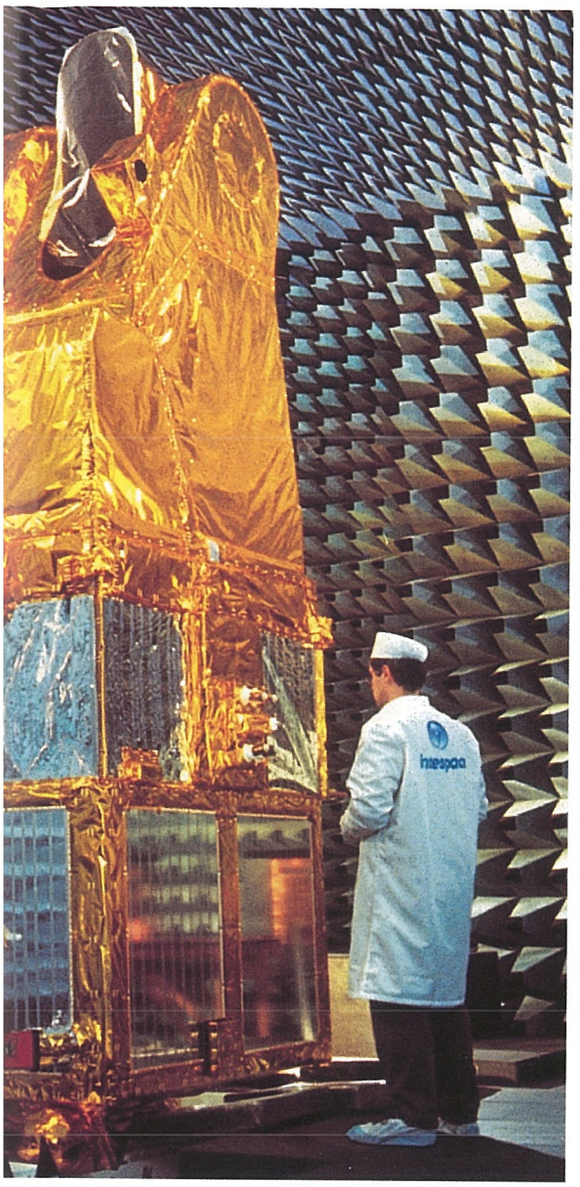
Saft's reputation for dependability has allowed it to expand beyond its first customer of the early 1960s – the French Space



CNES

Testing a telecommunications satellite

Agency (CNES). In 1970, it began supplying the multi-national European Space Agency and, through that relationship, its client base expanded to companies such as Telefunken of Germany, British Aerospace and the French aerospace companies, Matra and Aerospatiale. In 1977, the Indian Space Research Organization became Saft's first non-European client. However, because of American procurement policies which favored American suppliers for NASA and the military, the U.S. market was difficult to penetrate. The turn came in 1988, when Saft introduced its high-power lithium-thionyl chloride battery, used as a primary or reserve power source for rocket launches. "Unless you have something really different you won't be chosen," said Jacques Gouallard, Saft's marketing manager for space activities. "With the lithium battery breakthrough, we had a technical advance, and we demonstrated its performance so well



that NASA and the Air Force were motivated to go overseas."

The lithium cells offer high cell voltage of 3.3V, a high discharge rate up to one hour, an extended shelf life of five to seven years and lower maintenance costs – in addition to high energy density and thus lower weight. "They cut weight in half over silver-zinc batteries, saving 100 kilograms on the launch vehicle," Vannier-Bertrand said. "The satellite can then put this saved weight to work." Though the lithium battery was developed originally for launch vehicles, Saft is working to adapt it to new applications, where higher energy density and longer shelf-life are required. For example, Saft engineers are developing an application of the lithium technology as on-board energy for deep space probes, as a back-up power source on the Hermes manned space plane, now under development in Europe, and as a power supply for astronaut space suits.

The lithium breakthough helped Saft get its foot in the door of the U.S. market. Now Saft also supplies the Air Force with NiCd batteries for satellites, while these same batteries are being evaluated by NASA. After only five years, Saft is "co-leader" on the American space market.

LIGHTWEIGHT POWER

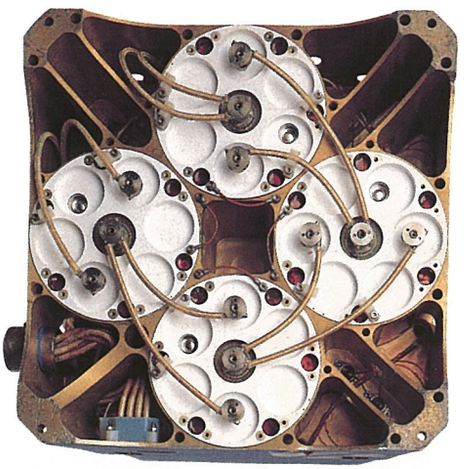
Saft is now introducing a nickel-hydrogen battery line for satellites. In development over the past 10 years, the battery's main advantage is its significantly higher massic energy – 50-60 kWh/kg – which results in a battery that is 30% lighter than a NiCd battery of similar energy capacity.

This is of particular importance for telecommunications and other high-altitude satellites, which function in geostationary orbits of 36,000 km. Weight is a vital factor in these applications, as it costs an estimated $18,000-$36,000 to lift one kilogram into geostationary orbit.

With significantly reduced battery weight, the satellite operator gains new flexibility. Launches are less expensive; the satellite can be more cost-efficient – for example by loading additional equipment, like transponders; it can benefit from higher energy capacity; or it can carry additional fuel to keep it in orbit much longer, thus expanding its lifespan.

Satellites in high geostationary orbit spend most of their time facing the sun. Their batteries are therefore required to cycle on and off only around 90 times a year. With such low cyclage requirements, they should last for at least 15 years – longer than the satellite's fuel supply.

The nickel-hydrogen battery also can be used for low-earth-orbit (LEO) satellites. Because of their lower orbits – around 100 miles – batteries for this application are in and out of the sun 14 times per 24-hour period. They must cycle on and off some 25 to 30 thousand times in a 5-year period – the lifespan of a typical LEO satellite.

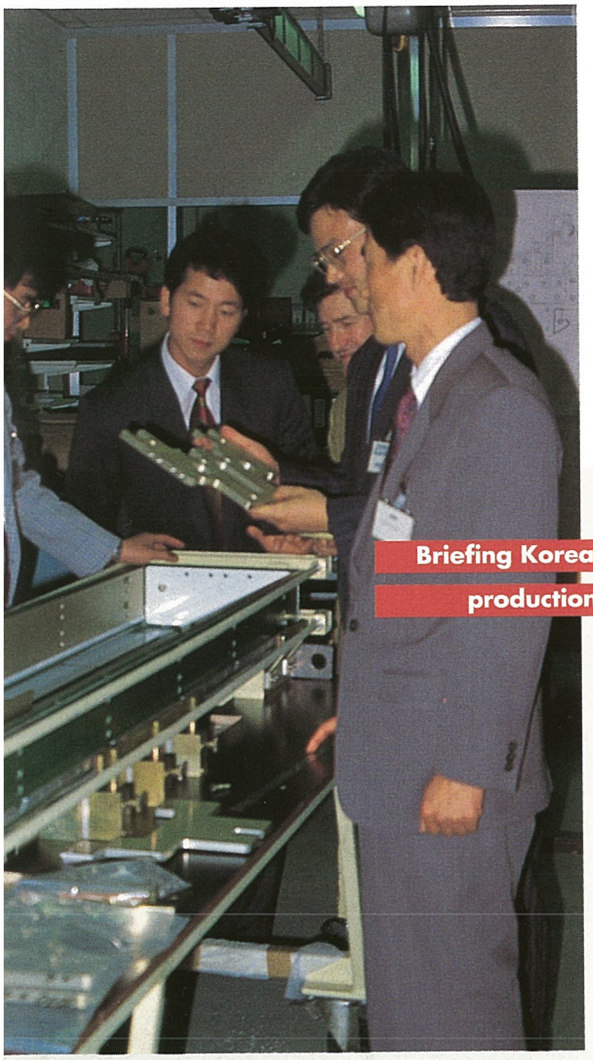


P. Simard

Lithium-thionyl chloride battery for launchers

Saft's nickel-hydrogen battery has been qualified by the European Space Agency. The company is currently seeking qualification for the new product in the United States. While the nickel-hydrogen battery is being launched, Saft engineers are busy at work on the next generation of satellite battery, due out at the end of the 1990s. Vannier-Bertrand promises the new battery "will make a drastic breakthrough over nickel-hydrogen, reducing weight by another 70 percent."

While the satellite market is currently stable, Saft is looking to a possible surge in the years ahead if current proposals for a global telephone system reach the stage of realization. The system would be based on a network of 30 to 40 satellites orbiting at medium altitude of several hundred miles, permitting global telecommunications from portable phones on the ground, on the seas or in the air. ■



Briefing Korean colleagues on production techniques

Gilberto Riccobono

processes. At the same time, Saft has sent an engineer to Korea to install manufacturing machinery and train production staffs.

In addition to the original technology transfer contract, worth over $2.7 million, Saft will continue to supply components to its Korean partner.

The deal negotiations, said Mr. Leocard, were helped by the presence of Saft's Korean office, which has a strong knowledge of Korean law and regulations. Saft also encountered the usual cultural differences in the negotiating process, he said, noting that that Global & Yuasa were particularly tough on delivery times.

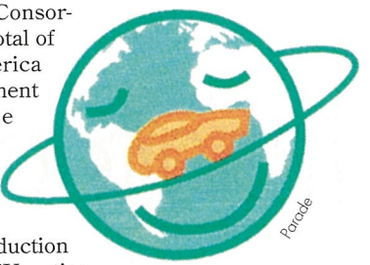
Throughout the technology transfer process, the Korean and French companies have been bridging the language gulf by employing a third language – technical English.

"We haven't needed interpreters, although with English we have to be very careful to make sure that everyone understands – in both directions," Elie Leocard said. "But we have succeeded in building up a real working team!"

IN BRIEF

BOOST FOR ELECTRIC VEHICLE RESEARCH

The next generation of electric vehicle batteries is on the horizon! The United States Advanced Battery Consortium (USABC) granted a total of $35.1 million to Saft America for research and development of two new couples. The nickel-metal hydride couple (NiMH) is expected to increase EV range two to four times and should be in industrial production by 1996. The long-term EV option, lithium aluminium iron disulfide (LiAl FeS_2), will offer ten-year lifetime, lower cost and reduced volume and weight. Cars powered by the LiAl FeS_2 should be on the road by the year 2000.



Parade

GREEN ENERGY MAKES IT BIG

Rechargeable power gets a break in Germany – Aldi, the giant German food chain, is planning a special "rechargeable kit" offer in 1800 stores. The kit includes a charger (manufactured by Bartec) and four Saft R6 batteries – the most common format for consumer electronics, like tape recorders and walkman. 180,000 kits will be sold under the brand-name "FIF". The chain, whose clientele includes over 90% of German households, is helping make rechargeable energy a way of life!

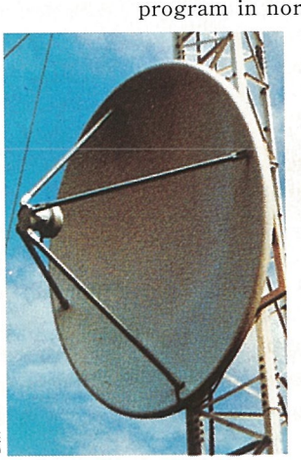
D.R

MORE POWER TO PORTABLES

1993 is Saft vintage at Samsung. The Korean mega-company has ordered $8 million worth of portable batteries from Saft Korea, to be supplied throughout the year. Manufactured by GS Saft (Japan) and by Saft plants worldwide, they will power cordless and cellular telephones, portable computers, walkmen, etc. Saft's complete range of products helped clinch the contract – backed up by Saft Korea's on-site assembly facilities for customizing batteries.

RECASTING TELECOMMUNICATIONS

As part of a telecommunications renovation program in northern Argentina, Saft Nife Argentina is supplying 46 SEM-type systems to Telecom Argentina. The SEMs provide continuous current power for digital telephonic controls in SMR power plants. Their easy installation and maintenance were the deciding factor in the selection. Saft Nife Argentina's local and group-wide experience also came into play, as well as its 'on the spot' ability to assemble and handle technical follow-up. The first system got underway in May 1993.



D.R

Cutting down on upkeep

The new ultra-low maintenance (ULM) battery reduces hassle and expense – a look at the latest in aviation...

In an economic environment that calls for cost reduction across the board, the launch of Saft's ULM battery this summer appears particularly well-timed. The ULM, an advanced nickel-cadmium aircraft battery which debuts at the Paris Air Show in June, is Saft's response to aircraft operators' growing demand for lower maintenance costs on batteries.

The ULM (ultra-low maintenance) will reduce maintenance by a factor of three, at the least – and perhaps even by a factor of eight, depending how the customer chooses to optimize maintenance against other design parameters.

MAJOR SAVINGS

This represents a significant cost savings for the aircraft operator. By eliminating most of the scheduled maintenance periods over the battery's lifetime, maintenance costs can be reduced by 60 to 90%.

The ULM battery, in development for the past six years, represents an "evolutionary" approach to meeting the industry's demand for lower maintenance, said Fred-Erik Hapiak, aviation marketing manager for Saft's Industrial Battery Division. "We're using Saft's state-of-the-art technology which has already been proved in other applications," he said.

The ULM features a plastic-bonded negative electrode, which replaces the sintered plate electrode of conventional NiCd batteries. As this electrode entails a significantly lower overcharging current, the amount of water consumed because of overcharging is reduced by a factor of three. This new electrode is also lighter than its sintered counterpart, and it provides higher energy density and more power at low temperatures. As a result, design variations are possible, optimizing either weight or electrolyte reserve.

Evolution is also the guiding principle in Saft's approach to the customer. "The ULM is fully interchangeable in form, fit and function with the customer's existing products. For most aircraft, it doesn't require modification," Hapiak said.

In 1992, the ULM won the recommendation of the American government's Naval Surface Warfare Center, the U.S. Navy's testing center. Saft recently received its first order for the ULM: Gulfstream Aerospace Corporation will be using the battery on a special-configuration G IV business jet. Saft America is currently tooling up its aircraft battery plant in Valdosta, Georgia, to produce it. In Europe, where the ULM will be manufactured at the Bordeaux (France) aircraft battery facility, it is currently being tested for a series of projects.

C. Jarlan

The ULM divides maintenance time by three

40 YEARS OF AVIATION EXPERTISE

Over the past ten years, Saft's aviation business has been steadily expanding. The company's market share for western aircraft recently reached around 60 percent – an all-time high. At the root of these gains are constantly improving product performance and credibility – Saft has been active in the aviation market since 1954 – and an increased sales and marketing effort, particularly in North America, which accounts for around half the global business. Saft markets a full line of semi-vented NiCd aircraft batteries to

The latest generation of Saft's aviation family

D.R.

Sydney Reames, Saft's aviation marketing director for North America, expects the ULM to boost Saft's leading position in the aviation market. "Customers are looking for additional value, and the ULM significantly reduces the cost of battery maintenance," Reames said. "Over the course of its life-cycle, customers may even save the equivalent of another battery."

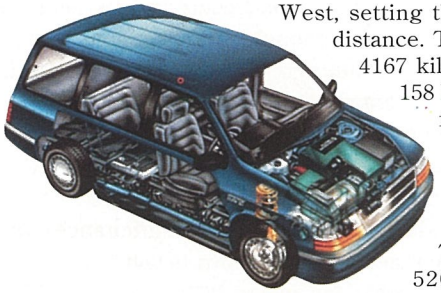
start engines and provide emergency back-up power on commercial aircraft, business jets, and helicopters. The batteries provide the surge required to start turbines faster than any competing battery. The ULM aircraft battery, now being introduced, offers operators substantial savings on battery maintenance costs. Saft's customized line of "Aviation Grade" sealed NiCd batteries power vital on-board safety functions such as cabin exit lighting and avionics equipment.

IN BRIEF

NEW PORTABLE CAPACITY

Portable battery production picks up momentum – Saft's portable cell plant at Nersac (France) is adding four new production lines. Once the first of the new lines gets underway, in August 1993, Nersac – now responsible for the majority of Saft's cylindrical cell production – will boost its production capacity by more than 30%. Afterwards, a 10% yearly increase is planned, to accommodate the rapidly-growing cellular telephone and portable computer markets.

WESTERN ODYSSEY FOR ELECTRIC VAN



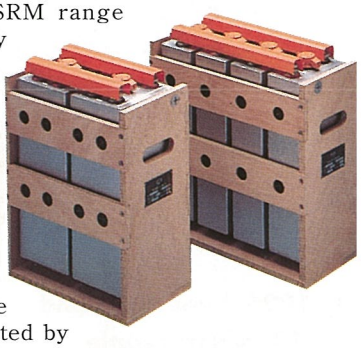
Chrysler

Chrysler's TE Van conquers the American West, setting the EV world record for distance. The electric van covered 4167 kilometers (2604 miles) in 158 hours, on an epic journey from Detroit to Los Angeles. Range varied from an average of 82 km to a maximum of 192, in the suburbs of Los Angeles. The 30-unit Saft STM 5200 battery stood up to temperature extremes, from a low of -10° C to to a high of 31° C, and made it through 55 recharges in fine form. The experiment allowed Saft engineers to gather invaluable information on recharging.

A CUSTOM-DESIGNED LIFE-SAVER

The "cardiac vest", a device which wraps around the chest to deliver cardio-pulmonary resuscitation, has recently been developed at Johns Hopkins University (Baltimore, USA). While the machine can be plugged into an AC outlet, researchers needed a light-weight, high-energy-density battery to take over in emergency situations. To find the ideal solution, Saft Nife America worked closely with Johns Hopkins: initial tests with aviation batteries were successful, and an even lighter silver-zinc battery was developed for on-site emergency applications. Following U.S. Food & Drug Administration approval, the vest will soon be on the market.

TRAVELING LIGHT



Compact power for changing rail demands... Saft's recently introduced SRM range reduces weight and volume by 20%, compared to its predecessors. The nickel-cadmium batteries provide backup power for lighting and other auxiliary systems in all trains, from high-speed networks to tramways. The SRM has already found favor worldwide: Kawasaki will be testing it on its new subway cars for New York City. And the Dutch national railroad, attracted by the SRM's low maintenance and long life, has ordered 167 batteries. Next in line: Japan, Chile and Singapore.

Telecom revolution

A new telecom era is at hand – Europe will soon be linked by a common cellular telephone system, the GSM.

The advanced cellular telephone system GSM is taking root in Europe. It provides secure and cost-effective telephone communications that are free of interference, even in dense population areas.

And thanks to its advanced digital technology, GSM (Global System for Mobile Communications) subscribers can make use of a wide range of new services – from fax and computer data transfers to call screening.

Unlike the analog systems installed in the United States and Europe in the 1980s, GSM is not just for business people on the go. It also holds promise in the future as a relatively low-cost way for developing countries to provide basic telecommunications services for their populations.

The GSM technical standard has now been adopted by 20 western European countries and a dozen non-European countries. Saft has joined the effort in developing a range of lighter, more compact and longer-lasting rechargeable batteries to meet the demands of the new GSM portable and hand-portable phones.

The stakes are high. By 1996, the number of GSM subscribers in Europe is expected to be between 8 and 10 million – double the number of people who will be using analog cellular systems by that time. This would create a market worth some $11 billion – for handsets alone.

P. Simard

While analog cellular systems have been used mostly by motorists in big cities, GSM is likely to find new applications as a pocket phone system, light and small enough to go with people whenever they want to be in touch away from their home or office – at the golf course, beach, race track or for a picnic in the park.

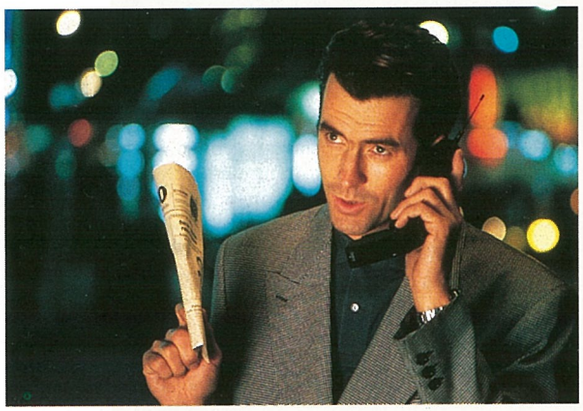
"As new models get smaller and less expensive, the main market for GSM will be hand-held," said Patrick Houze, Saft's worldwide marketing director for portable batteries.

CROSSING BORDERS

The system requires installation of a network of radio cells, measuring from several hundred meters to several kilometers across, depending on telephone traffic requirements. At the heart of each cell is a base station, which is connected to the local public telephone network. The user's handset is linked by a radio signal to the base station. When the user moves into an adjacent cell, the new cell's base station automatically takes over the signal without disturbing the call.

Currently being installed and marketed throughout most of Europe, GSM promises to revolutionize mobile telecommunications in that it will permit subscribers to cross national borders and still receive voice, text or data wherever they may be. Europe's complicated puzzle of different mobile telephone systems will be transformed into one network. In practice, each subscriber will carry a "smart card" – a credit-card-sized plastic card with a microprocessor chip – that he can insert into any GSM handset to

J.P. Caulliez



By 1996, between 8 and 10 million people will be GSM subscribers

The prismatic GP battery, designed for the slimmest handsets

make calls.

The smart card, rather than the phone or location, contains the subscriber's number and billing information. The subscriber can make calls wherever he goes, from anyone's handset, and still be billed correctly.

GSM's market development is dependent on advanced battery technology. Batteries play a key role in assuring compactness and lasting power – crucial criteria for a portable handset destined to be a pocket accessory like a calculator. Saft and its joint venture partner, Japan Storage Battery, have innovated in the development of a prismatic battery. "We call it the chewing-gum battery because it is flat like a pack of gum, instead of round," said Houze. "It's much easier to make a GSM handset terminal with a flat battery." This flat battery has been adopted by all key analog and digital handheld terminals.

The flat battery, made by the GS-Saft joint venture in Japan, provides 45-60 minutes of talking time before needing charging. For longer talking times, Saft provides more conventional cylindrical batteries, made in Angouleme, France; they power the handset for 90-120 minutes.

Later this year, Saft will introduce a new generation of GSM batteries based on nickel metal hydride technology that will offer 30-35% more autonomy. "The key is to offer more talk time – that's the main demand from the original equipment manufacturers," Houze said.

IN BRIEF

RUNNING WALKIE-TALKIES

Motorola, number-one manufacturer of portable telephones, honored Saft's VE 2/3 A 600 cell with its "Partnership for Growth" standard. Their order of 2 million cells for 1993 will equip portable mobile radios, or walkie-talkies. This was Saft's first cylindrical cell order from Motorola, already an established Saft client for prismatic GP batteries. An important mark of confidence from the world's largest nickel-cadmium consumer outside of Japan.

A FIRST IN ELECTRIC VEHICLE PRODUCTION

A step ahead in the electric vehicle race... Saft's Bordeaux (France) plant is gearing up for production of nickel-cadmium EV batteries for PSA (Peugeot-Citroën). Ground was broken for the new facility – the world's first EV battery production line – in early spring, and the building itself will be complete in the fall of 1993. The first batteries will be rolling off the line in December 1994. The plant is designed to stand up to growing EV demand: production will be able to equip 6,000 electric cars in 1995 and 11,000 vehicles in 1997. And the flexibility to accommodate changing technologies is built in.

Citroën

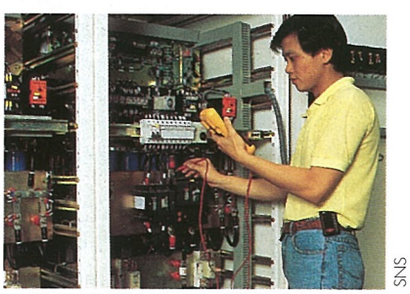
EXIT OPTIONS

Saft's security lighting marks the way out all over Europe – running exit signs in both Parisian airports, for example. Now, eight new products for mid-size installations fill out Saft's line of central battery systems. Powered by low-maintenance sealed lead-acid batteries, the PLN (non-maintained lighting) and PLP (maintained lighting) come in four different wattages (400-1000). Compact and remote-controlled, they offer an economical solution for restaurants, showrooms, large theatres, and supermarkets.


Tango

NEW FACILITY FOR SAFT-NIFE SINGAPORE

Saft is on the spot in Asia, with the inauguration of a new facility for Saft Nife Power Systems Singapore in March 1993. The recently completed factory consolidates the activities of the five former Singapore sites, bringing together industrial, aviation and advanced batteries, as well as power systems. Its on-site custom design facilities have the capacity to respond to the rapidly evolving demand in Singapore and neighboring Asian countries – for clients like Hyundai and Shell.


SNS

VXPK technology: ext

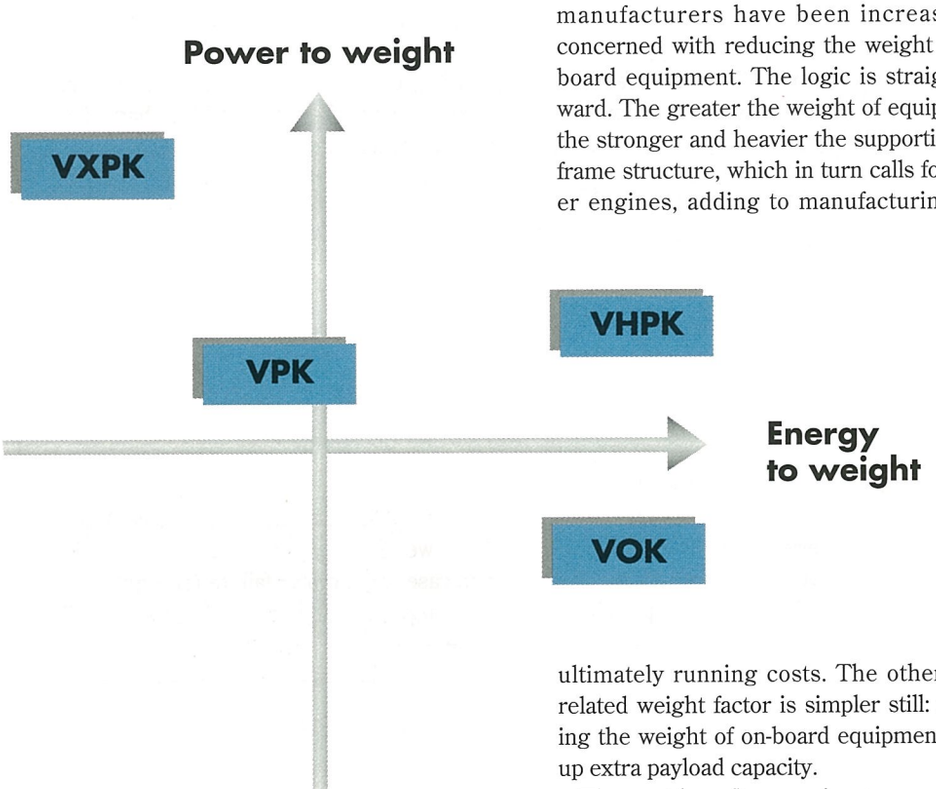
The cutting edge for power applications in aviation, the VXPK optimizes the power-to-weight ratio – an ultimately economic starting solution.

Saft's VXPK range of extra high-power NiCd batteries for aircraft was developed to respond to the needs of the aviation industry in the 1990s and beyond. As with Saft's other ranges of aircraft batteries – VOK, VPK and VHPK[1] – the changing requirements of the market have determined the targets to be achieved.

Battery technology always proceeds hand-in-hand with advances in aircraft and engine design, and in developing its VXPK range, Saft has worked closely with engine and turbine manufacturers to find the right solution for the starting requirements of a new generation of engines.

RIGOROUS SPECIFICATIONS

Different needs call for different batteries. Throughout the history of modern aviation, manufacturers have been increasingly concerned with reducing the weight of on-board equipment. The logic is straightforward. The greater the weight of equipment, the stronger and heavier the supporting airframe structure, which in turn calls for larger engines, adding to manufacturing and ultimately running costs. The other cost-related weight factor is simpler still: reducing the weight of on-board equipment frees up extra payload capacity.



The cost benefits accruing to even a few kilograms of reduced weight are considerable. For instance, it is generally accepted that each extra kilogram of equipment represents between $1500 and $10,000 in aircraft construction costs. A reduction of just one kilogram in the weight of a battery can therefore more than cover its cost to the aircraft manufacturer. Similar considerations apply for the operator. Delta Airlines, for example, estimates that the cost of flying 10 pounds (4.5 kg) of weight is $125 per year. If this weight saving can be made on each of three batteries, then the cost advantage over a ten-year period amounts to $3750 – approximately the cost of one of the batteries!

For the VXPK, the technically defined target was to achieve a 15% increase in the power-to-weight ratio in comparison with the most powerful product on the market, the Saft Delta Plus range (VHPK).

Another prime demand for the VXPK range was high performance at low temperatures. Once again, close collaboration with engine manufacturers enabled Saft to pinpoint their needs and find a solution. Performance was to be optimized for starting requirements at -25° C, a temperature identified as a critical specification, especially for military aircraft. In practice, both military and civilian aircraft regularly encounter even lower temperatures on the ground.

POWER OR ENERGY?

A third feature of the emergent VXPK range involves the differing requirements for power and energy in aircraft batteries. A brief overview of Saft's earlier generations of aircraft batteries will recall the changing emphases over the decades, and how Saft's product ranges have evolved to meet them.

VOK – EMPHASIS ON ENERGY

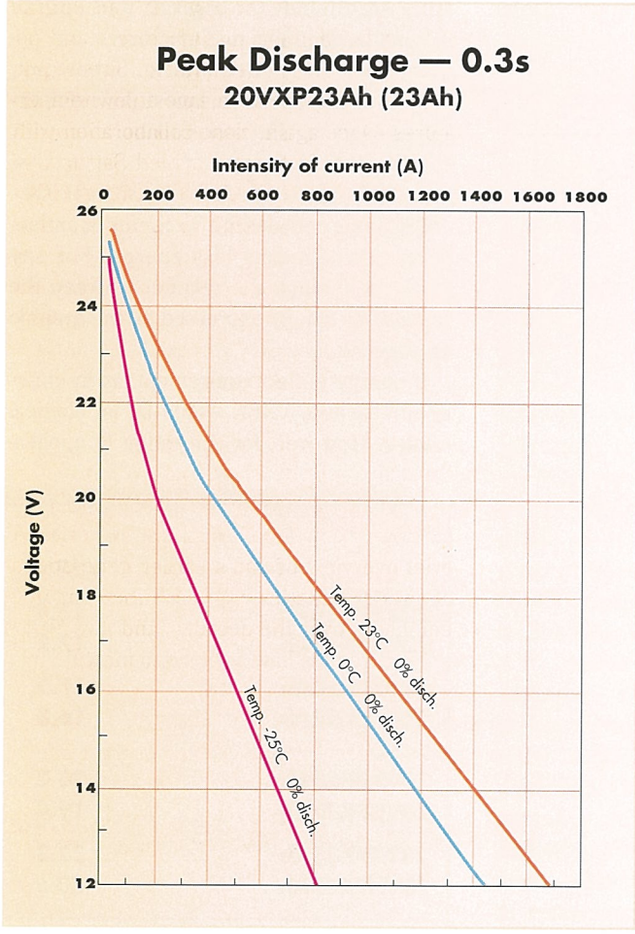
Saft's development of NiCd sintered-plate batteries was pioneered during the 1950s, when aircraft were switching from traditional lead-acid batteries to the more powerful, reliable, longer-lasting and lighter NiCd technology. The VOK range was launched

ra power, reduced weight

in the 1960s, dedicated largely to applications demanding more energy – the duration (watt-hours) of the current supplied. As well as being installed in French military and other aircraft, VO technology was used in many non-aviation applications – to power emergency lighting, for example.

VPK – EMPHASIS ON POWER

During the early 1970s, with Saft expanding on the military market outside France into NATO countries, the VPK range was developed to meet US military requirements. Here, in contrast to the VOK range, the primary emphasis was on power – a high current available for short periods.



Developed in accordance with the worldwide reference MS (the "military specifications" elaborated by the US defense department after World War II as a logistical system to keep the number of products supplied to a minimum), the VPK range today remains a highly respected technology installed on military and civilian aircraft world-wide.

The VOK and the VPK ranges use the same basic NiCd sintered-plate technology. Their differences – power versus energy – depend on the thickness of the sintered plates and the distance between electrodes. For power, surface area needs to be maximized: as the active area is increased, power density is reduced and there is lower current density on the electrode. So the VPK range uses thin plates (approx. 0.5 mm), with small inter-electrode distances. Conversely, for energy, surface area can be reduced: for the VOK range relatively thick plates (approximately 0.9 mm) are used.

VHPK – POWER AND ENERGY

In the early 1980s advances in membrane technology enabled Saft to launch the VHPK (Very High Power) range of batteries, marketed under the Delta Plus trademark.

Both of the previous ranges, the VOK and VPK, were designed with the same separators and cellophane membrane in the interelectrode space. They are semi-vented in order to prevent excessive gas recombination, which can occur when batteries are overcharged, leading to rising temperatures ("thermal runaway"). While the function of the membrane is electrochemical, that of the separators is largely mechanical, preventing short-circuit between the plates. In the VHPK range, the development of more resistant, thinner materials meant that the distance between elements could be reduced. More plates could then be put into the same volume without compromising either reliability or safety. The result was a product range optimizing both power and energy.

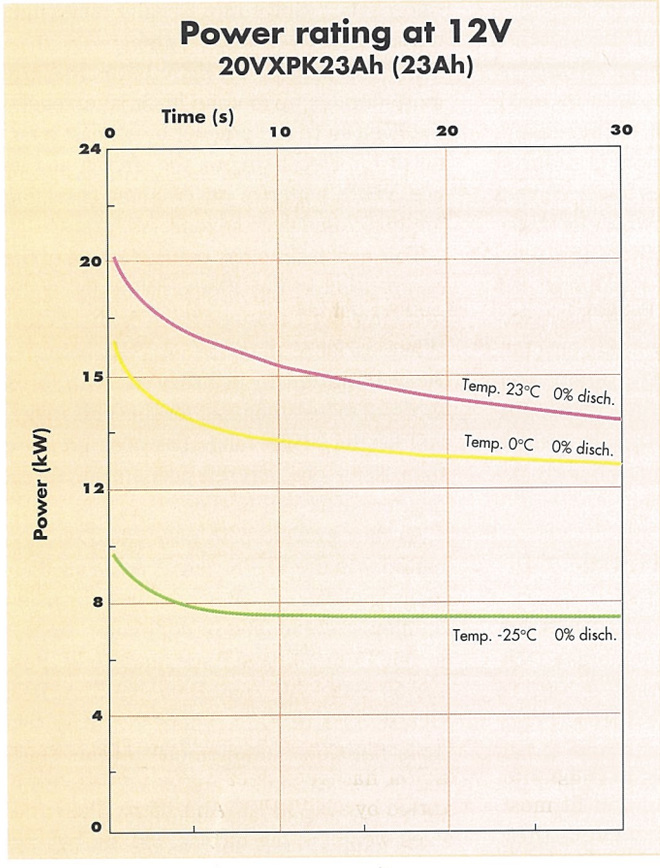
Furthermore, in VHPK batteries, the more durable membrane material extended the lifespan of the product by at least a factor of 1.5. Depending on the aircraft and its use, VHPK batteries can continue operating for up to – and even beyond – 10 years.

This new technology put Saft ahead of the competition in the 1980s, primarily in the growing civil transport aircraft sector. Whereas more than 75% of VOK batteries were installed in military aircraft, this dropped to less than half for the VPK range, and for the VHPK range has been no more than 25% – civil aircraft account for three-quarters of all VHPK sales.

As they provide both power and energy, batteries in the VHPK range can be used for many applications. They have been installed on almost every type of commuter aircraft in the 19 to 70 passenger range (e.g. Fokker 50, Saab 340, Saab 2000, N235, ATR42, DO228, LET 610G...), where they have two main functions: autonomous turbine starting (power capability) and emergency backup in case of generator failure (energy).

On large aircraft, such as the Boeing 747 or the Airbus, where engines are started by APUs (auxiliary power units) or by plugging into an airport's own power source, the batteries are primarily used to start the APU and/or for emergency backup. VHPK batteries also equip military aircraft (such as the UK's Tornado and Sweden's JAS39), as well as business jets.

VXPK: extra power, reduced weight



THE VXPK CONCEPT: OPTIMIZED DESIGN FOR POWER

The VXPK was designed as the cutting edge in power. The target of a 15% power-to-weight ratio improvement on the then-unsurpassed VHPK technology was achieved by 1986, when the VXPK concept was internally qualified. How was it done?

There are two basic approaches to increasing the power-to-weight ratio: either decreasing weight and keeping power constant, or increasing power while keeping the weight the same. Both approaches were adopted, using a combination of mechanical and electrochemical modifications. Wherever possible, weight was reduced by mechanical design improvements, like modifications to cell terminals. But the core of the VXPK concept was an extra-thin sintered plate (Xtra as in the "X" in VXPK). The thinner plates reduce the total amount of material required, thereby reducing weight; at the same time more plates can be placed in each cell, increasing the active surface area and so increasing power.

However, reducing the VXPK to a matter of thinner plates would be an oversimplification of what was at stake in developing this technology. The VXPK involved configuring a design that would optimize the power-to-weight ratio in a manufacturable product. This meant selecting the best parameters – in particular, optimum geometry for the electrodes. It was accomplished by Saft researchers applying computer modeling analysis to electrochemical theory, in conjunction with extensive follow-up testing. Saft's 40 years of experience in sintered-plate battery manufacturing was then mobilized to solve the practical question of commercial production of VXPK batteries.

Since the target specifications called for low-temperature efficiency as well as power, the right balance between electrode design and electrolyte also had to be found. This meant optimizing the concentration of the potassium hydroxide electrolyte for the specific plate configuration adopted.

The resulting overall design concept is truly significant for aircraft and engine original equipment manufacturers and operators throughout the world. Simply put, VXPK technology is the most powerful aircraft battery on the market today.

COMPARATIVE PERFORMANCE

Because cell design is a compromise, more power means less energy. For any given technology the relation between the two can be simply expressed by the graphic on page 12.

If energy is the requirement, as in emergency backup, VXPK would be an illogical choice. However, for the range of applica-

	+23°C	0°C
20VXPK16Ah	13.4	12.1
20VHPK17Ah	12.2	10.3
20VXPK20Ah	17.2	15.0
20VHPK23Ah	16.0	13.5
20VXPK23Ah	20.2	17.2
20VHPK27Ah	19.4	16.3
20VXPK31Ah	22.3	19.9
20VHPK37Ah	20.5	18.4

tions for which it was specifically engineered, the VXPK is unbeatable.

In a typical long-range airliner, for example, VXPK batteries would be appropriate for starting the APU, while another battery would supply emergency backup. The two tables below compare peak power and weight reduction for VXPK and VHPK applications.

VXPK APPLICATIONS

Two main features make high-power sintered-plate technology attractive. When the electrical system specification does not require optimization of battery energy, the adoption of VXPK technology will dramatically reduce weight, and hence costs, for commercial aircraft manufacturers and airline operators, as we have seen. For military applications as well, the decrease in equipment weight is multiplied in the weight of the aircraft structure. For example, in helicopters, a 9 kg reduction in battery weight results in a further 27 kg reduction in the aircraft mass.

Lighter, faster and more manoeuvrable aircraft can thus be built; or on-board armaments or other equipment can be increased. In addition, the VXPK's extra high power capabilities, in particular starting at cold temperatures, make it an attractive option for specific demanding applications.

Every kilogram shaved off battery weight by VXPK technology can save up to three in the production of the aircraft itself.

to be used commercially, it has been technically qualified by independent laboratories. VXPK batteries have also been selected in a number of confidential military programs.

We conclude this survey of VXPK technology by highlighting two such aircraft applications. The first of these is in a new combat helicopter, whose battery sizing requirement was predominantly based on a demanding starting sequence at -25°C. It has been fitted with two 20VXPK23Ah batteries. A titanium container further reduces battery weight. Compared with a Delta Plus (VHPK) battery sized according to the same starting specification, this solution reduces mass by 9 kg.

VXPK WEIGHT REDUCTION
(at equivalent power, -18°C)

Battery in VXP technology	Weight (Kg)	Projected weight for an equivalent power in VHP technology	Mass reduction (Kg)
20VXPK16Ah	19.1	22.1	3.0
20VXPK20Ah	24.2	27.8	3.6
20VXPK23Ah	28.0	32.5	4.5
20VXPK31Ah	34.6	39.1	4.5

Note: all batteries in stainless steel containers

COMPARATIVE PEAK POWER

(for form-fit interchangeable products)

24V batteries, 100% charged, 12V, 0.3 sec peak power.

Peak power in kW	
-18°C	-30°C
8.8	4.9
7.0	4.2
11.1	6.4
9.3	5.8
12.8	7.5
11.2	6.8
15.6	10.6
13.9	9.1

Four optimized cell sizes have been designed, within the 15 - 31Ah range. (See table at left, "Comparative Peak Power"). These four cell designs are packaged in standardized footprints and will fit most common applications. However, they should not be seen as standard, off-the-shelf products, but rather as design concepts customized and developed to meet requirements specified in advance. They are not intended to replace existing Saft batteries; their essential role lies in providing power applications for an emerging generation of aircraft. Although the VXPK range has yet

The second application is for a new version of a transport helicopter, with a two-hour emergency requirement. This specification has been met by a small turbine started by a 20VXPK31Ah battery. The combined weight of the turbine and the battery is no more than that of the 43Ah standard Delta Plus battery. In effect this means that without any increase in mass, the power capability has been increased and – since the battery starts a turbine – the emergency capability is now unlimited. ■

1) In Saft aviation product ranges the letters "O" and "P" refer to energy and power respectively.

Saft ULM batteries go a long way toward freezing your life cycle costs.

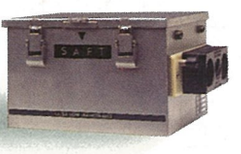
— DOB EN RESEAU —

Saft has designed its new line of Ultra Low Maintenance aircraft batteries with today's demanding environment in mind. By keeping battery servicing needs to a minimum, ULM also ensures Ultra Low Maintenance costs.

Saft's nickel-cadmium technology has always offered the longest life, highest performance and best value in aircraft batteries. With the ULM, we've also cut routine maintenance to the bone by significantly reducing the frequency of scheduled battery removal.

Saft's reputation for quality and customer service has driven us to the top of the industry, with batteries aboard virtually every type of civil and military aircraft now flying. And we blanket the globe with a vast product support network comprising more than 70 locations worldwide.

Today, thanks to ULM, Saft has put the freeze on your aircraft battery life cycle costs.



SAFT

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