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MILITARY APPLICATIONS OF LITHIUM BATTERIES

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Summary

Practically every weapon system requires a battery to provide electrical power for various functions. The lithium battery is becoming the "power source of choice" for a large number of these military systems. Lithium technology offers unique solutions to the combination of requirements imposed by military systems — low weight, low volume, long storage life, low life cycle cost, and immediate readiness over the full military environmental condition spectrum.

Batteries are used as a source of emergency primary or stand-by electrical power in almost all military equipment and weapons. During the past decade, lithium batteries have become the "power source of choice" for a large number of these applications. This is because lithium batteries offer excellent gravimetric energy density, high individual cell voltages, good charge maintenance, and offer a wide range of operating temperatures, especially at extreme low temperatures.

Primary lithium batteries have found the greatest use to date, especially the low rate, nonreserve and the thermal reserve types. The low rate, nonreserve systems are being used in sizes ranging from a few milliampere-hours to several thousand ampere-hours. The thermal reserve lithium batteries have replaced other thermal reserve batteries in almost all applications. The lithium thermals have expanded the range of active lifetimes from a few minutes to greater than one half hour, reduced weight/volume, and provided some limited open circuit activated stand prior to powering a load. A number of developing applications are expected to use high rate reserve, moderate rate nonreserve, and rechargeable batteries. This paper will discuss the above general classes of both existing and developing applications of lithium batteries for military use.

Thermal reserve batteries, commonly called thermal batteries, are electrochemical devices which require heat to become electrically active. At normal ambient temperature the electrolyte is a highly resistant, solid salt mixture. When the battery is internally heated, to about 500 °C, the electrolyte becomes a conductive, molten salt, thereby enabling electrical

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power to be extracted. These batteries are typically low cost, have excellent storage life (greater than 20 years), and operate over a broad temperature range. The most common chemistry used is the (Li-alloy/$LiCl \cdot KCl/FeS_2$) utilizing an Fe–$KClO_4$ or Zr–$BaCrO_4$ heat source. The thermal battery is expected to replace many aqueous reserve batteries used in weapons requiring less than 20 min of power. This replacement is projected to reduce significantly the cost of ownership of weapons such as tactical/strategic missiles and glide bombs. The thermal reserve battery has found its widest use in munitions and missiles. Some of the systems using the thermal reserve are:

- Mines — arming;
- Tactical missiles — guidance and control, target acquisition and fuzing;
- Aircraft seat ejection systems — ACES II and CREST;
- Glide bombs — main power and fuzing;
- Smart projectiles/bullets — guidance and fuzing;
- Radar jammers;
- Expendable decoys;
- Telemetry packages;
- Re-entry vehicles — main power;
- Shuttle payload deployment.

Reserve lithium batteries are devices in which a liquid and the electrolyte or catholyte is held in an external compartment or reservoir, and when electrical power is required the liquid is forced from the reservoir into the cell compartments of the battery, activating the battery so that electrical power can be extracted. The battery is electrochemically inactive prior to liquid injection into the cell compartment. The reservoir may be a coil tube, cylinder with piston, spherical with bladder, or a glass ampule. The activation or liquid transfer process may be initiated via mechanical spring, gas generator, or shock device. The most common chemistries utilized are: Li–$SOCl_2$, Li–SO_2Cl_2 and Li–V_2O_5. Reserve batteries are usually high rate devices except for the glass-ampule-type single cells used in mines. Some typical applications are:

- Smart projectiles — guidance and fuzing;
- Mines — sensing and fuzing;
- Artillery launched communications jammers;
- Underwater mines — sensing and fuzing;
- Strategic missiles — telemetry, range safety and tracking;
- Strategic missiles — electronics and ordnance;
- Sonobuoys;
- Acoustic and sonar devices;
- Munitions fuzing;
- Underwater propulsion and electronics devices.

Nonreserve lithium batteries are active systems in which power is available immediately by closing the switch or completing the electrical connection. These batteries are typically low-to-moderate rate devices ranging in capacities from a few milliampere-hours to many thousands of ampere-hours. There is a wide variety of chemistries employed, some of which include: Li–SO_2, Li–CF, Li–MnO_2, Li–$SOCl_2$, Li–SO_2Cl_2, Li–$SOCl_2$·BrCl and Li–SO_2Cl_2·Cl_2. The designs include flat plate prismatic, jelly roll, bobbin and disk electrode configurations. The active lithium system has a multitude of uses, some of which are:

- Life support devices — radios, survival avionics, lights, and beacons;
- Ground laser locator designators;
- Sonobuoys;
- Laser range finders;
- Tactical missile telemetry;
- Centaur — G vehicle, main power launch vehicle;
- Recording accelerometers;
- Night vision scopes;
- Memory stay alive — C-Mos RAM
airborne engine monitor
airborne radar
airborne data transfer modules
airborne computers

Rechargeable, secondary lithium batteries have been under development by the military since the early 1960s, but have yet to attain sufficient performance, cycle-life, and safety to be implemented into military devices. Recently, with the advent of limited cycle applications, the possibility of using secondary lithium batteries may be realized in manportable instruments (communication, sensing, and target acquisition devices) and missile ground power sources. Some of the chemistries being developed are: Li–TiS_2, Li–MoS_2, Li–MnO_2 with organic electrolytes; Li–SO_2, Li–transition metal oxides and halides with inorganic electrolytes. Until sufficient cycle life and safety is demonstrated, the widespread use of the rechargeable lithium battery is not likely to occur in military systems; for example, spacecraft (satellites) batteries require many thousands of cycles.