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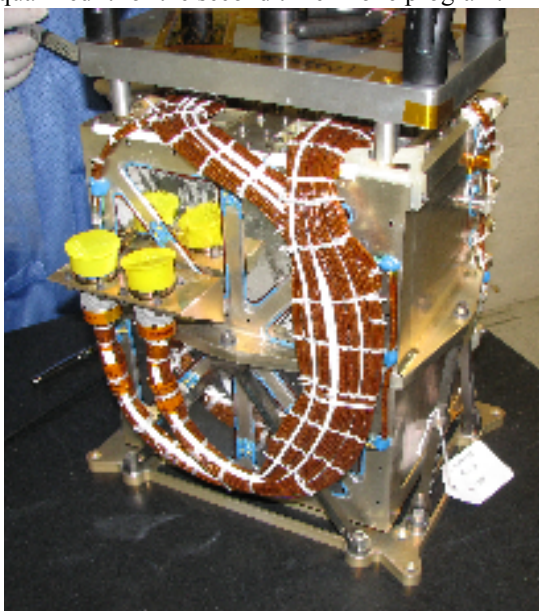
Title: NASA Needed an Innovative Battery Design to Work With an RTG on Mars Science Lab.

Short Description: Not many companies know more about surviving on Mars than the team of NASA and Yardney Technical Products, Inc. We have powered the Phoenix Lander and both of the Rovers, one of which is in its 8th year of operation on Mars. In 2006 NASA approached Yardney for an even more demanding mission. They needed a battery to power the Mars Science Laboratory, now known as Curiosity.

1) Opportunity/Problem: Space applications are frequently powered by a combination of energy sources – usually solar array/battery combinations. For Curiosity, the energy system included a Radioisotope Thermoelectric Generator (RTG), a state-of-the-art energy source that generates electricity from the natural decay of Plutonium-238. This is the first time an RTG, Li-ion battery and solar array have been used on the same energy system which has to function over all three stages of the mission, Cruise, Descent and Rover. Once on Mars, the RTG and the Li-ion battery will supply all energy to the vehicle. The RTG can be looked at like a solar panel. It provides electricity at a basically constant rate. Depending on what the rover is doing, the power requirements can change drastically. The battery needs to provide power during peak requirements that exceed the output of the RTG. The RTG will then re-charge the Li-ion battery when the power requirements are less than the RTG output.

All space missions start by exposing the payload to extreme conditions such as vibration, acoustic noise, pyrotechnic shock, extreme temperature fluctuations, etc. Launch vehicles are essentially very high tech, controlled explosions and whatever is along for the ride must withstand exposure to these elements. In addition to exposure to the launch environment, most batteries are not designed to be used in multiple orientations, zero gravity and in negative pressure or a vacuum.

2) Innovative Response/Solution: a) To withstand the rigors of launch environments, Yardney proposed a fully prismatic Lithium-Ion cell design that essentially eliminates any voids in the cell and prevents movement that can lead to work hardening, wear, and failure. This design also allows the manufacture of parallel-walled cell cases that can be packed tightly against each other with no void area like you would have with a conventional, commercial style round cell. After completing qualification testing and building the actual flight cells for the 28 V, 40 Ah MSL battery system, NASA upgraded the requirement to a 28 V **86** Ah system. Yardney very quickly modified our previous, innovative battery design to have more capacity and qualified it for the second time in one program!



Some of the most innovative design parameters of Yardney's batteries are inside the cell itself. In space missions, weight, volume, power, safety, durability and reliability are of exponentially more importance than here on earth. This is an environment where simple deficiencies or mistakes such as poor connections can (and have) caused multi-million dollar missions to end in complete failure. Yardney has tested and selected only the best raw materials and processes to manufacture the cell electrodes (anodes & cathode powders, foils, additives, etc). The use of nanotechnology in the processing of these materials has yielded critical surface area and particle configurations that achieve exceptional performance. To carry the electrons, Yardney employs an electrolyte solution that allows the cell to continue to perform even when exposed to extremely low temperatures where most other batteries would freeze and electron flow would cease. **b)** Without these innovative design features, the battery would not meet the size and weight restrictions of the mission, survive the rigors of the launch environment or operate as required in the cold vacuum of space. For this program, not only were the cell and battery designs innovative, but the manufacturing process had to be developed as well. The battery box for Curiosity also served as the cell restraint system and part of the battery mounting system. This required that the cells be positioned, compressed, and then carefully installed into the battery box all at once. The biggest advantage of this is reduced weight due to the elimination of side clamps, end clamps and both battery and mounting hardware.

3) Results: Our innovative approach and history of exceeding performance requirements on Mars missions resulted in Yardney Technical Products, Inc. being awarded the one and only contract to provide the batteries for the Mars Science Laboratory (Curiosity) program. This is approximately a 2.3 billion dollar program that would fail if the battery failed. The battery has been qualified and delivered to NASA JPL to be integrated into the vehicle. It is expected to arrive on Mars in August of 2012. The desired mission life is one Martian year – equivalent to 686 earth days.

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