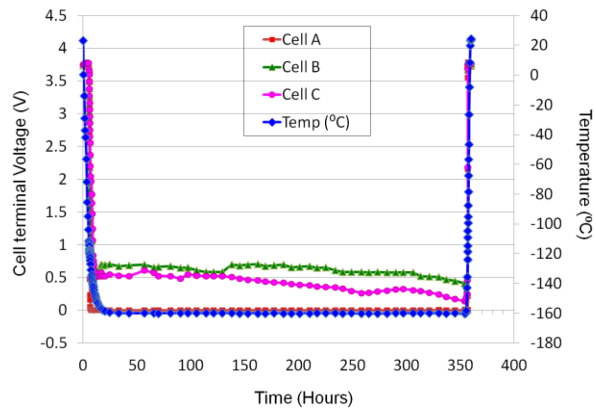
PASSIVE SURVIVABILITY OF 18650 LITHIUM-ION CELLS THROUGH LUNAR NIGHT ENVIRONMENT SCENARIO. K. Nandini[1], K. Usha[2], M. S. Srinivasan[3], M. Pramod[4], P. Satyanarayana[5] and M. Sankaran[6], [1] Battery Division Power Systems Group U R Rao Satellite Centre HAL Airport Road, Bangalore – 560017 India Phone: 080-2508-3668 nandinik@isac.gov.in, [2-4] Battery Division Power Systems Group U R Rao Satellite Centre HAL Airport Road Bangalore – 560017 India, [5] Power Systems Group U R Rao Satellite Centre HAL Airport Road Bangalore – 560017 India, [6]Communication and Power Area U R Rao Satellite Centre HAL Airport Road Bangalore – 560017 India.

Introduction: Every space exploration mission is unique in its design, approach and mission management and battery too, as a subsystem in any of such space-craft, has to cater to exceptional demands. A lunar rover mission for instance, requires the battery to support the peak power load when the power generation through solar panels is in-sufficient. At all such operations during lunar day, the battery pack temperature can be efficiently managed with-in the optimal window, using rover's thermal management elements. The real challenge is to endure passively through the lunar night, at prevailing temperatures as harsh as -180 °C for duration of 336 hours [1], to be able to operate in the subsequent lunar day. From a battery point of view this challenge is only one of its kind, where battery is required to operate (charge or discharge) at ambient temperatures and is required to survive passively (without any load) an exposure to extremely low temperatures, preferably, without any permanent loss or damage. Even though the works cited in literature [2-4] addresses the ways to tackle inferior charge/discharge characteristics of Li-ion batteries by altering electrolyte composition, there is hardly any information about the passive survivability of already existing chemistry of commercialized Li-ion cells, at extreme low temperatures below -150 °C and the present work aims to throw some light at this ambiguity.

Present study describes passive survivability of commercially-off-the-shelf (COTS) 18650 lithium-ion cells tested in an environmental scenario similar to lunar night (cryogenic temperatures at vacuum). Survivability of the cells in particular and battery pack in general is crucial for resumption of function of any lunar exploration rover after hibernation at every lunar night. The test is designed to include a batch of Commercial lithium-ion cells from different manufactures, with different nameplate capacities and different States of Charge. The cell behavior during the test is monitored in-situ using cell terminal voltage measurements. Complementary tests like, visual examination, dimensional measurements, Residual Gas Analysis to detect any leakage, electrical tests to appraise electrical performance and 3 dimensional x-ray computed tomography analysis to view cell internal features, are carried out at ambient conditions, on all cells both prior-to and after soaking at low temperatures, to comprehend the effect of exposure to extreme low temperatures.

Results indicate successful survivability of tested commercial Lithium-ion cells after extreme thermal soak without any significant physical or internal damage or electrical performance degradation. Variation in cell terminal voltage with temperature is a reversible change attributed to the reversible phenomenon of freezing of cell electrolyte, which furthermore is confirmed through ex-situ measurement of freezing point of electrolyte extracted from tested cells.

Digital Formats: The plot below shows the variation of recorded cell terminal voltage with time and temperature for sample COTS Li-ion cells: Cell A, Cell B and Cell C, during thermal soak at -160°C soak for 336 hours inside liquid nitrogen cooled shroud under vacuum.



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