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IMPACT OF SHUTTLE ENVIRONMENT ON PRELAUNCH HANDLING OF NICKEL–HYDROGEN BATTERIES

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Summary

Deployment of the ASC I spacecraft from the Space Shuttle "Discovery" in August 1985 set a new milestone in nickel–hydrogen battery technology This communications satellite, built by RCA Astro-Electronics Division for the American Satellite Company, is equipped with two 35 A h nickel–hydrogen batteries and is the first such satellite launched into orbit via the Space Shuttle. The prelaunch activities, combined with the environmental constraints on-board the Shuttle, led to the development of a new battery handling procedure An outline of the prelaunch activities, with particular attention to battery charging, is presented.

Introduction

On August 27, 1985, at 07.02 hours EDT, the Space Shuttle "Discovery" lifted off from its launch pad at Cape Canaveral, carrying with it the ASC I* communications satellite built by RCA Astro-Electronics Division ASC I is the first satellite launched into orbit via the Shuttle that is equipped with nickel–hydrogen batteries While handling of nickel–hydrogen batteries during prelaunch activities was commonplace on the Ariane** launch vehicle, a more lengthy timeline needed to be evolved for NASA's prelaunch activities.

The satellite

ASC I is a communications satellite capable of transmitting via both C- and Ku-bands Electrical power for satellite operation is normally supplied by solar arrays; however, two $Ni–H_2$ batteries are provided for eclipse

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*ASC I is owned and operated by the American Satellite Company

**Ariane launch vehicle manufactured by Arianespace, launched from CSG, Kourou, French Guiana

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operation and when power requirements exceed the solar array capacity during peak daytime loading. The $Ni-H_2$ batteries, having a 35 A h nameplate capacity, are of similar design to those used on other RCA-built communications satellites [1]

Launch site test sequence

The batteries arrived at the Eastern Test Range already integrated with the satellite and in the electrically discharged condition. During the Spacecraft Electrical Performance and Evaluation Tests (SEPET), the batteries received a conditioning cycle. This included a complete charge, discharge, and electrical letdown, which served as a final conditioning cycle prior to launch and provided spacecraft-level performance data for comparison use during the prelaunch charge sequence.

The next major battery event occurred when the spacecraft was installed in the Shuttle Cargo Bay, and prelaunch charging commenced. Between these two events, the batteries were generally kept in an electrically letdown condition, with the cell-level deep discharge resistors enabled All active periods were kept brief, and all open-circuit stands (time periods) were minimized. This was done to facilitate safe handling of the spacecraft during other prelaunch operations A typical ground operations flow is shown in Fig 1

Prelaunch battery charging

When ASC I was installed in the Shuttle Cargo Bay, the batteries were electrically drained and the deep discharge resistors enabled Battery charging commenced with the closure of the cargo bay doors The Shuttle environment was maintained in the 60 - 65 °F (15 5 - 18.3 °C) range during the first portion of the prelaunch charge to help maintain cooler batteries for a more efficient charge This technique yielded battery temperatures similar to those experienced on Ariane-type launches The maximum battery temperature limit of 30 °C was never reached, and a successful, cool, prelaunch charge was accomplished

The prelaunch handling goal was to maximize the state of charge of the battery prior to launch The general charge sequence is shown in Fig. 2 Each battery was charged at a nominal $C/20$ rate (where C is its nameplate capacity) for a total input of 160% of rated capacity, then placed on $C/60$ (trickle) charge or $C/120$ (low rate trickle) charge until launch. The choice between charging at $C/60$ or $C/120$ depends upon the thermal conditions, the $C/120$ rate was capable of maintaining the battery's state of charge and prevented battery temperatures from rising above 30 °C

Telemetry was used to monitor battery voltage, charge current, temperatures, and sample cell pressures throughout the task Battery tem-

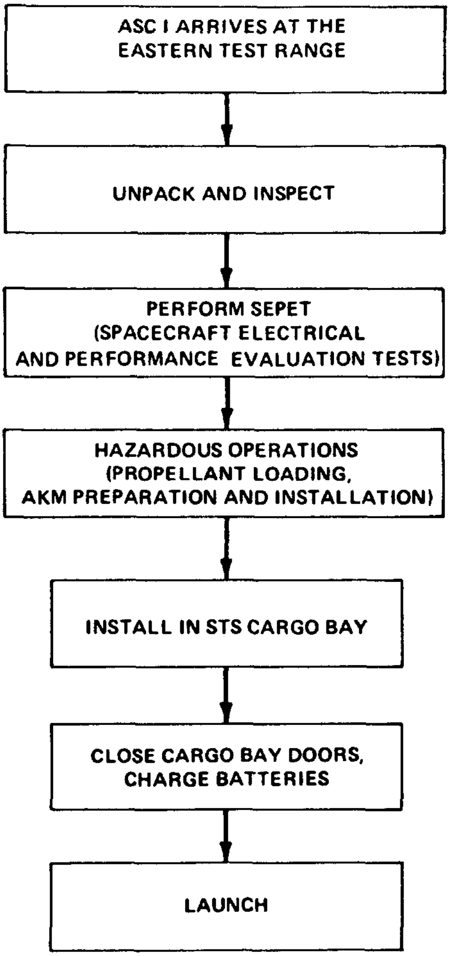

Fig 1 General KSC ground operations flow

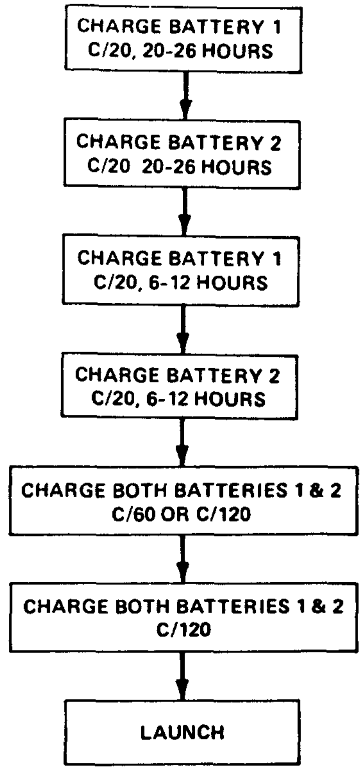

Fig 2 General prelaunch charge sequence

peratures throughout the $C/20$ charge portion were predominantly in the 18 - 22 °C range, with occasional brief excursions to approximately 28 °C

Conclusions

The prelaunch battery charging technique onboard the Shuttle was kept simple A 32h charge portion at the $C/20$ rate in the 18 - 22 °C range (with brief excursions to 28 °C) was successfully used for the initial full charge for each battery A low-rate trickle charge ($C/120$) was used to maintain the batteries in the fully charged condition until spacecraft launch from the Shuttle

Reference

1 S. J Gaston, The GSTAR and Spacenet nickel–hydrogen batteries for geosynchronous orbit applications, *Proc. 19th Intersoc Energy Conv. Eng Conf*, *1984*, pp. 257 - 263