



NOAA Pacific Marine Environmental Laboratory
Ocean Climate Stations Project

TECHNICAL NOTE 4

Capacity Issue with AA Li Batteries in SBE37's

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Introduction

This report is a summary of a capacity issue discovered with the Saft AA Lithium batteries, deployed in Seabird SBE37's in 2010. The problem was limited to pumped versions of the instrument, and not all deployed sensors were affected. PMEL engineers worked directly with Seabird to develop and implement a solution using two ElectroChem D-cell lithium batteries for 2012 deployments.

Background

In May 2011, Dan Dougherty alerted OCS that one of the SBE37IMP TCP's on the KE008 mooring had started to report constant values. Communication with the instruments was known to be good. The Flex system queries the SBE37's with the "SL" command, causing the instrument to return the data from its last sample. The same sample data were just being sent repeatedly, as though instrument had stopped taking new samples.

Jennifer Keene contacted Seabird technical support, and received a reply from Joel Reiter on May 18. It was believed that the problem might be related to low battery voltage. The instrument power is checked internally during the time that the pump is running. If the voltage is reported below a set threshold, no new sample is taken, but the instrument will still send its last sample whenever queried.

Seabird Electronics issued Field Service Bulletin 23 in November 2011. Other users had reported similar problems with batteries failing long before the end of their predicted lifetime. The interim solution was to change the battery life calculation, decreasing expected endurance.

KE008 Instruments

The Flex data acquisition system on the KE008 mooring stopped returning data on September 14, 2011. By the time the mooring was recovered on November 14, 2011, ten of the 13 SBE37's had stopped sampling due to low batteries. All instruments were sent to Seabird for evaluation, but due to a miscommunication, the service department discarded all batteries before J. Reiter could inspect them. Table 1 summarizes the status of the SBE37's recovered.

Instrument	S/N	Status on Recovery (Dep. 9/29/10, Rec. 11/14/11)	V1	V2
SBE37SMP TC	4562	Conductivity readings 0 after 10:00 2/21/11. Still logging.	6.93	3.23
SBE37IMP TC	7793	Still logging.	6.93	3.21
SBE37IMP TCP	7102	Not sampling. Low battery message on recovery.	6.87	3.17
SBE37IMP TCP	7103	Not sampling. Low battery message on recovery.	6.97	3.17
SBE37IMP TCP	7104	Not sampling. Low battery message on recovery.	6.92	3.16
SBE37IMP TCP	7105	Not sampling. Low battery message on recovery.	6.95	3.16
SBE37IMP TCP	7106	Not sampling. Low battery message on recovery.	6.96	3.17
SBE37IMP TCP	7107	Not sampling. Low battery message on recovery.	6.97	3.16
SBE37IMP TCP	7781	Still logging.	6.86	3.19
SBE37IMP TCP	7782	Started reporting constant data after 22:00 4/27/11. Not sampling. Low battery message on recovery.	6.83	3.18
SBE37IMP TCP	7783	Started reporting constant data after 20:00 5/26/11. Not sampling. Low battery message on recovery.	7.01	3.18
SBE37IMP TCP	7784	Started reporting constant data after 12:00 3/13/11. Data output stopped after 13:00 3/29/11. Unable to establish comms on recovery.	-	-
SBE37IMP TCP	7785	Not sampling. Low battery message on recovery.	6.93	3.23

Table 1: Sampling status of SBE37's recovered from OCS mooring KE008.

Testing at Seabird Electronics

Based on customer feedback, Seabird believed that only *pumped* SBE37's using firmware version 3 had battery life problems. These units use 12 AA lithium batteries in parallel. Instruments with older firmware did not have a problem. Newer instruments using version 4 firmware use the same 12 AA batteries, but in series, instead of parallel. No problems have been reported yet for this battery pack.

J. Reiter performed extensive testing of the problem SBE37 v3 battery packs at Seabird. He determined that battery orientation (deployed button up or down) affected the lifespan, due to the chemical makeup of the cells. Testing cells from various manufacturers, and different battery types, Joel found spiral wound and bobbin style cells each performed differently, and preferred orientation varied between manufacturers. Temperature was also found to be a performance factor. Batteries lasted longer in warmer water, and apparently dead packs in cold environments would start working again as soon as the temperature was increased.

The effect of changing sampling rate, and thus the duty cycle on the battery, was also tested. The batteries were found to last through more samples if the time between samples was shortened, performing better under a more constant load. With longer intervals between sampling, it is believed that a passivation layer formed within the lithium cells during the quiescent periods. This chemical layer within the cell made the transfer of electrons more

difficult, shortening battery life. However, increasing the sampling rate to extend the battery life is limited as a solution by memory capacity in the instrument.

Additional testing was done on the instrument firmware. The version 3 software has a built in power level failsafe. This causes the instrument to stop sampling if the battery voltage drops below a set threshold. By varying the time at which the voltage measurement was taken, it was found that the pump caused “pack droop.” The battery pack voltage appeared lower than it actually was, due to the higher current draw during the pump cycle. This effect was causing the power failsafe in the firmware to stop the sampling.

PMEL EDD Involvement

Since many other programs within PMEL use Seabird instruments, Scott Stalin took an interest in the battery life issue, and the EDD group became involved in this investigation. Joel Reiter, Dave Walter, and David Murphy from Seabird came to the NOAA campus for several meetings in March 2012. Discussion of the issues, ongoing testing, and possible solutions, were held with a small group from PMEL.

Initially, Seabird wanted to utilize the existing battery pack for the SBE37's, so several different battery vendors were suggested. At EDD's suggestion, J. Keene purchased batteries from Interstate Batteries and Tadiran for testing. The results of testing these and other batteries at Seabird showed that Electrochem cells performed better and more consistently than the others. However, even at a government-discounted rate of \$28 each, they were prohibitively expensive, with 12 required for each instrument.

Solution

In late March 2012, S. Stalin suggested the use of two D-cell lithium batteries, in place of the 12 AA's. D. Walter at Seabird quickly developed a new battery pack to accommodate this solution. J. Reiter also changed the instrument firmware, so that the power level detection occurred at the end of the pump cycle, hopefully reducing “power fail events.”

After brief testing of a prototype at Seabird, J. Keene ordered 34 Electrochem BCX D-cells (P/N 3B0075, \$70.56/ea). The batteries arrived at PMEL on April 18, 2012. Dirk Tagawa welded tabs on, and D. Walter came to pick them up and take them back to Seabird, where modifications were made to 15 OCS-owned instruments. J. Reiter and D. Walter returned the instruments to PMEL April 20th. J. Keene turned them all on for testing with the KEO Flex system over the weekend, with no apparent issues. Logging was stopped on April 23rd, and they were immediately packed into a container for shipment to Japan.

Even though no instruments on the 2011 Papa mooring had any power issues, it was decided to put the new battery packs in the instruments for the 2012 deployment. An additional 26 D-cells were received from Electrochem on May 7, 2012. D. Walter made the instrument modifications and returned them to PMEL the week prior to the Papa shipment date, May 21, 2012.

Results

In 2012, 28 OCS-owned SBE37's were modified. Of these, 12 were deployed on the Papa mooring on June 2, 2012, and 14 were deployed at KEO on July 4, 2012. The remaining three were returned as unused spares.

Papa	KEO	Spares
7090 (SMP)	3802 (SMP)	4562 (SMP)
6140	7793	7102
6141	7103	7788
6142	7104	
6145	7105	
6146	7106	
7786	7107	
7787	7108	
7789	7780	
7790	7781	
7791	7782	
7792	7783	
	7784	
	7785	

Table 2: OCS-owned SBE37's with modified D-cell battery packs.

The Papa instruments had a communication problem not related to the battery packs, which caused one instrument to stop logging several days before recovery. The KEO instruments were all functioning upon recovery. EDD took possession of three battery packs from the recovered Papa instruments for testing to end of life.

In early 2013, the remaining OCS-owned v3 SBE37's were also sent to Seabird for battery pack modifications, so now all OCS v3 instruments use D-cell battery packs. These included:

SBE37-SMP	SBE37-IMP		
7088	6072	7091	7785
7089	6073	7092	8419
	6074	7093	8420
	6075	7094	8421
	6076	7095	8422
	6077	7096	8423
	6078	7097	8424
	6079	7098	
		7099	
		7100	
		7101	

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