

BATTERY TECHNOLOGY CENTER INC.

June 28, 2003

Mr. John Connell
Crown Battery Co. Inc.
P.O. Box 990
Fremont OH 43420-0990

Dear Mr. Connell:

As you requested, Battery Technology Center Inc. has analyzed off-gassing from two Crown batteries to determine whether they contain carbon monoxide (CO). The two batteries were a group 31, with low Sb-lead positive grids and Ca-lead negative grids, and an Embassy 12CE100 with CaSn-lead positive grids and Ca-lead negative grids. These two batteries are sold by Crown to the Zoeller Co. for use in their Aquanot™ sump pump systems.

- 1) Battery nondestructive examination. The gr. 31 battery had a date code of E3032G3, with open-circuit voltage 12.761, CCA (Midtronics Micro 200 tester) 1145, and impedance (HP 4328A milliohmmeter) of 2.45 milliohms. The other battery (12CE100) had a date code of E3, open-circuit voltage 12.759, CCA 864 and impedance 3.4 milliohms.
- 2) Battery gas generation and collection. We attempted unsuccessfully to enclose a battery in a sealed box (vacuum oven) and collect the gas after it passed through a wet-test meter to measure gas flow. The back pressure to operate this meter was greater than the leak pressure of the oven system, so no gas was collected. Instead, two gang vent caps were modified with plastic pipe nipples for the gr. 31 and each cell of the 12CE100 was drilled and tapped to also accept a pipe nipple. A small vessel with 6 inlet and one outlet pipe nipple was available. Tygon tubing connected each cell vent nipple with one of the vessel input nipples, and another tube connected the vessel outlet to a Kevlar sample collection bag after gassing commenced. For charge, a battery was connected to a small lab power supply which had adjustable output voltage and current. Since gas flow is proportional to current, the voltage was set to maximum, 20 volts, and the current was adjusted to produce gas. At each current setting, it took some time for the voltage to stabilize- a shorter time for each successively higher current. Bag 4061 was collected from the gr. 31 charged at 2.5 amps. Bag 4102 was collected from the 12CE100 at the beginning of charge at 2.5 amps followed by bag 4104 collected later. Bag 4068 was collected from a modified (as described below) gr. 31 battery also charged at 2.5 amps. This battery began to gas at 15.906 volts (i.e. over 2.65 volts per cell). The gr. 31 battery was modified by dumping out most of the electrolyte (256 ml per cell average), then adding 40 ml of strong electrolyte (1.369 sp. Gr.). This simulates a low electrolyte level and high acid gravity that could occur eventually if this battery were not maintained (watered).
- 3) Gas analysis. The battery off-gasses were analyzed by an outside laboratory (Air Quality Services Inc., Brentwood PA) using a SRI model 8610 gas chromatograph. For each bag, one scan was done using a thermal conductivity detector for oxygen, hydrogen, nitrogen and carbon dioxide. Then another scan was done on each bag where the gasses were first passed through a "methanizer" to convert CO to methane, then through another 8610 with a flame ionization detector. This technique is very sensitive and can detect 0.5 parts per million of CO.

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4) Results

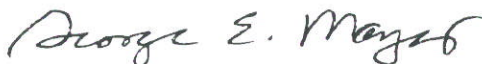
Bag	Battery	Sp.gr.	level	sample	Ppm CO	%O2	%H2	%N2	CO2
4061	gr. 31	normal	normal	normal	none	33.2	64.4	2.4	788ppm
4068	gr. 31	high	low	normal	none	30.8	53.5	15.5	1040ppm
4102	12CE100	normal	normal	early	none	12.4	24.7	55.3	7.7%
4104	12CE100	normal	normal	later	none	26.5	71.8	1.6	1348ppm

The nitrogen and carbon dioxide in each sample shows some air in the gas collection system. The high CO2 and nitrogen in the 12CE100 are from manufacturing of the battery. NO SAMPLE SHOWED ANY DETECTABLE CARBON MONOXIDE

- 5) Conclusions.. We conclude that no CO is produced from the overcharge of the two Crown batteries used by Zoeller. The CO sensors are subject to false positive alarms from any reducing gas, such as hydrogen. The "professional " units used by fire departments, EMS, etc. need to be calibrated frequently, but as far as we know, there is no calibration for interferences such as hydrogen. As you know, all secondary aqueous batteries produce hydrogen and oxygen upon severe overcharge. This is less of a problem with nonantimonial VRLA batteries such as the 12CE100. In such a sealed battery, the evolution of oxygen on the positives depolarizes the negatives, to partially convert these to lead sulfate which in turn minimizes (or precludes) hydrogen generation. Any alternative charger that purports to not produce gassing during charge is, in our opinion, not fully charging the battery, and battery performance will degrade.

Battery Technology Center Inc. is an independent battery testing and research lab located in Pittsburgh PA. Our capabilities are described on our website www.batterytechknowledge.com. We have done battery research and testing for various Federal agencies (DOD: Navy, Army; DOE; NASA; DOJ) and many battery manufacturers and users worldwide. If you or your colleagues have any questions or comments, please call me at 412-826-3495.

Very truly yours,



George E. Mayer, Ph.D.

President and Principal Scientist, BTC Inc.

BATTERY TECHNOLOGY CENTER INC. 865 William Pitt Way. Pittsburgh PA 15238