VRLA BOOSTED BATTERIES – 10 YEARS LATER: AN MTS ALLSTREAM SUCCESS STORY

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ABSTRACT

This paper will provide ten years of in-service field data results of 40 strings of VRLA boosted batteries installed in the MTS Allstream Network in 2001. During a company merger 11 years ago, the above noted stock of battery strings was acquired by MTS Allstream. These batteries were purchased by the company from two different VRLA vendors. The batteries were discovered during the warehouse clean-up after four years of shelf life. Allstream Engineering worked with the two battery suppliers to boost the batteries and bring them back to life for re-use. The methods used by the two vendors to recover the batteries, the Allstream Engineering design considerations, and the financial savings have been discussed in the IEEE paper *Bringing Back to Life an AT&T Canada Venture*[1] presented and published by Robert Szasz, P.Eng. at INTELEC, October 2002, Montreal, Canada ©2002 IEEE. These batteries were installed at 20 Allstream Network sites and have served very well since installation in 2001. Field data results and reliability of these battery strings will be reviewed. Battery backup during the August 2003 hydro blackout will be discussed, and battery string status after ten years in service (14 years after manufacture date) will be reported. These batteries will be compared with field test data of similar, non-boosted batteries.

MANUFACTURER'S COMMENTS

Allstream Engineering approached the two VRLA vendors to inspect the batteries in the warehouse and provide their recommendation for an Allstream decision to either scrap or re-use the batteries. C&D stated that no data exists as to the impact on performance life when manufacturer storage recommendations have not been followed. GNB stated that their batteries could recover reasonably well after two years of storage, but no data was available for batteries stored three to four years. Hence, both manufacturers would not provide any warranty. The following are the details of the manufacturers' comments:

C&D[3]

- The operation of each battery (or, rather, the lack of operation) has been outside of C&D parameters, which specify that the cells must be on charge at the recommended voltage by the date shown on the packing (within six months from shipment).
- No data exists as to the impact on performance or life when C&D recommendations have not been followed.
- Hence, any success in recovering capacity should be considered as something of a bonus.
- There is no way that, in a similar situation, flooded lead-acid batteries could have been recovered.
- C&D cannot provide warranty for such batteries but was willing to assist in testing and boosting.

GNB[4]

- We have seen these batteries recover reasonably well after two years of storage. "Reasonably well" means the battery achieved 90% or better of spec rating after one or two cycles.
- You may well find excellent capacity in your battery. It will likely provide years of quality service. Since the delicate chemistry has been compromised, your battery will not perform to optimum levels, although it may seem to.
- It may perform like an older battery, with reduced life expectations.
- Proper routine maintenance monitoring will help you identify when these batteries are reaching end of life.
- If you achieve 90% or better of spec performance after one or two cycles, you should deploy them with reduced expectations.
- GNB cannot extend its normal warranty to these batteries. The chemistry changes affect long-term life in very complex ways that cannot be defined by simple math.

Following the manufacturers' comments above, it was agreed by Allstream and each vendor to boost one string of each battery and provide test results for Allstream approval. Each of the pilot boosted batteries passed the discharge tests and, as a result, approval was given to both vendors to proceed with boosting of the balance of battery strings. Each battery string had been discharge tested and all passed the tests. Each of the two suppliers developed their own boosting program. The C&D battery boosting program was a combination of constant voltage and constant current. The GNB battery boosting program was a combination of constant voltage charges and discharges only. Both methodologies were reviewed by the author in detail in the IEEE paper[1]. Batteries then were shipped and installed at 20 Allstream Network sites in 2001. Allstream saved a significant amount of capital, approximately $300,000, for the 2001 budget by avoiding the purchase of new battery strings for these 20 network sites. The saved capital funds were made available to fund power upgrades at a number of additional sites.

FIELD DATA SERVICE RESULTS

Ten years of field data service results reported in this paper are compared to first year results previously reported in the IEEE paper[1]. The first battery strings were installed in April 2001, with the last ones in September - October 2001. The boosted batteries were in service for five years at all 20 sites, for eight years at 13 sites, and for ten years at 11 sites. (Seven sites closed and the batteries were decommissioned and disposed of after six years in service).

Allstream criteria for evaluation of the state of health of the batteries was the conductance measurements using Midtronics Celltron meters. Conductance readings were compared initially with the Midtronics conductance (Mho) reference and factory test figures. All subsequent readings were referenced to base line readings after the battery installation. There were no discharge tests performed during the ten years in service of these batteries. The first readings, taken in April 2002 at five sites for HD-300 strings in service either for six or nine months, indicated a low conductance average in the range of 72% to 81% (see Table 1A)[1]. In consultation with C&D and under their guidance, distilled water of 3 oz/cell was added to all cells. The conductance readings taken shortly after water was added improved significantly to an average of 92% to 95% (see Table 1B)[1]. The strings were charged on equalize for 48 hours. Readings taken again one week later showed further conductance improvements, to an average of 102%. In addition to adding distilled water, C&D retrofitted all the cells with their MAXIMIZER™ cap system (an internal catalyst technology) with the purpose of reducing corrosion of the positive grids and eliminating the dry-out. The catalyst recombines the hydrogen and some of the oxygen given off at the plates, thereby greatly reducing the water loss from VRLA cells[2].

The next set of conductance readings at the same sites were taken six months later. Conductance readings and corrective measures at the balance of the sites were completed by June 2002. The batteries were monitored by taking the quarterly conductance and voltage readings and recording the data in the company database. Additional water was added when conductance readings dropped below the reference base line in 2003, 2005, 2008 and 2009. Conductance readings after nine years, shown in Table 1C, are all over 100% (except one cell 99%) with an average 105% of reference.

Table 1A. C&D, HD-300, Allstream Field Test Data 2002 - Welland T/C BEFORE Topping up Cells with H_2O
Ref Value Entered: 1800 Siemens (Mhos), Ref Temp: 20°C, String Average: 1271 S, String % of Ref: 72%

Cell #	Volts	Conductance Siemens (Mhos)	% Ref		Cell #	Volts	Conductance Siemens(Mhos)	% Ref
01	2.25	0971	54		**13**	2.26	1272	72
02	2.25	1058	60		**14**	2.25	1406	80
03	2.25	1137	65		**15**	2.25	1093	62
04	2.26	1100	63		**16**	2.23	1463	83
05	2.26	1367	77		**17**	2.21	1868	106
06	2.25	1134	65		**18**	2.23	2027	115
07	2.25	1086	62		**19**	2.25	1152	66
08	2.25	1086	62		**20**	2.26	1201	68
09	2.25	0988	55		**21**	2.26	1195	68
10	2.26	1159	66		**22**	2.25	1233	70
11	2.26	1123	69		**23**	2.23	1775	101
12	2.26	1310	74		**24**	2.25	1209	69

Table 1B. C&D, HD-300, Allstream Field Test Data 2002 - Welland T/C AFTER Topping up Cells with H_2O Ref Value Entered: 1800 Siemens (Mhos), Ref Temp: 20°C, String Average: 1610 S, String % of Ref: 92%								
Cell #	**Volts**	**Conductance Siemens (Mhos)**	**% Ref**		**Cell #**	**Volts**	**Conductance Siemens (Mhos)**	**% Ref**
01	2.25	1382	78		**13**	2.26	1621	93
02	2.25	1414	80		**14**	2.25	1687	96
03	2.25	1448	82		**15**	2.25	1559	89
04	2.23	1509	85		**16**	2.21	1812	103
05	2.25	1660	95		**17**	2.21	1970	112
06	2.25	1591	91		**18**	2.23	1884	107
07	2.25	1491	84		**19**	2.25	1576	90
08	2.25	1516	86		**20**	2.26	1521	86
09	2.25	1418	80		**21**	2.26	1638	94
10	2.25	1528	86		**22**	2.25	1647	94
11	2.25	1564	89		**23**	2.21	1963	112
12	2.25	1604	92		**24**	2.25	1643	94

Table 1C. C&D, HD-300, Allstream Field Test Data 2010 - Welland T/C AFTER Nine Years in Service Entered: 1800 Siemens (Mhos), Ref Temp: 20°C, String Average: 1898, String % of Ref: 105								
Cell #	**Volts**	**Conductance Siemens (Mhos)**	**% Ref**		**Cell #**	**Volts**	**Conductance Siemens (Mhos)**	**% Ref**
01	2.270	1860	103		**13**	2.270	1964	109
02	2.276	1871	104		**14**	2.265	1784	99
03	2.289	1919	107		**15**	2.266	1867	104
04	2.276	1964	109		**16**	2.276	2031	113
05	2.271	1968	109		**17**	2.293	1860	103
06	2.270	1844	102		**18**	2.287	1976	110
07	2.265	1953	108		**19**	2.270	1860	103
08	2.265	1825	101		**20**	2.281	1866	103
09	2.276	1871	104		**21**	2.276	1952	108
10	2.279	1842	102		**22**	2.266	1847	103
11	2.270	1854	103		**23**	2.265	2011	111
12	2.282	1890	105		**24**	2.270	1891	105

Voltage and conductance readings of the HD-1100 string, manufactured in 1998 and in service for one year, are shown in Table 1D[1] below. These batteries were performing very well, with the string % Reference of 105% without the need to add any water. However, after eight years in service, this battery string was failing testing with low conductance readings (less than 60%) . As a result, it was replaced in September 2009.

Table 1D. C&D, HD-1100, Allstream Field Test Data 2002 - Guelph T/C Ref Value Entered: 4600 Siemens (Mhos), Liberty 2000, Type HD-1100, C&D Order No. 0312401-01 Ref Temp: 21°C, String Average: 4767 S, String % of Ref: 105%										
JAR	**R- Volts**	**Jar-G Siemens**	**% Ref**	**Initial Cond**		**JAR**	**R- Volts**	**Jar-G Siemens**	**% Ref**	**Initial Cond**
01	2.25	5156s	115	5111		**12**	2.25	5200	116	5227
02	2.28	5031s	112	4979		**13**	2.25	4796	106	5157
03	2.25	4833s	107	4937		**14**	2.26	5011	111	5045
04	2.25	4466	99	4640		**15**	2.25	4833	107	4958
05	2.25	4669	103	4753		**16**	2.25	4892	108	4995
06	2.25	4971	111	4793		**17**	2.26	4669	103	4895
07	2.25	4705	104	4874		**18**	2.25	4971	111	4814
08	2.25	5135	114	4714		**19**	2.25	4833	107	4793
09	2.26	4871	111	5111		**20**	2.26	4971	111	5066
10	2.25	5178	115	5275		**21**	2.25	5290	118	5204
11	2.28	4990	111	5111		**22**	2.25	5290	118	5111
12	2.25	5200	116	5227		**23**	2.25	5267	117	5134
13	2.25	4796	106	5157		**24**	2.25	4872	107	4814

Cell voltages and conductance readings of GNB batteries installed at Glencoe in July 2001 were taken in March 2002 after eight months in service. The batteries were performing well, with conductance readings with a string % Reference of 97% (Table 2A)[1]. Batteries continue to perform very well after nine years, with similar conductance readings of 98% of the reference (Table 2B).

Table 2A. GNB Allstream Field Test Data 2002 – Glencoe T/C (GNB 90 A-07) Conductance Reference 1300 S, String Average: 1263 S, String % of Ref: 97%								
Cell #	**Voltage**	**Conductance (Mhos)**	**% Ref**		**Cell #**	**Voltage**	**Conductance (Mhos)**	**% Ref**
01	2.250	1249	96		**13**	2.250	1266	97
02	2.250	1268	98		**14**	2.250	1268	97
03	2.250	1243	96		**15**	2.260	1282	99
04	2.250	1299	100		**16**	2.250	1291	99
05	2.260	1338	103		**17**	2.260	1217	94
06	2.230	1299	100		**18**	2.250	1228	94
07	2.250	1274	98		**19**	2.250	1217	94
08	2.250	1299	100		**20**	2.270	1332	102
09	2.250	1279	98		**21**	2.250	1183	91
10	2.260	1263	97		**22**	2.230	1094	84
11	2.250	1254	96		**23**	2.250	1241	95
12	2.230	1326	102		**24**	2.260	1309	100

Table 2B. GNB Allstream Field Test Data 2010– Glencoe T/C (GNB 90 A-07) AFTER Nine Years in Service Conductance Reference 1300, String Average: 1272S, String % of Ref: 98 %								
Cell #	**Voltage**	**Conductance (Mhos)**	**% Ref**		**Cell #**	**Voltage**	**Conductance (Mhos)**	**% Ref**
01	2.240	1280	98		**13**	2.230	1306	100
02	2.270	1280	98		**14**	2.240	1293	99
03	2.210	1223	94		**15**	2.230	1259	97
04	2.260	1323	102		**16**	2.230	1223	94
05	2.240	1249	96		**17**	2.240	1203	93
06	2.230	1307	101		**18**	2.230	1241	95
07	2.260	1284	99		**19**	2.240	1316	101
08	2.240	1303	100		**20**	2.260	1252	96
09	2.230	1271	98		**21**	2.240	1280	98
10	2.240	1303	100		**22**	2.230	1237	95
11	2.240	1319	101		**23**	2.240	1168	90
12	2.240	1379	106		**24**	2.290	1223	94

AUGUST 2003: MAJOR HYDRO OUTAGE IN SOUTHWESTERN ONTARIO / NORTHEASTERN US

The boosted batteries were subjected to a real major outage event two years after their deployment in the field. On August 14, 2003 at approximately 16:13 EST, a catastrophic power failure impacted most of Ontario as well as the northeastern United States. The impact affected businesses as well as residences, with blackouts ranging from 2 to 30+ hours. The batteries performed extremely well to their rating and even better with sites running on these boosted batteries from 10 to 26 hours. Had Allstream not deployed two strings of batteries per site, some sites would have failed before hydroelectric power was restored. The hydro outage in some areas was up to 72 hours. Cell voltages and conductance readings of C&D batteries installed at Welland were taken 12 days after the outage on August 26, 2003. Conductance readings were within a string average of 104 % of the reference (Table 3).

Table 3. C&D, HD-300, Allstream Field Test Data 2003 - Welland T/C AFTER 2003 Hydro Outage Entered: 1800 Siemens (Mhos), Ref Temp: 20°C, String Average: 1870, String % of Ref: 104								
Cell #	**Voltage**	**Conductance (Mhos)**	**% Ref**		**Cell #**	**Voltage**	**Conductance (Mhos)**	**% Ref**
01	2.230	1812	101		**13**	2.250	1875	104
02	2.250	1831	102		**14**	2.250	1853	103
03	2.250	1902	106		**15**	2.250	1868	104
04	2.250	1852	103		**16**	2.230	1762	98
05	2.230	2038	113		**17**	2.210	1964	109
06	2.230	1795	100		**18**	2.230	1866	104
07	2.230	1849	103		**19**	2.250	1837	102
08	2.230	1843	102		**20**	2.250	1869	104
09	2.230	1819	101		**21**	2.250	1915	106
10	2.250	1853	103		**22**	2.250	1930	107
11	2.250	1843	102		**23**	2.230	1972	110
12	2.250	1912	106		**24**	2.250	1831	102

NON-BOOSTED BATTERIES SERVICE DATA

The following Tables 4A and 4B provide field test data of similar type and vintage of GNB batteries that were installed less than six months after manufacturing date. The batteries were installed in 1999 and were rehydrated in 2009. Table 4A readings were taken in September 2009, and Table 4B readings were taken after rehydration in December 2009. Battery conductance average in 2009, ten years after the manufacturing date, was in the 60% range, similar to some of the boosted batteries. The battery conductance continued to deteriorate to less than 50% to 60% in 2010 and batteries were replaced October 2010 after 11 years in service.

Table 4A. GNB 90A-13, Allstream Field Test Data – Woodward FOTS Readings taken September 2009
Entered: 2500 Siemens (Mhos), Ref Temp: 27°C, String Average:1590, String % of Ref: 63

Cell #	Voltage	Conductance (Mhos)	% Ref		Cell #	Voltage	Conductance (Mhos)	% Ref
01	2.259	1798	72		**13**	2.251	1574	63
02	2.254	1294	52		**14**	2.248	1792	72
03	2.248	1747	70		**15**	2.242	1676	67
04	2.248	1242	50		**16**	2.248	1258	50
05	2.248	1450	58		**17**	2.248	1792	72
06	2.259	1739	70		**18**	2.248	1711	68
07	2.254	1581	63		**19**	2.248	1141	45
08	2.254	1944	78		**20**	2.242	1642	65
09	2.254	1707	68		**21**	2.237	1489	59
10	2.248	1626	65		**22**	2.248	1343	54
11	2.248	1631	65		**23**	2.248	1765	70
12	2.247	1483	59		**24**	2.259	1754	70

Table 4B. GNB 90A-13, Allstream Field Test Data – Woodward FOTS Readings taken 11/12/2009
Entered: 2500 Siemens (Mhos), Ref Temp: 24°C, String Average:1750, String % of Ref: 70

Cell #	Voltage	Conductance (Mhos)	% Ref		Cell #	Voltage	Conductance (Mhos)	% Ref
01	2.250	1950	78		**13**	2.250	1808	72
02	2.240	1471	59		**14**	2.240	1898	76
03	2.240	1898	76		**15**	2.240	1814	72
04	2.250	1380	55		**16**	2.240	1443	58
05	2.240	1709	68		**17**	2.240	2047	82
06	2.250	1873	75		**18**	2.240	1784	71
07	2.250	1735	70		**19**	2.240	1350	54
08	2.250	1975	79		**20**	2.240	1895	76
09	2.250	1861	74		**21**	2.240	1808	72
10	2.250	1843	74		**22**	2.250	1487	59
11	2.240	1837	73		**23**	2.250	1937	77
12	2.240	1598	64		**24**	2.250	1908	76

CONCLUSIONS

This paper has described the Allstream success story of 40 strings of VRLA boosted batteries that, in spite of being left without refreshing charges for extended periods of time, once boosted in 2001, have served well in the field for five to ten years of reliable service. Allstream Engineering was able to work with the two suppliers to condition batteries for deployment into service. Allstream Engineering design concepts to deploy two strings of batteries per site served well during various outages and proved well during a major hydro outage in the summer of 2003, when all boosted batteries performed at their specification rating.

At the time of this writing, the boosted batteries have been in service for at least five years at all 20 sites, and 11 sites are still in service after ten years. The batteries were regularly monitored to ensure that they were serving sufficiently. In addition to that, “bringing back to life” 40 strings of VRLA batteries, deploying them in the Allstream Network, and monitoring them for ten years has allowed further research into VRLA technology. The present findings should be a valuable contribution to data gathering for the industry and valuable data for the two manufacturers.

The ten year results of deploying these batteries into the Allstream Network have indicated that these batteries have performed as well as or even better when compared with similar batteries in the Allstream Network that have been installed and charged within the recommended six months period from date of manufacture.

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