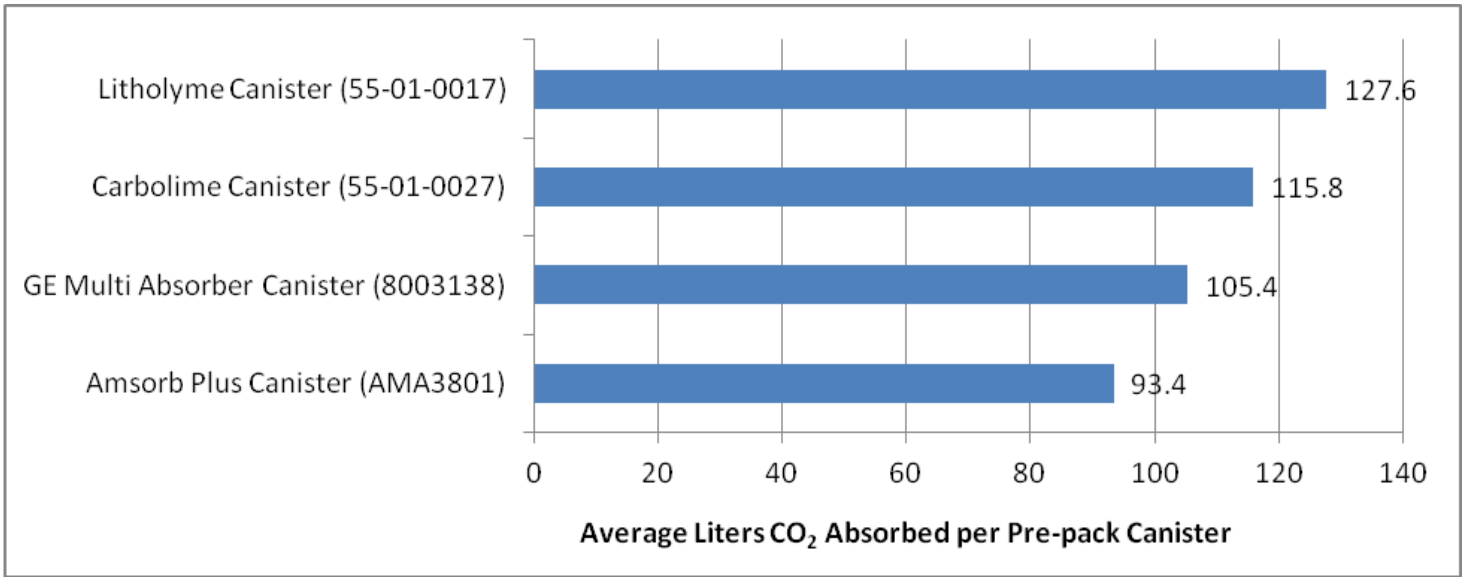
Comparative CO_2 Absorbent Capacity Analysis: GE Multi Style Pre-pack Canisters

Litholyme®, GE Medisorb®, Carbolime®, and Amsorb Plus®

Test Summary

The following study by engineers at Allied Healthcare Products, Inc. compares competitive pre-pack cartridges designed to fit GE® Avance®, Aespire®, and Aisys® anesthesia workstations. This comparative study was performed on a GE Avance workstation in a controlled environment under accelerated conditions. The table below is a summary of the results in liters of CO_2 absorbed per canister. The following pages provide detailed supporting information on experimental setup, test parameters, and test data.

Brand of GE Multi absorber Style Pre-Pack Cartridge	**Liters of CO_2 Absorbed per canister**
Amsorb Plus Canister (AMA3801)	**93.4**
GE Multi Absorber Canister (8003138)	**105.4**
Carbolime Canister (55-01-0027)	**115.8**
Litholyme Canister (55-01-0017)	**127.6**



Test Report

Date: 10June2013

Test Report: **GE Multi Absorber Style Cartridge Absorbency Test**

Author: WJ Kullmann

Test Conducted by: WJ Kullmann

Test Equipment:

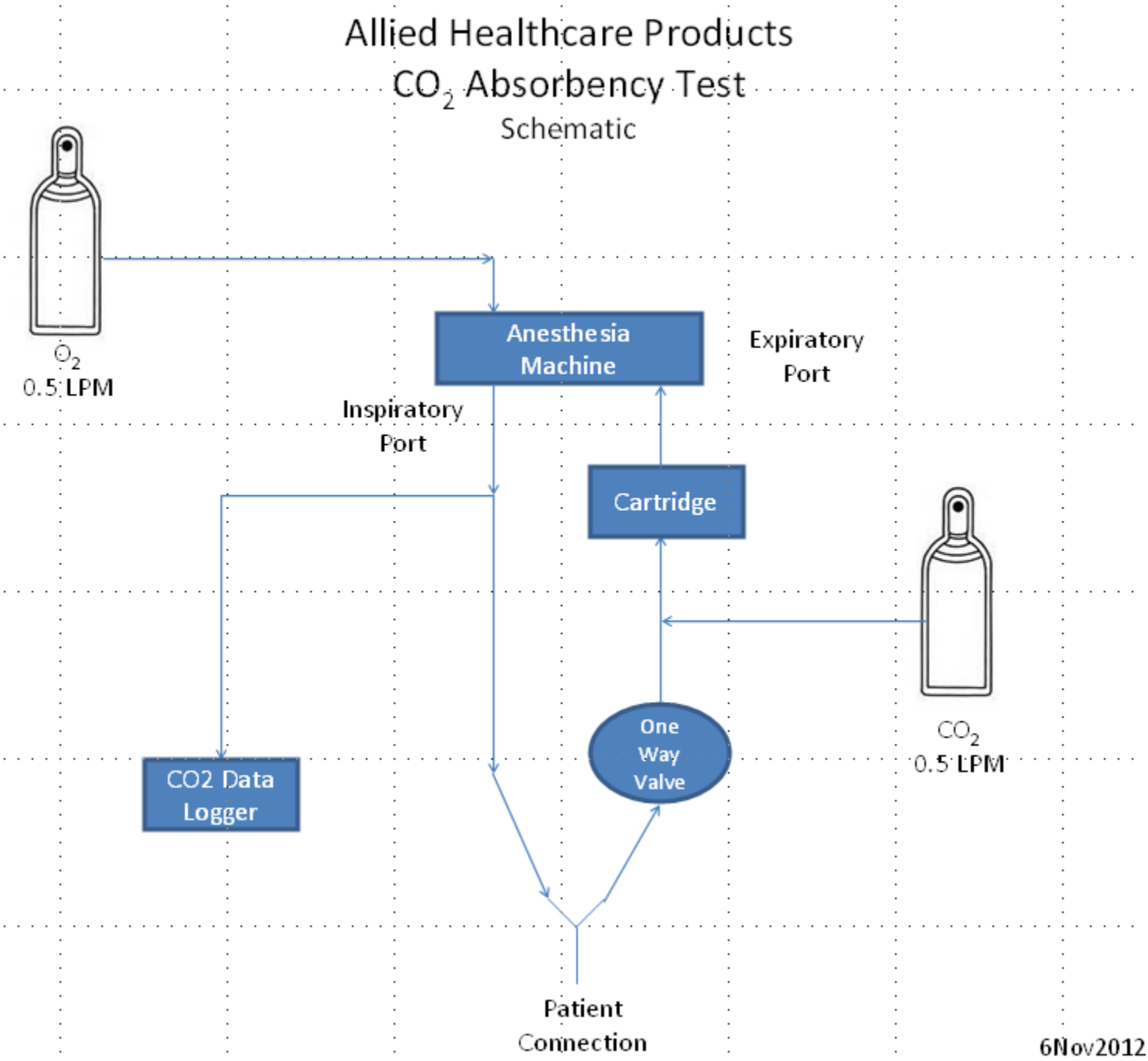
- Anesthesia Machine: GE Avance
  - Serial Number: ANBQ01561
- Flow Analyzer: RT-200 # R05G
  - Calibration Date: 11/12 Calibration Due Date:5/13
- Flow Analyzer: RT-200 # Q04WS
  - Calibration Date: 9/12 Calibration Due Date:3/13
- Scale:
  - Calibration Date: 8/12 Calibration Due Date: 8/13
- CO_2 Sampling Data Logger: Tool # 4297
  - Calibration Date: 4/12 Calibration Due Date:4/13
  - Calibration Date: 4/13 Calibration Due Date:4/14
- Thermometer Tool# 4388
  - Calibration Date: 8/12 Calibration Due Date:8/14
- Timer Tool# 4387
  - Calibration Date: 8/12 Calibration Due Date:8/14

Test Purpose:

This test will measure the absorption capability of various CO_2 absorbent disposal cartridges in an accelerated usage test.

Test Report

Test Configuration / Schematic:



Test Report

Accelerated Test Description:

The capacity of a carbon dioxide absorbent may be tested by performing an absorption (utilization) experiment under conditions that simulate clinical use. This test will use an accelerated test method for comparison purposes. A fully functional anesthesia machine will be used to simulate clinical use. The accelerated method will consist of continually introducing test gas CO_2 into the patient return (expiratory) limb of the breathing circuit to simulate the exhaled breath of a patient. The simulated method will allow the test to be run continuously and will provide consistency throughout the test period. Gas concentrations are monitored at the inspiratory limb of the patient breathing circuit and is downstream of the absorbent cartridge. The test gas CO_2 is introduced into the expiratory limb of the patient circuit at a rate of 0.50 lpm. A one way check valve is installed between the patient connection and the anesthesia machine to ensure proper flow direction of the test gas. Fresh gas to the anesthesia machine will be supplied at a flow of 0.50 LPM of oxygen and will be metered within the anesthesia machine. Scavenging will be provided at approximately 25 cmH_2O.

The test is concluded when the CO_2 concentration in the inspiratory limb reaches a "breakthrough" concentration of 0.5 % CO_2. The capacity of the absorbent is determined by:

1. The amount of time to reach "breakthrough" (0.5% CO_2).
2. The volume amount of CO_2 delivered to the patient circuit.

The deliverables of this test will be expressed as:

1. Time to "breakthrough" (hours and minutes).
2. Volume CO_2 / kg absorbent. (L/kg).

Test Operating Conditions:

The test breath parameters will be as follows:

- 12 breaths per minute
- I:E Ratio of 1:2
- 500 ml Tidal Volume

Room temperature will be maintained at a temperature between 65 and 73° F.

Test Report

Test Procedure:

1. Measure / record the test cartridge weight.
2. Label the test cartridge as the test date.
3. Record the cartridge ID, Lot / Control # and Expiration date.
4. Record ambient room temperature.
5. Attach the absorbent cartridge to the anesthesia machine.
6. Turn on the anesthesia machine and set the following gas parameters:
    a. Set the anesthesia machine scavenging to 25 cmH20.
    b. Set the fresh gas flow to 0.50 lpm Oxygen.
7. Perform a machine full self test.
8. Set the CO_2 flow to 0.50 lpm. Measure the CO_2 flow on the Flow Analyzer and attach to the expiratory side of the patient circuit.
9. Set the cycle counter to zero.
10. Set the timer to zero.
11. Set the breath parameters on the anesthesia machine to the following:
    a. Vt = 500 ml
    b. BPM = 12
    c. I/E = 1:2
    d. O_2 flow to .5 lpm
12. Record the start time.
13. Record data throughout the test on the data sheet.
14. The test is completed at a CO_2 percent of 0.50.

Video:

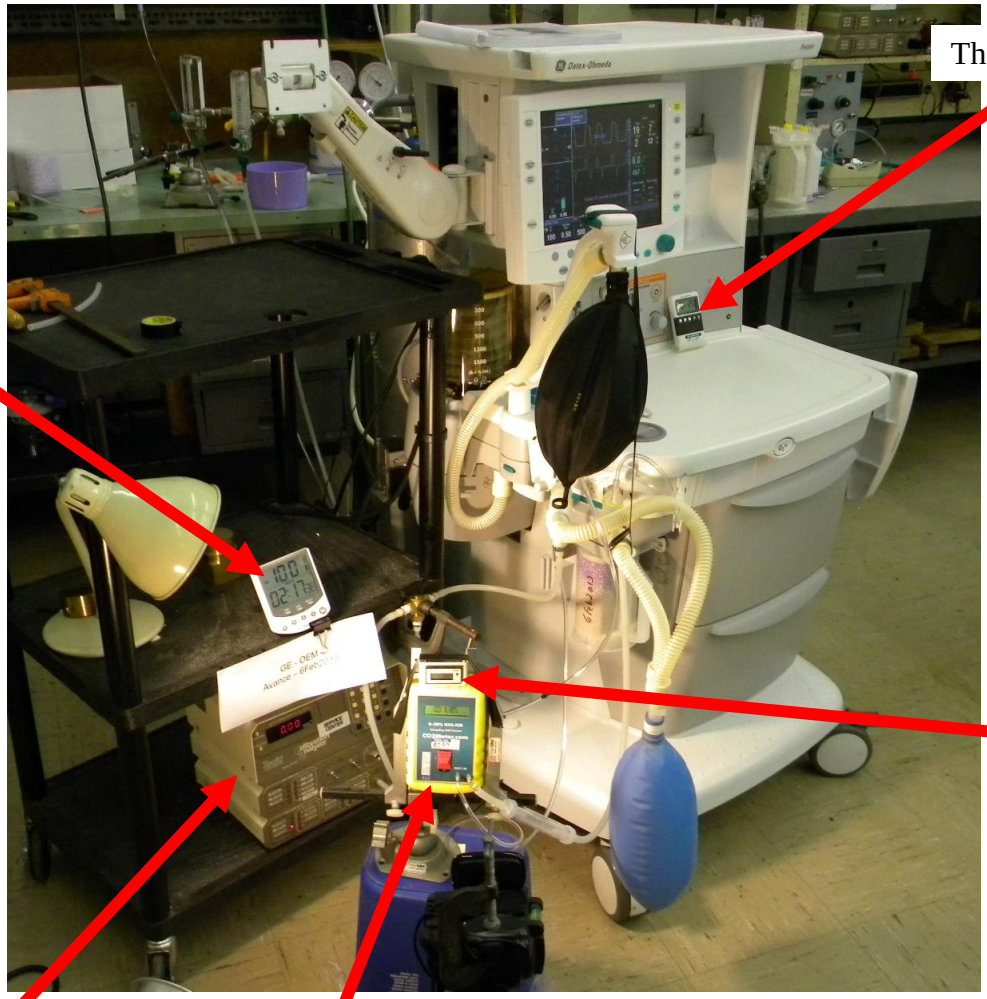
The test was video taped.

The file path for the video is:

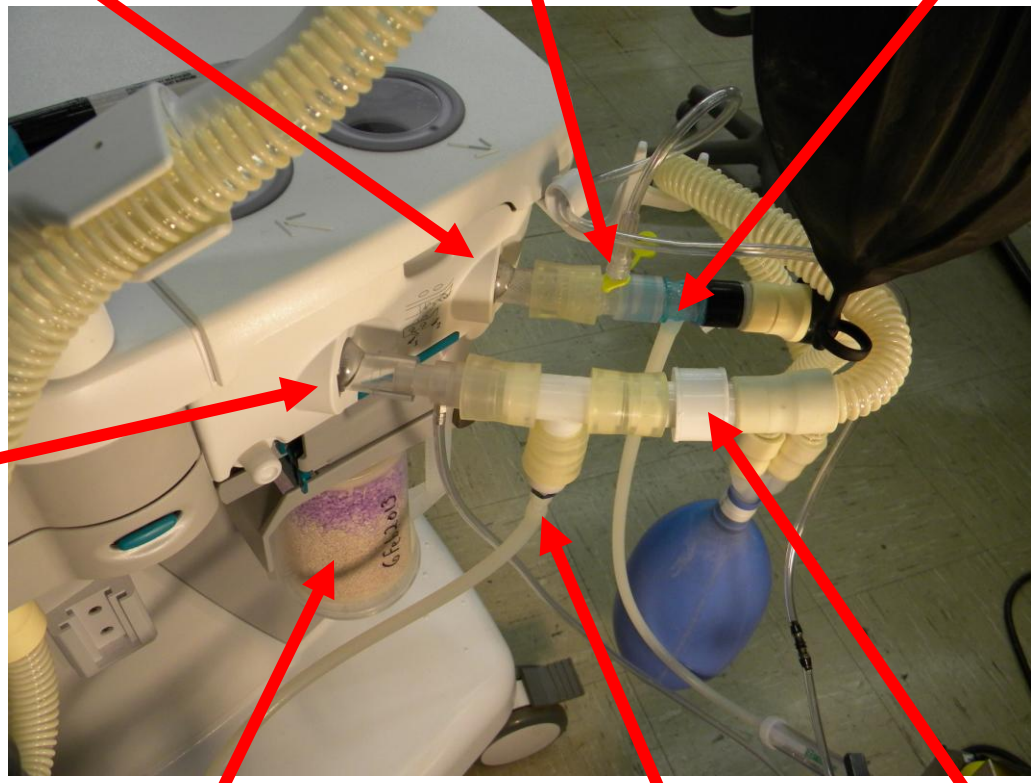
P:/Engineering/RandD Engineering/ Absorbency Testing/ GE Multi Absorber Style

Test Report

- **Test Set-Up Photos: GE Avance**



Test Report


To Patient Port
Cycle Counter Pick up
CO_2 Meter Pick up
From Patient Port
Test Cartridge
CO_2 Test Gas Source
One Way Valve

Test Report

Results:

Under identical test conditions, the following averages were measured:

	Liters of CO_2 Absorbed per Cartridge	CO_2/Kg	Canister Life * (Minutes)
• **GE Multi Absorber (OEM) canister :**	**105.4**	127.1	211
• **Litholyme :**	**127.6**	128.6	255
• **Amsorb Plus:**	**93.4**	112.4	187
• **Carbolime :**	**115.8**	113.6	232

*** Accelerated Testing Results, see page 3 for test description.**

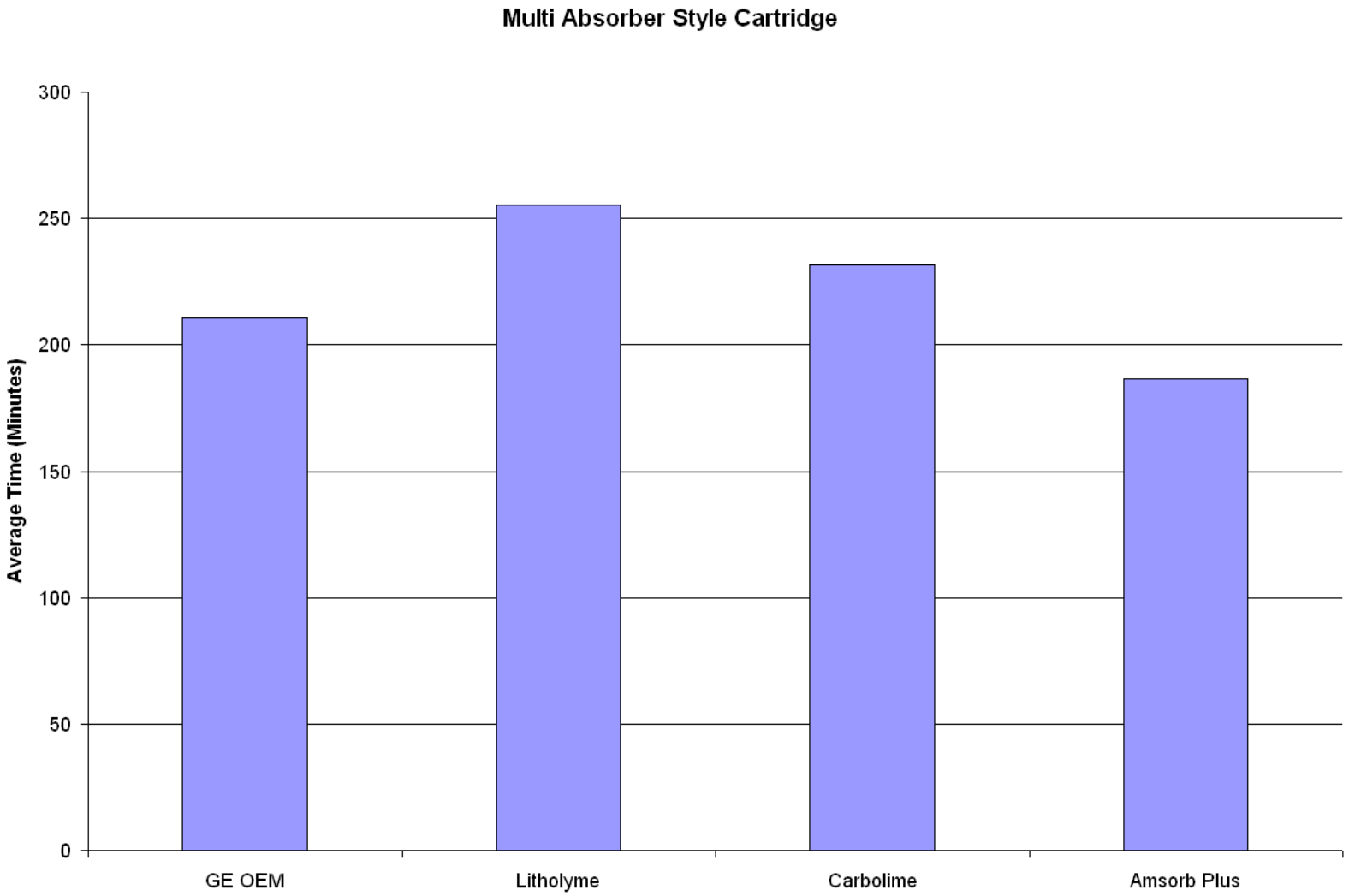
Test Report

Absorbency Test Results Summary - GE Multi Absorber Style Canister

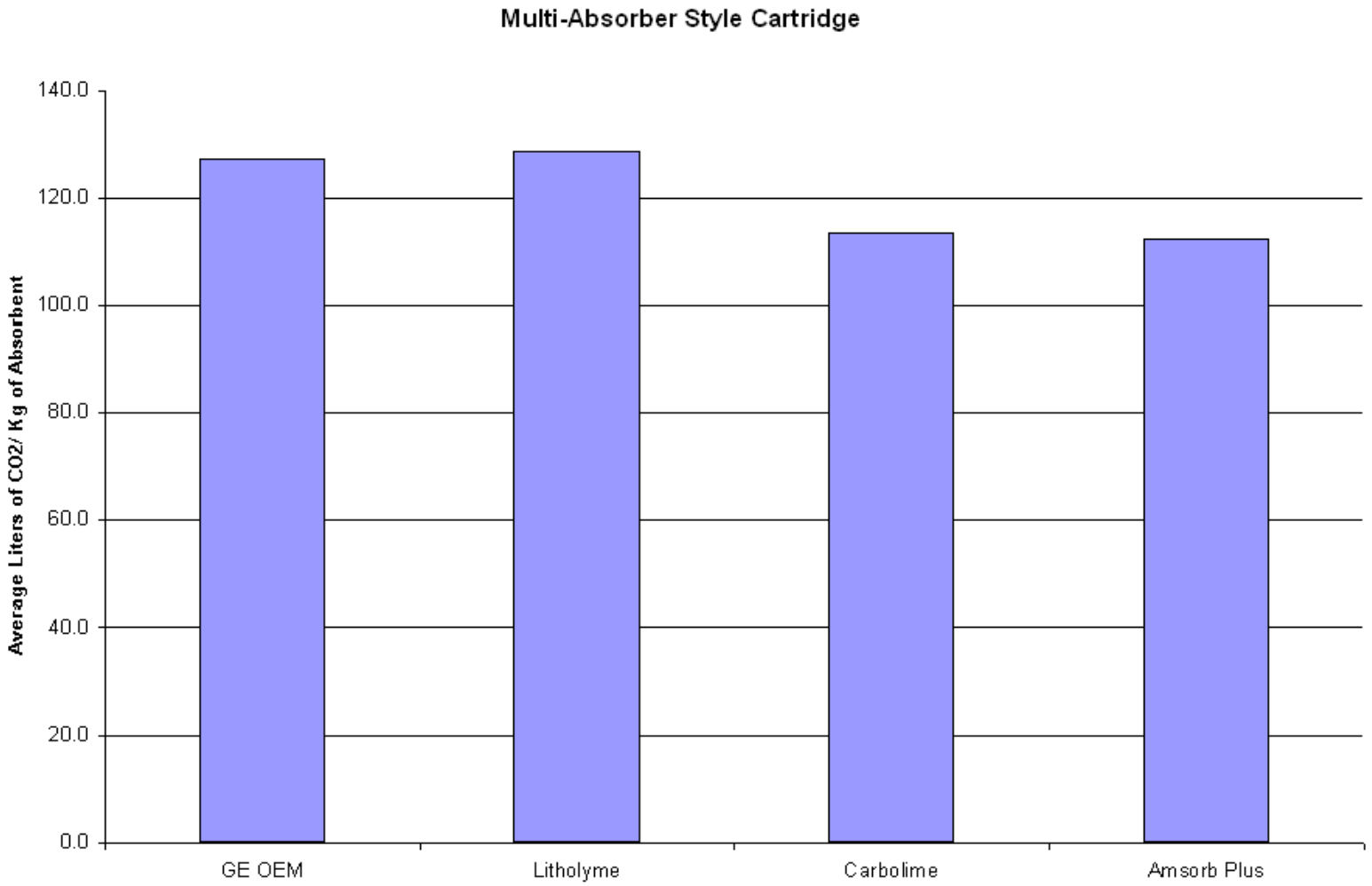
Constants		
g per lb	Vt	CO_2
453.6	(L)	Flow (lpm)
	0.5	0.5

Container	Gross Weight (grams)	Empty Container Weight (grams)	Net Absorbent Weight (grams)	Net Absorbent Weight (Kg)	Net Absorbent Weight (lb)	Time (hr:Min)	Time Minutes	CO2 Used (Liters)	Liters of CO_2 per Kg (Calculated)	Liters of CO_2 per lb (Calculated)
GE OEM Multi Absorber #1	996.4	162.0	834.4	0.8344	1.840	4:08	248	124.00	**148.6**	**67.4**
GE OEM Multi Absorber #2	995.8	162.0	833.8	0.8338	1.838	3:31	211	105.50	**126.5**	**57.4**
GE OEM Multi Absorber #3	974.8	162.0	812.8	0.8128	1.792	2:54	174	87.00	**107.0**	**48.6**
GE OEM Multi Absorber #4	993.0	162.0	831.0	0.8310	1.832	3:30	210	105.00	**126.4**	**57.3**
Averages				**0.828**	**1.825**		211	**105.4**	**127.1**	
Litholyme #1	1253.3	223.2	1030.1	1.0301	2.271	3:57	237	118.50	**115.0**	**52.2**
Litholyme #2	1207.3	223.2	984.1	0.9841	2.170	4:03	243	121.50	**123.5**	**56.0**
Litholyme #3	1217.0	223.2	993.8	0.9938	2.191	4:34	274	137.00	**137.9**	**62.5**
Litholyme #4	1189.5	223.2	966.3	0.9663	2.130	4:27	267	133.50	**138.2**	**62.7**
Averages				**0.994**	**2.190**		255	**127.6**	**128.6**	
Amsorb Plus #1	1076.6	250.0	826.6	0.8266	1.822	3:10	190	95.00	**114.9**	**52.1**
Amsorb Plus #2	1077.9	250.0	827.9	0.8279	1.825	3:02	182	91.00	**109.9**	**49.9**
Amsorb Plus #3	1083.5	250.0	833.5	0.8335	1.838	3:19	199	99.50	**119.4**	**54.1**
Amsorb Plus #4	1084.3	250.0	834.3	0.8343	1.839	2:56	176	88.00	**105.5**	**47.8**
Averages				**0.831**	**1.831**		187	**93.4**	**112.4**	
Carbolime #1	1236.0	223.2	1012.8	1.0128	2.233	3:44	224	112.00	**110.6**	**50.2**
Carbolime #2	1239.3	223.2	1016.1	1.0161	2.240	3:48	228	114.00	**112.2**	**50.9**
Carbolime #3	1233.5	223.2	1010.3	1.0103	2.227	3:41	221	110.50	**109.4**	**49.6**
Carbolime #4	1257.4	223.2	1034.2	1.0342	2.280	4:13	253	126.50	**122.3**	**55.5**
Averages				**1.018**	**2.245**		232	**115.8**	**113.6**	

Test Report


Multi Absorber Style Cartridge
Average Time (Minutes)
300
250
200
150
100
50
0
GE OEM
Litholyme
Carbolime
Amsorb Plus

Test Report


Multi-Absorber Style Cartridge
Average Liters of CO2/ Kg of Absorbent
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
GE OEM
Litholyme
Carbolime
Amsorb Plus

DATA

Test Report

Absorbency Test Results Summary - GE Multi Absorber Style Canister

Constants		
g per lb	Vt	CO_2
453.6	(L)	Flow
	0.5	(lpm)
		0.5

Container	Gross Weight (grams)	Empty Container Weight (grams)	Net Absorbent Weight (grams)	Net Absorbent Weight (Kg)	Net Absorbent Weight (lb)	Time (hr:Min)	Time Minutes	CO2 Used (Liters)	Liters of CO_2 per Kg	Liters of CO_2 per lb
GE OEM Multi Absorber #1	996.4	162.0	834.4	0.8344	1.840	4:08	248	124.00	**148.6**	**67.4**
GE OEM Multi Absorber #2	995.8	162.0	833.8	0.8338	1.838	3:31	211	105.50	**126.5**	**57.4**
GE OEM Multi Absorber #3	974.8	162.0	812.8	0.8128	1.792	2:54	174	87.00	**107.0**	**48.6**
GE OEM Multi Absorber #4	993.0	162.0	831.0	0.8310	1.832	3:30	210	105.00	**126.4**	**57.3**
Averages				**0.828**	**1.825**		211	**105.4**	**127.1**	

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Test Report

Test Data: GE Multi Absorber (OEM)

GE OEM Multi Absorber Cartridge - Data										
	Test Date	Canister ID	Canister Lot #	Canister Expiration Date	Anesthesia Machine Self Test	Time	Elapsed Time (Hours:Minutes)	Cycle	% CO_2	Comments
GE OEM # 1	6Feb2013	6Feb2013	9711211	12/2013	Pass	7:44		0		**Start of Test**
						8:30		580	-0.034	
						9:32		1327	-0.022	
						10:00		1662	0.004	
						10:29		2021	0.047	
						10:57		2348	0.132	
						11:25		2683	0.265	
						11:40		2866	0.369	
						11:43		2905	0.400	
						11:48		2963	0.450	
						11:52	4 Hrs 8 Min	3016	0.500	**End of test**
GE OEM # 2	8Feb2013	8Feb2013	9711211	8Feb2013	Pass	7:07		0		**Start of Test**
						7:59		1037	-0.031	
						8:55		1492	-0.016	
						9:50		2020	0.099	
						10:00		2133	-0.151	
						10:18		2355	0.318	
						10:29		2482	0.407	
						10:38		2585	0.490	
						10:38	3 Hrs 31 Min	2592	0.510	**End of test**

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Test Report

Test Data: GE Multi Absorber (OEM)

GE OEM # 3	11Feb2013	11Feb2013	9711211	12/2013	Pass	10:23		0		Start of Test
						11:02		466	0.001	
						11:25		751	0.009	
						11:38		898	0.024	
						12:20		1406	0.118	
						12:23		1446	0.131	
						12:40		1650	0.238	
						1:08		1978	0.411	
						1:14		2056	0.459	
						1:17	2 Hrs 54 Min	2091	0.510	End of test
GE OEM # 4	25Feb2013	25Feb2013	9711211	12/2013	Pass	8:08		0		Start of Test
						9:39		1095	-0.023	
						9:53		1264	-0.028	
						10:47		1914	0.061	
						10:56		2019	0.113	
						11:08		2173	0.217	
						11:19		2287	0.341	
						11:31		2443	0.420	
						11:38	3 Hrs 30 Min	2582	0.501	End of test

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Test Report

Litholyme:

Absorbency Test Results Summary - GE Multi Absorber Style Canister

Constants		
g per lb	Vt	CO_2
453.6	(L)	Flow
	0.5	(lpm)
		0.5

Container	Gross Weight (grams)	Empty Container Weight (grams)	Net Absorbent Weight (grams)	Net Absorbent Weight (Kg)	Net Absorbent Weight (lb)	Time (hr:Min)	Time Minutes	CO2 Used (Liters)	Liters of CO_2 per Kg	Liters of CO_2 per lb
Litholyme #1	1253.3	223.2	1030.1	1.0301	2.271	3:57	237	118.50	**115.0**	**52.2**
Litholyme #2	1207.3	223.2	984.1	0.9841	2.170	4:03	243	121.50	**123.5**	**56.0**
Litholyme #3	1217.0	223.2	993.8	0.9938	2.191	4:34	274	137.00	**137.9**	**62.5**
Litholyme #4	1189.5	223.2	966.3	0.9663	2.130	4:27	267	133.50	**138.2**	**62.7**
Averages				**0.994**	**2.190**		255	**127.6**	**128.6**	

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Test Report

Test Data: Litholyme

Litholyme Cartridge - Data										
	Test Date	Canister ID	Canister Lot #	Canister Expiration Date	Anesthesia Machine Self Test	Time	Elapsed Time (Hours:Minutes)	Cycle	% CO_2	Comments
Litholyme # 1	5Feb2013	5Feb2013	L234912AEZ	12/2014	Pass	6:39		0		Start of Test
						7:42		770	-0.023	
						9:14		1860	0.080	
						9:28		2028	0.126	
						9:52		2316	0.219	
						10:20		2652	0.383	
						10:26		2724	0.416	
						10:30		2772	0.445	
						10:34		2820	0.481	
						10:36	3 Hrs 57 Min	2844	0.500	End of test
* Adjusted Cycle Count. Counter Failed at count 770.										
Litholyme # 2	7Feb2013	7Feb2013	L234912AEZ	12/2014	Pass	8:12		0		Start of Test
						8:55		497	-0.033	
						9:22		829	-0.027	
						10:00		1275	-0.012	
						10:24		1565	0.011	
						10:52		1909	0.066	
						11:21		2260	0.166	
						11:36		2439	0.232	
						11:57		2682	0.343	
						12:05		2787	0.422	
						12:12		2861	0.456	
						12:15	4 Hrs 3 Min	2904	0.504	End of test

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Test Report

Test Data: Litholyme

Litholyme # 3	12Feb2013	12Feb2013	L28312EZ	10/2014	**Pass**	10:22		0		**Start of Test**
						10:47		315	-0.039	
						11:24		760	-0.034	
						12:03		1226	-0.038	
						12:35		1616	-0.034	
						1:10		2029	-0.022	
						1:44		2442	0.024	
						2:16		2829	0.142	
						2:40		3113	0.310	
						2:49		3218	0.400	
						2:56	4 Hrs 34 Min	3307	0.500	**End of test**
Litholyme # 4	01March2013	01March2013	L29712EZ	10/2014	**Pass**	8:37		0		**Start of Test**
						9:13		428	-0.033	
						10:20		1235	-0.029	
						10:56		1666	-0.020	
						11:23		1994	0.000	
						11:51		2326	0.052	
						12:00		2429	0.074	
						12:14		2598	0.122	
						12:34		2840	0.229	
						12:54		3081	0.304	
						12:58		3123	0.425	
						1:04	4 Hrs 27 Min	3193	0.501	**End of test**

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Test Report

Test Data : Amsorb Plus

Absorbency Test Results Summary - GE Multi Absorber Style Canister

Constants		
g per lb	Vt	CO_2
453.6	(L)	Flow
	0.5	(lpm)
		0.5

Container	Gross Weight (grams)	Empty Container Weight (grams)	Net Absorbent Weight (grams)	Net Absorbent Weight (Kg)	Net Absorbent Weight (lb)	Time (hr:Min)	Time Minutes	CO2 Used (Liters)	Liters of CO_2 per Kg	Liters of CO_2 per lb
Amsorb Plus #1	1076.6	250.0	826.6	0.8266	1.822	3:10	190	95.00	**114.9**	**52.1**
Amsorb Plus #2	1077.9	250.0	827.9	0.8279	1.825	3:02	182	91.00	**109.9**	**49.9**
Amsorb Plus #3	1083.5	250.0	833.5	0.8335	1.838	3:19	199	99.50	**119.4**	**54.1**
Amsorb Plus #4	1084.3	250.0	834.3	0.8343	1.839	2:56	176	88.00	**105.5**	**47.8**
Averages				**0.831**	**1.831**		187	**93.4**	**112.4**	

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Test Report

Test Data: Amsorb Plus

Amsorb Plus Cartridge - Data										
	Test Date	Canister ID	Canister Lot #	Canister Expiration Date	Anesthesia Machine Self Test	Time	Elapsed Time (Hours:Minutes)	Cycle	% CO_2	Comments
Amsorb Plus # 1	16April2013	16April2013	261112F41	2015-10	**Pass**	8:25		0		**Start of Test**
						8:33		96	-0.031	
						8:47		259	-0.026	
						9:17		629	-0.017	
						9:34		826	0.002	
						9:51		1032	0.021	
						10:06		1212	0.066	
						10:21		1392	0.106	
						10:51		1752	0.149	
						11:03		1896	0.334	
						11:11		1992	0.406	
						11:20	2 Hrs 56 Min	2112	0.500	**End of test**
* Adjusted Cycle Count. Counter Failed at count 826.										
Amsorb Plus # 2	1May2013	1May2013	261112F41	2015-10	**Pass**	8:32		0		**Start of Test**
						9:15		527	-0.033	
						9:59		1057	0.002	
						10:12		1201	0.022	
						10:40		1546	0.080	
						11:02		1807	0.175	
						11:11		1910	0.227	
						11:20		2025	0.290	
						11:34		2190	0.396	
						11:42	3 Hrs 10 Min	2283	0.501	**End of test**

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Test Report

Test Data: Amsorb Plus

Amsorb Plus # 3	2May2013	2May2013	261112F41	2015-10	**Pass**	9:14		0		**Start of Test**
						10:19		783	-0.020	
						10:44		1081	0.014	
						11:08		1376	0.056	
						11:22		1544	0.108	
						11:44		1807	0.202	
						12:01		2008	0.316	
						12:10		2116	0.409	
						12:14		2163	0.472	
						12:16	3 Hrs 02 Min	2196	0.503	**End of test**
Amsorb Plus # 4	3May2013	3May2013	261112F41	2015-10	**Pass**	7:58		0		**Start of Test**
						8:59		730	-0.034	
						9:28		1074	-0.020	
						10:07		1545	0.020	
						10:14		1634	0.044	
						10:40		1937	0.131	
						10:52		2086	0.210	
						11:05		2241	0.335	
						11:13		2336	0.427	
						11:17	4 Hrs 27 Min	2390	0.500	**End of test**

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Test Report

Carbolime

Absorbency Test Results Summary - GE Multi Absorber Style Canister

Constants		
g per lb	Vt	CO_2
453.6	(L)	Flow
	0.5	(lpm)
		0.5

Container	Gross Weight (grams)	Empty Container Weight (grams)	Net Absorbent Weight (grams)	Net Absorbent Weight (Kg)	Net Absorbent Weight (lb)	Time (hr:Min)	Time Minutes	CO2 Used (Liters)	Liters of CO_2 per Kg	Liters of CO_2 per lb
Carbolime #1	1236.0	223.2	1012.8	1.0128	2.233	3:44	224	112.00	**110.6**	**50.2**
Carbolime #2	1239.3	223.2	1016.1	1.0161	2.240	3:48	228	114.00	**112.2**	**50.9**
Carbolime #3	1233.5	223.2	1010.3	1.0103	2.227	3:41	221	110.50	**109.4**	**49.6**
Carbolime #4	1257.4	223.2	1034.2	1.0342	2.280	4:13	253	126.50	**122.3**	**55.5**
Averages				**1.018**	**2.245**		232	**115.8**	**113.6**	

Allied HEALTHCARE PRODUCTS INC. GLOBAL SUPPORT OF LIFE™

Test Report

Test Data: Carbolime

Carbolime Cartridge - Data										
	Test Date	Canister ID	Canister Lot #	Canister Expiration Date	Anesthesia Machine Self Test	Time	Elapsed Time (Hours:Minutes)	Cycle	% CO_2	Comments
Carbolime # 1	26Feb2013	26Feb2013	C03713EZ	02/2015	Pass	8:46		0		Start of Test
						9:52		799	-0.037	
						10:24		1180	-0.033	
						11:00		1614	-0.003	
						11:24		1897	0.050	
						11:33		2005	0.077	
						11:58		2303	0.204	
						12:19		2562	0.388	
						12:26		2641	0.477	
						12:28	3 Hrs 41 Min	2663	0.501	End of test
Carbolime # 2	27Feb2013	27Feb2013	C03713EZ	02/2015	Pass	7:29		0		Start of Test
						9:23		1393	-0.033	
						10:16		2008	-0.011	
						10:34		2244	0.020	
						11:08		2644	0.148	
						11:11		2689	0.163	
						11:24		2844	0.262	
						11:33		2945	0.360	
						11:37		2991	0.419	
						11:42	4 Hrs 13 Min	3051	0.501	End of test

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Carbolime # 3	4March2013	4March2013	C03713EZ	02/2015	**Pass**	9:57		0		**Start of Test**
						10:31		411	-0.027	
						11:17		965	-0.029	
						12:19		1711	0.025	
						12:42		1988	0.094	
						1:15		2376	0.258	
						1:20		2437	0.306	
						1:26		2510	0.355	
						1:32		2579	0.403	
						1:41	3 Hrs 44 Min	2689	0.501	
Carbolime # 4	07March2013	07March2013	C03713EZ	02/2015	**Pass**	8:05		0		**Start of Test**
						9:03		696	-0.027	
						10:24		1674	-0.010	
						10:46		1934	0.021	
						11:05		2164	0.083	
						11:31		2482	0.253	
						11:37		2554	0.313	
						11:43		2622	0.372	
						11:47		2664	0.412	
						11:53	3 Hrs 48 Min	2734	0.505	**End of test**