August 27, 2013

Mr. Tim Racke
Chief Operating Officer
AIR CYCLE CORPORATION
2200 Ogden Ave., Suite 100
Lisle, IL 60532

Via e-mail: Tim@aircycle.com

Bureau Veritas Project No. 07013-000035.00

Subject: **Mercury Emission Sampling and Noise Exposure Monitoring for the Bulb Eater® *3***

Dear Mr. Racke:

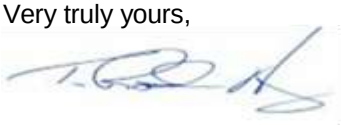
Bureau Veritas North America, Inc., (Bureau Veritas) Health Safety and Environmental Services, is pleased to provide you with a copy of the Industrial Hygiene report from the June 10, 2013 assessment at the Air Cycle Corporation facility located at 2200 Ogden Avenue, Suite 100 in Lisle, Illinois. This assessment was conducted by Ms. Alma R. Herrera, Industrial Hygienist with Bureau Veritas.

Should you have questions in regard to the enclosed report, or need assistance with other industrial hygiene issues, please feel free to contact me at 630.536.5901.

Please take a minute to share your opinion with us regarding our service by completing our web-based quality survey. Click on the following link, or copy and paste it into your web browser to access the site.

https://www.surveymonkey.com/s.aspx?sm=wQJCi3b_2f7ADPZ2loSwY_2b6g_3d_3d

Very truly yours,



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Mercury Emission Sampling and Noise Exposure Monitoring for the Bulb Eater® *3*

Completed At: Air Cycle Corporation
2200 Ogden Avenue, Suite 100
Lisle, Illinois 60532

Bureau Veritas Project Number: 07013-000035.00

Report Date: August 23, 2013

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FINAL REPORT

Move Forward with Confidence

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1.0 INTRODUCTION

Mr. Tim Racke, Chief Operating Officer with Air Cycle Corporation, retained Bureau Veritas North America, Inc. (Bureau Veritas / BVNA) to conduct an industrial hygiene assessment on the Bulb Eater® *3* at the Air Cycle Corporation facility located at 2200 Ogden Avenue, Suite 100 in Lisle, Illinois. The scope of work for this project was described in Bureau Veritas' Proposal No. 0709.13.058 Revision 1 dated February 27, 2013 and addressed to Mr. Racke. Additionally, the scope of work for this project was also discussed in an email from Mr. Rod Harvey with Bureau Veritas to Mr. Racke dated April 1, 2013. The project was completed in accordance with Bureau Veritas Standard Terms and Conditions dated October 5, 2012.

Ms. Alma R. Herrera, Industrial Hygienist with Bureau Veritas, completed the industrial hygiene assessment on June 10, 2013. Mr. Racke was Bureau Veritas' primary contact while on-site.

2.0 BACKGROUND

2.1 PURPOSE OF TEST

The Bulb Eater® *3* tests were performed to quantify airborne concentrations of mercury vapor emissions at various points around the machine, at the operators breathing zone, and at several locations in the lamp staging areas during the crushing operations, filter replacements, and drum change-outs. All the data was compared to the Occupational Health and Safety Administration (OSHA) Permissible Exposure Limit (PEL) and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for mercury.

2.2 BULB EATER® *3*

The Bulb Eater® drum-top lamp crushing machine has been in practical usage as a volume reduction method to aid in the recycling of fluorescent lamps since 1998. To date there are approximately 8,000 Bulb Eaters in service worldwide. With increased interest in operational safety and operator exposure to mercury vapor, Air Cycle Corporation has developed the next generation machine, Bulb Eater® *3,* to address these interests. The Bulb Eater® *3* includes the following design features that achieve these goals:

- Single model that crushes linear, CFL, and U-bend lamps
- Lower angle entry tube (lower entry height - easier to use)
- Cyclone separator upstream of the filtering system that acts as a gross pre-filter to extend the life of the filters downstream
- Five stage filter system:
    1. Cyclonic Separator
    2. Cartridge Filter
    3. High Efficiency Particulate Air (HEPA) Filter

4. Activated Carbon Filter
5. Final HEPA Filter

- Only two hose connections, no casual connections of hoses
- On-board controls with Intelli Technology®
  - Additional sensing points that assist with machine diagnostics and maintenance/filter change-outs
  - LCD display that advertises which mode the machine is in and any defaults that might occur

Bureau Veritas performed the following tasks during two test cycles:

- Performed wipe tests on drum top before and after lamp crushing sessions. These were collected and analyzed in accordance with the OSHA ID-145 method.

- Measured vapor concentrations with Air Cycle Corporation's direct-reading instrument (Mercury Instruments [MI] Mercury Tracker 3000 IP, calibrated on 3/14/2013) and hopcalite tubes designed for mecury vapor collection (NIOSH 6009) during the two test cycles. One of the test cycles was conducted while workers crushed one drum full in an open warehouse area, and the second test was conducted while workers crushed one drum full in a closed office space (approximately 880 lamps during each of the crsuhing sessions over a 55-70 minute period).

  - For each test cycle Bureau Veritas collected: six (6) samples, including two (2) personal samples on each operator (one stopped after approximately 200 lamps, with no drum/filter change-out) while the other ran for the duration of the test and included the drum/filter change out, one (1) on a seperate operator that assists with the drum change out; one (1) at the exhaust of the carbon filter; one (1) approximately 10 feet away from the Bulb Eater® 3; and one (1) in the lamp staging area.

  - Collected direct readings using the Mercury Tracker in the locations specified by Air Cycle Corporation. A diagram with the sample locations is provided in Table B, Figure 4 of this report. Readings were collected in 10 -15 minute intervals until the drum was full.

  A detailed description of the test procedure is provided in Appendix C.

- Measured personal noise exposure levels on the person operationg the Bulb Eater® 3.

- Measured general sound levels levels utilizing a Sound Level Monitor during the operation of the Bulb Eater® 3.

- Submitted the collected air samples (along with quality control blank samples) to the Bureau Veritas American Industrial Hygiene Association (AIHA) accredited laboratory in Novi, Michigan for analysis. The Laboratory is accredited by the American Industrial Hygiene Association

(AIHA), Laboratory # 100967. To review the scope of accreditation, visit the accreditation organization website at www.aiha.org.

- Prepared this written report documenting Bureau Veritas' evaluation. The report will include a description of sampling and analytical methods, interpretation of the analytical results, a discussion of findings, and conclusions.

The following appendices supplement the results of the industrial hygiene assessment discussed in this report:

- Appendix A Data Tables
  - Table 1 Results of Personal Air Monitoring and Analysis for Mercury
  - Table 2 Results of Area Air Monitoring and Analysis for Mercury
  - Table 3 Results of Surface Wipe Sampling and Analysis for Mercury
  - Table 4 Results of Personal Noise Dosimeter Measurements (OSHA PEL Measurement Parameters)
  - Table 5 Results of Area Noise Level Measurements
  - Table 6 Direct Reading Measurements for Mercury
  - Table 7 Direct Reading Measurements for Mercury during Drum and Filter Changes
- Appendix B BVNA Laboratory Reports
- Appendix C Equipment and Assessment Procedures
- Appendix D Abbreviations and Glossary
- Appendix E Equipment Calibration Certificates
- Appendix F References

3.0 DESCRIPTION OF OPERATIONS

Air Cycle Corporation is a sustainable solutions and technologies company developing tools and services to help clients implement a comprehensive environmental program at their facilities. The tools and services include fluorescent lamp, ballast, battery, e-waste recycling, food waste diversion, and cleaning and sanitizing systems. Bureau Veritas performed this assessment on Air Cycle Corporation's Bulb Eater® *3* fluorescent lamp crushing machine.

3.1 BULB EATER® *3* OVERVIEW

Air Cycle Corporation manufactures the Bulb Eater® *3* line of drum-top fluorescent lamp crushing machines. The Bulb Eater® *3* mounts on top of a 55-gallon drum as shown in Figure 1. The spent linear fluorescent lamp is fed through a 30 degree entry tube connected to the Bulb Eater® *3* lid assembly. An electric motor spins a chain inside the unit breaking each inserted lamp. Entry tubes for linear lamps are available in 48-in lengths. Each entry tube connects to the top of the unit by a threaded connection. The system also includes a feed chute that accommodates the crushing of Compact Fluorescent Lamps (CFLs) and U-tube lamps. A vacuum pump pulls the mercury vapor through the unit's four-stage filtration system that is preceded by a cyclone filter. The first two stages consist of a filter cartridge followed by a HEPA filter to remove particulates. The cartridge and HEPA filters are contained together in a single housing and followed by an activated carbon filter which is the mercury vapor removal system. Lastly, another HEPA filter follows the carbon filter.

Depending on the lamp type and cleanliness, the filter cartridge should be replaced after filling approximately six 55-gallon drums with crushed lamp waste. The first HEPA filter should be replaced approximately every 15 drums of lamp waste. The activated carbon filter, which is contained in a metal housing, has a calculated life of approximately 1500 hours of running time (approximately 1,000,000 fluorescent lamps). The Bulb Eater® *3* system will crush approximately 850 or more T-12 or 1400 or more T-8 4-foot spent fluorescent lamps into a 55-gallon drum. The average weight of a full drum of crushed fluorescent lamps is approximately 530 pounds (including weight of drum). With trained, experienced operators the unit is capable of processing 30 lamps per minute.

Operational differences between the Bulb Eater® *3* and the current model Bulb Eater® include:

- Digital control with LCD display
- Self-diagnostic fault codes
- Higher motor speed for increased lamp waste by weight per drum
- Two filtration stages have been added: a Cyclonic separator and an additional final HEPA filter
- Bag filter has been upgraded to a higher volume cartridge filter
- Ease of handling to speed up filter and drum change-outs
- Reduced linear entry tube angle for better operator comfort
- Welded and bolted connections for improved sealing
- Continuous monitoring of carbon life

The end result is the next generation, Bulb Eater® *3*. Figure 1 depicts the Bulb Eater® *3* mounted to a 55-gallon drum.

Figure 1
Bulb Eater® *3*

3.2 LAMP TEST INVENTORY SELECTION

Spent 4-foot (ft) T-8 lamps, 4-ft T-12 lamps, and U-bend lamps, were crushed during the tests. Each 4-foot lamp contains on average a concentration of mercury ranging from 3 to 10 milligrams. Table A contains a breakout of the type and number of lamps crushed.

Table A: Test Lamp Inventory

Lamp Types	Approximate Number of Lamps Collected	Percentage of Total
4-ft, T-8	36	2%
4-ft, T-12	1,686	96%
U-Bend	40	2%
Total	**1,762**	**100 %**

Note: The majority of the spent lamps that were crushed were the standard efficiency type. Approximately 10% were green-tip, low mercury type.

3.3 TEST SITE PREPARATION

The Bulb Eater® *3* was tested in two separate areas within Air Cycle Corporation's headquarter facility in Lisle, Illinois. The first test was conducted in an open warehouse area (14 foot ceiling height) which was equipped with ceiling fans creating some downward air flow. Lamps were staged for crushing in fiber drums within 12 feet of the machine tested. See Figure 2 for photo of the warehouse test area.

The second test was conducted in an enclosed office area (approximately 14 feet x 12 feet, and 9 foot ceiling height). The heating, ventilation, and air conditioning (HVAC) system to this area supplies make-up air, but does not have a return vent. Prior to conducting the second test, a protective 10-foot x 8-foot polyethylene tarp was laid on the carpeted floor for protection. The crushed lamp waste collection drum was centered on the protective floor tarp prior to initiating the test. The tarp served as a barrier between the crushed lamp waste collection drum and the carpeted floor in the event of accidental lamp breakage and also eased clean up after the tests. See Figure 3 for photo of office test area.

The Bulb Eater® *3* unit was assembled on a 55-gallon waste drum in the respective test areas by the operator and helper prior to testing in accordance with Air Cycle Corporation Bulb Eater® *3* owner's manual instructions. All fittings, clamps, and fasteners were put in place and inspected to ensure proper attachment, tightness, and seals prior to each test cycle.

Figure 2
Bulb Eater® 3 in Warehouse Area – Test 1

Figure 3
Bulb Eater® 3 in Office Area – Test 2

3.4 SAFETY PRECAUTIONS

The Bulb Eater® *3* operator, operator assistant, and Industrial Hygienist wore personal protective equipment (PPE) during crushing operations. The PPE worn included neoprene-coated, chemical, and cut-resistant gloves; chemical safety glasses, and earplugs.

The warehouse floor area and plastic floor tarp were periodically checked using the Mercury Tracker 3000 IP for mercury contamination during the test operations and prior to clean-up after each test.

3.5 MERCURY EMISSIONS SAMPLE LOCATIONS

The Bulb Eater® *3* primary sample locations were measured with a factory calibrated (on 3/14/2013) mercury vapor meter, Mercury Tracker 3000 IP direct reading instrument (DRI). The DRI sample locations are presented in Figure 4 and the descriptions of each sample point are provided in Table B.

Figure 4

Bulb Eater® 3 Sample Locations

Table B: The Bulb Eater® 3 Sample Points	
Sample Point	**Description**
A_1	Ambient Hg concentration before test cycle (4-6 " above floor, 5-6 ft. from drum)
A_2	Ambient Hg concentration 30 min. into test cycle, motor on (4-6" above floor, 5-6 ft. from drum)
A_3	Ambient Hg concentration after test cycle, motor off (4-6" above floor, 5-6 ft. from drum)
B	Fluorescent lamp chute entry point
C	Motor housing area
I	Filter air exit
L	Fluorescent lamp chute entry connection to drum top
M	Drum lid rim area near chute entry connection to drum top
N	Drum lid rim area near safety cover (opposite of M)
O	Operator breathing zone
P	Airlock connection to cyclone filter
Q	Cyclone filter connection to flexible hose
R	Flexible hose connection to filter lid
S	Filter lid connection to filter housing
T	Filter housing connection to vacuum
U	Vacuum connection to carbon canister
V	Safety cover
W	Belt of all-in-one chute
X	Compact fluorescent lamp hopper (open safety cover)
Y_1	Fluorescent lamp chute entry point (full drum, machine not running) (not shown in figure)
Y_2	Filtered air exit (full drum, machine not running) (not shown in figure)
Y_3	Max reading from drum lid rim area circumference (full, sealed drum) (not shown in figure)
Z_1	Operator breathing zone (during filter replacement) (not shown in figure)
Z_2	Operator breathing zone (during drum change-out) (not shown in figure)

4.0 STANDARDS AND GUIDELINES

4.1 AIRBORNE CONTAMINANTS

Results of air samples collected during this assessment are compared against the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) established in 29 CFR 1910.1000 Table Z-2 and the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs - 2013 Edition). The OSHA PELs are enforceable as a governmental regulation while the ACGIH TLVs are not. Bureau Veritas' considered both the OSHA PELs and the ACGIH TLVs in forming conclusions. Specific exposure limits are provided in Table C and in Tables 1 – 2 in Appendix A.

Table C: OSHA and ACGIH Exposure Limits

Substance	OSHA PEL 8-hour TWA (mg/m^3)	ACGIH TLV 8-hour TWA (mg/m^3)
Mercury	0.1	0.025, Skin

OSHA: Occupational Safety and Health Administration
PEL: Permissible Exposure Limit
ACGIH: American Conference of Governmental Industrial Hygienists
TLV: Threshold Limit Value
TWA: Time Weighted Average
mg/m^3: Milligrams per cubic meter of air
Skin: Skin, eye and mucous membrane contact as a significant pathway of absorption

4.2 NOISE

OSHA mandates limits for personal noise exposure that are based on the period of time the employee is exposed to noise at a specific intensity, measured in decibels using the "A"-weighting scale (dBA). The OSHA PELs for noise are provided in Table D.

Table D: OSHA Noise Exposure Limits[a]

Duration Per Day (hours)	OSHA PEL (dBA)
16	85
12	87
10	88
8	**90**
4	95
2	100
1	105
0.5	110
0.25	115

[a]: Measured in decibels using, a 5dB exchange rate, an "A" weighted filter, 80 to 130 dBA range, and slow response mode.

The OSHA Noise Standard (29 CFR 1910.95) specifies a PEL of 90 dBA and an Action Level (AL) of 85 dBA as eight-hour TWAs.

5.0 SUMMARY OF RESULTS

5.1 AIRBORNE CONTAMINANTS

Bureau Veritas collected a total of six (6) personal air samples and six (6) area air samples as described in Table E. Photos are provided in Appendix C.

Table E: Bulb Eater® *3* Air Sampling Summary	
Sample Type	**Samples Collected**
Test 1 - Warehouse	
Air - Personal • 1 STEL on Operator • 1 Task-duration on Operator (including the filter and drum change-outs) • 1 Task-duration on Operator Assistant	3
Air – Area • 1 - 10-feet southwest of Bulb Eater® 3 • 1 Filter Exhaust • 1 Lamp Staging Area	3
Air - Field Blanks	1
DRI – Mercury Tracker	69
Totals	**76**
Test 2 - Office	
Air - Personal • 1 STEL on Operator • 1 Task-duration on Operator (including the filter and drum change-outs) • 1 Task-duration on Operator Assistant	3
Air – Area • 1 - 10-feet southwest of Bulb Eater® 3 • 1 Filter Exhaust • 1 Lamp Staging Area	3
Air - Field Blanks	1
DRI – Mercury Tracker	69
Totals	**76**

All air sample results collected during this assessment were below the limits of analytical detection and were less than the OSHA PEL and the ACGIH TLV.

Area sample results cannot be compared to the ACGIH TLV or the OSHA PEL; however, the results may be useful in evaluating potential exposure risks. Results of area monitoring for mercury measured during this assessment are not necessarily representative of employees' exposures and were not used in forming conclusions. Area samples were collected at a height of approximately 5-feet, representing the operator's breathing zone height, except for the filter exhaust samples which were placed on the floor at approximately 1-inch from the filter exhaust.

Detailed results of air sampling and analysis are provided in Tables 1 through 3 in Appendix A.

5.2 DIRECT READING INSTRUMENT MEASUREMENTS

Approximately 138 DRI measurements were made with the Mercury Tracker DRI during the Bulb Eater® *3* tests. These measurements were made to assess mercury vapor leakage points and to obtain real-time, mercury vapor test personnel exposure data on the Bulb Eater® *3* unit during and after tests, and on the sealed waste collection drums.

A summary of the Mercury Tracker 3000 IP DRI sample results for the Bulb Eater® *3* tests are presented in Table 6 in Appendix A. DRI measurements were made within two to three inches of the Bulb Eater® *3* unit at each of the sample locations. The DRI values shown in Table 6 are the peak instantaneous values, or highest recorded data, during a 30 second measurement period where the readings were taken each second. They are not calculated 8-hour TWA values.

The sample measurements highlighted in the color blue reveal locations on the Bulb Eater® *3* where four of the 138 DRI measurements were greater than the ACGIH TLV-TWA of 0.025 milligrams per cubic meter (mg/m^3) and the OSHA PEL-TWA of 0.100 mg/m^3. The four DRI measurements were performed at the operator's breathing zone during the filter replacement and the drum change-out tasks in both tests. The actual measurement duration was approximately 30 seconds. Detailed data of these measurements are provided in Table 7, Appendix A. The DRI values shown in Table 7 are the instantaneous values recorded each second during the 30 second measurement period. They are not calculated 8-hour TWA values. All other readings shown in Table 6 (134 each) were well below both the OSHA PEL-TWA and ACGIH TLV-TWA.

The four measurements collected during the filter replacement and the drum change-out tasks are summarized in Table F and detailed results of all DRI measurements are provided in Tables 6 and 7 in appendix A.

Table F: Bulb Eater® *3* DRI Measurements (Four of 138 highest DRI measurements)			
Sample Point	**Location**	**Mercury Concentration (mg/m^3)**	**Test Area**
Z1	Operator breathing zone (during filter replacement) (not shown in figure)	0.191	Test 1 Warehouse
Z2	Operator breathing zone (during drum change-out) (not shown in figure)	0.416	
Z1	Operator breathing zone (during filter replacement) (not shown in figure)	0.192	Test 2 Office
Z2	Operator breathing zone (during drum change-out) (not shown in figure)	0.157	

5.3 QUANTITATIVE SAMPLING FOR PRESENCE OF MERCURY SURFACE CONTAMINATION

A surface sampling wipe was used to quantify the amount of mercury on the lid of the Bulb Eater® *3* assembly on the waste drums before and after each test cycle. Based on the analytical results of the sampling wipes, the presence or absence of mercury was confirmed on each drum before and after filling each drum with crushed lamps.

The results are summarized in Table G below and detailed results are provided in Table 3, Appendix A.

Table G: Bulb Eater® *3* Mercury Surface Contamination	
Location	Results
Test 1 – Before	Non-detected
Test 1 – After	Detected
Test 2 – Before	Non-detected
Test 2 – After	Non-detected

mg/in^2: milligrams per square inch

Bureau Veritas used a completely unfolded surface sampling wipe to wipe the circumference of the Bulb Eater® *3* lid/drum assembly. The sampling wipe was folded in half and the circumference was wiped a second time. The sampling wipe was then folded a third time and the circumference was wiped a third time. The presence of mercury on the lid was detected after operation in Test 1 as indicated in Table 3, Appendix A.

5.4 NOISE

Bureau Veritas collected a total of two (2) personal noise dosimetry measurements on the employee operating the Bulb Eater® *3*. One personal noise dosimetry measurement was collected during Test 1 in the Warehouse and the second measurement was collected during Test 2 in the Office. The operator's calculated 8-hour TWA measured noise exposures were 80 dBA and 85 dBA for Test 1 (Warehouse) and Test 2 (Office), respectively. The two (2) 8-hour calculated employee exposures to noise measured during this assessment were less than the OSHA PEL and equivalent to or less than the OSHA AL.

A summary of the general area noise measurements is provided in Table H. Detailed results of personal and general area sound level measurements are provided in Tables 4 and 5, respectively, in Appendix A.

Table H: Bulb Eater® *3* Sound Pressure Levels

Location	Noise Level Range (dBA)
Warehouse Bay Test Area	81 – 97
Warehouse Bay Test Area – Top of Bulb Eater® *3*	88 – 98
Office Test Area	89 – 99
Office Test Area – Top of Bulb Eater® *3*	94 – 99

dBA: Decibels in the A-weighting scale

The noise dosimeters used in this assessment are accurate to ±2 dBA. Employees' noise exposures measured at or above 83 dBA as an 8-hour TWA are potentially at or above the OSHA AL and the ACGIH TLV. BVNA recommends all employees with calculated or measured exposures of 83 dBA 8-hour TWA or above wear hearing protection during the operation of the Bulb Eater®.

6.0 DISCUSSION

Bureau Veritas collected a total of six (6) personal air samples, six (6) area air samples, 138 DRI measurements were collected with the Mercury Tracker 3000 IP DRI, and four (4) surface sampling wipes were collected to quantify the amount of mercury on the surface of the Bulb Eater® *3*.

A total of 884 lamps (864 T-12 lamps and 20 U-lamps) were crushed during the first test (warehouse) and 878 lamps (822 T-12 lamps, 36 T-8 lamps, and 20 U-lamps) during the second test (office). The Bulb Eater® *3* operator and assistant personal air sample results collected during this assessment were below the limits of analytical detection (or none detected) and less than the OSHA PEL of 0.1 mg/m^3 and the ACGIH TLV of 0.025 mg/m^3 for mercury. While four (4) of the 138 DRI peak, instantaneous measurements collected during the two test cycles were greater than the OSHA PEL-TWA and the ACGIH TLV-TWA, the durations were brief (from 3 seconds to 22 seconds) as reported in

Table 7, Appendix A. The readings occurred during the filter replacement and the drum change-out activities. According to the manufacturer, these activities are performed from once per month on the high end, to as infrequently as once per year depending on the number of spent lamps to be crushed. Per the Bulb Eater® *3* Operating & Maintenance Manual, when these activities are executed properly, they should take less than 10 seconds each. The four readings occurred when the personal air samples were being taken and were also factored into the 8-hour TWA's. As noted above the operator's and operator assistant's air sample TWA's were below the OSHA and ACGIH limits. This short duration exposure during drum and filter changes has minimal effect on overall worker exposure.

Area sample results cannot be directly compared to the ACGIH TLV or the OSHA PEL; however, the results may be useful in evaluating potential exposure risks. The DRI measurements were collected at various potential emission points (connections) during both tests. The measurements collected during Test 1 (warehouse) ranged from 0.0001 mg/m^3 to 0.0018 mg/m^3 and from 0.0007 mg/m^3 to 0.0070 mg/m^3 during Test 2 (office). With the exception of the four DRI readings that were collected during the drum and filter replacements, no other DRI readings exceeded 0.0007 mg/m^3. It is understood that area sample results cannot be directly compared to the ACGIH TLV or OSHA PEL, however, the continuum of these DRI readings logically indicate that those standards were not exceeded.

Based on the air contaminant sampling results, the operator and operator assistant were not exposed to excessive concentrations of mercury emissions during either of the Bulb Eater® *3* fluorescent lamp crushing operations. The DRI measurements during the drum change-out and filter replacement operations have the potential to be greater than both ACGIH TLV-TWA and OSHA PEL-TWA mercury vapor exposure limits. As noted above, these readings are for short, infrequent durations. These operations include the Bulb Eater® *3* unit removal from the full crushed lamp collection drum; full crushed lamp collection drum lid removal, replacement or tightening; and during filter unit removal and replacement. Additionally, the full waste drum exterior/Bulb Eater® *3* assembly may exhibit mercury particulate at the end of crushing operations.

Bureau Veritas collected a total of two (2) personal noise dosimetry measurements on the employee operating the Bulb Eater® *3*. The operator's calculated 8-hour TWA measured noise exposures were 80 dBA during Test 1 (warehouse) and 85 dBA during Test 2 (Office). The two (2) 8-hour calculated employee exposures to noise measured during this assessment were less than the OSHA PEL and equivalent or less than the OSHA AL and ACGIH TLV. However, BVNA recommends that all employees with calculated or measured exposures of 83 dBA 8-hour TWA or above wear hearing protection during the operation of the Bulb Eater® *3*.

7.0 CONCLUSION

Bureau Veritas offers the following conclusions based on the Bulb Eater® *3* assessment and test data:

1. The Bulb Eater® *3* system can crush an average of 880 lamps with an average 4-foot length well within 70 minutes into one 55-gallon drum period if the spent lamps are properly staged and an assistant is used to aid in lamp handling.

2. Operator and operator assistant are not exposed to excessive mercury concentrations in air as the personal air sampling results in this assessment did not exceed the OSHA or ACGIH exposure limits at any time during the actual crushing operations or when averaged over an 8-hour work period. All air sample results collected during this assessment were below the limits of analytical detection.

3. The chute safety covers, designed to seal open ends of lamp chutes, adequately contain soiled lamp chutes during storage and non-use.

4. Residual powder adhering to the crushing mechanism of the Bulb Eater® *3* system emits mercury vapor when the unit is separated from a full, 55-gallon crushed lamp collection drum (i.e. during drum change-out). Durations are short as exhibited in Table 7 in Appendix A.

8.0 QUALITY ASSURANCE

As a world leader in providing services that our clients depend on, we continually strive to provide the highest quality. This report has been reviewed as a part of our quality process.

Report submitted by:

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ARH/ck

APPENDIX A

Data Tables

Table 1
Results of Personal Air Sampling and Analysis for Mercury

Air Cycle Corporation
Lisle, Illinois
June 10, 2013

Bureau Veritas Project No. 07013-000035.00

Sample No.	Sample Description	Sampling Time Start/Stop	Sample Duration (minutes)	Lab Results over Sample Duration (mg/m^3)	Calculated 8-hour TWA (mg/m^3)
OSHA PEL (8-hour TWA)					0.1
ACGIH TLV (8-hour TWA)					0.025
Test 1 – Warehouse					
4600202226	Ged Zukas Bulb Eater® 3 Operator – short-term, crushed 200 lamps	0933/0948	15	< 0.015	ND
4600202230	Ged Zukas Bulb Eater® 3 Operator – task-duration, crushed a total of 884 lamps (864 T-12 lamps and 20 U lamps)	0933/1108	95	< 0.0023	ND
4600202228	Eric Iglesias Bulb Eater® 3 Operator Assistant	0933/1107	94	< 0.0023	ND
Test 2 – Office					
4643100665	Ged Zukas Bulb Eater® 3 Operator – short term, crushed 200 lamps	1152/1211	19	< 0.011	ND
4643100663	Eric Iglesias Bulb Eater® 3 Operator Assistant	1152/1323	91	< 0.0022	ND
4643100660	Ged Zukas Bulb Eater® 3 Operator – task duration, crushed 878 lamps (822 T-12 lamps, 36 T-8 lamps, and 20 U-lamps)	1152/1324	92	< 0.0022	ND
4643100662	Field Blank	--	--	< 0.00005 mg	--

OSHA: Occupational Safety and Health Administration
PEL: Permissible Exposure Limit
TWA: Time Weighted Average
ACGIH: American Conference of Governmental Industrial Hygienists
TLV: Threshold Limit Value
mg/m^3: Milligrams per cubic meter
<: Less Than
ND: None Detected

Note: The analytical detection limit of the analytical method used for mercury is 0.00005 mg. The sample result was less than the analytical detection limit and it is reported as a measure of weight only as it was not exposed to a volume of air. All the sample results were also less than the analytical detection limit: therefore, the 8-hour TWA calculations were not performed, but reported as none detected.

Table 2
Results of Area Air Sampling and Analysis for Mercury

Air Cycle Corporation
Lisle, Illinois
June 10, 2013

Bureau Veritas Project No. 07013-000035.00

Sample No.	Sample Description	Sampling Time Start/Stop	Sample Duration (minutes)	Lab Results over Sample Duration (mg/m^3)
OSHA PEL (8-hour TWA)				0.1
ACGIH TLV (8-hour TWA)				0.025
Test 1 – Warehouse				
4600202224	Approximately 10-feet southwest of Bulb Eater® 3	0933/1112	99	< 0.0021
4600202231	Bulb Eater® 3 Filter Air Exhaust	0933/1110	97	< 0.0022
4600202229	Lamp Staging Area, approximately 8-feet from Bulb Eater® 3	0933/1109	96	< 0.0022
Test 2 – Office				
4643100657	Approximately 8-feet north of Bulb Eater® 3, on north wall	1152/1325	93	< 0.0022
4643100666	Bulb Eater® 3 Filter Air Exhaust	1152/1326	94	< 0.0021
4643100661	Lamp Staging Area, outside office	1152/1328	96	< 0.0021
4643100662	Field Blank	--	--	< 0.00005 mg

OSHA: Occupational Safety and Health Administration
PEL: Permissible Exposure Limit
TWA: Time Weighted Average
ACGIH: American Conference of Governmental Industrial Hygienists
TLV: Threshold Limit Value
mg/m^3: Milligrams per cubic meter
<: Less Than

Table 3
Results of Surface Wipe Sampling and Analysis for Mercury

Air Cycle Corporation
Lisle, Illinois
June 10, 2013

Bureau Veritas Project No. 07013-000035.00

Sample No.	Sample Description	Lab Results (mg)	Calculated Concentration (mg/in2)
	Test 1 – Warehouse		
D1-1	Drum #1, wiped around the circumference of the drum with the Bulb Eater® 3 lid on before crushing lamps.	0.00017	0.000001
D1-2	Drum #1, wiped around the circumference of the drum with the Bulb Eater® 3 lid on after filling the drum with crushed lamps. Filter was changed on this drum.	0.023	0.156
	Test 2 – Office		
D2-1	Drum #2, wiped around the circumference of the drum with the Bulb Eater® 3 lid on before crushing lamps. There may have been some residual left from Test #1.	0.0026	0.000018
D2-2	Drum #2, wiped around the circumference of the drum with the Bulb Eater® 3 lid on after filling the drum with crushed lamps. Filter was changed on this drum.	0.0023	0.000016

mg/in^2: Milligrams per square inch

[a]: The calculated concentration of mercury on the surface of the drum was calculated using the circumference (73.8 inches) of the Bulb Eater® 3 Lid and 2-inch around the circumference. The area used for the calculations was 147.6 square inches.

Notes:

1. D1-2 had a higher detection of mercury due to a small amount of powder that was spilled when the operator was changing the cartridge filter.
2. The Lab results are in mg/in^2 (surface area calculations), not mg/m^3 (volumetric calculations) like the OSHA & ACGIH limits.

Table 4
Results of Personal Noise Dosimeter Measurements

Air Cycle Corporation
Lisle, Illinois
June 10, 2013

Bureau Veritas Project No. 07013-000035.00

Meter No.	Sample Description	Sampling Time Start / Stop	Sample Duration (minutes)	Measured Dose (%)	Projected Dose (8-hour TWA Dose, %)	Projected 8-hour TWA (dBA)
OSHA PEL (8 – hr TWA)					100	90
OSHA AL (8 – hr TWA)					50	85
Test 1 – Warehouse						
CA476	Ged Zukas Bulb Eater® 3 Operator	0922/1057	95	5	25	80
Test 2 – Office						
CA476	Ged Zukas Bulb Eater® 3 Operator	1145/1317	92	9	47	85

OSHA: Occupational Safety and Health Administration
PEL: Permissible Exposure Limit
TWA: Time Weighted Average
AL: Action Level
dBA: Decibels A-scale Slow Meter Response

Table 5
Results of Short Term Area Noise Level Measurements

Air Cycle Corporation
Lisle, Illinois
June 10, 2013

Bureau Veritas Project No. 07013-000035.00

Location	Noise Level (dBA)			
	Range	OSHA Average	Range	OSHA Average
OSHA PEL (8 – hour TWA)		90		90
OSHA AL (8 – hour TWA)		85		85
Test 1 – Warehouse	**Beginning of Test (Drum Empty)**		**Drum ¾ Full**	
Above Bulb Eater® 3	96-98	97	84-86	85
Direction: Northeast of Bulb Eater® 3				
5-feet, Operator Position	91	91	80-84	82
7-feet	89	89	--	--
9-feet	88	88	--	--
11-feet	86	86	--	--
13-feet	85-87	86	--	--
15-feet	82-84	83	--	--
Direction: West of Bulb Eater® 3				
2-feet	90-92	91	85-87	86
4-feet	85-88	87	83-86	85
6-feet	84-88	86	80-84	82
8-feet	84-86	85	--	--
10-feet	81-85	83	--	--
Direction: South of Bulb Eater® 3				
2-feet	95-97	96	87-90	89
4-feet	89-93	91	84-87	86
6-feet	86-90	88	82-86	84
8-feet	85-88	87	80-84	82
10-feet	84-87	86	--	--
Direction: East of Bulb Eater® 3				
2-feet	96	96	88-92	90
4-feet	94	94	86-90	88
6-feet	90	90	85-88	87
8-feet	89	89	83-87	85
10-feet	87-90	89	83-85	84

OSHA: Occupational Safety and Health Administration
PEL: Permissible Exposure Limit
TWA: Time Weighted Average
AL: Action Level
dBA: Decibels A-scale Slow Meter Response
--: Sound level measurements were not collected once the noise levels dropped below 85 dBA

Table 5 (continued)
Results of Short Term Area Noise Level Measurements

Air Cycle Corporation
Lisle, Illinois
June 10, 2013

Bureau Veritas Project No. 07013-000035.00

Location	Noise Level (dBA)			
	Range	OSHA Average	Range	OSHA Average
OSHA PEL (8 – hour TWA)		90		90
OSHA AL (8 – hour TWA)		85		85
Test 2 – Office	**Beginning of Test (Drum Empty)**		**Drum ¾ Full**	
Above Bulb Eater® 3	95-96	96	92-95	94
Direction: Northeast of Bulb Eater® 3				
Operator Position	--	94	--	91
2-feet	--	98	--	93
4-feet	--	96	--	91
6-feet	--	94	--	91
Direction: Northwest of Bulb Eater® 3				
2-feet	--	99	--	94
4-feet	--	97	--	91
6-feet	--	92	--	91
Direction: Southwest of Bulb Eater® 3				
2-feet	--	99	--	96
4-feet	--	96	--	94
6-feet	--	95	--	93
Direction: Southeast of Bulb Eater® 3				
2-feet	--	96	--	95
4-feet	--	97	--	93
6-feet	--	94	--	91

OSHA: Occupational Safety and Health Administration
PEL: Permissible Exposure Limit
TWA: Time Weighted Average
AL: Action Level
dBA: Decibels A-scale Slow Meter Response
--: Sound level ranges were not recorded, only average

Table 6
Direct-Reading Measurements for Mercury

Air Cycle Corporation
Lisle, Illinois
June 10, 2013

Bureau Veritas Project No. 07013-000035.00

Sample Point	Description	1st Reading (mg/m^3)	2nd Reading (mg/m^3)	3rd Reading (mg/m^3)	4th Reading (mg/m^3)
Test 1 – Warehouse (884 Lamps Crushed)					
Start Time		0956	1015	1030	1048
End Time		1000	1020	1035	1052
Ambient Temperature: 75 ^{O}F					
A1	Ambient Hg concentration before test cycle (4-6 " above floor, 5-6 ft. from drum)	0.0003	--	--	--
A2	Ambient Hg concentration 30 min. into test cycle, motor on (4-6" above floor, 5-6 ft. from drum)	--	0.0032	--	--
A3	Ambient Hg concentration after test cycle, motor off (4-6" above floor, 5-6 ft. from drum)	--	--	--	0.0006
B	Fluorescent lamp chute entry point	0.0001	0.0005	0.0007	0.0008
C	Motor housing area	0.0003	0.0020	0.0010	0.0006
I	Filter air exit	0.0001	0.0006	0.0011	0.0006
L	Fluorescent lamp chute entry connection to drum top	0.0002	0.0003	0.0010	0.0005
M	Drum lid rim area near chute entry connection to drum top	0.0002	0.0005	0.0011	0.0004
N	Drum lid rim area near safety cover (opposite of M)	0.0002	0.0004	0.0007	0.0005
OBZ	Operator breathing zone	0.0002	0.0006	0.0009	0.0007
P	Airlock connection to cyclone filter	0.0002	0.0005	0.0009	0.0005
Q	Cyclone filter connection to flexible hose	0.0002	0.0003	0.0009	0.0006
R	Flexible hose connection to filter lid	0.0003	0.0005	0.0011	0.0007
S	Filter lid connection to filter housing	0.0003	0.0007	0.0008	0.0006
T	Filter housing connection to vacuum	0.0003	0.0008	0.0008	0.0006
U	Vacuum connection to carbon canister	0.0002	0.0009	0.0008	0.0006
V	Safety cover	0.0002	0.0006	0.0009	0.0005
W	Belt of all-in-one chute	0.0003	--	--	0.0018[a]
X	Compact fluorescent lamp hopper (open safety cover while crushing linear lamps)	0.0002	--	--	0.0017[a]
Y1	Fluorescent lamp chute entry point (full drum, machine not running) (not shown in figure)	0.0005	--	--	0.0018[a]
Y2	Filtered air exit (full drum, machine not running) (not shown in figure)	--	--	--	0.0005
Y3	Max reading from drum lid rim area circumference (full, sealed drum) (not shown in figure)	--	--	--	0.0008
Z1	Operator breathing zone (during filter replacement) (not shown in figure)	--	--	--	**0.190**
Z2	Operator breathing zone (during drum change-out) (not shown in figure)	--	--	--	**0.416**

mg/m^3: Milligrams per cubic meter of air
[a]: Direct-reading measurements collected after crushing 20 U-lamps
--: No measurement collected
Note: The DRI values highlighted in blue are the peak instantaneous or highest recorded values during a 30 second measurement period.

Table 6 (continued)
Direct-Reading Measurements for Mercury
Air Cycle Corporation
Lisle, Illinois
June 10, 2013

Bureau Veritas Project No. 07013-000035.00

Sample Point	Description	1st Reading (mg/m^3)	2nd Reading (mg/m^3)	3rd Reading (mg/m^3)	4th Reading (mg/m^3)
Test 2 – Office (878 Lamps Crushed)					
Start Time		1204	1230	1248	1305
End Time		1210	1236	1253	1310
Ambient Temperature: 70 ^{O}F					
A1	Ambient Hg concentration before test cycle (4-6 " above floor, 5-6 ft. from drum)	0.0001	--	--	--
A2	Ambient Hg concentration 30 min. into test cycle, motor on (4-6" above floor, 5-6 ft. from drum)	--	0.0030	--	--
A3	Ambient Hg concentration after test cycle, motor off (4-6" above floor, 5-6 ft. from drum)	--	--	--	0.0007
B	Fluorescent lamp chute entry point	0.0007	0.0023	0.0014	0.0006
C	Motor housing area	0.0007	0.0021	0.0006	0.0009
I	Filter air exit	0.0008	0.0010	0.0005	0.0009
L	Fluorescent lamp chute entry connection to drum top	0.0006	0.0018	0.0009	0.0009
M	Drum lid rim area near chute entry connection to drum top	0.0006	0.0019	0.0009	0.0009
N	Drum lid rim area near safety cover (opposite of M)	0.0006	0.0018	0.0009	0.0009
OBZ	Operator breathing zone	0.0007	0.0020	0.0009	0.0007
P	Airlock connection to cyclone filter	0.0007	0.0018	0.0009	0.0009
Q	Cyclone filter connection to flexible hose	0.0007	0.0018	0.0009	0.0009
R	Flexible hose connection to filter lid	0.0007	0.0017	0.0015	0.0010
S	Filter lid connection to filter housing	0.0015	0.0019	0.0011	0.0009
T	Filter housing connection to vacuum	0.0009	0.0026	0.0019	0.0009
U	Vacuum connection to carbon canister	0.0010	0.0017	0.0009	0.0009
V	Safety cover	0.0007	0.0018	0.0009	0.0009
W	Belt of all-in-one chute	0.0024	--	--	0.0007[a]
X	Compact fluorescent lamp hopper (open safety cover while crushing linear lamps)	0.0038	--	--	0.0005[a]
Y1	Fluorescent lamp chute entry point (full drum, machine not running) (not shown in figure)	0.0021	--	--	0.0070[a]
Y2	Filtered air exit (full drum, machine not running) (not shown in figure)	--	--	--	0.0006
Y3	Max reading from drum lid rim area circumference (full, sealed drum) (not shown in figure)	--	--	--	0.0092
Z1	Operator breathing zone (during filter replacement) (not shown in figure)	--	--	--	**0.192**
Z2	Operator breathing zone (during drum change-out) (not shown in figure)	--	--	--	**0.157**

mg/m^3: Milligrams per cubic meter of air
[a]: Direct-reading measurements collected after crushing 20 U-lamps
--: No measurement collected
Note: The DRI values highlighted in blue are the peak instantaneous or highest recorded values during a 30 second measurement period.

Table 7

Direct-Reading Measurements for Mercury During Filter Replacement and Drum Change-out Tasks

Air Cycle Corporation
Lisle, Illinois
June 10, 2013

Bureau Veritas Project No. 07013-000035.00

	Run Time: Full Drum Time After Shut Off: 10 Minutes			
	Measurement Period: Approximately 30 seconds			
	Drum Change #1	Drum change #2	Filter Replacement #1	Filter Replacement #2
	(mg/m^3) per second	(mg/m^3) per second	(mg/m^3) per second	(mg/m^3) per second
	0.0006	0.0024	0.0020	0.0009
	0.0007	0.0024	0.0041	0.0010
	0.0011	0.0024	0.0109	0.0013
	0.0022	0.0024	0.0201	0.0033
	0.0175	0.0051	0.034	0.0150
	0.0632	0.0139	0.0835	0.0496
	0.1231	0.0282	0.1507	0.0882
	0.2070	0.0554	0.1795	0.1364
	0.2999	0.0943	0.1901	0.1781
	0.3685	0.1569	0.1433	0.192
	0.4160	0.0593	0.1149	0.1654
	0.3962	0.0968	0.1055	0.1306
	0.3362	0.1124	0.1006	0.0875
	0.0271	0.1137	0.0956	0.0522
	0.2100	0.0964	0.0952	0.0313
	0.1652	0.0599	0.0973	0.0214
	0.1371	0.0309	0.0979	0.0181
	0.1198	0.0196	0.0970	0.0180
	0.1105	0.0156	0.0976	0.0177
	0.1038	0.0137	0.0936	0.0168
	0.0966	0.0127	0.0857	0.0162
	0.0847	0.0117	0.0769	0.0147
	0.0745	0.0105	0.0669	0.0114
	0.0634	0.0091	0.0550	0.0085
	0.0519	0.0080	0.0439	0.0073
	0.0417	0.0075	0.0334	0.0062
	0.0323	0.0076	0.0249	0.0048
	0.0238	0.0076	0.0192	0.0040
	0.0176	0.0073	0.0157	0.0037
	0.0142	0.0071	0.0129	0.0036
Number of 1 sec readings > ACGIH limit (0.025 mg/m^3)	22	11	22	10
Number of 1 sec readings > OSHA limit (0.100 mg/m^3)	14	3	7	5

mg/m^3: Milligrams per cubic meter

Note: The yellow highlighted values are the peak values during each task

APPENDIX B

Bureau Veritas Laboratory Report

June 18, 2013

Alma Herrera
BUREAU VERITAS - CHICAGO
4343 Commerce Court
Suite 120 & 120A
Lisle, IL 60532

Bureau Veritas Work Order No. 13060509

Reference: 07013-000035.00/

Dear Alma Herrera:

Bureau Veritas North America, Inc. received 17 samples on June 11, 2013 for the analyses presented in the following report.

Enclosed is a copy of the Chain-of-Custody record, acknowledging receipt of these samples. Please note that any unused portion of the samples will be discarded 30 days after the date of this report, unless you have requested otherwise.

This material is confidential and is intended solely for the person to whom it is addressed. If this is received in error, please contact the number provided below.

We appreciate the opportunity to assist you. If you have any questions concerning this report, please contact a Client Services Representative at (800) 806-5887.

Sincerely,

Karen Coonan

Karen Coonan

Client Services Representative
Electronic signature authorized through password protection

Bureau Veritas North America, Inc.
Health, Safety, and Environmental Services
22345 Roethel Drive
Novi, MI 48375
Main: (248) 344.1770
Fax: (248) 344.2655
www.us.bureauveritas.com

CASE NARRATIVE

Date: *18-Jun-13*

CLIENT: BUREAU VERITAS - CHICAGO

Project: 07013-000035.00/

Work Order No 13060509

The results of this report relate only to the samples listed in the body of this report.

Unless otherwise noted below, the following statements apply: 1) all samples were received in acceptable condition, 2) all quality control results associated with this sample set were within acceptable limits and/or do not adversely affect the reported results, and 3) the industrial hygiene results have not been blank corrected.

ANALYTICAL RESULTS

Date: *18-Jun-13*

Client: **BUREAU VERITAS - CHICAGO**

Project: **07013-000035.00/** **Work Order No: 13060509**

Sample Identification: **4600202226**

Lab Number: **001A** **Date Sampled: 6/10/2013**

Sample Type: **Hopcalite Tube** **Date Received: 6/11/2013**

Analyst: **RS** **Air Volume (L): 3.44**

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.015	<0.0018	0.05	NIOSH 6009	06/14/2013

Sample Identification: **4600202230**

Lab Number: **002A** **Date Sampled: 6/10/2013**

Sample Type: **Hopcalite Tube** **Date Received: 6/11/2013**

Analyst: **RS** **Air Volume (L): 21.8**

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.0023	<0.00028	0.05	NIOSH 6009	06/14/2013

Sample Identification: **4600202228**

Lab Number: **003A** **Date Sampled: 6/10/2013**

Sample Type: **Hopcalite Tube** **Date Received: 6/11/2013**

Analyst: **RS** **Air Volume (L): 22.09**

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.0023	<0.00028	0.05	NIOSH 6009	06/14/2013

ANALYTICAL RESULTS

Date: *18-Jun-13*

Client: BUREAU VERITAS - CHICAGO

Project: 07013-000035.00/ **Work Order No:** 13060509

Sample Identification: 4600202224

Lab Number: 004A **Date Sampled:** 6/10/2013

Sample Type: Hopcalite Tube **Date Received:** 6/11/2013

Analyst: RS **Air Volume (L):** 23.31

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.0021	<0.00026	0.05	NIOSH 6009	06/14/2013

Sample Identification: 4600202231

Lab Number: 005A **Date Sampled:** 6/10/2013

Sample Type: Hopcalite Tube **Date Received:** 6/11/2013

Analyst: RS **Air Volume (L):** 22.89

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.0022	<0.00027	0.05	NIOSH 6009	06/14/2013

Sample Identification: 4600202229

Lab Number: 006A **Date Sampled:** 6/10/2013

Sample Type: Hopcalite Tube **Date Received:** 6/11/2013

Analyst: RS **Air Volume (L):** 23.09

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.0022	<0.00026	0.05	NIOSH 6009	06/14/2013

ANALYTICAL RESULTS

Date: *18-Jun-13*

Client: BUREAU VERITAS - CHICAGO

Project: 07013-000035.00/ **Work Order No:** 13060509

Sample Identification: 4643100665

Lab Number: 007A **Date Sampled:** 6/10/2013

Sample Type: Hopcalite Tube **Date Received:** 6/11/2013

Analyst: RS **Air Volume (L):** 4.73

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.011	<0.0013	0.05	NIOSH 6009	06/14/2013

Sample Identification: 4643100663

Lab Number: 008A **Date Sampled:** 6/10/2013

Sample Type: Hopcalite Tube **Date Received:** 6/11/2013

Analyst: RS **Air Volume (L):** 22.84

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.0022	<0.00027	0.05	NIOSH 6009	06/14/2013

Sample Identification: 4643100660

Lab Number: 009A **Date Sampled:** 6/10/2013

Sample Type: Hopcalite Tube **Date Received:** 6/11/2013

Analyst: RS **Air Volume (L):** 22.91

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.0022	<0.00027	0.05	NIOSH 6009	06/14/2013

ANALYTICAL RESULTS

Date: *18-Jun-13*

Client: BUREAU VERITAS - CHICAGO

Project: 07013-000035.00/ **Work Order No:** 13060509

Sample Identification: 4643100657

Lab Number: 010A **Date Sampled:** 6/10/2013

Sample Type: Hopcalite Tube **Date Received:** 6/11/2013

Analyst: RS **Air Volume (L):** 23.25

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.0022	<0.00026	0.05	NIOSH 6009	06/14/2013

Sample Identification: 4643100666

Lab Number: 011A **Date Sampled:** 6/10/2013

Sample Type: Hopcalite Tube **Date Received:** 6/11/2013

Analyst: RS **Air Volume (L):** 23.97

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.0021	<0.00025	0.05	NIOSH 6009	06/14/2013

Sample Identification: 4643100661

Lab Number: 012A **Date Sampled:** 6/10/2013

Sample Type: Hopcalite Tube **Date Received:** 6/11/2013

Analyst: RS **Air Volume (L):** 24.19

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	<0.0021	<0.00025	0.05	NIOSH 6009	06/14/2013

ANALYTICAL RESULTS

Date: *18-Jun-13*

Client: **BUREAU VERITAS - CHICAGO**

Project: **07013-000035.00/** **Work Order No: 13060509**

Sample Identification: **4643100662 BLANK**

Lab Number: **013A** **Date Sampled: 6/10/2013**

Sample Type: **Hopcalite Tube** **Date Received: 6/11/2013**

Analyst: **RS** **Air Volume (L): NA**

Analyte	Analytical Results (µg)	Analytical Results (mg/m^3)	Analytical Results (ppm)	Reporting Limit (µg)	Test Method	Date Analyzed
Mercury	<0.05	--	--	0.05	NIOSH 6009	06/14/2013

General Notes:
<: Less than the indicated reporting limit (RL).
--: Information not available or not applicable.
Back sections (if applicable) were checked and showed no significant breakthrough unless otherwise noted.

ANALYTICAL RESULTS

Date: *18-Jun-13*

Client: BUREAU VERITAS - CHICAGO

Project: 07013-000035.00/

Sample Type: Wipe

Method Reference OSHA ID-145

RL (µg): 0.1

Work Order No: 13060509

Date Received: 6/11/2013

Analyst: RS

Lab No.	Sample Identification	Date Collected	Air Volume (liters)	Mercury (µg)	Mercury (mg/m^3)	Mercury (ppm)	Date Analyzed
014A	D1-1	06/10/13	0	0.17	--	--	06/18/2013
015A	D1-2	06/10/13	0	23	--	--	06/18/2013
016A	D2-1	06/10/13	0	2.6	--	--	06/18/2013
017A	D2-2	06/10/13	0	2.3	--	--	06/18/2013

General Notes:
<: Less than the indicated reporting limit (RL).
--: Information not available or not applicable.
Back sections (if applicable) were checked and showed no significant breakthrough unless otherwise noted.

Request for Laboratory Analytical Services

For Lab Use Only

Lab Project No.

130160509

Bureau Veritas North America, Inc.

Report results to:

Name: Alma Herrera. Alma.herrera@us.bureauveritas.com
Company: Bureau Veritas North America
Mailing Address: 4343 Commerce Court, Suite 120
City, State, Zip: Lisle, Illinois 60532
Telephone No: 708-595-1338

Bureau Veritas Project Number: 07013-000035.00
Client: Air Cycle Corporation
Client Address: 2200 Ogden Avenue, Suite 100
Client City, State: Lisle, IL

Collected by: Alma R. Herrera **Collector's Signature:** Alma R. Herrera
Relinquished by: Alma R. Herrera **Date/Time** 6-10-13 2030 **Received by:** [signature] **Date/Time** 6/11 11:45
Relinquished by: **Date/Time** **Received by:** **Date/Time**
Method of Shipment: FedEx **Sample Condition on Receipt:**
Authorized by: Alma R. Herrera **Acceptable:** ✓ **Other: (Explain)**

Client Sample Identification	Date Sampled	Matrix/Media	Time Sampled (minutes)	Air Volume (Liters)	ANALYSIS REQUESTED (List each analyte on the lines below, multiple analytes per line)
✓ 4600202226	6/10/2013	Carulite (Hydrar)	15.00	3.44	Mercury
✓ 4600202230	6/10/2013	Carulite (Hydrar)	95.00	21.80	Mercury
✓ 4600202228	6/10/2013	Carulite (Hydrar)	94.00	22.09	Mercury
✓ 4600202224	6/10/2013	Carulite (Hydrar)	99.00	23.31	Mercury
✓ 4600202231	6/10/2013	Carulite (Hydrar)	97.00	22.89	Mercury
✓ 4600202229	6/10/2013	Carulite (Hydrar)	96.00	23.09	Mercury
✓ 4643100665	6/10/2013	Carulite (Hydrar)	19.00	4.73	Mercury
✓ 4643100663	6/10/2013	Carulite (Hydrar)	91.00	22.84	Mercury
✓ 4643100660	6/10/2013	Carulite (Hydrar)	92.00	22.91	Mercury
✓ 4643100657	6/10/2013	Carulite (Hydrar)	93.00	23.25	Mercury
✓ 4643100666	6/10/2013	Carulite (Hydrar)	94.00	23.97	Mercury
✓ 4643100661	6/10/2013	Carulite (Hydrar)	96.00	24.19	Mercury
✓ 4643100662	6/10/2013	Carulite (Hydrar)	0.00	0.00	Mercury
✓ D1-1	6/10/2013	Wipe	0.00	0.00	Mercury
✓ D1-2	6/10/2013	Wipe	0.00	0.00	Mercury
✓ D2-1	6/10/2013	Wipe	0.00	0.00	Mercury
✓ D2-2	6/10/2013	Wipe	0.00	0.00	Mercury

APPENDIX C

Equipment and Assessment Procedures

EQUIPMENT AND ASSESSMENT PROCEDURES

Air Cycle Corporation
Lisle, Illinois

Bureau Veritas Project No. 07013-000035.00

Visit Date: June 10, 2013

Test Procedure

Bureau Veritas followed Air Cycle Corporation's test procedure as described in the Protocol for Bulb Eater® *3* Testing document sent to Bureau Veritas on June 7, 2013.

Air Cycle Corporation's Protocol for Bulb Eater® 3 Testing

Crush one drum-full (approximately 880 lamps) each in open warehouse area and closed office space over 60-90 minute period. Use following procedure for each drum-full test:

1. Record ambient temperature.
2. Perform wipe test on drum top before lamp crushing session.
3. Use collection tube/air pump at following locations (total of 6):
    i. 2 on machine operator.
        a. 1 stops after approximately 200 lamps (with no drum/filter change-out), while other pump runs for duration of total test.
    ii. 1 on separate operator assistant that helps during drum change.
    iii. 1 at exhaust of carbon filter.
    iv. 1 at 10-20 feet away from machine.
    v. 1 at lamp staging area.
4. Test for noise levels:
    i. Personal noise exposure levels on person operating the machine.
    ii. General sound level during machine operation utilizing a Sound Level Monitor (supplied by Bureau Veritas) during machine operation.
    iii. Measurements near machine in same locations as Direct Reading Instrument.
5. Use Direct Reading Instrument to collect data at the sampling points noted on the attached Sample Point Diagram (points A1 through V) at distance of approx. 2 inches.
    i. Sniff sample points at 10-15 minute intervals until drum is full.
    ii. At an intermediate time or drum level crush CFLs and/or u-bend lamps, and take sniff points on all-in-one chute as noted in attached diagram (points W and X).
6. Perform wipe test on drum top after lamp crushing session.
7. Use Direct Reading Instrument to collect data at the sampling points noted on the attached diagram (points Y1 through Y3) during non-operational period.
    i. With BE-3 not running, attached to full drum of crushed lamps.
        a. At lamp chute entry point.

b. At filtered air exit.

ii. On sealed drum of crushed lamps

8. Use Direct Reading Instrument to collect data during filter replacement and drum change-out at distance of approximately 2 inches from operator. (points Z1 and Z2 in attached diagram).
   i. Using Direct Reading Instrument (probe at operator's breathing level)
   ii. With collection tube/air pump on operator

Personal and Area Air Sampling

Bureau Veritas collected the personal and area air samples for mercury vapor with portable battery-powered sampling pumps by passing air at the recommended flowrate through the collection media presented in the Sampling and Analytical Methods Table. Sample collection media was placed near the employee's breathing zone and connected to the sampling pump's air inlet with Tygon® tubing. Each sampling pump's flowrate was measured with a primary calibration standard, Bios DryCal® Defender 510 calibrator (serial number 113857, calibrated on 4/1/13), before and after the monitoring session. The Bios DryCal® Defender 510 calibration certificate is provided in Appendix E.

Breathing zone samples were collected by attaching the sampler in the "breathing zone" of the operator(s) being monitored. The "breathing zone" is defined as a hemisphere forward of the shoulders with a radius of approximately 6 to 9 inches.

Laboratory Analyses of Personal and Area Air Samples

All samples for laboratory analysis collected during this assessment were analyzed by the Bureau Veritas Novi, Michigan Laboratory, which is accredited by the American Industrial Hygiene Association (AIHA), Laboratory # 100967. To review the scope of accreditation, visit the accreditation organization website at www.aiha.org.

SAMPLING AND ANALYTICAL METHODS			
Substance	**Flow Rate (LPM)**	**Sampling Media**	**Analytical Method**
Mercury	0.250	Hopcalite tube, SKC 226-17-1A	NIOSH 6009 AA Cold Vapor

NIOSH: National Institute of Occupational Safety and Health
LPM: Liters per minute

Direct Reading Instrument Measurements

A factory calibrated mercury vapor meter(on 3/14/2013), Mercury Tracker 3000 IP direct reading instrument (DRI), was used to measure concentrations in the ambient air before, after, and during each test cycle at all mechanical connections, junctures, and openings where mercury vapor could be emitted. The Mercury Tracker 3000 IP was also used to spot check mercury vapor concentrations in the

operator's breathing zone, to check for mercury surface contamination on the unit and waste drum, and to measure breathing zone mercury vapor concentrations during waste drum change-out operations.

The Mercury Tracker 3000 IP is manufactured by Mercury Instruments GmbH Analytical Technologies in Germany and is distributed by Mercury Instruments USA, Littleton, Colorado. The instrument has a range of 0.0000 to 2,000 milligrams of mercury per cubic meter (mg/m^3) of air, an accuracy of 0.0001 mg/m^3, and a mercury vapor sensitivity of 0.0001 mg/m^3. The instrument's response time is continuous (which has no measuring cycles or regenerations required) and the microprocessor automatically re-zeroes the digital meter every minute. The Mercury Tracker 3000 IP direct reading instrument was operated continuously during every period of the test cycles.

Quantitative Sampling of Mercury Surface Contamination

A mercury surface sampling wipe was used to quantify the concentration of mercury on the surface of the Bulb Eater® *3* assembly on the waste drums before and after each test cycle. The sampling wipe was completely unfolded and used to wipe the circumference of the Bulb Eater® *3* lid/drum assembly. The sampling wipe was then folded in half and the circumference was wiped a second time. The sampling wipe was then folded a third time and the circumference was wiped a third time. The wipe samples were analyzed using the OSHA ID-145 Method.

Noise and Sound Level Measurements

Noise exposures were monitored with a Cirrus® DoseBadge set for an 80 dBA threshold, 5 dB exchange rate, and an 80-130 dBA range, according to OSHA regulations/criteria. The dosimeter (serial number CA476) was calibrated before and after each measurement with Cirrus® Badge Reader, serial number 40274 (calibrated on September 17, 2012). The results of these measurements are shown in Table 4 in Appendix A. The calibration certificates for the personal noise dosimetry dose badge and the calibrator are provided in Appendix E.

The last column in the Noise Dosimeter Measurements table is the Equivalent 8-hour TWA noise level in dBA. The equivalent 8-hour TWA noise level in dBA was calculated from the following formula:

$$Eq.\,8-hr.\,TWA = 90\ dBA + 16.61 * Log_{10}\left(\frac{D}{100} * \frac{Shift\ time - break\ time}{Sample\ time - break\ time\ during\ sample}\right)$$

Where: D is the noise dose in % measured by the noise dosimeter during the sample time.
The above formula assumes break time is taken in an area where the noise level is below 80 dBA.

A Casella™ CEL-63X sound level meter (serial number 0711798, calibrated on February 15, 2013) was used to measure general area noise levels. The meter was calibrated with a Casella™ calibrator Model CEL-110/2 (serial number 021137, calibrated on February 15, 2013). The results of these measurements are provided in the Table 5 in Appendix A. The calibration certificates for the sound level meter and the calibrator are provided in Appendix E.

Bulb Eater® 3 testing set-up showing portable battery-powered sampling pump and Mercury Tracker 3000 IP

Mercury Tracker 3000 IP panel face

Air samples for mercury vapor taken with calibrated, portable battery-powered sampling tube/pumps

Noise exposures were monitored with Cirrus® DoseBadges and air samples for mercury vapor were taken with calibrated, portable battery-powered sampling pumps on Bulb Eater® *3*'s operator, Ged Zukas

Alma Herrera, Industrial Hygenist, collecting data with the Mercury Tracker 3000 IP

Alma Herrera, Industrial Hygenist, collecting data w/ Mercury Tracker 3000 IP

APPENDIX D

Abbreviations and Glossary

ABBREVIATIONS AND GLOSSARY

Air Cycle Corporation
Lisle, Illinois

Bureau Veritas Project No. 07013-000035.00

Visit Date: June 10, 2013

Abbreviations

Abbreviation	Description
ACGIH	American Conference of Governmental Industrial Hygienists
CIH	Certified Industrial Hygienist
dBA	Decibels in the A-weighting scale
DRI	Direct Reading Instrument
ft	Foot or Feet
HEPA	High Efficiency Particulate Air
Hg	Mercury
in	Inch
in^2	Square Inch
mg	Milligram
mg/m^3	Milligram per cubic meter of air
OSHA	Occupation Safety and Health Administration
PEL	Permissible Exposure Limit
PPE	Personal Protective Equipment
T-8	Tubular, 1-inch diameter, linear fluorescent lamp
T-12	Tubular, 1.5-inch diameter, linear fluorescent lamp
TLV	Threshold Limit Value
TWA	Time-Weighted Average

Glossary

American Conference of Governmental Industrial Hygienists (ACGIH®). The American Conference of Governmental Industrial Hygienists *Threshold Limit Values for Chemical Substances and Physical Agents, and Biological Exposure Indices*, 2013 Edition. The ACGIH TLVs are guidelines and are not enforceable as a government regulation. The ACGIH states that their TLVs are intended to be applied only by persons trained in industrial hygiene and should be used in the control of occupational health hazards, and they should not be used as fine lines between safe and unsafe conditions.

Fluorescent Lamp. Discharge lamp of the low-pressure mercury type in which most of the light is emitted by a layer of fluorescent material excited by the ultraviolet radiation from the discharge. This term is most commonly applied to low-pressure tubular fluorescent lamps.

Permissible Exposure Limit (PEL). The allowable 8-hour time-weighted average regulatory exposure limit for an air contaminant established by OSHA to which nearly all workers may be repeatedly exposed on a daily basis without adverse health effects.

Threshold Limit Value (TLV). Refers to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. TLVs, as issued by ACGIH, are recommendations and should be used as guidelines for good practices.

Time-weighted average (TWA). The average airborne exposure in an 8-hour work shift of a 40-hour workweek established by OSHA that will not be exceeded .

U.S. Occupational Safety and Health Administration (OSHA). An agency of the U.S. Department of Labor, which is the regulatory and enforcement agency for occupational safety and health in most U.S. industrial sectors. This Federal agency lists over 500 substances as air contaminants and establishes the limits of exposure by inhalation to these substances.

APPENDIX E

Equipment Calibration Certificates

Certificate of Calibration

Air Cycle

Tracker 3000IP

Serial Number 0510/756

Cal Factor as left: 1.15

Cal. Performed: March 14, 2013

Cal. Expires: March 14, 2014

Calibration Device: MC 3000 Mercury Calibrator serial # 1005/006.
MC 3000 utilizes the Mercury Vapor Function NIST IR6643. Huber, Laesecke, Friend.
Mass flow controllers have been calibrated against standards which are supported by NIST test#18010C

Signature

3-14-13

Date

mercury INSTRUMENTS

Air Cycle Corporation

CALIBRATION REPORT

mercury INSTRUMENTS

Calibration ID: 537794
Instrument: Tracker 3000IP
Serial Number: 0510/756
Calibration Date: 3/14/2013
Calibration Expires: 3/14/2014

3/14/2013

Dear MR. Sklenar,

Please find enclosed the annual maintenance and calibration report for your , serial number 0510/756.

We would like to thank you for taking the time to properly maintain and calibrate your mercury instrument. Please do not hesitate to contact us at (303) 972-3740 and feel free to visit us on line at www.mercury-usa.com

Thank you for your continued business and we look forward to working with you in the future.

Best Regards,

Nick Hummell
Mercury Instruments USA

Air Cycle Corporation
Calibration ID: 537794
Instrument: Tracker 3000IP
Serial Number: 0510/756
Calibration Date: 3/14/2013
Calibration Expires: 3/14/2014

Calibration Report #537794

	1	2	3	4	5
Reference Gas Concentration µg/m³ Hg° Reference to 20°C & 101.3 KPa (760 torr)	33.17 U (k = 2) .51 ug/m³ 1.5% Relative	69.97 U (k = 2) 1.82 ug/m³ 2.6% Relative	111.66 U (k = 2) 1.63 ug/m³ 1.5% Relative	148.12 U (k = 2) 2.29 ug/m³ 1.5% Relative	186.77 U (k = 2) 2.75 ug/m³ 1.5% Relative
Instrument reading µg/m³ Hg° Cal Factor as found = 1.26	35.6	77.1	120.3	158.1	204.6
Instrument Reading µg/m³ Hg° Cal Factor as left = 1.15	33.5	70.3	111.6	148.4	186.6
Pump Volume = 1.84l/m					

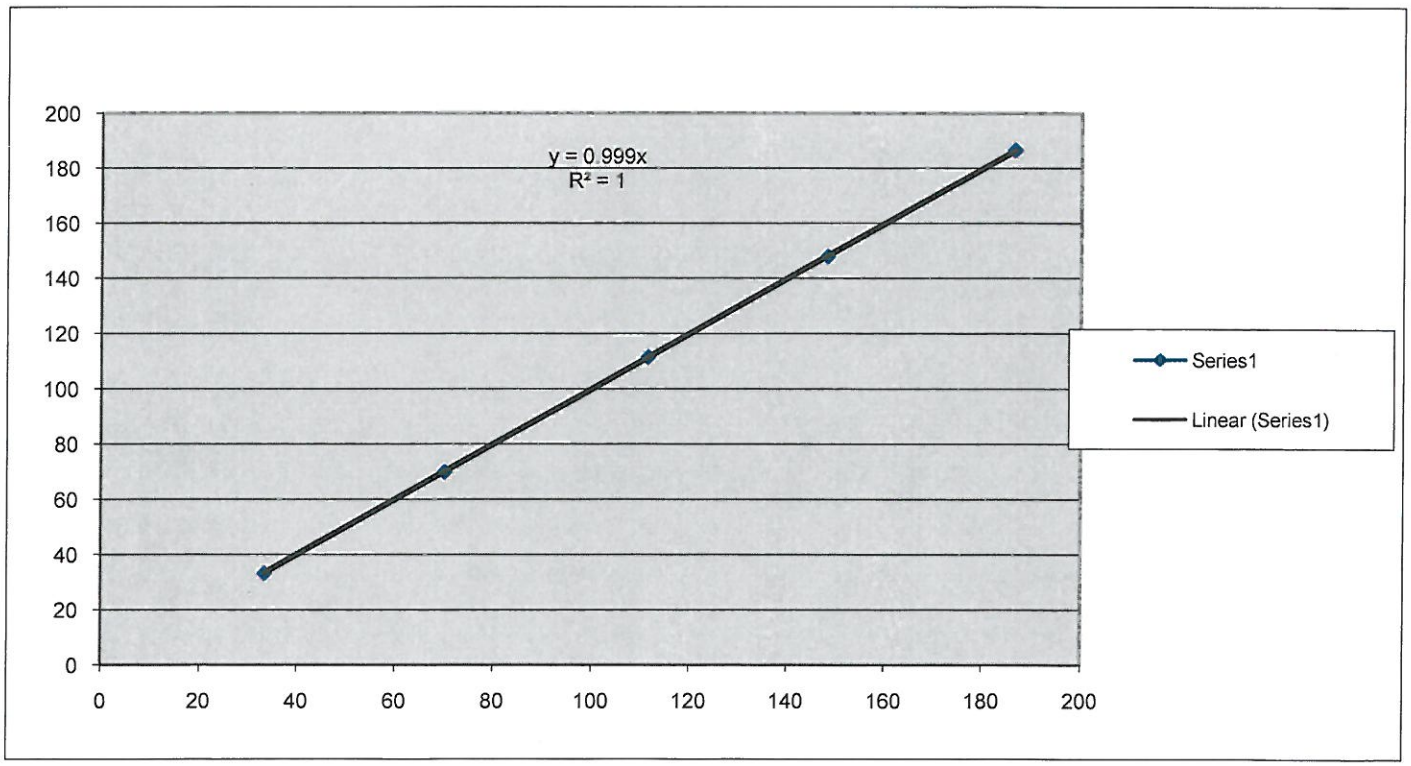
Calibration Device:
MC 3000 Calibrator Serial # 081011099 NIST Vendor Prime
Certified by NIST Material Measurements Laboratory Analytical Chemistry Division
Gaithersburg, MD 20899-8393
NIST report # 639.03-12-141

Annual Service

- ✓ Replacement of carbon filter
- ✓ Replacement of all internal tubing
- ✓ Thorough cleaning of instrument
- ✓ Decontamination of glassware
- ✓ Deep cleansing of all fittings
- ✓ Complete electronic function check
- ✓ 5 Point Calibration with MC3000 Mercury Calibrator

Calibration Factor as left **1.15**

Instrument Readings (ug/m3)	Reference Gas (ug/m3)	U (k = 2) ug/m3	U (k = 2) % Relative
33.5	33.17	**0.51**	**1.5**
70.3	69.97	**1.82**	**2.6**
111.6	111.66	**1.63**	**1.5**
148.4	148.12	**2.29**	**1.5**
186.6	186.77	**2.75**	**1.5**



Device Data serial #0510/756

Operational Hours	8354
Lamp Voltage	6.40V
Software Version	2.80
Absorbance Test	PASS
No Pressure Cal. Gradient (pt correct only)	
No Pressure Cal. Constant (pt correct only)	
Data Logger Option	Yes
Combi Version	No

Notes:

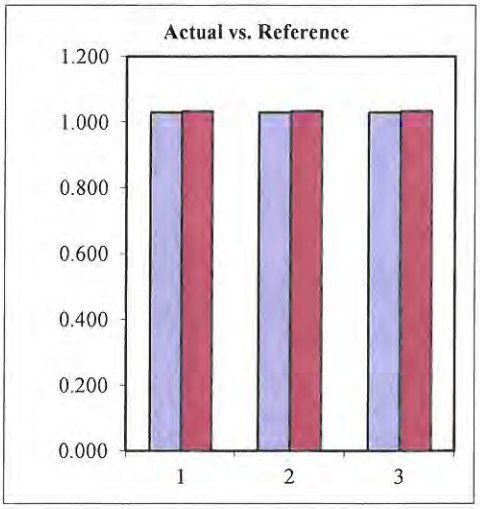
Mercury Tracker 3000IP received an annual service and calibration. On the date calibrated, this instrument operated within specified tolerances.

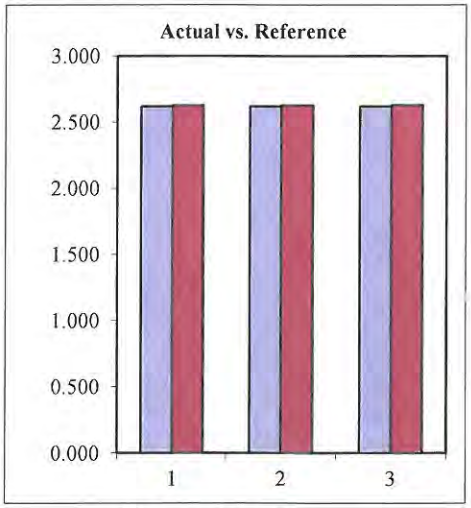
CERTIFICATE OF CALIBRATION

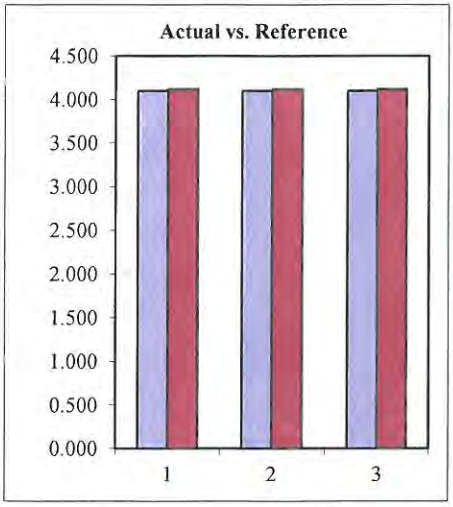
Primary Flow Calibrator

Manufacturer:	Bios	**Calibration Date:**	April 1, 2013
Model Number:	510-M	**Date Due:**	April 1, 2014
Serial Number:	113857	**Temperature:**	72.1 °F
Service Order:	13199	**Relative Humidity:**	31 %
Reference Number:	13199-510M-113857	**Pressure:**	30.08 inHG

@ 1.0 LPM	Reference L/min	Actual L/min	Relative Difference	Percent Difference
1	1.029	1.0327	0.004	0.36%
2	1.029	1.0328	0.004	0.37%
3	1.029	1.0331	0.004	0.40%
@ 2.6 LPM				
1	2.618	2.6263	0.008	0.32%
2	2.618	2.6264	0.008	0.32%
3	2.618	2.6269	0.009	0.34%
@ 4.1 LPM				
1	4.099	4.1173	0.018	0.44%
2	4.099	4.1173	0.018	0.44%
3	4.099	4.1173	0.018	0.44%







Standards

Manufacturer	Description	Model No.	Serial No.	Certificate No.	Due Date
TSI	Mass Flow Meter	4043	40430838004	N/A	10/8/2013

CIH Equipment Company, Inc. certifies that the instrument specified above meets the manufacturer specifications and was calibrated using standards traceable to National Institute of Standards and Technology (NIST) or have been derived from accepted values of natural physical constants or have been derived by the ratio type of self calibration techniques. The reported uncertainty of measurement is stated as the combined standard uncertainty multiplied by a coverage factor k = 2. The measured value and the associated expanded uncertainty represent the interval (y±U), which contains the value of the measured quantity with a probability of approximately a 95% confidence interval. The uncertainty was estimated following the guidelines of the ISO-17025 and the GUM. U = ±0.298%

Calibrated By: _____ Date: 04/01/13

Thomas Dickens - Calibration Technician

1806 South Highland Ave • Clearwater, FL 33756-1762 • USA • PH: (727) 584-5063 • FX: (727) 581-5921
Toll Free: (888) 873-2443 • Website: http://www.cihequipment.com

197 Cahaba Valley Pkwy
Pelham AL 35124
Phone : 888-464-3872
Fax : 205-980-5764
www.ohdusa.com

Certificate Of Calibration

Customer	Bureau Veritas
Calibration Number	19812-8822
Date Received	Friday, August 31, 2012
Manufacture	Cirrus Research,plc
Model	CR:110A
Serial #	**CA476**

Calibration Information

Date Calibrated **9/7/2012** Next Calibration Due By **9/6/2013**

Calibration Procedure CR_110_Validation_Procedure

Technician John Thompson

Standards Used to Perform Calibration

Manufacture	Model	Description	Serial Number	Reference #	Calibration Date
Cirrus Research	RC:100B	doseBadge Calibrator	038147	19182-7680	5/15/2012
Fluke	45	DMM	71055010	604319	1/5/2012
Fluke	45	DMM	6145041	604437	1/5/2012
TTI	TGA1241	Waveform Generator	294202	603754	1/4/2012

OHD,llc certifies that the unit listed above meets or exceeds all the current manufacturer's specifications. Furthermore it has been calibrated with the instruments listed above, whose accuracies are traceable to the National Institute of Standards and Technlogy(NIST). Devices for which there are no NIST calibration standards are measured aqainst in-house performance standards using accepted test procedures.

Approved By

OCCUPATIONAL HEALTH DYNAMICS
OHD

197 Cahaba Valley Pkwy
Pelham AL 35124
Phone : 888-464-3872
Fax : 205-980-5764
www.ohdusa.com

Certificate Of Calibration

Customer Bureau Veritas
Calibration Number 19866-8942
Date Received Tuesday, September 11, 2012
Manufacture Cirrus Research,plc
Model RC:110A
Serial # **40274**

Calibration Information

Date Calibrated ***9/18/2012*** Next Calibration Due By ***9/17/2013***

Calibration Procedure RC_110A_Validation_Procedure
Technician John Thompson

As Found dBA Level	As Left dBA Level	As Found Frequency	As Left Frequency
114.11	114.00	1002.00	1002.00
Tolerance = 114.00dBA (+/- 0.3dBA) for dBA Level and 1000Hz (+/- 1.5%) for Frequency			

Standards Used to Perform Calibration

Manufacture	Model	Description	Serial Number	Reference #	Calibration Date
BK Tool Kit	2704B	DMM	34410050094	671722	5/17/2012
Cirrus Research	CR:511E	Acoustic Calibrator	033099	20121434-56896	5/9/2012
Cirrus Research	CR:811A	SLM	B15903FD-191	20121434-56901	5/9/2012

OHD,llc certifies that the unit listed above meets or exceeds all the current manufacturer's specifications. Furthermore it has been calibrated with the instruments listed above, whose accuracies are traceable to the National Institute of Standards and Technlogy(NIST). Devices for which there are no NIST calibration standards are measured aqainst in-house performance standards using accepted test procedures.

Approved By

CIH EQUIPMENT COMPANY, INC.

CERTIFICATE OF CALIBRATION

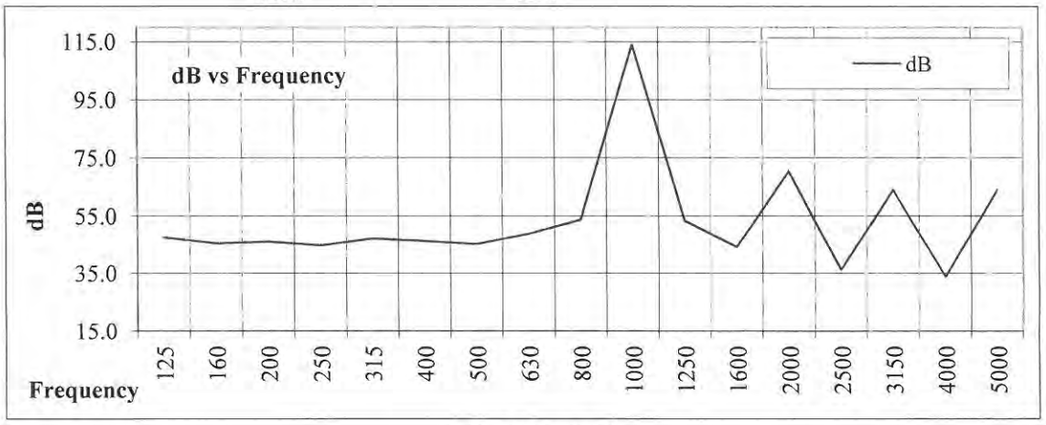
Acoustical Calibrator

Manufacturer:	Casella	**Calibration Date:**	February 15, 2013
Model Number:	CEL110/2	**Date Due:**	February 15, 2014
Serial Number:	021137	**Temperature:**	73.8 °F
Service Order:	12917	**Relative Humidity:**	53 %
Reference Number:	12917-CEL1102-021137	**Barometric Pressure:**	29.91 inHG

Frequency (HZ)	Linear dB
125	47.5
160	45.4
200	46.0
250	44.7
315	47.2
400	46.2
500	45.1
630	48.7
800	53.7
1000	114.0
1250	53.3
1600	44.1
2000	70.2
2500	36.3
3150	63.8
4000	33.8
5000	63.8

Center Frequency
1000.2 Hz

THD
0.004 %



STANDARDS

Manufacturer	Description	Model No.	Serial No.	Certificate No.	Due Date
RION	Sound Calibrator	NC-72	502474	25691	3/8/2013
Stanford Research	Function Generator	DS360	33001	A1199700	8/30/2013
Fluke	Multimeter	8840A/AF	AF407041	A1199701	8/30/2013
GRAS	Microphone	40AE	18833	25690	3/8/2013
E-MU	DAQ	EM8740A	8740050000648H	N/A	3/15/2013
Virtins Technology	Spectrum Analyzer	Pro v3.2	B0D1DD6C	N/A	3/15/2013

CIH Equipment Calibration Laboratory certifies that the instrument specified above meets the manufacturer's specifications and was calibrated using standards and instruments listed above where the accuracy is traceable to National Institute of Standards and Technology (NIST), and the calibration systems and records are in compliance to ANSI S1.40-1984

Calibrated By: _____ Date: 02/15/13

Thomas Dickens - Calibration Technician

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Toll Free: (888) 873-2443 • Website: http://www.cihequipment.com

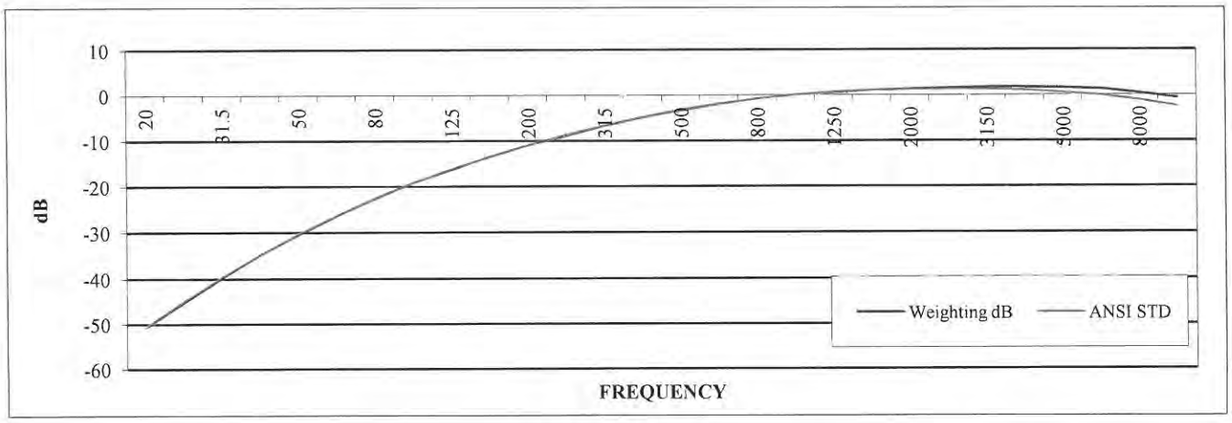
CIH EQUIPMENT COMPANY, INC.

CERTIFICATE OF CALIBRATION

Sound Level Meter Type 1

Manufacturer:	Casella	**Calibration Date:**	February 15, 2013
Model Number:	Cel-633B	**Date Due:**	February 15, 2014
Serial Number:	0711798	**Temperature:**	73.9 °F
Service Order:	12917	**Relative Humidity:**	55 %
Reference Number:	12917-Cel633B-0711798	**Barometric Pressure:**	29.91 inHG

Frequency (HZ)	Meter Actual Display (dB)	Meter Weighting dB	ANSI STD	Tolerance	Relative Difference
20	63.4	-50.6	-50.5	± 2.5	-0.1
25	69.0	-45.0	-44.7	± 2	-0.3
31.5	74.4	-39.6	-39.4	± 1.5	-0.2
40	79.4	-34.6	-34.6	± 1.5	0.0
50	83.7	-30.3	-30.2	± 1	-0.1
63	87.8	-26.2	-26.2	± 1	0.0
80	91.6	-22.4	-22.5	± 1	0.1
100	94.9	-19.1	-19.1	± 1	0.0
125	97.8	-16.2	-16.1	± 1	-0.1
160	100.7	-13.3	-13.4	± 1	0.1
200	103.1	-10.9	-10.9	± 1	0.0
250	105.2	-8.8	-8.6	± 1	-0.2
315	107.3	-6.7	-6.6	± 1	-0.1
400	109.1	-4.9	-4.8	± 1	-0.1
500	110.7	-3.3	-3.2	± 1	-0.1
630	112.0	-2.0	-1.9	± 1	-0.1
800	113.2	-0.8	-0.8	± 1	0.0
1000	114.0	0.0	0.0	± 1	0.0
1250	114.5	0.5	0.6	± 1	-0.1
1600	115.0	1.0	1.0	± 1	0.0
2000	115.3	1.3	1.2	± 1	0.1
2500	115.5	1.5	1.3	± 1	0.2
3150	115.7	1.7	1.2	± 1	0.5
4000	115.7	1.7	1.0	± 1	0.7
5000	115.6	1.6	0.5	± 1.5	1.1
6300	115.3	1.3	-0.1	+ 1.5 to - 2	1.4
8000	114.4	0.4	-1.1	+ 1.5 to - 3	1.5
10000	113.4	-0.6	-2.5	+ 2 to -4	1.9



STANDARDS

Manufacturer	Description	Model No.	Serial No.	Certificate No.	Due Date
RION	Sound Calibrator	NC-72	502474	25691	3/8/2013
Stanford Research	Function Generator	DS360	33001	A1199700	8/30/2013

CIH Equipment Calibration Laboratory certifies that the instrument specified above meets the manufacturer's specifications and was calibrated using standards and instruments also listed below where the accuracy is traceable to National Institute of Standards and Technology (NIST), and the calibration systems and records are in compliance to ANSI S1.4-1983

The reported uncertainty of measurement is stated as the combined standard uncertainty multiplied by a coverage factor k = 2. The measured value and the associated expanded uncertainty represent the interval (y±U), which contains the value of the measured quantity with a probability of approximately a 95% confidence interval. The uncertainty was estimated following the guidelines of the ISO 17025 and the GUM. U = ±0.37dB

Calibrated By: _____ Date: 02/15/13

Thomas Dickens - Calibration Technician

1806 South Highland Ave • Clearwater, FL 33756-1762 • USA • PH: (727) 584-5063 • FX: (727) 581-5921
Toll Free: (888) 873-2443 • Website: http://www.cihequipment.com

APPENDIX F

References

REFERENCES

Air Cycle Corporation
Lisle, Illinois

Bureau Veritas Project No. 07013-000035.00

Visit Date: June 10, 2013

1. Air Cycle Corporation Bulb Eater® *3* Owner's Manual

2. The American Conference of Governmental Industrial Hygienists *Threshold Limit Values for Chemical Substances and Physical Agents, and Biological Exposure Indices*, 2013 Edition.

3. U.S. Occupational Safety and Health Administration (OSHA) Code of Federal Regulations (CFR) Title 29 Section 1910.1000, Air Contaminants, Table Z-2

4. Test Protocol Development by Mr. Tad Radzinski, President, Sustainable Solutions Corporation