mostardi platt

# Relative Accuracy Test Audit
# Test Report

## Lansing Board of Water and Light
## REO Town Facility
## HRSG #1 Stack
## Lansing, Michigan 48901
## October 24, 2017

## Report Submittal Date
## November 21, 2017



## Project No. M174302A

888 Industrial Drive
Elmhurst, Illinois 60126
630-993-2100

# 1.0 EXECUTIVE SUMMARY

MOSTARDI PLATT conducted a Continuous Emissions Monitoring System (CEMS) Relative Accuracy Test Audit (RATA) test program for Lansing Board of Water and Light at the REO Town Facility in Lansing, Michigan, on the HRSG #1 Stack on October 24, 2017. This report summarizes the results of the test program and test methods used in accordance with the Mostardi Platt test protocol dated September 6, 2017. Mostardi Platt is a self-certified air emissions testing body (AETB). A copy of Mostardi Platt's self-certification can be found in Appendix A.

The test location, test date, and test parameters are summarized below.

| TEST INFORMATION | | |
|---|---|---|
| **Test Location** | **Test Date** | **Test Parameters** |
| HRSG #1 Stack | October 24, 2017 | Oxygen ($O_2$) and Nitrogen Oxides ($NO_x$) |

The purpose of the test program was to demonstrate the relative accuracies of the HRSG #1 Stack $O_2$ and $NO_x$ analyzers during the specified operating conditions. The test results from this test program indicate that each CEMS component meets the United States Environmental Protection Agency (USEPA) annual performance specification for relative accuracy as published in 40 Code of Federal Regulations Part 75 (40CFR75) and 40 Code of Federal Regulations (40CFR60).

| RATA RESULTS | | | | | | |
|---|---|---|---|---|---|---|
| **Test Location** | **Date** | **Parameter** | **Units** | **Relative Accuracy Acceptance Criteria** | **Relative Accuracy (RA)** | **Bias Adjustment Factor (BAF)** |
| HRSG #1 Stack | 10/24/17 | $NO_x$ | lb/mmBtu | ≤ 0.015 lb/mmBtu mean difference | 0.002 lb/mmBtu mean difference | 1.094 |
| | | $NO_x$ | ppm @ 15% $O_2$ | ≤ 20.0% of the mean reference value | 10.41% | N/A |
| | | $O_2$ | % dry | ≤ 7.5% of the mean reference value | 1.21% | N/A |

The gas cylinders used to perform the RATA are summarized below.

| GAS CYLINDER INFORMATION | | | | |
|---|---|---|---|---|
| **Parameter** | **Gas Vendor** | **Cylinder Serial Number** | **Cylinder Value** | **Expiration Date** |
| $NO_x$ | Airgas | CC401436 | 0.0 ppm | 5/25/2025 |
| $NO_x$ | Airgas | XC031629B | 18.95 ppm | 7/19/2020 |
| $NO_x$ | Airgas | CC325403 | 35.85 ppm | 9/06/2019 |
| $O_2$ | Airgas | XC031629B | 0.0 % | 7/19/2020 |
| $O_2$ | Airgas | CC401436 | 12.39 % | 5/25/2025 |
| $O_2$ | Airgas | CC283878 | 21.04 % | 1/26/2023 |

No deviations, additions, or exclusions from the test protocol, test methods, the Mostardi Platt Quality Manual, or the ASTM D7036-12 occurred. The specific test conditions encountered did not interfere with the collection of the data.

The identifications of the individuals associated with the test program are summarized below.

| TEST PERSONNEL INFORMATION | | |
|---|---|---|
| **Location** | **Address** | **Contact** |
| Test Coordinator | Lansing Board of Water and Light<br>1232 Haco Drive<br>P.O. Box 13007<br>Lansing, Michigan 48912 | Ms. Trista Gregorski<br>Engineer, Environmental Services<br>(517) 702-6865 (phone)<br>trista.gregorski@lbwl.com |
| Test Facility | Lansing Board of Water and Light<br>REO Town Facility<br>1201 S. Washington Ave.<br>Lansing, Michigan 48917 | |
| Testing Company Supervisor | Mostardi Platt<br>888 Industrial Drive<br>Elmhurst, Illinois 60126 | Mr. Chris Eldridge<br>Project Supervisor<br>630-993-2100 (phone)<br>celdridge@mp-mail.com<br>QI Group V (certified on 3/4/16) |
| Testing Company Personnel | | Mr. Christopher Buglio<br>Test Technician |

Copies of the QI certifications for test personnel are included in Appendix B.

# 2.0 TEST METHODOLOGY

Emission testing was conducted following the United States Environmental Protection Agency (USEPA) methods specified in 40CFR75 and 40CFR60, Appendix A in addition to the Mostardi Platt Quality Manual and the test protocol. Schematics of the test section diagrams and sampling trains used are included in Appendix C and D respectively. Calculation and nomenclature are included in Appendix E. Copies of analyzer print-outs for each test run are included in Appendix F. CEM data and process data as provided by Lansing Board of Water and Light are included in Appendix G.

The following methodologies were used during the test program:

## Method 3A Oxygen ($O_2$) Determination

Stack gas $O_2$ concentrations and emission rates were determined in accordance with USEPA Method 3A, 40CFR60, Appendix A. A Servomex analyzer was used to determine the $O_2$ concentrations in the manner specified in the Method. The instrument has a paramagnetic detector 21.04%. High-range calibrations were performed using USEPA Protocol gas. Zero nitrogen (a low ppm pollutant in balance nitrogen calibration gases) was introduced during other instrument calibrations to check instrument zero. High- and a mid-range % $O_2$ levels in balance nitrogen were also introduced. Zero and mid-range calibrations were performed using USEPA Protocol gas after each test run. Copies of the gas cylinder certifications are found in Appendix J. This testing met the performance specifications as outlined in the Method.

## Method 7E Nitrogen Oxides ($NO_x$) Determination

Stack gas $NO_x$ concentrations and emission rates were determined in accordance with USEPA Method 7E, 40CFR60, Appendix A. A Thermo Scientific Model 42C Chemiluminescence Nitrogen Oxides Analyzer was used to determine nitrogen oxides concentrations, in the manner specified in the Method. The instrument operated in the nominal range of 0 ppm to 50 ppm with the specific range determined by the high-level span calibration gas of 35.85 ppm.

The Model 42C High Level is based on the principle that nitric oxide (NO) and ozone ($O_3$) react to produce a characteristic luminescence with an intensity linearly proportional to the NO concentration. Infrared light emission results when electronically excited nitrogen dioxide ($NO_2$) molecules decay to lower energy states. Specifically,

$$NO+O_3 \rightarrow NO_2+O_2+h\upsilon$$

$NO_2$ must first be transformed into NO before it can be measured using the chemiluminescent reaction. $NO_2$ is converted to NO by a molybdenum $NO_2$-to-NO converter heated to about 326 °C. The flue gas air sample is drawn into the Model 42C High Level through the sample bulkhead. The sample flows through a particulate filter, a capillary, and then to the mode solenoid valve. The solenoid valve routes the sample either straight to the reaction chamber (NO mode) or through the $NO_2$-to-NO converter and then to the reaction chamber (NOx mode).

Dry air enters the Model 42C High Level through the dry air bulkhead, through a flow sensor, and then through a silent discharge ozonator. The ozonator generates the necessary ozone concentration needed for the chemiluminescent reaction. The ozone reacts with the NO in the ambient air sample to produce electronically excited $NO_2$ molecules. A photomultiplier tube (PMT) housed in a thermoelectric cooler detects the $NO_2$ luminescence.

The NO and $NO_x$ concentrations calculated in the NO and $NO_x$ modes are stored in memory. The difference between the concentrations are used to calculate the $NO_2$ concentration. The Model 42C High Level outputs NO, $NO_2$, and $NO_x$ concentrations to both the front panel display and the analog outputs.

Stack gas was delivered to the analyzer via a Teflon® sampling line, heated to a minimum temperature of 250°F. Excess moisture in the stack gas was removed using a refrigerated condenser. The entire system was calibrated in accordance with the Method, using USEPA Protocol gases introduced at the probe, before and after each test run. This testing met the performance specifications as outlined in the Method.

A list of calibration gases used and the results of all calibration and other required quality assurance checks are found in Appendix H. Copies of the gas cylinder certifications are found in Appendix I. The $NO_2$ to NO converter test can be found in Appendix J. This testing met the performance specifications as outlined in the Method.

# 3.0 TEST RESULT SUMMARIES

**Client:** Lansing Board of Water and Light
**Location:** HRSG #1 Stack
**Facility:** REO Town Facility
**Date:** 10/24/17
**Project #:** M174302
**Test Method:** 7E, 3A
**Fuel Type:** Natural Gas
**Fuel Factor:** 8710

## O2 based NOx lb/mmBtu RATA

### CEM Monitor Information

| | | | |
|---|---|---|---|
| **$NO_x$ Monitor/Model:** | Thermo Fisher Scientific | **$NO_x$ Serial # :** | 1207552009 |
| **O2 Monitor/Model:** | Thermo Fisher Scientific | **O2 Serial # :** | 1207552009 |

| 1=accept 0=reject | Test Run | Test Date | Start Time | End Time | RM $NO_x$ lb/MMBtu | CEM $NO_x$ lb/MMBtu | (RM-CEM) Difference (di) | (RM-CEM) Difference$^2$ ($di^2$) |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 10/24/17 | 06:50 | 07:10 | 0.032 | 0.025 | 0.007 | 0.000 |
| 1 | 2 | 10/24/17 | 07:24 | 07:44 | 0.028 | 0.025 | 0.003 | 0.000 |
| 1 | 3 | 10/24/17 | 07:58 | 08:18 | 0.029 | 0.026 | 0.003 | 0.000 |
| 1 | 4 | 10/24/17 | 08:31 | 08:51 | 0.027 | 0.026 | 0.001 | 0.000 |
| 1 | 5 | 10/24/17 | 09:04 | 09:24 | 0.027 | 0.025 | 0.002 | 0.000 |
| 1 | 6 | 10/24/17 | 09:36 | 09:56 | 0.028 | 0.025 | 0.003 | 0.000 |
| 1 | 7 | 10/24/17 | 10:08 | 10:28 | 0.029 | 0.026 | 0.003 | 0.000 |
| 1 | 8 | 10/24/17 | 10:40 | 11:00 | 0.029 | 0.026 | 0.003 | 0.000 |
| 1 | 9 | 10/24/17 | 11:13 | 11:33 | 0.029 | 0.027 | 0.002 | 0.000 |
| 1 | 10 | 10/24/17 | 11:45 | 12:05 | 0.029 | 0.027 | 0.002 | 0.000 |

| | | |
|---|---|---|
| **n** | **9** | |
| **t(0.025)** | **2.306** | |
| **Mean Reference Method Value** | **0.028** | **RM avg** |
| **Mean CEM Value** | **0.026** | **CEM avg** |
| **Sum of Differences** | **0.022** | **di** |
| **Mean Difference** | **0.002** | **d** |
| **Sum of Differences Squared** | **0.000** | **$di^2$** |
| **Standard Deviation** | **0.001** | **sd** |
| **Confidence Coefficient 2.5% Error (1-tail)** | **0.001** | **cc** |
| **Relative Accuracy - APS** | **0.002** | **lb/mmBtu difference [A]** |
| **Bias Adjustment Factor** | **1.094** | **BAF** |

[A] Relative accuracy for low emission sources with $NO_x$ emissions of ≤ 0.200 lbs/mmBtu based on a mean difference of +/- 0.015 lbs/mmBtu for annual RATA testing, or +/- 0.020 lbs/mmBtu for semi-annual RATA testing.

**Client:** Lansing Board of Water and Light | **Location:** HRSG #1 Stack
**Facility:** REO Town Facility | **Date:** 10/24/17
**Project #:** M174302 | **Test Method:** 7E, 3A

## NOx ppmvd @ 15% O2 RATA

### CEM Monitor Information

| | | | |
|---|---|---|---|
| **$NO_x$ Monitor/Model:** | Thermo Fisher Scientific | **$NO_x$ Serial # :** | 1207552009 |
| **$O_2$ Monitor/Model:** | Thermo Fisher Scientific | **$O_2$ Serial # :** | 1207552009 |

| 1=accept 0=reject | Test Run | Test Date | Start Time | End Time | RM NOx ppmvd @ 15 %O2 | CEM NOx ppmvd @ 15 %O2 | (RM-CEM) Difference (di) | (RM-CEM) Difference$^2$ ($di^2$) |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 10/24/17 | 06:50 | 07:10 | 8.8 | 6.9 | 1.9 | 3.6 |
| 1 | 2 | 10/24/17 | 07:24 | 07:44 | 7.6 | 6.9 | 0.7 | 0.5 |
| 1 | 3 | 10/24/17 | 07:58 | 08:18 | 8.0 | 7.1 | 0.9 | 0.8 |
| 1 | 4 | 10/24/17 | 08:31 | 08:51 | 7.3 | 7.0 | 0.3 | 0.1 |
| 1 | 5 | 10/24/17 | 09:04 | 09:24 | 7.4 | 6.9 | 0.5 | 0.3 |
| 1 | 6 | 10/24/17 | 09:36 | 09:56 | 7.7 | 6.9 | 0.8 | 0.6 |
| 1 | 7 | 10/24/17 | 10:08 | 10:28 | 7.8 | 7.1 | 0.7 | 0.5 |
| 1 | 8 | 10/24/17 | 10:40 | 11:00 | 8.0 | 7.2 | 0.8 | 0.6 |
| 1 | 9 | 10/24/17 | 11:13 | 11:33 | 7.9 | 7.2 | 0.7 | 0.5 |
| 1 | 10 | 10/24/17 | 11:45 | 12:05 | 7.9 | 7.3 | 0.6 | 0.4 |

| | | |
|---|---|---|
| **n** | **9** | |
| **t(0.975)** | **2.306** | |
| **Mean Reference Method Value** | **7.733** | **RM avg** |
| **Mean CEM Value** | **7.067** | **CEM avg** |
| **Sum of Differences** | **6.000** | **di** |
| **Mean Difference** | **0.667** | **d** |
| **Sum of Differences Squared** | **4.260** | **$di^2$** |
| **Standard Deviation** | **0.180** | **sd** |
| **Confidence Coefficient 2.5% Error (1-tail)** | **0.139** | **cc** |
| **Relative Accuracy** | **10.41** | **RA** |

**Client:** Lansing Board of Water and Light **Location:** HRSG #1 Stack
**Facility:** REO Town Facility **Date:** 10/24/17
**Project #:** M174302 **Test Method:** 3A

## $O_2$ % (dry) RATA

**CEM Monitor Information**

| **$O_2$ Monitor/Model:** | Thermo Fisher Scientific | | | | **$O_2$ Serial # :** | 1207552009 | | |
|---|---|---|---|---|---|---|---|---|
| **1=accept 0=reject** | **Test Run** | **Test Date** | **Start Time** | **End Time** | **RM $O_2$ % (dry)** | **CEM $O_2$ % (dry)** | **(RM-CEM) Difference (di)** | **(RM-CEM) Difference$^2$ ($di^2$)** |
| 0 | 1 | 10/24/17 | 06:50 | 07:10 | 15.4 | 15.2 | 0.2 | 0.04 |
| 1 | 2 | 10/24/17 | 07:24 | 07:44 | 15.4 | 15.2 | 0.2 | 0.04 |
| 1 | 3 | 10/24/17 | 07:58 | 08:18 | 15.3 | 15.2 | 0.1 | 0.01 |
| 1 | 4 | 10/24/17 | 08:31 | 08:51 | 15.4 | 15.2 | 0.2 | 0.04 |
| 1 | 5 | 10/24/17 | 09:04 | 09:24 | 15.4 | 15.2 | 0.2 | 0.04 |
| 1 | 6 | 10/24/17 | 09:36 | 09:56 | 15.4 | 15.2 | 0.2 | 0.04 |
| 1 | 7 | 10/24/17 | 10:08 | 10:28 | 15.3 | 15.2 | 0.1 | 0.01 |
| 1 | 8 | 10/24/17 | 10:40 | 11:00 | 15.3 | 15.2 | 0.1 | 0.01 |
| 1 | 9 | 10/24/17 | 11:13 | 11:33 | 15.3 | 15.3 | 0.0 | 0.00 |
| 1 | 10 | 10/24/17 | 11:45 | 12:05 | 15.3 | 15.3 | 0.0 | 0.00 |
| | | | | **n** | **9** | | | |
| | | | | **t(0.025)** | **2.306** | | | |
| | | | | **Mean Reference Method Value** | **15.344** | | **RM avg** | |
| | | | | **Mean CEM Value** | **15.222** | | **CEM avg** | |
| | | | | **Sum of Differences** | **1.100** | | **di** | |
| | | | | **Mean Difference** | **0.122** | | **d** | |
| | | | | **Sum of Differences Squared** | **0.190** | | **$di^2$** | |
| | | | | **Standard Deviation** | **0.083** | | **sd** | |
| | | | | **Confidence Coefficient 2.5% Error (1-tail)** | **0.064** | | **cc** | |
| | | | | **Relative Accuracy** | **1.21** | | **RA** | |