CleanAir

CleanAir Engineering
7936 Conner Road
Powell, TN 37849-3513
800-208-6162
www.cleanair.com

DTE BLUEWATER ENERGY CENTER DRIFT ACCEPTANCE TEST REPORT

DTE Bluewater Energy Center

East China, MI

Kiewit Engineering Group Inc.	CleanAir Project No. 14643
10055 Trainstation Circle	Report No. CA22-10D
Lone Tree, CO 80124	Revision 0
Client Reference No. 03032022	August 26, 2022

This confidential test report was generated by Clean Air Engineering, a licensed CTI Testing Agency.

Submitted by:

Skyler Turner

Reviewed by:

Corey Mullen

TEST REPORT REVISION HISTORY

Version	Revision	Date	Pages	Comments
Final	0	August 26, 2022	All	Original version of document.

PROJECT CONTACT INFORMATION

Primary Client Contact	Primary CleanAir Contact
Adam Decker	Shane Tucker
Kiewit Engineering Group Inc.	Test Director
10055 Trainstation Circle	7936 Conner Road
Lone Tree, CO 80124	Powell, TN 37849
Cell: (303) 325-0441	Office: 865-938-7555
adam.decker@kiewit.com	stucker@cleanair.com

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1. EXECUTIVE SUMMARY

Clean Air Engineering (CleanAir) was contracted by Kiewit Engineering Group Inc. (Kiewit), to generate this test report for the drift emissions testing of the cooling tower serving the DTE Bluewater Energy Center facility.

The objective of the test effort documented in this report was to accurately quantify the drift emission rate of the cooling tower to assess compliance with contract requirements. Two drift test runs were completed on cells 7A and 7B. The tests were conducted on July 15 and July 16, 2022.

There was one deviation to the site specific drift test plan written by CleanAir.

1. The test plan indicated that a calibrated, CleanAir supplied power meter would be used to measure the fan motor power; however, due to safety concerns, all parties agreed to use the panel readouts.

Both calcium and magnesium were used as tracers for the analyses described in this report. Although the magnesium level in the circulating water was below the suggested threshold value of 100 mg/L specified in the test plan, magnesium based results are reported given the ratio of the mass collected on the bead pack relative to the detection limit was acceptable.

Based on the test data collected during July 15 and 16, 2022, the drift emission rate for the DTE Bluewater Energy Center cooling tower was 0.00088% of the circulating water flow rate based on calcium and magnesium as the chosen tracers. Summarized test results are shown below in Table 1-1.

Table 1-1: Drift Emissons Test Results

Cell #	Test ID	Date	Drift Rate Ca	Drift Rate Mg	Drift Rate Average
7A	Test 1	7/15/22	0.00109%	0.00105%	0.00107%
7A	Test 2	7/16/22	0.00103%	0.00096%	0.00099%
Cell 7A Average			**0.00103%**		
7B	Test 1	7/15/22	0.00076%	0.00074%	0.00075%
7B	Test 2	7/16/22	0.00071%	0.00068%	0.00069%
Cell 7B Average			**0.00072%**		
Tower Average			**0.00088%**		

In the event that changes to this report are required, the changes will be documented in the revision log and resubmitted to Kiewit for distribution to the appropriate parties.

End of Section

2. TEST OVERVIEW

Scope of Work

CleanAir was retained by Kiewit to perform thermal performance and drift emissions testing on the cooling tower that serves the cooling needs of the DTE Bluewater Energy Center facility.

The drift emissions testing was conducted in accordance with the site-specific drift test plan written by CleanAir under the guidelines of the CTI ATC-140 (2011), Isokinetic Drift Test Code.

The objective of the test effort was to accurately quantify the drift emission rate of the cooling tower to assess compliance with contract requirements. Two drift test runs were completed on two cells of the cooling tower.

Cooling Tower Description

The tested cooling tower is a 14-cell induced draft counterflow tower. The cooling tower is designed to cool 203,970 gpm, with each cell cooling 14,569 gpm, from a design hot-water temperature of 105.6°F, to a cold-water temperature of 82.0°F, with an inlet wet bulb temperature of 73.0°F. Each cell of the tower is equipped with a single fan driven by a 250 bhp motor. Hot water is delivered to the tower via seven 36-inch diameter supply risers.

Test Schedule

The testing was executed according to the schedule shown in Table 2-1.

Table 2-1: Test Schedule

Date	List of Activities
July 12, 2022	Deployed thermal test equipment on tower.
July 13, 2022	Collected thermal test data. Measured fan motor power and water flow rate on riser 6.
July 14, 2022	Collected thermal test data. Measured fan motor power and water flow rate on remaining six risers. Began removing thermal test equipment.
July 15, 2022	Finished removing thermal test equipment from tower. Conducted drift test 1 on cells 7A and 7B.
July 16, 2022	Conducted drift test 2 on cells 7A and 7B. Removed drift equipment. Demobilized from site.

A list of personnel participating on site during the test is shown in Table 2-2.

Table 2-2: Test Participants

Name	Company	Role
Shane Tucker	CleanAir Engineering	Test Director
Skyler Turner	CleanAir Engineering	Test Engineer
Wyatt Miller	CleanAir Engineering	Test Engineer
Benjamin Lafferty	International Cooling Tower (ICT)	Witness
Jonathan Stiefel	Kiewit Engineering Group Inc.	Witness
Zack Robinson	Kiewit Engineering Group Inc.	Witness

End of Section

3. METHODOLOGY

Test Execution

Prior to testing, CleanAir inspected the cooling tower to ensure that it was ready to test. CleanAir observed little to no water droplets in the exhaust plenum and there was no standing water on the structural beams inside the plenum. No excessive foam was observed in the cold-water basin. The CleanAir test crew performed drift emissions testing on July 15 and July 16, 2022.

Test Instruments

The temporary test instrumentation supplied by CleanAir was calibrated at the CleanAir calibration facility in Powell, TN with the exception of the pitot tube which was calibrated at the TVA Flow Lab in Norris, TN. The instruments were installed by the CleanAir test crew. Provided instruments met the requirements set forth in the CTI ATC-140 test code Section 3: Instruments and Measurements.

The parameters measured during the test and the number of instruments used are shown in Table 3-1.

Table 3-1: Test Instrumentation

Parameter	Number of Instruments
Isokinetic Sampling Trains	2
Ambient Air Sampler	1
Circulating Water Flow Rate	1
Barometric Pressure	1
Wind Speed	1

Water flow to the tower was measured in the seven 36-inch diameter hot water risers. Each riser was equipped with two pitot taps. A 20-point diameter traverse was performed in each of the 14 taps.

Fan motor amperage, voltage, and kilowatts were recorded from the available panel readouts in the motor control center. This measurement was used as the basis for checking that the fan motor power was within the ±10% window prescribed by the drift test code (ATC-140).

Barometric pressure was measured once during each day of testing with a hand-held electronic barometer.

Wind speed was measured on the fan deck, upwind of the tested cells with a RM Young wind speed device.

The concentration of the potential tracer elements (calcium and magnesium) in the ambient air was determined with a high-volume ambient sampler placed approximately 100 ft from the side of the cooling tower.

Sample Locations

The sampling locations were based on the net stack area and located at the centroids of equal area of the annular sample zones based on 4 radii and 6 points per radius. The position of the sampling locations is calculated by:

$$X_i = \frac{D_s}{2} - \sqrt{\left[\left(\frac{2N-2i+1}{8N}\right)(D_s^2 - D_h^2)\right] + \left(\frac{D_h}{2}\right)^2} \quad \text{(Eq. 1)}$$

Where:

X_i	=	sample location i, distance from wall
D_s	=	stack diameter at the sampling plane
D_h	=	effective hub diameter
N	=	number of sampling points on a single radius
i	=	sampling point number

CleanAir measured the diameter of the fan stack and the effective hub diameter at the exit plane while deploying the test equipment.

Six locations on each of four radii were sampled for each test run. Table 3-2 contains the radial sampling stations at the stack exit plane for both tested cells.

Table 3-2: Radial Sampling Positions

Sampling Position	Inches
1	7.8
2	24.2
3	42.1
4	61.9
5	84.4
6	111.1

Drift Emission Measurements

During the execution of the drift tests, the airflow speed and direction were measured at each of the sampling stations in order to set the "target" sampling velocity at the inlet to the glass bead pack. The air speed and direction measurements were made with an S-type "double" pitot consisting of two pitots positioned at 90 degrees to each other and mounted on the end of the sampling boom near the sampling nozzle. The differential pressure of the angle sensing pitot was measured locally with a Magnahelic gauge. The velocity pressure of the flow measuring pitot was measured with an inclined manometer or differential pressure sensor. The angle of rotation of the sample train was directly measured with a protractor after the sample train was aligned with the flow.

The flow rate through the sampling train was measured with a certified orifice in a dimensional flow section. Differential pressure across the orifice was also measured with an inclined manometer or a differential pressure sensor. Barometric pressure, inlet temperature (stack temperature) and flow section temperature were measured to correct for the density difference between the air at the sampling probe inlet and the air flowing through the orifice. After assembly in the field, the sampling train was leak checked under a strong vacuum to ensure the integrity of the sampling train.

The primary collection media for the HGBIK test is a Teflon cylinder containing tightly packed Pyrex beads. Exhaust air from the cooling tower containing the mineral bearing drift droplets is drawn through the bead pack and backup filter by a large vacuum pump. The outside of the cylinder is heated so that when drift droplets impact the heated beads, moisture is driven off and the non-volatile solids present in the drift (metallic salts) are deposited on the beads. The backup filter captures any mineral mass which escapes the bead pack. The drift rate is a function of the collected mineral mass as explained below. One glass bead cylinder and one backup filter are used per test.

The ambient concentration of the potential tracer elements was determined by deploying a high-volume sampler near the air inlets of the tested cells. One filter was exposed for each test day. The objective of this sampling was to provide guidance as to the selection of tracer elements and to note any excursions in the ambient concentrations which could have impacted the test results.

Test and Operating Conditions

The surface tension of the circulating water was measured to ensure that the surface tension of the water was above the 63 dynes/cm limit specified in the test plan. The results of the surface tension measurements are provided in Table 3-3.

Table 3-3: Surface Tension Measurements

Date	Dynes/cm
7/15/22	71.32
7/16/22	72.45

The circulating water chemistry stability during the tests was determined by review of the water chemistry analyses to evaluate compliance with the test plan specification. The circulating water chemistry stability measurements, which were compliant with the test code specifications, are summarized in Table 3-4. The variation in circulating water chemistry is defined as the greater of the maximum minus the average or the average minus the minimum, divided by the average value.

Table 3-4: Circulating Water Analysis

Date	Ca Sample 1 mg/L	Ca Sample 2 mg/L	Ca Sample 3 mg/L	Variation <10%	Mg Sample 1 mg/L	Mg Sample 2 mg/L	Mg Sample 3 mg/L	Variation <10%
7/15/22	204	205	213	3%	61	57	64	6%
7/16/22	204	207	191	5%	67	60	58	9%

A summary of the selection criteria and target values for the candidate tracers are presented in Tables 3-5 and 3-6. The values of the stack to ambient concentration ratios listed in Tables 3-5 and 3-6 were calculated using the analysis of the filter from the ambient sampler. Target values were assigned by CleanAir in the drift emissions test plan.

Table 3-5: Elemental Tracer Selection Criteria Cell 7A

July 15, 2022 - Cell 7A Test Run 1	Target	Ca	Mg
Ratio of bead pack concentration to RDL	>5	6.65	1.93
Ratio of bead pack concentration to procedural blank	>5	NA	NA
Ratio of stack concentration to ambient concentration	>5	2.61	3.43
July 16, 2022 - Cell 7A Test Run 2	**Target**	**Ca**	**Mg**
Ratio of bead pack concentration to RDL	>5	29.90	8.95
Ratio of bead pack concentration to procedural blank	>5	NA	NA
Ratio of stack concentration to ambient concentration	>5	6.52	NA

Table 3-6: Elemental Tracer Selection Criteria Cell 7B

July 15, 2022 - Cell 7B Test Run 1	Target	Ca	Mg
Ratio of bead pack concentration to RDL	>5	25.60	7.78
Ratio of bead pack concentration to procedural blank	>5	NA	NA
Ratio of stack concentration to ambient concentration	>5	1.74	2.29
July 16, 2022 - Cell 7B Test Run 2	**Target**	**Ca**	**Mg**
Ratio of bead pack concentration to RDL	>5	22.20	6.84
Ratio of bead pack concentration to procedural blank	>5	NA	NA
Ratio of stack concentration to ambient concentration	>5	4.69	NA

The results listed as "NA" in Tables 3-5 and 3-6 indicate that analyses of the procedural blank returned a non-detect for the tracer element. Non-detect means the concentration was below the detection limit of the analysis technique. In this case, "NA" indicates that these criteria are acceptable. In all cases the ratios of the bead pack concentration to the detection limit and the procedural blank were within the acceptable values.

The test plan specified that ratio of tracer stack concentraton to tracer ambient concentration be at least five. This concentration ratio is a quality assurance check intended to support selection of a tracer element for which the drift rate is not influenced by the ambient concentration of the tracer element, as elevated ambient concentrations could introduce a positive bias on the reported drift rate. Both calcium and magnesium were used as tracers for the analysis described in this report.

CTI ATC-140 (2011) dictates that an ambient air sample be collected during each drift test run to evaluate the amount of the tracer element in the air in the vicinity of the tower. Substantial amounts of the tracer in the ambient air may lead to a reported drift rate that is artificially high. This positive bias occurs when mineral bearing ambient air enters the tower and the minerals are not scrubbed by the falling water within the tower, but the minerals are captured by the drift sampling equipment. Since the scrubbing effect of individual cooling towers is unknown, as indicated in ATC-140, a correction for the ambient concentration cannot be applied.

The primary drift emissions data was in compliance with all the operating condition requirements of the test plan and ATC-140, with the exception of fan motor power on cell 7B being slightly below the limit for test 1. The tower operating conditions are shown in Tables 3-7 and 3-8.

Table 3-7: Operating Conditions Cell 7A

Description	Units	Test Plan Requirement	Design	Test	Data	Test Value
Circulating Water Flow Rate (per cell)	gpm	± 10%	14,569	1 and 2	15,746	8.08%
Fan Motor Power (corrected for air density)	bhp	± 10%	250.0	1 and 2	225.3	-9.88%
Wind Speed	mph	<75% average exit velocity	NA	1	16.2 (max)	7.91
				2	16.6 (max)	7.70

Table 3-8: Operating Conditions Cell 7B

Description	Units	Test Plan Requirement	Design	Test	Data	Test Value
Circulating Water Flow Rate (per cell)	gpm	± 10%	14,569	1 and 2	15,746	8.08%
Fan Motor Power (corrected for air density)	bhp	± 10%	250.0	1	224.0	-10.40%
Fan Motor Power (corrected for air density)	bhp	± 10%	250.0	2	225.2	-9.92%
Wind Speed	mph	<75% average exit velocity	NA	1	17.0 (max)	7.91
				2	16.0 (max)	7.70

End of Section

4. CALCULATIONS

Air Velocity Calculations

Air Velocity with Flow Sensing Portion of Double "S-type" Pitot

$$V_{stack} = 1097 * C_{pitot} * \sqrt{\frac{\Delta P_{pitot}}{\rho_{stack}}} \quad \text{(Eq. 2)}$$

Where:

V_{stack} = stack air velocity at measurement point, ft/min
C_{pitot} = coefficient for S-type pitot tube, dimensionless
ΔP_{pitot} = manometer deflection for pitot tube, inwg
ρ_{stack} = density of saturated air at stack temperature and pressure, lbm/ft^3

The density is a function of the barometric pressure, the stack temperature and stack gas composition. The composition of the stack gas is assumed to be saturated air.

The velocity of the air entering the sampling nozzle is adjusted by valve manipulation to match, as closely as possible, the air velocity at each of the sampling stations.

Mass Air Flow Rate through Metering Section

$$\dot{m}_{air} = C_D * \sqrt{\rho_{meter} * \Delta P_{orifice}} \quad \text{(Eq. 3)}$$

Where:

$\dot{m}_{air}$ = mass air flow rate through sampling train, lbm/min
C_D = discharge coefficient for metering section, (lbm/min)/(inwg-lbm/ft^3)$^{.5}$
$\Delta P_{orifice}$ = differential pressure measurement for metering orifice, inwg
ρ_{meter} = density of saturated air at orifice temperature and pressure, lbm/ft^3

Air Velocity at HGBIK Tube Inlet

$$V_{tube} = \frac{\dot{m}_{air}}{\rho_{stack} * A_{tube}} \quad \text{(Eq. 4)}$$

Where:

V_{tube} = velocity of the air entering the HGBIK tube inlet, ft/min
A_{tube} = area of HGBIK tube inlet, ft^2

Drift Emissions Calculations

Exiting Tracer Mass

The test apparatus is used to collect an integrated sample of the exiting tracer mass from across the stack.

$$W_T = (M_{GB} - M_{GBB}) + (M_F - M_{FB}) \quad \text{(Eq. 5)}$$

Where:

W_T = the net mass recovered from the glass bead pack and the back-up filter for the selected tracer element (e.g. µg magnesium)

M_{GB} = mass recovered from the glass bead pack for the selected tracer element (e.g. µg magnesium)

M_{GBB} = mass recovered from the glass bead field blank for the selected tracer element (e.g. µg magnesium)

M_F = mass recovered from the back-up filter for the selected tracer element (e.g. µg magnesium)

M_{FB} = mass recovered from the back-up filter field blank for the selected tracer element (e.g. µg magnesium)

Total Circulating Water Emitted as Drift

$$\%Drift = 100 * K_1 * \frac{A_{SP}}{A_N} * \frac{w_T}{Q_{WT} * t_s * C_{TC}} \quad \text{(Eq. 6)}$$

Where:

A_N = nozzle area, m^2

A_{SP} = sample plane area, m^2

C_{TC} = circulating water tracer concentration, mg/L

K_1 = 0.001 mg/µg for SI units

Q_{WT} = water flow rate during test, L/s

t_s = total sample time, s

Although the equations listed above are for one element, when available in enough concentration, multiple elements are analyzed and used in parallel as a quality assurance step. This is beneficial since an unexpectedly high concentration in a blank or ambient sample for one element may not be present for other elements. A sample calculation is included in Appendix C.

The test samples were brought to CleanAir for chemical recovery. The glass bead packs were rinsed with multiple rinses of ultrapure hydrochloric acid and water solutions. The chemical mass on the filters were recovered by digestion in an acid solution. The samples were sent to a laboratory for chemical analyses by Inductively Coupled Plasma (ICP) which provides a highly accurate analysis of a relatively small sample.

End of Section

5. DRIFT EMISSONS SUMMARY

Performance Evaluation

Table 5-1 summarizes the results of the tests conducted at the DTE Bluewater Energy Center cooling tower from July 15-July 16, 2022.

Table 5-1: Drift Emissons Test Results

Cell #	Test ID	Date	Drift Rate Ca	Drift Rate Mg	Drift Rate Average
7A	Test 1	7/15/22	0.00109%	0.00105%	0.00107%
7A	Test 2	7/16/22	0.00103%	0.00096%	0.00099%
Cell 7A Average			**0.00103%**		
7B	Test 1	7/15/22	0.00076%	0.00074%	0.00075%
7B	Test 2	7/16/22	0.00071%	0.00068%	0.00069%
Cell 7B Average			**0.00072%**		
Tower Average			**0.00088%**		

The calculated drift emission rate for the DTE Bluewater cooling tower was 0.00088% of the circulating water flow rate. Composite results were based on calculations using calcium and magnesium as the chosen tracers.

Laboratory analyses are included in Appendix D. Drift test data and calculations are included in Appendix B.

End of Section