



## EXECUTIVE SUMMARY

Chase Young Environmental Testing Inc (CYET) was retained by Allnex USA, Inc. (Allnex) to conduct a compliance emissions test program on the inlet and outlet of the Vapor Recovery Unit (VRU) and the Water Scrubber at the Allnex Methylated Resins Plant located in Kalamazoo, MI. The emissions test program was conducted on August 23-25, 2022 and was performed in accordance with CYET project number 221646 Emission Test Plan as well as the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Air Quality Division (AQD) acceptance letter.

The emissions test program included performance of the compliance demonstration procedures for large control devices for the vapor recovery unit (VRU), which consists of the methanol scrubber – Equipment ID 631-509, and cryogenic condenser – Equipment ID 631-516. In addition, the emissions test program included performance of the compliance demonstration procedures for large control devices for the water scrubber – Equipment ID 631-501. The tests were conducted to determine compliance with permit number MI-ROP-B1677-2018a issued by EGLE. In addition, Subpart OOO requires that Allnex reduce the organic HAP emissions from the VRU by 95%, and the Water Scrubber by 62%. The results of the test program are presented in Tables 1 and 2.

It should be noted that the water scrubber at 15 GPM setpoint (Test Runs 7-9) had a HAP removal efficiency of 48.0% which is less than the 62% limit listed in 40CFR, Part 63 Subpart OOO § 63.1407 (a)(3)(ii), however, it satisfies the alternative standard listed in § 63.1407 (b)(1) which states: “Vent all organic HAP emissions from a non-reactor batch process vent ... to a non-combustion control device achieving an outlet organic HAP concentration of 50 ppmv or less”. All other test results are in compliance with the limits listed in Table 3.

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**Table 1**  
**VRU Overall Emission Summary**  
**Test Dates: August 23-24, 2022**

<b>Condition</b>	<b>Outlet MeOH Emission Rate (lb/hr)</b>	<b>Outlet HCOH Emission Rate (lb/hr)</b>	<b>Outlet VOC<sup>1</sup> Emission Rate (lb/hr)</b>	<b>HAP Removal Efficiency</b>
Recycled MeOH, <-50°C	0.28	0.00	3.54	98.4%
Recycled MeOH, -50°C to -30°C	0.11	0.00	2.01	98.9%
Fresh MeOH, <-30°C	0.29	0.00	1.84	96.3%

**Table 2**  
**Water Scrubber Overall Emission Summary**  
**Test Dates: August 24-25, 2022**

<b>Scrubber Setpoint (GPM)</b>	<b>Outlet MeOH Emission Rate (lb/hr)</b>	<b>Outlet HCOH Emission Rate (lb/hr)</b>	<b>Outlet VOC<sup>1</sup> Emission Rate (lb/hr)</b>	<b>HAP Removal Efficiency</b>
25	0.04	0.02	0.17	89.5%
20	0.18	0.08	0.61	65.2%
15	0.10	0.04	0.27	48.0%

<sup>1</sup>VOC was determined as the sum of the emission rate of Formaldehyde, Methanol, Methylal, and Methyl Formate as measured by USEPA methods 2, 3, 4, and 320.

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Appendix D	Equipment Calibration and Span Gas Documents
Appendix E	Example Calculations
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Appendix G	Process Flow Diagram and Process Data
Appendix H	EGLE AQD Test Plan Acceptance Letter



## 1. Introduction

Chase Young Environmental Testing Inc (CYET) was retained by Allnex USA, Inc. (Allnex) to conduct a compliance emissions test program on the inlet and outlet of the Vapor Recovery Unit (VRU) and the Water Scrubber at the Allnex Methylated Resins Plant located in Kalamazoo, MI. The emissions test program was conducted on August 23-25, 2022 and was performed in accordance with CYET project number 221646 Emission Test Plan as well as the Michigan Department of Environment, Great Lakes, and Energy (EGLE) Air Quality Division (AQD) acceptance letter. The purpose of this report is to document the results of the test program.

The emissions test program included performance of the compliance demonstration procedures for large control devices for the vapor recovery unit (VRU), which consists of the methanol scrubber – Equipment ID 631-509, and cryogenic condenser – Equipment ID 631-516. In addition, the emissions test program included performance of the compliance demonstration procedures for large control devices for the water scrubber – Equipment ID 631-501. The tests were conducted to determine compliance with permit number MI-ROP-B1677-2018a issued by EGLE. In addition, Subpart OOO requires that Allnex reduce the organic HAP emissions from the VRU by 95%, and the Water Scrubber by 62%.

### 1.a Identification, Location, and Dates of Test

Sampling and analysis for the emission test program was conducted on August 23-25, 2022 at the Allnex Methylated Resins Plant located in Kalamazoo, MI. The test program was conducted on the VRU (Equipment ID 631-509, and Equipment ID 631-516) and the water scrubber (Equipment ID 631-501).

Testing on the VRU consisted of triplicate 60-minute test runs conducted simultaneously at the inlet and outlet for each of 3 conditions (fresh methanol @ <-30°C, Recycled methanol between -50°C and -30°C, and recycled methanol @ <-50°C).

Testing on the water scrubber consisted of triplicate 60-minute test runs conducted simultaneously at the inlet and out for each of 3 scrubber set points (25 GPM, 20 GPM, and 15 GPM).

### 1.b Purpose of Testing

AQD issued Renewable Operating Permit No. MI-ROP-B1677-2018a to Allnex on December 6, 2018. This permit limits emissions as summarized by Table 3. Subpart OOO requires that Allnex reduce the organic HAP emissions from the VRU by 95%, and the Water Scrubber by 62%.

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**Table 3  
Reporting Units and Emission Limits**

Unit ID/ Source Name	Operating Parameter	Pollutant	Reporting Units	Emission Limit	Emission Limit Reference
VRU	Recycled Methanol @ >-50°C	VOC <sup>1</sup>	lb/hr	24.7	MI-ROP-B1677-2018a
VRU	Recycled Methanol @ <-50°C	VOC <sup>1</sup>	lb/hr	6.1	MI-ROP-B1677-2018a
VRU	Fresh Methanol @ <-30°C	VOC <sup>1</sup>	lb/hr	6.1	MI-ROP-B1677-2018a
VRU	NA	HCHO	lb/hr	1.3	MI-ROP-B1677-2018a
VRU	NA	MeOH	lb/hr	6.1	MI-ROP-B1677-2018a
VRU	NA	HAP Removal Efficiency	RE% by weight	95	40CFR, Part 63 Subpart OOO
Water Scrubber	NA	VOC <sup>1</sup>	ton/year	6.4	MI-ROP-B1677-2018a
Water Scrubber	NA	HCHO	lb/hr	0.09	MI-ROP-B1677-2018a
Water Scrubber	NA	MeOH	lb/hr	8.0	MI-ROP-B1677-2018a
Water Scrubber	NA	HAP Removal Efficiency	RE% by weight	62	40CFR, Part 63 Subpart OOO

<sup>1</sup>VOC was determined as the sum of the emission rate of Formaldehyde, Methanol, Methylal, and Methyl Formate as measured by USEPA methods 2, 3, 4, and 320.

### 1.c Source Description

The emissions test program included performance of the compliance demonstration procedures for large control devices for the vapor recovery unit (VRU), which consists of the methanol scrubber – Equipment ID 631-509, and cryogenic condenser – Equipment ID 631-516. In addition, the emissions test program included performance of the compliance demonstration procedures for large control devices for the water scrubber – Equipment ID 631-501.

Figures 2-5 present the test port and traverse/sampling point locations used at each site.

### 1.d Test Program Contacts

The contact for the source and test report is:

Mr. Brandon Phillips  
Safety, Health and Environmental Manager  
Allnex USA Inc.  
(269) 385-1242

Names and affiliations for personnel who were present during the testing program are summarized by Table 4.

**Table 4  
Test Personnel**

<b>Name, Title, and Email</b>	<b>Affiliation</b>	<b>Telephone</b>
Mr. Brandon Phillips Safety, Health and Environmental Manager Brandon.Phillips@allnex.com	Allnex USA Inc. 2715 Miller Road Kalamazoo, Michigan 49001	(269) 385-1242
Mr. Brandon Chase Senior Environmental Engineer bchase@cyetinc.com	CYET 28744 Groveland Street Madison Heights, MI 48071	(248) 506-0107
Mr. Matthew Young Senior Project Manager myoung@cyetinc.com	CYET 28744 Groveland Street Madison Heights, MI 48071	(248) 744-9133
Mr. Mukund Venkitachalam Senior Scientist Mukund.Venkitachalam@rwdi.com	RWDI 600 Southgate Dr Guelph, ON N1G 4P6, Canada	(519) 823-1311
Mr. Juan Vargas Scientist Engineer Juan.Vargas@rwdi.com	RWDI 2239 Star Ct Rochester Hills, MI 48309	(248) 841-8442
Ms. Lindsey Wells Environmental Quality Analyst wellsL8@michigan.gov	Technical Programs Unit Air Quality Division – Field Operations Michigan Dept of Environment, Great Lakes & Energy	(517) 282-2345

## 2. Summary of Results

Sections 2.a through 2.d summarize the results of the emissions compliance test program.

### 2.a Operating Data

Process data monitored during the emissions test program include:

1st LUWA Feed Rate (GPM), VRU Temp (°C), Water Scrubber Feed Rate (GPM), Methanol Scrubber Recirc Rate (GPM), Methanol Scrubber Feed Rate (GPM), and Fresh Methanol / Recycled Methanol status.

Process operating data is included in Appendix G.

## **2.b Applicable Permit**

The applicable permit for this emissions test program is Renewable Operating Permit (ROP) No. MI-ROP-B1677-2018a.

## **2.c Results**

The overall results of the emission test program are summarized by Tables 1 and 2 (see Section 5.a, and Appendix A). Emission limits are presented in Table 3 (see section 1.b, and Appendix A). Detailed emission rates are presented in Tables 5-10 in Appendix A.

It should be noted that the water scrubber at 15 GPM setpoint (Test Runs 7-9) had a HAP removal efficiency of 48.0% which is less than the 62% limit listed in 40CFR, Part 63 Subpart 000. All other test results are in compliance with the limits listed in Table 3.

## **3. Source Description**

Sections 3.a through 3.e provide a detailed description of the process.

### **3.a Process Description**

Allnex operates under renewable operating permit MI-ROP-B1677-2018a which includes the cryogenic condenser (ID 631-516), and Water Scrubber (631-501) for Cymel® 303LF production at the methylated resins plant.

The first control device included in this emissions test program is a methanol scrubber followed by a cryogenic condenser (VRU). The second control device included in this emissions test program is a water scrubber.

### **3.b Process Flow Diagram**

A process flow diagram is included in Appendix G.

### **3.c Raw and Finished Materials**

Raw materials for the Methylated Resins production process include water, HCOH, MeOH, Melamine, acids, and a base. Process chemistry for the Cymel® 303LF is proprietary. However, because of the set chemistry of the process, the quantity of each raw material used is approximately constant in terms of quantity used per batch or per gallon of product.

### **3.d Process Capacity**

The facility is rated at 76.6 million pounds of methylated resin product per year, based on a 12-month rolling time period.



### 3.e Process Instrumentation

Process data monitored during the emissions test program include:

1st LUWA Feed Rate (GPM), VRU Temp (°C), Water Scrubber Feed Rate (GPM), Methanol Scrubber Recirc Rate (GPM), Methanol Scrubber Feed Rate (GPM), and Fresh Methanol / Recycled Methanol status.

Process operating data is included in Appendix G.

## 4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used.

### 4.a Sampling Train and Field Procedures

Sampling and analysis procedures followed the methods codified at 40 CFR 60, Appendix A and 40 CFR 63, Appendix A:

- Method 1 - *“Sample and Velocity Traverses for Stationary Sources”* was used to determine the sampling locations and the stack traverse points.
- Method 2 - *“Determination of Stack Gas Velocity and Volumetric Flowrate”* was used to determine average exhaust gas velocity.
- Method 3 - *“Gas Analysis for Determination of Dry Molecular Weight” (Fyrite Method)* was used to evaluate the molecular weight of the exhaust gas.
- Method 4 - *“Determination of Moisture Content in Stack Gases”* was used to determine the moisture content of the exhaust gas.
- Method 320 - *“Measurement of Vapor Phase Organic and Inorganic Emissions By Extractive Fourier Transform Infrared (FTIR) Spectroscopy”* was used to Measure the Formaldehyde, Methanol, Methylal, and Methyl Formate content of the exhaust gas.

USEPA Method 1 was utilized to determine the necessary sampling points in which to collect the air pollutants. This method is applicable to sources that are not cyclonic or swirling, and the duct diameter is greater than 12 inches. The sample location was verified to meet at least 2 duct diameters downstream, and at least 0.5 duct diameters upstream of any flow disturbances.

The test team verified the absence of cyclonic flow in the field. The existence of cyclonic flow is determined by measuring the flow angle at each sample point. The flow angle is the direction of flow and the axis of the duct. If the average of the absolute values of the flow angles is greater than 20 degrees, cyclonic flow exists. None of the sources sampled indicated cyclonic flow.

USEPA Method 2 was utilized to measure exhaust gas velocity pressures and temperatures utilizing an S-type pitot tube equipped with a thermocouple, and an inclined manometer.

The S-Type Pitot tube dimensions were verified to be within the specified limits of Method 2 Figure 2-2, Therefore a baseline pitot tube coefficient of 0.84 (dimensionless) was assigned. All thermocouple systems used during testing used the alternative Method 2 thermocouple calibration procedures specified in ALT-011 to ensure that the temperature of each thermocouple and reference thermometer agree to within  $\pm 2$  °F.

The sampling apparatus was setup onsite, noting that the manometer is level and zeroed continuously throughout sampling. A pre- and post-test leak check of the system was performed by reaching at least 3" H<sub>2</sub>O on both the impact and static pressure sides of the S-type pitot tube, and closing off the system. The system leak check passes when the pressure remains stable for a minimum of 15 seconds. The velocity head and temperature are then measured at each sampling point specified by USEPA Method 1.

Molecular weight determinations were evaluated using the Fyrite® procedure. The equipment used for this evaluation consists of a one-way squeeze bulb with connecting tubing and a set of Fyrite® combustion gas analyzers (O<sub>2</sub> and CO<sub>2</sub>). A grab sample of the exhaust gas was analyzed for each test run.

The Fyrite analyzers are audited monthly by collecting a known concentration of O<sub>2</sub> and CO<sub>2</sub> (protocol 1 gas cylinder) in a tedlar bag and analyzing using the fyrite. Three consecutive samples are measured and must agree with the protocol 1 gas cylinder values within  $\pm 0.5\%$ .

USEPA Method 4 was used to measure the moisture content of the gas utilizing the FTIR system (USEPA Method 320) as stipulated in Method 4 Section 16.3.

Testing for methanol, methylal, methyl formate, and formaldehyde was accomplished using the FTIR simultaneously at the inlet and outlet of the VRU and Water Scrubber. At the outlet specifically for both sources, the exhaust gas was sampled by drawing a sample stream of flue gases through a stainless steel probe attached to a heated filter and a heated sample line that is attached to the Automated Sampling Console (ASC-10ST). The ASC-10ST sampling console delivers a continuous sample to the MKS MultiGas 2030 FTIR for analysis.

The heated filter and line were maintained at approximately 375°F and the MKS MultiGas 2030 FTIR and MAX Analytical ASC-10ST gas components were at 375°F. The end of the probe was connected to a heated Teflon sample line, which delivers the sample gases from the stack to the FTIR system. The heated sample line is designed to maintain the gas temperature above 375°F in order to prevent condensation of stack gas moisture within the line.

The sample was then routed through a manifold system and introduced to the individual CEM's for measurement. As recommended by EGL, the sample line and heated filter were heated to 375°F.



The ASC-10ST was used to deliver calibration gases (Calibration Transfer Standard (CTS), QA Spike and Nitrogen) to the FTIR in direct (to analyzer) and system (to probe) modes.

A laptop computer was utilized for operating the MKS MultiGas 2030 FTIR and MAX Analytical ASC-10ST sampling console and logging the multi-gas FTIR data. Data was logged as one minute averages for the actual test period (FTIR PRN files and Spectra). All concentration data were determined using the MKS 2030 MultiGas FTIR software.

At the inlet location specifically for both sources in the FTIR sampling system, the exhaust gas was sampled by drawing a slip stream sample through a heated stainless-steel probe connected to a sintered filter and a heated sample line that is attached to Voyager FTIR Assembly. The Voyager FTIR sampling console delivers a continuous sample to the MKS MultiGas 2030 FTIR for analysis. The heated filter and line were maintained at approximately 250°F and the MKS MultiGas 2030 FTIR and other sampling components were at 375°F. The end of the probe was connected to a heated Teflon sample line, which delivers the sample gases from the stack to the FTIR system. The heated sample line was maintained at 375°F in order to prevent condensation of stack gas moisture within the line.

The Voyager FTIR automated pump assembly system was used to deliver the exhaust gas and nitrogen to the FTIR in direct (to analyzer) and system (to probe) modes.

#### **4.b Recovery and Analytical Procedures**

This test program did not include laboratory samples, consequently, sample recovery and analysis are not applicable to this test program.

#### **4.c Sampling Ports**

A diagram of the stacks indicating traverse point and sampling locations and stack dimensions is included as Figures 2-5.

#### **4.d Traverse Points**

A diagram of the stacks indicating traverse point and sampling locations and stack dimensions is included as Figures 2-5.

### **5. Test Results and Discussion**

Sections 5.a through 5.k provide a summary of the test results.

#### **5.a Results Tabulation**

The overall results of the emissions test program are summarized by Tables 1 and 2. Detailed results for the emissions test program are summarized by Tables 5-10 in Appendix A.

**Table 1**  
**VRU Overall Emission Summary**  
**Test Dates: August 23-24, 2022**

Condition	Outlet MeOH Emission Rate (lb/hr)	Outlet HCOH Emission Rate (lb/hr)	Outlet VOC <sup>1</sup> Emission Rate (lb/hr)	HAP Removal Efficiency
Recycled MeOH, <-50°C	0.28	0.00	3.54	98.4%
Recycled MeOH, -50°C to -30°C	0.11	0.00	2.01	98.9%
Fresh MeOH, <-30°C	0.29	0.00	1.84	96.3%

**Table 2**  
**Water Scrubber Overall Emission Summary**  
**Test Dates: August 24-25, 2022**

Scrubber Setpoint (GPM)	Outlet MeOH Emission Rate (lb/hr)	Outlet HCOH Emission Rate (lb/hr)	Outlet VOC <sup>1</sup> Emission Rate (lb/hr)	HAP Removal Efficiency
25	0.04	0.02	0.17	89.5%
20	0.18	0.08	0.61	65.2%
15	0.10	0.04	0.27	48.0%

<sup>1</sup>VOC was determined as the sum of the emission rate of Formaldehyde, Methanol, Methylal, and Methyl Formate as measured by USEPA methods 2, 3, 4, and 320.

### 5.b Discussion of Results

It should be noted that the water scrubber at 15 GPM setpoint (Test Runs 7-9) had a HAP removal efficiency of 48.0% which is less than the 62% limit listed in 40CFR, Part 63 Subpart OOO § 63.1407 (a)(3)(ii), however, it satisfies the alternative standard listed in § 63.1407 (b)(1) which states: “Vent all organic HAP emissions from a non-reactor batch process vent ... to a non-combustion control device achieving an outlet organic HAP concentration of 50 ppmv or less”. All other test results are in compliance with the limits listed in Table 3.

### 5.c Sampling Procedure Variations

The following method variations were requested for the VRU testing:

- Because MeOH concentration were anticipated to be very elevated at the VRU inlet sampling location and because inlet and outlet MeOH concentrations were variable as well as the exhaust gas flowrate being variable, MeOH concentrations were determined using Method 320 instead of Method 18 or 308.
- Because the exhaust gas flowrate through the VRU system is variable and because the VRU inlet and outlet sampling locations are only 6 inches in diameter, exhaust gas flowrate was measured using stationary pitot tubes fixed in position at the center of the stack. The VRU Diagrams in Appendix B of this document show the velocity pressure and FTIR sampling locations.

- Because of the configuration of the stack test ports, a small S-type pitot tube was used in lieu a standard pitot tube.
- Because the exhaust flowrates and gas characteristics are variable, prior to the first test run and after the last test run, the sampling locations were be checked for cyclonic flow at the center of the duct.
- Prior to and after each test run, pitot leak checks were conducted.
- The accuracy of the differential pressure transmitter was verified by CYET before and after the test program. Tubing was teed to a manometer and the manometer readings checked against the high and low-pressure sides of both transmitters. Each transmitter side was checked at four levels (zero, low, mid, and high) three times with values recorded on calibration data sheets.
- The static pressure at the sampling locations was measured once before beginning the emissions test program and once at the end of the emissions test program.
- Exhaust gas temperature were measured and recorded at fifteen-minute intervals during each test run.
- Bag grab samples were collected at the exhaust from the FTIR unit and analyzed for O<sub>2</sub> and CO<sub>2</sub> content as well as concentration data for other compounds as measured by the FTIR used to analyze for exhaust gas HCOH and MeOH concentrations.
- MeOH, HCOH, methylal, and methyl formate concentration data from the FTIR was used along with the O<sub>2</sub>/CO<sub>2</sub> fyrite results to calculate the dry molecular weight using a modified Eq 3-1 from Method 3. The balance of the gas stream is assumed to be nitrogen.
- Because of the high methanol concentrations anticipated at the inlet and outlet sampling locations, the Method 320 MeOH and HCOH analyte spikes were performed in ambient air as opposed to the sample stream. This approach will confirm the FTIR/sampling system to accurately deliver and quantify a known concentration of MeOH.

With respect to the methods listed above, the following method variations were requested for the water scrubber testing:

- MeOH concentrations were determined using Method 320 instead of Method 18 or 308.
- Because methanol concentrations at the water scrubber inlet are elevated, the Method 320 MeOH and HCOH analyte spikes at the water scrubber inlet were performed in ambient air as opposed to the sample stream. Method 320 spiking was conducted at the water scrubber outlet. This will confirm the FTIR/sampling system to accurately deliver and quantify a known concentration of MeOH.

The aforementioned method deviations were approved for use in the test plan acceptance letter dated June 30, 2022. The approval letter from EGLE is provided in Appendix H.

#### **5.d Process or Control Device Upsets**

No upset conditions occurred during testing.

#### **5.e Control Device Maintenance**

There was no control equipment maintenance performed during the emissions test program.

#### **5.f Re-Test**

The emissions test program was not a re-test.

#### **5.g Audit Sample Analyses**

No audit samples were collected as part of the test program.

#### **5.h Calibration Sheets**

Relevant equipment calibration documents are provided in Appendix D.

#### **5.i Sample Calculations**

Sample calculations are provided in Appendix E.

#### **5.j Field Data Sheets**

Field documents relevant to the emissions test program are presented in Appendix C. Field documents relevant to the FTIR are presented in Appendix F.

#### **5.k Laboratory Data**

There are no laboratory results for this test program. FTIR data is provided electronically in Appendix F.




## MEASUREMENT UNCERTAINTY STATEMENT

Both qualitative and quantitative factors contribute to field measurement uncertainty and should be taken into consideration when interpreting the results contained within this report. Whenever possible, CYET personnel reduce the impact of these uncertainty factors through the use of approved and validated test methods. In addition, CYET personnel perform routine instrument and equipment calibrations and ensure that the calibration standards, instruments, and equipment used during test events meet, at a minimum, test method specifications as well as the specifications of our Quality Manual and ASTM D 7036-04. The limitations of the various methods, instruments, equipment, and materials utilized during this test have been reasonably considered, but the ultimate impact of the cumulative uncertainty of this project is not fully identified within the results of this report.

## **REPORT SIGNATURES**

CYET operated in conformance with the requirements of ASTM D7036-04 during this emissions test project and this emissions test report:

This report was prepared by:   
Brandon Chase  
Senior Environmental Engineer

This report was reviewed by:   
Matthew Young  
Senior Project Manager

# Appendix A – Emission Results Tables

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**Table 1**  
**VRU Overall Emission Summary**  
**Test Dates: August 23-24, 2022**

<b>Condition</b>	<b>Outlet MeOH Emission Rate (lb/hr)</b>	<b>Outlet HCOH Emission Rate (lb/hr)</b>	<b>Outlet VOC<sup>1</sup> Emission Rate (lb/hr)</b>	<b>HAP Removal Efficiency</b>
Recycled MeOH, <-50°C	0.28	0.00	3.54	98.4%
Recycled MeOH, -50°C to -30°C	0.11	0.00	2.01	98.9%
Fresh MeOH, <-30°C	0.29	0.00	1.84	96.3%

<sup>1</sup>VOC was determined as the sum of the emission rate of Formaldehyde, Methanol, Methylal, and Methyl Formate as measured by USEPA methods 2, 3, 4, and 320.

**Table 2**  
**Water Scrubber Overall Emission Summary**  
**Test Dates: August 24-25, 2022**

<b>Scrubber Setpoint (GPM)</b>	<b>Outlet MeOH Emission Rate (lb/hr)</b>	<b>Outlet HCOH Emission Rate (lb/hr)</b>	<b>Outlet VOC<sup>1</sup> Emission Rate (lb/hr)</b>	<b>HAP Removal Efficiency</b>
25	0.04	0.02	0.17	89.5%
20	0.18	0.08	0.61	65.2%
15	0.10	0.04	0.27	48.0%

<sup>1</sup>VOC was determined as the sum of the emission rate of Formaldehyde, Methanol, Methylal, and Methyl Formate as measured by USEPA methods 2, 3, 4, and 320.

**Table 3**  
**Reporting Units and Emission Limits**

Unit ID/ Source Name	Operating Parameter	Pollutant	Reporting Units	Emission Limit	Emission Limit Reference
VRU	Recycled Methanol @ >-50°C	VOC <sup>1</sup>	lb/hr	24.7	MI-ROP-B1677-2018a
VRU	Recycled Methanol @ <-50°C	VOC <sup>1</sup>	lb/hr	6.1	MI-ROP-B1677-2018a
VRU	Fresh Methanol @ <-30°C	VOC <sup>1</sup>	lb/hr	6.1	MI-ROP-B1677-2018a
VRU	NA	HCHO	lb/hr	1.3	MI-ROP-B1677-2018a
VRU	NA	MeOH	lb/hr	6.1	MI-ROP-B1677-2018a
VRU	NA	HAP Removal Efficiency	RE% by weight	95	40CFR, Part 63 Subpart OOO
Water Scrubber	NA	VOC <sup>1</sup>	ton/year	6.4	MI-ROP-B1677-2018a
Water Scrubber	NA	HCHO	lb/hr	0.09	MI-ROP-B1677-2018a
Water Scrubber	NA	MeOH	lb/hr	8.0	MI-ROP-B1677-2018a
Water Scrubber	NA	HAP Removal Efficiency	RE% by weight	62	40CFR, Part 63 Subpart OOO

<sup>1</sup>VOC was determined as the sum of the emission rate of Formaldehyde, Methanol, Methylal, and Methyl Formate as measured by USEPA methods 2, 3, 4, and 320.

**Table 4  
Test Personnel**

Name, Title, and Email	Affiliation	Telephone
Mr. Brandon Phillips Safety, Health and Environmental Manager Brandon.Phillips@allnex.com	Allnex USA Inc. 2715 Miller Road Kalamazoo, Michigan 49001	(269) 385-1242
Mr. Brandon Chase Senior Environmental Engineer bchase@cyetinc.com	CYET 28744 Groveland Street Madison Heights, MI 48071	(248) 506-0107
Mr. Matthew Young Senior Project Manager myoung@cyetinc.com	CYET 28744 Groveland Street Madison Heights, MI 48071	(248) 744-9133
Mr. Mukund Venkitachalam Senior Scientist Mukund.Venkitachalam@rwdi.com	RWDI 600 Southgate Dr Guelph, ON N1G 4P6, Canada	(519) 823-1311
Mr. Juan Vargas Scientist Engineer Juan.Vargas@rwdi.com	RWDI 2239 Star Ct Rochester Hills, MI 48309	(248) 841-8442
Ms. Lindsey Wells Environmental Quality Analyst wellsL8@michigan.gov	Technical Programs Unit Air Quality Division – Field Operations Michigan Dept of Environment, Great Lakes & Energy	(517) 282-2345

**Table 5**  
**VRU Emission Rates - Recycled Methanol, < -50°C**  
**Allnex USA Inc.**

Parameter		Run 1	Run 2	Run 3	Average
Sampling Date		8/23/2022	8/23/2022	8/23/2022	
Sampling Time		10:34-11:33	11:45-12:44	13:03-14:02	
Inlet Flowrate (scfm)		43	21	22	29
Outlet Flowrate (scfm)		58	48	37	48
Inlet	Methanol Concentration (%)	13.93	12.87	13.49	13.43
	Formaldehyde Concentration (ppmv)	26.08	26.03	33.88	28.66
	Methanol Mass Flowrate (lb/hr)	30.03	13.62	14.93	19.53
	Formaldehyde Mass Flowrate (lb/hr)	0.01	0.00	0.00	0.00
	Total HAP Mass Flowrate (lb/hr)	30.04	13.63	14.93	19.53
Outlet	Methanol Concentration (%)	0.11	0.13	0.12	0.12
	Formaldehyde Concentration (ppmv)	4.76	5.89	6.70	5.78
	Methyl Formate Concentration (ppmv)	119.49	116.53	106.23	114.08
	Methylal Concentration (ppmv)	4,033.94	5,956.88	7,904.17	5,965.00
	Methanol Mass Flowrate (lb/hr)	0.32	0.31	0.22	0.28
	Formaldehyde Mass Flowrate (lb/hr)	0.00	0.00	0.00	0.00
	Methyl Formate Mass Flowrate (lb/hr)	0.06	0.05	0.04	0.05
	Methylal Mass Flowrate (lb/hr)	2.76	3.36	3.50	3.21
	Total VOC Mass Flowrate (lb/hr)	3.14	3.73	3.76	3.54
	Total HAP Mass Flowrate (lb/hr)	0.32	0.31	0.22	0.28
HAP Removal Efficiency (%)		<b>98.9</b>	<b>97.7</b>	<b>98.5</b>	<b>98.4</b>

VOC: volatile organic compounds (includes methanol, formaldehyde, methyl formate, and methylal)  
HAP: hazardous air pollutant (includes methanol and formaldehyde only)

scfm: standard cubic feet per minute

ppmv: parts per million on a volume to volume basis

lb/hr: pounds per hour

MW = molecular weight (Methanol = 32.04, Formaldehyde = 30.026,  
Methyl Formate = 60.052, Methylal = 76.095)

24.055: molar volume of air at standard conditions (68°F, 29.92" Hg)

35.31: ft<sup>3</sup> per m<sup>3</sup>

453,600: mg per lb

**Equations**

lb/hr = ppmv \* MW/24.055 \* 1/35.31 \* 1/453,600 \* scfm\* 60

**Table 6**  
**VRU Emission Rates - Recycled Methanol, -50°C to -30°C**  
**Allnex USA Inc.**

Parameter		Run 4	Run 5	Run 6	Average
Sampling Date		8/23/2022	8/23/2022	8/23/2022	
Sampling Time		15:45-16:44	16:53-17:52	17:58-18:57	
Inlet Flowrate (scfm)		4	29	12	15
Outlet Flowrate (scfm)		3	15	3	7
Inlet	Methanol Concentration (%)	13.09	14.52	12.62	13.41
	Formaldehyde Concentration (ppmv)	34.21	42.10	29.71	35.34
	Methanol Mass Flowrate (lb/hr)	2.87	20.92	7.68	10.49
	Formaldehyde Mass Flowrate (lb/hr)	0.00	0.01	0.00	0.00
	Total HAP Mass Flowrate (lb/hr)	2.87	20.93	7.68	10.49
Outlet	Methanol Concentration (%)	0.27	0.32	0.33	0.31
	Formaldehyde Concentration (ppmv)	11.58	12.15	10.66	11.46
	Methyl Formate Concentration (ppmv)	246.52	254.55	248.89	249.99
	Methylal Concentration (ppmv)	19,847.66	22,192.75	24,279.55	22,106.65
	Methanol Mass Flowrate (lb/hr)	0.04	0.23	0.06	0.11
	Formaldehyde Mass Flowrate (lb/hr)	0.00	0.00	0.00	0.00
	Methyl Formate Mass Flowrate (lb/hr)	0.01	0.03	0.01	0.02
	Methylal Mass Flowrate (lb/hr)	0.78	3.85	1.00	1.88
	Total VOC Mass Flowrate (lb/hr)	0.84	4.12	1.07	2.01
	Total HAP Mass Flowrate (lb/hr)	0.05	0.23	0.06	0.11
HAP Removal Efficiency (%)		<b>98.4</b>	<b>98.9</b>	<b>99.2</b>	<b>98.9</b>

VOC: volatile organic compounds (includes methanol, formaldehyde, methyl formate, and methylal)  
HAP: hazardous air pollutant (includes methanol and formaldehyde only)

scfm: standard cubic feet per minute

ppmv: parts per million on a volume to volume basis

lb/hr: pounds per hour

MW = molecular weight (Methanol = 32.04, Formaldehyde = 30.026,

Methyl Formate = 60.052, Methylal = 76.095)

24.055: molar volume of air at standard conditions (68°F, 29.92" Hg)

35.31: ft<sup>3</sup> per m<sup>3</sup>

453,600: mg per lb

**Equations**

$$\text{lb/hr} = \text{ppmv} * \text{MW}/24.055 * 1/35.31 * 1/453,600 * \text{scfm} * 60$$

**Table 7**  
**VRU Emission Rates - Fresh Methanol**  
**Allnex USA Inc.**

Parameter		Run 7	Run 8b	Run 9	Average
Sampling Date		8/24/2022	8/24/2022	8/24/2022	
Sampling Time		8:21-9:20	11:18-12:17	12:23-13:22	
Inlet Flowrate (scfm)		9	8	24	13
Outlet Flowrate (scfm)		8	12	24	15
Inlet	Methanol Concentration (%)	12.08	13.08	16.59	13.92
	Formaldehyde Concentration (ppmv)	0.00	1.70	2.37	1.36
	Methanol Mass Flowrate (lb/hr)	5.22	4.90	20.11	10.08
	Formaldehyde Mass Flowrate (lb/hr)	0.00	0.00	0.00	0.00
Total HAP Mass Flowrate (lb/hr)		5.22	4.90	20.11	10.08
Outlet	Methanol Concentration (%)	0.28	0.54	0.37	0.40
	Formaldehyde Concentration (ppmv)	6.75	4.25	4.01	5.00
	Methyl Formate Concentration (ppmv)	228.29	408.75	306.99	314.68
	Methylal Concentration (ppmv)	6,222.80	12,334.57	7,614.91	8,724.09
	Methanol Mass Flowrate (lb/hr)	0.11	0.33	0.45	0.29
	Formaldehyde Mass Flowrate (lb/hr)	0.00	0.00	0.00	0.00
	Methyl Formate Mass Flowrate (lb/hr)	0.02	0.05	0.07	0.04
	Methylal Mass Flowrate (lb/hr)	0.57	1.77	2.18	1.51
	Total VOC Mass Flowrate (lb/hr)	0.69	2.14	2.70	1.84
	Total HAP Mass Flowrate (lb/hr)	0.11	0.33	0.45	0.29
HAP Removal Efficiency (%)		<b>97.9</b>	<b>93.3</b>	<b>97.8</b>	<b>96.3</b>

VOC: volatile organic compounds (includes methanol, formaldehyde, methyl formate, and methylal)  
HAP: hazardous air pollutant (includes methanol and formaldehyde only)

scfm: standard cubic feet per minute

ppmv: parts per million on a volume to volume basis

lb/hr: pounds per hour

MW = molecular weight (Methanol = 32.04, Formaldehyde = 30.026,

Methyl Formate = 60.052, Methylal = 76.095)

24.055: molar volume of air at standard conditions (68°F, 29.92" Hg)

35.31: ft<sup>3</sup> per m<sup>3</sup>

453,600: mg per lb

**Equations**

lb/hr = ppmv \* MW/24.055 \* 1/35.31 \* 1/453,600 \* scfm\* 60

**Table 8  
Scrubber Emission Rates - 25 GPM  
Allnex USA Inc.**

Parameter		Run 1	Run 2	Run 3	Average
Sampling Date		8/24/2022	8/24/2022	8/24/2022	
Sampling Time		14:32-15:31	15:39-16:38	16:45-17:44	
Inlet Flowrate (scfm)		4,210	4,300	4,209	4,240
Outlet Flowrate (scfm)		3,895	3,917	3,905	3,905
Inlet	Methanol Concentration (ppmv)	10.08	59.34	8.88	26.10
	Formaldehyde Concentration (ppmv)	0.55	49.74	1.75	17.35
	Methanol Mass Flowrate (lb/hr)	0.21	1.27	0.19	0.56
	Formaldehyde Mass Flowrate (lb/hr)	0.01	1.00	0.03	0.35
Total HAP Mass Flowrate (lb/hr)		0.22	2.27	0.22	0.91
Outlet	Methanol Concentration (ppmv)	1.19	4.37	0.88	2.15
	Formaldehyde Concentration (ppmv)	0.49	2.24	0.47	1.07
	Methyl Formate Concentration (ppmv)	0.20	0.07	0.00	0.09
	Methylal Concentration (ppmv)	1.22	4.62	1.22	2.35
	Methanol Mass Flowrate (lb/hr)	0.02	0.09	0.02	0.04
	Formaldehyde Mass Flowrate (lb/hr)	0.01	0.04	0.01	0.02
	Methyl Formate Mass Flowrate (lb/hr)	0.01	0.00	0.00	0.00
	Methylal Mass Flowrate (lb/hr)	0.06	0.21	0.06	0.11
	Total VOC Mass Flowrate (lb/hr)	0.10	0.34	0.08	0.17
	Total HAP Mass Flowrate (lb/hr)	0.03	0.13	0.03	0.06
HAP Removal Efficiency (%)		85.6	94.4	88.4	89.5

VOC: volatile organic compounds (includes methanol, formaldehyde, methyl formate, and methylal)  
HAP: hazardous air pollutant (includes methanol and formaldehyde only)

scfm: standard cubic feet per minute

ppmv: parts per million on a volume to volume basis

lb/hr: pounds per hour

MW = molecular weight (Methanol = 32.04, Formaldehyde = 30.026,

Methyl Formate = 60.052, Methylal = 76.095)

24.055: molar volume of air at standard conditions (68°F, 29.92" Hg)

35.31: ft<sup>3</sup> per m<sup>3</sup>

453,600: mg per lb

**Equations**

$$\text{lb/hr} = \text{ppmv} * \text{MW}/24.055 * 1/35.31 * 1/453,600 * \text{scfm} * 60$$



**Table 9  
Scrubber Emission Rates - 20 GPM  
Allnex USA Inc.**

Parameter		Run 4	Run 5	Run 6	Average
Sampling Date		8/25/2022	8/25/2022	8/25/2022	
Sampling Time		8:05-9:05	9:12-10:11	10:20-11:19	
Inlet Flowrate (scfm)		4,410	4,256	4,270	4,312
Outlet Flowrate (scfm)		4,031	4,098	4,009	4,046
Inlet	Methanol Concentration (ppmv)	140.37	47.42	3.67	63.82
	Formaldehyde Concentration (ppmv)	15.30	5.88	0.46	7.21
	Methanol Mass Flowrate (lb/hr)	3.09	1.01	0.08	1.39
	Formaldehyde Mass Flowrate (lb/hr)	0.32	0.12	0.01	0.15
	Total HAP Mass Flowrate (lb/hr)	3.40	1.12	0.09	1.54
Outlet	Methanol Concentration (ppmv)	16.65	8.07	2.16	8.96
	Formaldehyde Concentration (ppmv)	8.01	3.87	0.91	4.26
	Methyl Formate Concentration (ppmv)	0.41	0.35	0.00	0.25
	Methylal Concentration (ppmv)	14.76	5.58	1.14	7.16
	Methanol Mass Flowrate (lb/hr)	0.33	0.17	0.04	0.18
	Formaldehyde Mass Flowrate (lb/hr)	0.15	0.07	0.02	0.08
	Methyl Formate Mass Flowrate (lb/hr)	0.02	0.01	0.00	0.01
	Methylal Mass Flowrate (lb/hr)	0.71	0.27	0.05	0.34
	Total VOC Mass Flowrate (lb/hr)	1.21	0.52	0.11	0.61
	Total HAP Mass Flowrate (lb/hr)	0.49	0.24	0.06	0.26
HAP Removal Efficiency (%)		<b>85.7</b>	<b>78.7</b>	<b>31.0</b>	<b>65.2</b>

VOC: volatile organic compounds (includes methanol, formaldehyde, methyl formate, and methylal)  
HAP: hazardous air pollutant (includes methanol and formaldehyde only)

scfm: standard cubic feet per minute

ppmv: parts per million on a volume to volume basis

lb/hr: pounds per hour

MW = molecular weight (Methanol = 32.04, Formaldehyde = 30.026,

Methyl Formate = 60.052, Methylal = 76.095)

24.055: molar volume of air at standard conditions (68°F, 29.92" Hg)

35.31: ft<sup>3</sup> per m<sup>3</sup>

453,600: mg per lb

**Equations**

lb/hr = ppmv \* MW/24.055 \* 1/35.31 \* 1/453,600 \* scfm\* 60

**Table 10**  
**Scrubber Emission Rates - 15 GPM**  
**Allnex USA Inc.**

Parameter		Run 7	Run 8	Run 9	Average
Sampling Date		8/25/2022	8/25/2022	8/25/2022	
Sampling Time		11:42-12:41	12:54-13:53	14:05-15:04	
Inlet Flowrate (scfm)		4,333	4,431	4,436	4,400
Outlet Flowrate (scfm)		4,024	4,079	3,995	4,033
Inlet	Methanol Concentration (ppmv)	3.72	4.35	51.44	19.84
	Formaldehyde Concentration (ppmv)	0.40	0.55	42.87	14.61
	Methanol Mass Flowrate (lb/hr)	0.08	0.10	1.14	0.44
	Formaldehyde Mass Flowrate (lb/hr)	0.01	0.01	0.89	0.30
Total HAP Mass Flowrate (lb/hr)		0.09	0.11	2.03	0.74
Outlet	Methanol Concentration (ppmv)	2.40	2.47	9.76	4.88
	Formaldehyde Concentration (ppmv)	1.03	1.07	4.86	2.32
	Methyl Formate Concentration (ppmv)	0.00	0.00	0.00	0.00
	Methylal Concentration (ppmv)	1.23	1.25	5.96	2.81
	Methanol Mass Flowrate (lb/hr)	0.05	0.05	0.19	0.10
	Formaldehyde Mass Flowrate (lb/hr)	0.02	0.02	0.09	0.04
	Methyl Formate Mass Flowrate (lb/hr)	0.00	0.00	0.00	0.00
	Methylal Mass Flowrate (lb/hr)	0.06	0.06	0.28	0.13
	Total VOC Mass Flowrate (lb/hr)	0.13	0.13	0.57	0.27
Total HAP Mass Flowrate (lb/hr)	0.07	0.07	0.29	0.14	
HAP Removal Efficiency (%)		23.7	34.3	85.9	48.0

VOC: volatile organic compounds (includes methanol, formaldehyde, methyl formate, and methylal)  
HAP: hazardous air pollutant (includes methanol and formaldehyde only)

scfm: standard cubic feet per minute

ppmv: parts per million on a volume to volume basis

lb/hr: pounds per hour

MW = molecular weight (Methanol = 32.04, Formaldehyde = 30.026,

Methyl Formate = 60.052, Methylal = 76.095)

24.055: molar volume of air at standard conditions (68°F, 29.92" Hg)

35.31: ft<sup>3</sup> per m<sup>3</sup>

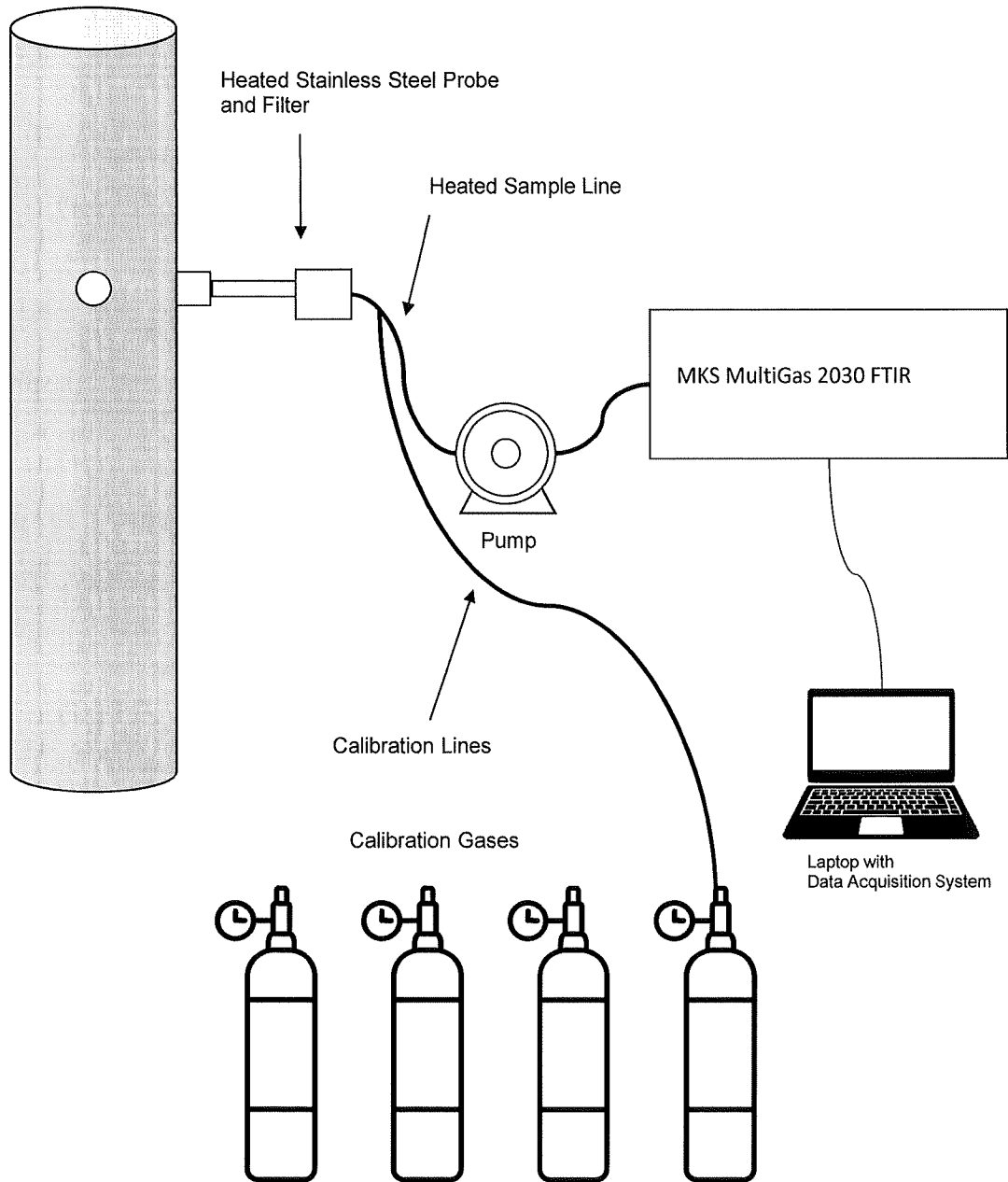
453,600: mg per lb

**Equations**

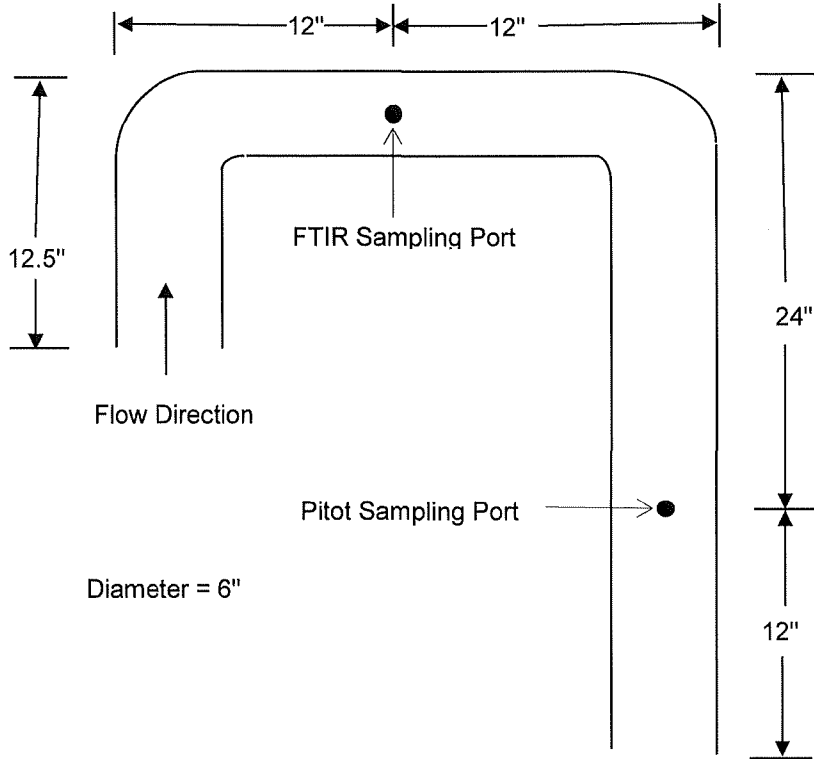
lb/hr = ppmv \* MW/24.055 \* 1/35.31 \* 1/453,600 \* scfm\* 60

# Appendix B – Figures

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**Figure 1**  
**USEPA Method 320 Sampling Train**



DRAWING IS NOT TO SCALE

**Figure No. 2**

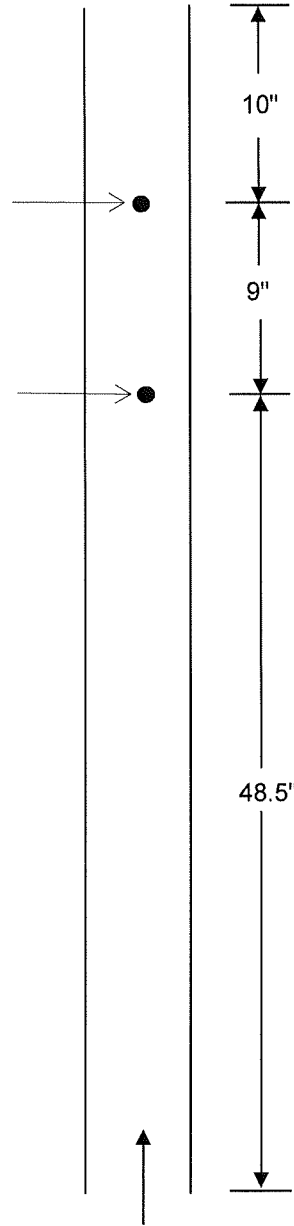
**Site:**  
VRU Inlet Sampling Location  
Allnex USA Inc.  
Kalamazoo, Michigan

**Chase Young Environmental Testing Inc**  
28744 Groveland St  
Madison Heights, Michigan 48071

Diameter = 6"

FTIR Sampling Port

Pitot Sampling Port



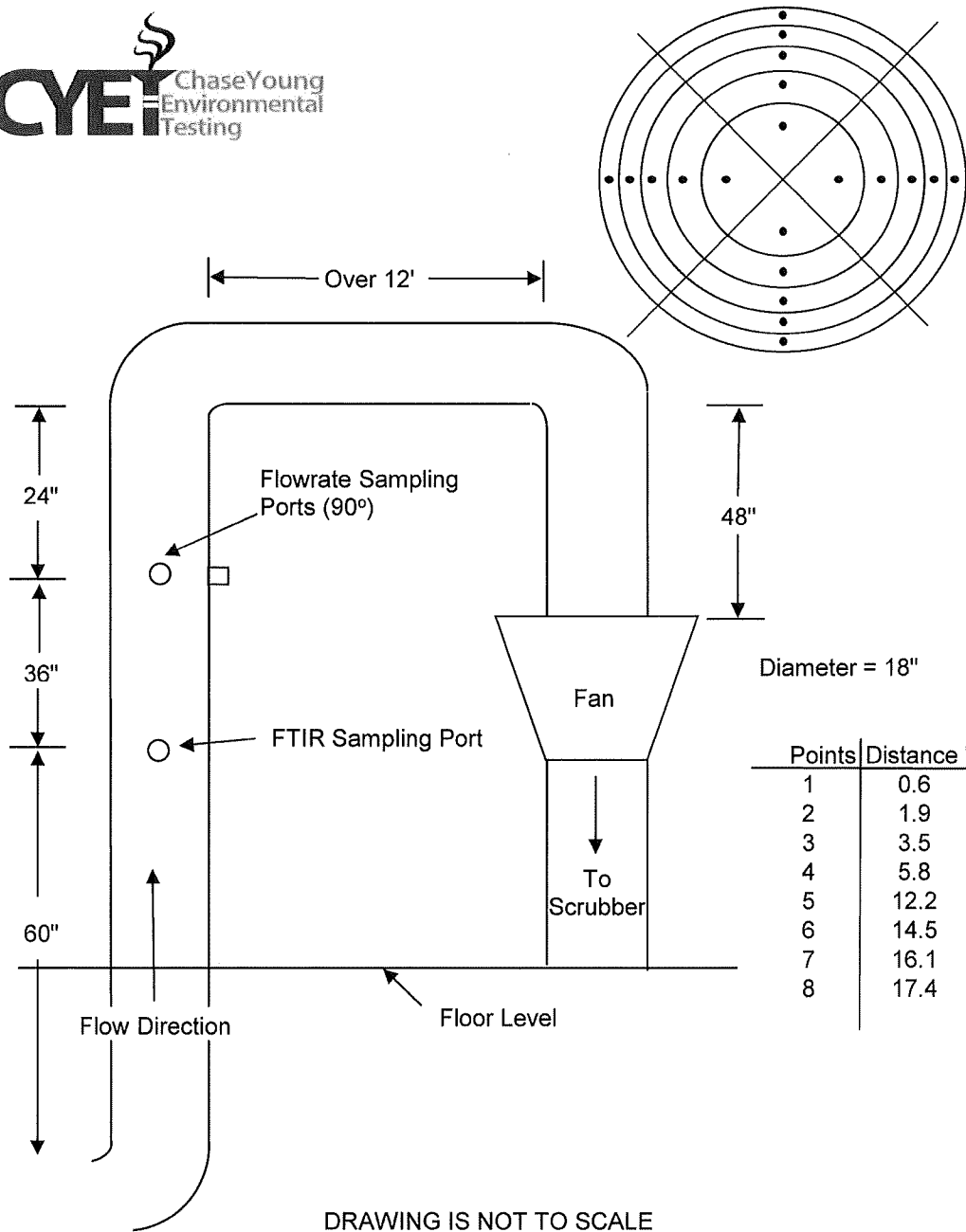
DRAWING IS NOT TO SCALE

Flow Direction

**Figure No. 3**

**Site:**  
**VRU Outlet Sampling Location**  
**Allnex USA Inc.**  
**Kalamazoo, Michigan**

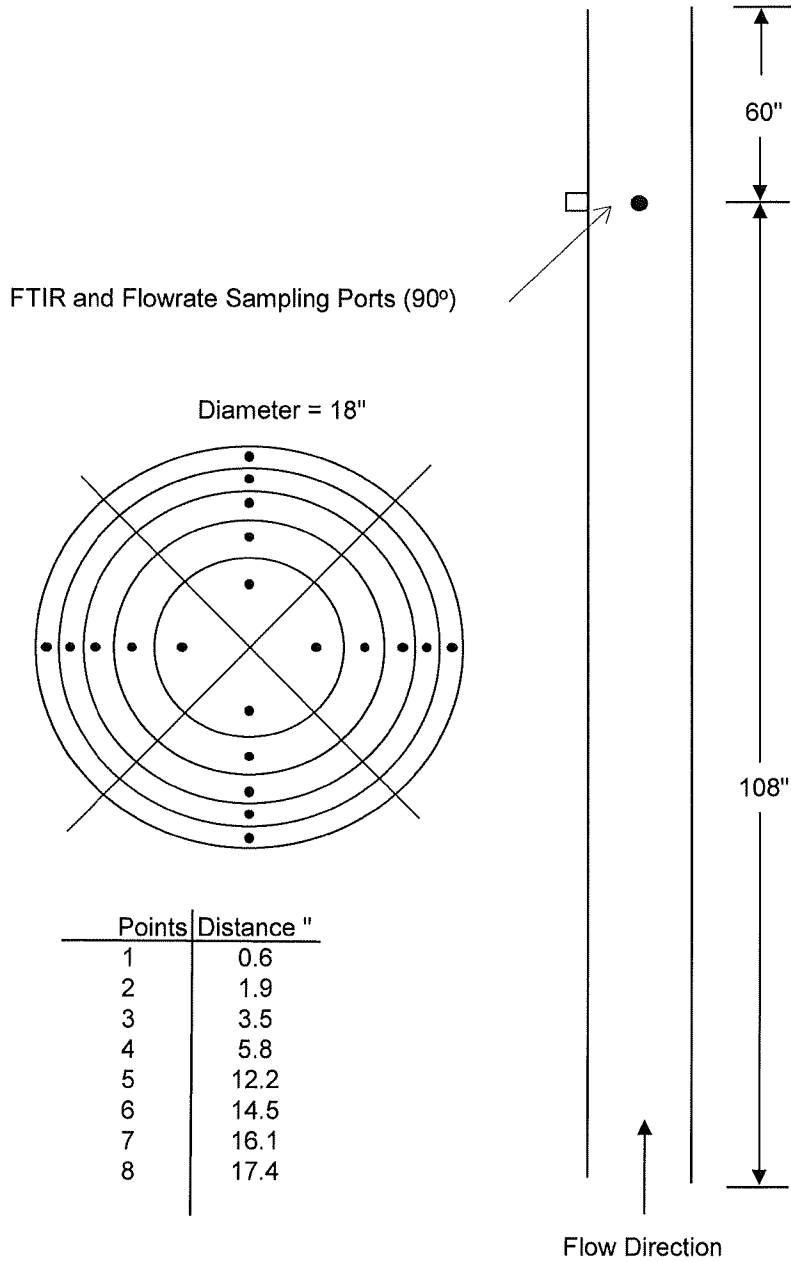
**Chase Young Environmental Testing**  
**Inc**  
**28744 Groveland St**  
**Madison Heights, Michigan 48071**



**Figure No. 4**

**Site:**  
Scrubber Inlet Sampling Location  
Allnex USA Inc.  
Kalamazoo, Michigan

**Chase Young Environmental Testing  
Inc**  
28744 Groveland St  
Madison Heights, Michigan 48071



DRAWING IS NOT TO SCALE

**Figure No. 5**

**Site:**  
**Scrubber Outlet Sampling Location**  
**Allnex USA Inc.**  
**Kalamazoo, Michigan**

**Chase Young Environmental Testing**  
**Inc**  
**28744 Groveland St**  
**Madison Heights, Michigan 48071**