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NEW SOURCE PERFORMANCE STANDARD EMISSION TEST PLAN

Report Title:	Emission Test Plan for the Verification of Air Pollutant Emissions from a Natural Gas Fired Internal Combustion Engine Emergency Generator Set
Test Date:	October 28, 2020

Facility Information	
Name:	University of Michigan, South Quadrangle Residence Hall
Street Address:	1239 Kipke Drive
City, County:	Ann Arbor, Washtenaw
State Registration No.:	M0675

Emission Unit Information	
Permit No.:	MI-ROP-M0675-2014a
Emission Unit:	Cummins GTA38 CC, 550 kW SI-RICE genset

Testing Contractor	
Company:	Impact Compliance & Testing, Inc.
Mailing Address:	37660 Hills Tech Drive Farmington Hills, MI 48331
Phone:	(734) 464-3880
Project No.:	2000139

NSPS EMISSION TEST PLAN
FOR THE
VERIFICATIONS OF AIR POLUTANT EMISSIONS
FROM A
NATURAL GAS FUELED INTERNAL COMBUSTION ENGINE
EMERGENCY GENERATOR SET

UNIVERSITY OF MICHIGAN
SOUTH QUADRANGLE RESIDENCE HALL

Scheduled Test Date: October 28, 2020

The University of Michigan (University) operates a natural gas fired, spark-ignition reciprocating internal combustion engine (SI-RICE) emergency generator set located inside of the South Quadrangle Residence Hall (SQ) located at 600 East Madison Street in Ann Arbor, Washtenaw County.

The SI-RICE emergency generator set is a Cummins Model GTA38 CC that has a rated electricity output of 550 kW, a horsepower rating of approximately 850 HP, and is subject to the SI-RICE New Source Performance Standard (NSPS) codified in 40 CFR Part 60 Subpart JJJJ. The SI-RICE NSPS specifies that:

1. *Owners and operators of stationary SI ICE with a maximum engine power greater than or equal to 75 kW (except gasoline and rich burn engines that use LPG) must comply with the emission standards in Table 1 to this subpart for their stationary SI ICE.*

2. *If you are an owner or operator of a stationary SI internal combustion engine greater than 500 HP...you must conduct an initial performance test within 1 year of engine startup and conduct subsequent performance testing every 8,760 hours or 3 years, whichever comes first, thereafter to demonstrate compliance.*

Emission testing for this unit was previously performed on November 9, 2017 and is being repeated within three (3) years of the previous test event. Since the generator set is only operated during emergency events, it will not have accumulated 8,760 operating hours since the previous test event. The testing will consist of triplicate, one-hour sampling periods for nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compound (VOC, as non-methane hydrocarbons) emissions.

The emission testing presented in this test plan will be performed by Impact Compliance & Testing, Inc. (ICT), a Michigan-based environmental consulting and testing company. This test plan has been prepared in accordance with the Michigan Department of Environment, Great Lakes, and Energy-Air Quality Division (EGLE-AQD) *Format for Submittal of Source Emission Test Plans and Reports* (November 2019).

1.0 IDENTIFICATION AND DESCRIPTION OF THE SOURCE TO BE TESTED

1.1 Contact Person(s) for Source and Test Plan Information

Questions concerning the engine performance tests should be addressed to:

Mr. Stephen O'Rielly
Manager, Environment, Health & Safety
University of Michigan
1239 Kipke Drive
Ann Arbor, MI 48109-1010
(734) 763-4642
sorielly@umich.edu

Tyler J. Wilson
Senior Project Manager
Impact Compliance & Testing, Inc.
37660 Hills Tech Drive
Farmington Hills, MI 48331
(734) 464-3880
Tyler.Wilson@ImpactCandT.com

1.2 Identification and Description of Source to be Tested

The unit to be tested is a Cummins Model GTA38 CC SI-RICE generator set.

1.3 Type and Typical Quantity of Raw/Finished Materials Used in Each Process

The SI-RICE generator set is fueled exclusively with pipeline natural gas.

1.4 Description of Cyclical or Batch Operations

The SI-RICE generator set is classified as an emergency generator and is only operated to provide electricity to the Institute for the SQ during power outages and for periodic maintenance testing.

1.5 Basic Operation Parameters Used to Regulate the Process

The SI-RICE is equipped with an air to fuel ratio controller which is set to maintain efficient fuel combustion and maximize power output. A Cummins representative will be on site during the test event to connect a load bank to mimic the electricity demand for generator set operation.

1.6 Rated Capacity of the Processes

The SI-RICE generator set is rated at 850 HP and the connected generator produces up to 550 kW of electricity. Testing will be performed while the generator set is operated at or near (within 10%) of 550 kW.

2.0 DESCRIPTION OF EMISSION CONTROL EQUIPMENT

The engine is equipped with a non-selective catalytic reduction (NSCR) system for passively controlling CO, NOx, and hydrocarbon (HC) emissions. The NSCR system consists of two catalyst beds that allow CO and HC to be oxidized by the oxygen that is a component of the NOx. This system relies on a low concentration of oxygen at the catalyst bed inlet. The engine is equipped with controls to adjust the fuel-air-ratio of the engine intake manifold.

The NSCR is passive in nature and its efficiency is dependent on exhaust gas temperature and oxygen content as well as catalyst bed condition. In accordance with 40 CFR 60.4243, the air-to-fuel ration controller will be optimized for emissions reduction.

3.0 PERMIT NUMBER AND EMISSION LIMITS

The SQ emergency generator is not currently identified in Renewable Operating Permit (ROP) No. MI-ROP-M0675-2014a issued to the University. It will be included when the permit is renewed and added to Flexible Group FG-EMERG-JJJJ.

The SQ emergency generator is subject to the requirements of the SI-RICE NSPS (40 CFR Part 60 Subpart JJJJ), which specifies that stationary emergency engines that have a rating greater than or equal to 130 HP are subject to the emission standards in Table 1 of Subpart JJJJ.

Table 1 of Subpart JJJJ specifies the following emission standards for stationary emergency SI-RICE that have a rating greater than or equal to 130 HP.

Emission	CO		NOx		VOC	
Unit	(g/bhp-hr)	(ppmvd)†	(g/bhp-hr)	(ppmvd)†	(g/bhp-hr)	(ppmvd)†
SQ generator	4.0	540	2.0	160	1.0	86

† Parts per million by volume, dry basis, corrected to 15% oxygen. VOC concentration is C_3 (propane).

The source has the option of demonstrating compliance with either the mass emission rate (g/bhp-hr) or the exhaust gas pollutant concentration (ppmvd at 15% oxygen).

4.0 POLLUTANTS TO BE MEASURED

The SI-RICE exhaust gas will be sampled and analyzed to determine NOx, CO, and VOC concentrations. Exhaust gas oxygen and moisture content will be measured to correct the concentration data to dry basis at 15% oxygen as appropriate.

5.0 DESCRIPTION OF SAMPLING TRAINS

The following test methods will be used to measure the specified engine air pollutant emission and exhaust parameters.

Analyte or Exhaust Parameter	Sampling Methodology	Analytical Methodology
Oxygen	USEPA Method 3A	Zirconia ion or paramagnetic detector
Moisture	USEPA Method 4	Water gain in chilled impingers
NOx Concentration	USEPA Method 7E	Chemiluminescence instrumental analyzer
CO Concentration	USEPA Method 10	Non-dispersive infrared (NDIR) instrumental analyzer
VOC/NMOC Concentration	USEPA Method 25A and Alt 096	Flame ionization analyzer (FIA) with internal methane separation column

6.0 DETAILED SAMPLING AND ANALYSIS PROCEDURES

6.1 Measurement of oxygen concentrations (USEPA Method 3A)

Engine exhaust O_2 content measurements will be performed concurrently with each CO, NOx, and VOC/NMOC sampling period using an instrumental analyzer in accordance with Method 3A. A Servomex gas analyzer that uses a paramagnetic sensor (or equivalent) will be used to measure the O_2 content of the engine exhaust gas.

Samples of the engine exhaust gas will be delivered to the instrument analyzer using an extractive gas sampling system that prevents condensation or contamination of the sample. The exhaust gas samples will be conditioned (i.e., dried) prior to being introduced to the instrument analyzer. Therefore, O_2 measurements correspond to standard, dry gas conditions.

Attachment 1 provides a general diagram of the sampling location.

Attachment 2 provides information of the extractive gas sampling and conditioning system that will be used to deliver engine exhaust gas to the instrumental analyzers.

6.2 Determination of exhaust gas moisture content (USEPA Method 4)

The engine exhaust gas moisture content will be determined in accordance with the USEPA Method 4 chilled impinger method for each test period. A sample of the engine exhaust gas will be extracted at a constant rate from the centroid of one of the exhaust stacks (non-isokinetic). A non-heated probe will be used to extract the gas since the temperature of the exhaust gas is expected to be greater than 300°F. Moisture in the sampled gas stream will be collected in the chilled impinger train and determined gravimetrically (or volumetrically) based on the water gain measured in the impinger train.

A calibrated dry gas meter will be used to measure the total sample volume. The Method 4 train will be operated for 35 minutes to achieve a minimum gas sample volume of 25 dry standard cubic feet (dscf).

Attachment 3 provides a description of the USEPA Method 4 sampling procedures.

6.3 NOx measurements using an instrumental analyzer (USEPA Method 7E)

Engine exhaust NOx concentrations will be determined during each sampling period using a Thermo Environmental Instruments Inc. Model 42C NO-NO_2-NOx Analyzer (or equivalent) that incorporates chemiluminescence technology for the measurement of NOx concentrations in accordance with USEPA Method 7E.

A continuous sample of the engine exhaust gas will be delivered to the instrument analyzer using an extractive gas sampling system described in Attachment 2. The exhaust gas samples will be conditioned (i.e., dried) prior to being introduced to the instrument analyzer. Therefore, NOx measurements correspond to dry, standard conditions.

The specified instrument analyzer will be calibrated using certified NOx concentrations in nitrogen. The calibration gases will be diluted (using a certified gas divider) with nitrogen to obtain intermediate NOx concentrations and to demonstrate linearity of the instrument analyzer.

6.4 CO measurements via instrumental analyzer (USEPA Method 10)

Engine exhaust CO concentrations will be determined during each test period using a CO analyzer that utilizes non-dispersive infrared (NDIR) technology (or equivalent) in accordance with USEPA Method 10 for measurement of CO concentration in exhaust gases.

A continuous sample of the engine exhaust gas will be delivered to the instrument analyzer using an extractive gas sampling system described in Attachment 2. The exhaust gas samples will be conditioned (i.e., dried) prior to being introduced to the instrument analyzer. Therefore, CO measurements correspond to standard, dry gas conditions.

The instrumental analyzer will be calibrated using certified CO concentrations in nitrogen. The calibration gases will be diluted (using a certified gas divider) with nitrogen to obtain intermediate CO concentrations and to demonstrate linearity of the instrument analyzer.

6.5 Measurement of VOC/NMOC concentrations (USEPA Method 25A/Alt 096)

VOC as non-methane hydrocarbon (NMHC or NMOC) concentration in the engine exhaust will be determined using a Thermo Environmental Instruments, Inc. (TEI), Model 55i Methane-NMHC analyzer in accordance with USEPA Method 25A and Alternate Method (ALT) 096 for direct measurement of VOC/NMHC concentrations in the engine exhaust gas.

The TEI 55i is an automated batch analyzer that repeatedly collects and analyzes samples of the exhaust gas stream that are drawn into the instrument by the internal sampling pump. The sampled gas is separated by an internal gas chromatography (GC) column into methane and non- methane fractions and each fraction is analyzed separately using a flame ionization detector (FID), in accordance with USEPA Method 25A. The VOC/NMHC concentration will be reported relative to a propane calibration standard (parts per million as propane, C_3). The exhaust gas sample is delivered directly to the VOC instrumental analyzer; therefore, the recorded data correspond to standard conditions with no moisture correction (wet basis). Moisture data will be used to correct the VOC concentration to dry basis before comparison to the emission standard.

The USEPA Office of Air Quality Planning and Standards (OAQPS) has issued several alternate test methods approving the use of the TEI 55-series analyzer as an effective instrument for measuring VOC from gas-fueled engines (ALT-066, ALT-078 and ALT-096).

The instrument will be calibrated using certified propane concentrations in hydrocarbon-free air. The calibration gases will be diluted (using a certified gas divider) with hydrocarbon-free air to obtain intermediate concentrations and to demonstrate linearity of the instrument analyzer.

Attachment 2 provides information of a typical extractive gas sampling and conditioning system that will be used to deliver engine exhaust gas samples to the TEI Model 55i analyzer.

Attachment 4 provides the approval letter from the USEPA for the use of Alt-096 (TEI Model 55i Analyzer) for measuring engine VOC/NMOC emissions.

7.0 <u>NUMBER AND LENGTH OF SAMPLING RUNS</u>

The emission testing will consist of three (3) one-hour test periods for O_2, CO, NOx, and VOC/NMOC concentrations.

8.0 SAMPLING LOCATION DIMENSIONS

Actual sample location measurements will be verified prior to conducting the tests and reported with the results.

The sampling locations are expected to have identical dimensions.

Stack diameter (ID):	9.5 inches
Discharge orientation:	Vertical, unobstructed
Rain cap:	None

Distance to nearest	
Downstream disturbance (A):	> 0.5 diameters
Upstream disturbance (B):	> 2.0 diameters

The sampling location will be in a horizontal section of the exhaust stack above and near the engine. The stack exhausts to ambient outside air vertically, on the roof of the SQ.

9.0 ESTIMATED FLUE GAS CONDITIONS

Sampling Location	Temperature (°F)	Expected O_2 Conc. (%)	Expected Moisture (%)
SQ Engine Exhaust	500	0.25	18.1

10.0 PROJECTED PROCESS OPERATING CONDITIONS

A Cummins representative will be on site during the test event to connect a load bank to mimic the electricity demand for generator set operation. The generator set will be operated within 10% of maximum rated capacity during the air pollutant emission tests (i.e., between 495 and 605 kW).

11.0 PROCESS OR CONTROL EQUIPMENT DATA TO BE COLLECTED

For each test period, a Cummins representative will monitor and record the electricity produced by the generator (kW). Data will be recorded continuously or at least every 15-minutes.

12.0 CHAIN OF CUSTODY / LABORATORY PROCEDURES

N/A

13.0 FIELD QA/QC PROCEDURES

13.1 Instrument Calibration and System Bias Checks

At the beginning of each test day, three-point instrument analyzer calibrations will be initially performed by injecting calibration gas directly into the inlet sample port for each instrument analyzer. System bias checks will be performed prior to, and at the conclusion, of each test period by introducing the appropriate upscale calibration gas and zero gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and verifying the instrument analyzer response against the initial instrument calibration readings.

For Method 25A/Alt 096, the TEI 55i analyzer will be calibrated with propane and will have periodic drift checks performed. For determining instrument linearity (5%) a four-point instrument analyzer calibration will be performed at the beginning of each test day by injecting calibration gas into the sampling system (at the base of the stainless steel sampling probe prior to the particulate filter and Teflon® heated sample line) and verifying the instrument analyzer response against the certified calibration gases. Calibration drift (3%) will be calculated based on the pre-test and post-test calibrations using the zero and mid-level calibration gases.

The instrument analyzers will be calibrated with USEPA Protocol 1 certified O_2, CO, and NOx concentrations in nitrogen and zeroed using nitrogen. For the TEI 55i calibration gases, certified propane concentrations in hydrocarbon free air will be used and the analyzer will be zeroed with hydrocarbon free air. A STEC Model SGD-710C ten-step gas divider will be used (as needed) to obtain intermediate calibration gas concentrations.

13.2 Verification of gas dilution calibration equipment

A STEC Model SGD-710C 10-step gas divider will be used to obtain appropriate calibration span gases. The ten-step STEC gas divider was NIST certified within the last 12 months with a primary flow standard in accordance with Method 205. When cut with an appropriate zero gas, the ten-step STEC gas divider delivers calibration gas values ranging from 0% to 100% (in 10% step increments) of the USEPA Protocol 1 calibration gas introduced into the system. The field evaluation procedures presented in Section 3.2 of Method 205 will be followed prior to use of gas divider.

13.3 NO_2 – NO Converter Test

The NO_2 – NO conversion efficiency of the TEI Model 42C instrumental analyzer will be verified prior to the commencement of the performance tests. A USEPA Protocol 1 certified NO_2 calibration gas will be used to verify the efficiency of the NO_2 – NO converter. The instrument analyzer NO_2 – NO converter uses a catalyst at high temperatures to convert the NO_2 to NO for measurement. The conversion efficiency of the instrument analyzer will be deemed acceptable if the calculated NO_2 – NO conversion efficiency is greater than or equal to 90%.

13.4 Sampling System Response Time Determination

The response time of the sampling system will be determined prior to the commencement of the engine performance tests by introducing upscale gas and zero gas, in series, into the sampling system using a tee connection at the base of the sample probe. The elapsed time for the analyzer to display a reading of 95% of the expected concentration will be determined using a stopwatch.

Test periods will commence once the sampling probe has been in place for at least twice the system response time.

13.5 Determination of Exhaust Gas Stratification

Prior to conducting the test program (or as part of the first sampling period), a stratification test will be performed in order to determine representative stack gas sampling locations (i.e., pollutant concentration measurement locations) in accordance with the preliminary traverse procedures specified in Section 8.1.2 of USEPA Method 7E. Three points along a line passing through the centroid of the stack, located at 16.7, 50.0, and 83.3%, will be sampled for a minimum twice the response time.

13.6 Instrumental Analyzer Interference Check

The instrumental analyzers used to measure NO_X, CO, and O_2 have had an interference response test preformed prior to their use in the field, pursuant to the interference response test procedures specified in USEPA Method 7E. The appropriate interference test gases (i.e., gases that would be encountered in the exhaust gas stream) were introduced into each analyzer, separately and as a mixture with the analyte that each analyzer is designed to measure. All of analyzers exhibited a composite deviation of less than 2.5% of the span for all measured interferent gases. No major analytical components of the analyzers have been replaced since performing the original interference tests.

13.7 Meter Box Calibrations

The dry gas meter and gas sampling console, which will be used to extract a measured amount of exhaust gas from the stack for moisture content determinations, will be calibrated prior to and after the testing program. This calibration uses the critical orifice calibration technique presented in USEPA Method 5.

The digital pyrometer in the metering console will be calibrated using a NIST traceable Omega® Model CL 23A temperature calibrator.

14.0 TESTING PERSONNEL

The testing will be performed by employees of ICT that are experienced and properly trained on the execution of the reference test methods.

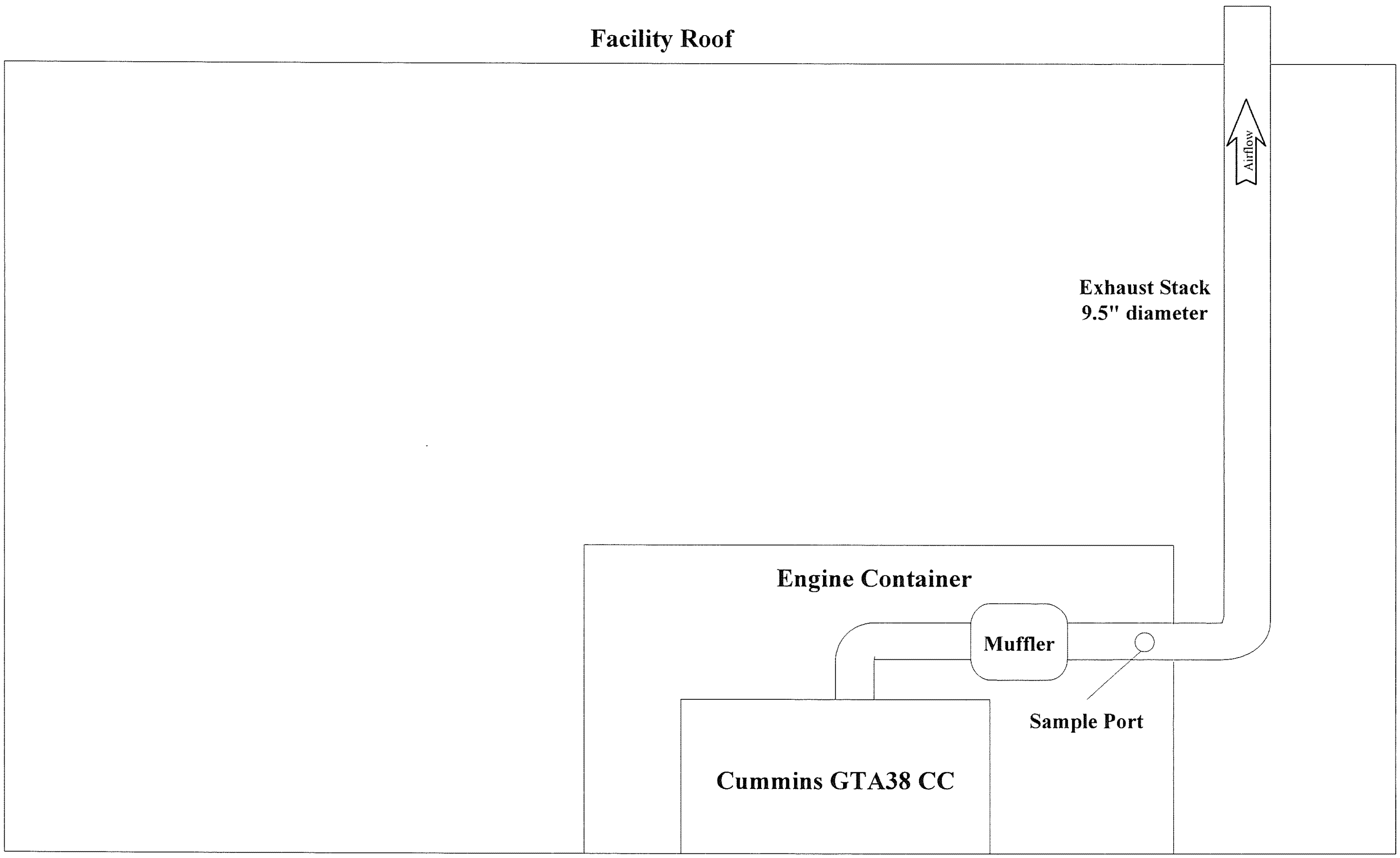
Engine operating parameters or specific monitoring data that is required for the emission tests will be collected by a Cummins representative and provided to ICT for inclusion in the final test report.

Test Plan Prepared By:

Tyler J. Wilson
Senior Project Manager
Impact Compliance & Testing, Inc.

ATTACHMENT 1

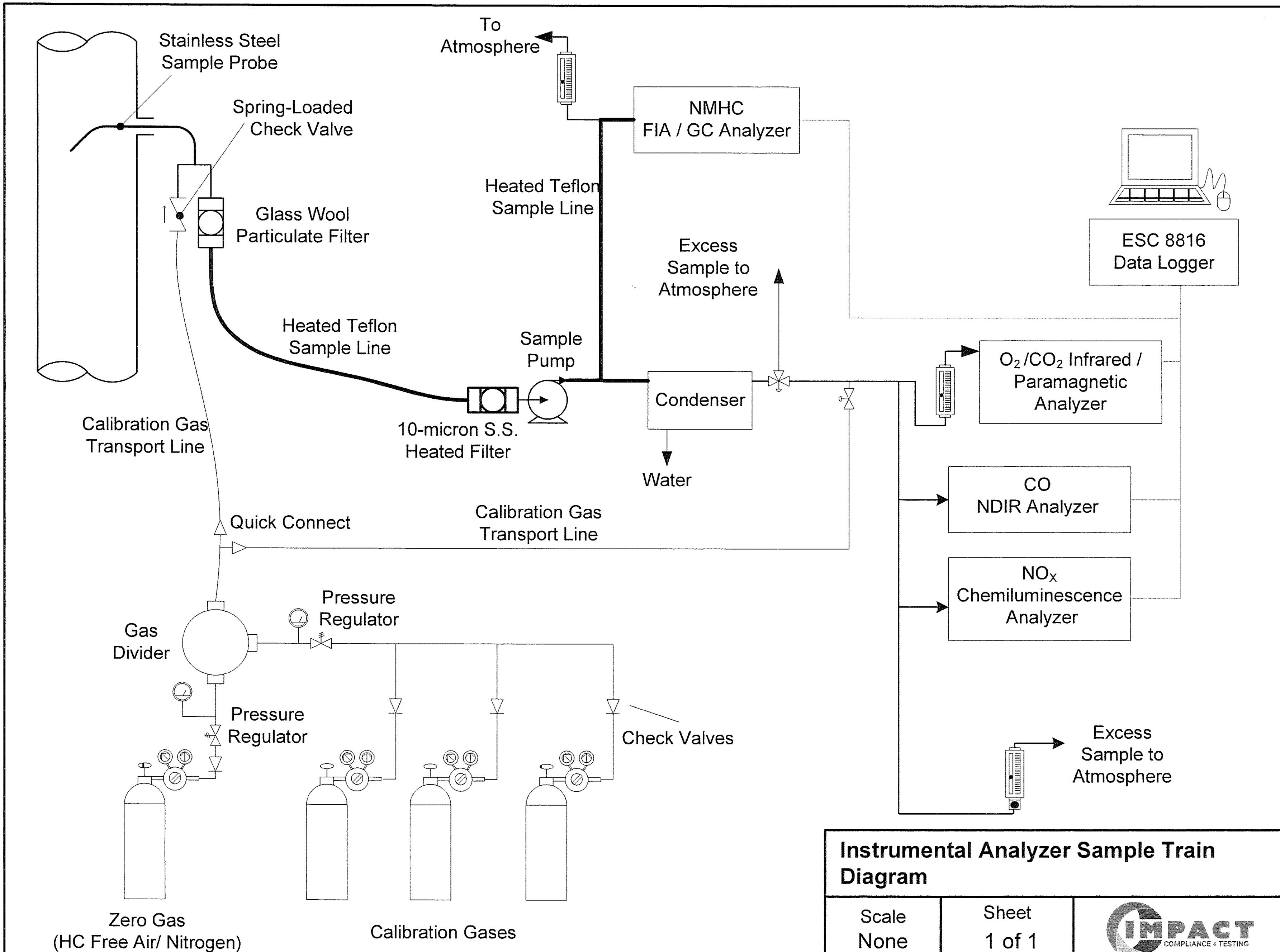
EXHAUST STACK DRAWING



9/15/17	**University of Michigan, South Quad** **Engine Exhaust Sample Location**		
	Scale None	Sheet 1 of 1	ICT

ATTACHMENT 2

INSTRUMENTAL ANALYZER SAMPLING TRAIN DIAGRAM AND
EXTRACTIVE GAS SAMPLING PROCEDURES



Instrumental Analyzer Sample Train Diagram

Scale	Sheet	
None	1 of 1	IMPACT COMPLIANCE & TESTING