Attachment H

PFAS Stack Test Report (Linden NJ)

Results of the November 19-20, 2024, PFAS Mass Balance Study at the Aries Clean Technologies Biosolids Gasification Facility Located in Linden, New Jersey

Biosolids Gasification Process

Barr Project No. 30201003.00

Prepared for
Aries Clean Technologies

Prepared by
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Results of the November 19-20, 2024, PFAS Mass Balance Study at the Aries Clean Technologies Biosolids Gasification Facility Located in Linden, New Jersey

April 2025

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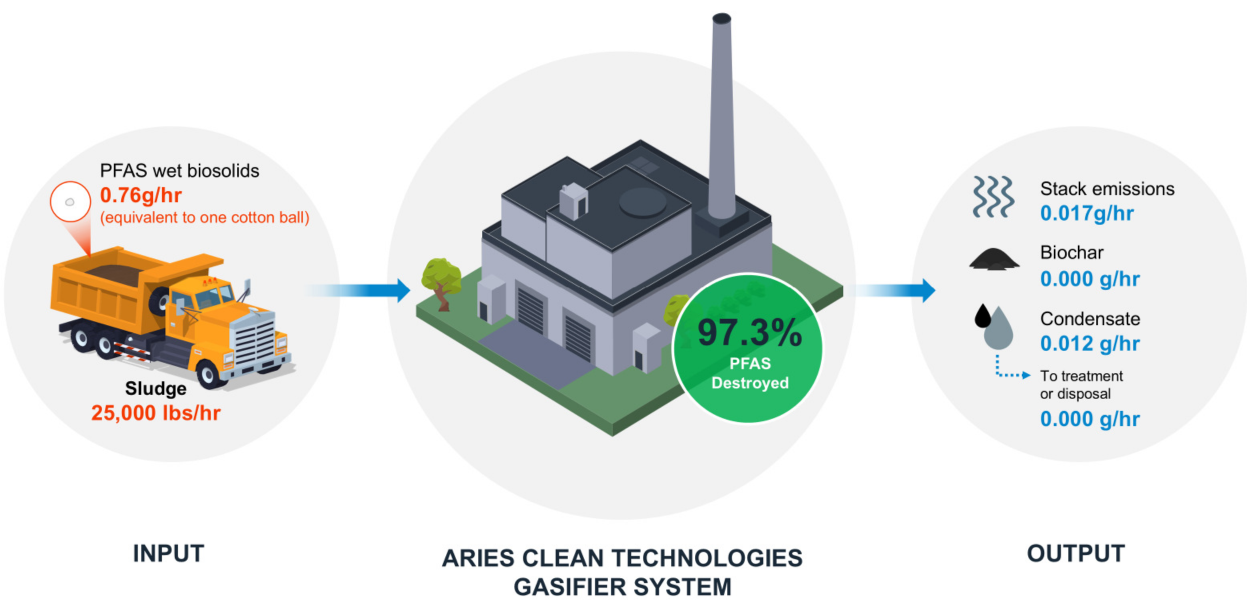
Executive Summary

Aries Clean Technologies (Aries) contracted Barr Engineering Co. (Barr) to perform a mass balance assessment for per- and poly-fluoroalkyl substances (PFAS) compounds at their biosolids gasification facility in Linden, New Jersey which included PFAS emission testing. The information gathered was used to assess PFAS destruction capabilities of the biosolids gasification system. The test was performed on November 19 and 20, 2024 using USEPA Other Test Method 45 (OTM-45) REV1 to measure stack gas concentrations and mass emission rates of PFAS compounds, while EPA Method 1633 and EPA Method 537 was used to measure solids and liquids samples for PFAS.

The information was gathered to assess PFAS destruction of the biosolids gasification system. Process samples were collected by Aries operators for wet biosolids (~20% solids by weight). The facility's influent was, on average, 25,000 pounds per hour of wet biosolids, roughly a single truck of product. As a result of the EPA Method 1633 analysis, the wet biosolids contained 0.76 grams per hour of PFAS, which is the vast majority of the PFAS input to the gasifier process. This is equivalent in mass to a cotton ball of PFAS within the truck or 67 parts per billion (nanogram PFAS/gram wet biosolids).

The results of the test indicated that the Aries Biosolids Gasification process effectively destroys PFAS with as much as 97.3% PFAS destruction and removal efficiency (DRE), which is significant given the low mass of PFAS entering the system. There is potential to increase this DRE to 98.9% upon treatment or disposal of the condensate stream from the dryer system, pending technical and economic evaluations. Continued operation and optimization of the gasification system has the potential to increase the PFAS destruction capabilities of the system. It is reasonable to expect that even greater PFAS destruction can be achieved with continued process optimization. This future performance can be verified with a future stack emission and mass balance test.



1 Introduction

Aries contracted Barr Engineering Co. to perform a mass balance for per- and poly-fluoroalkyl substances (PFAS) compounds including stack emissions testing at their biosolids gasification facility in Linden, New Jersey. PFAS emissions testing and solids/liquids sampling were completed at the facility on November 19 and 20, 2024.

Tim Russell of Barr led the test team on-site. Joel Thornton of Aries assisted with site coordination during the tests while the normal Aries operating staff assisted with testing on-site. A list of project participants is in Appendix H.

The stack testing utilized EPA OTM-45 REV 1 for the determination of PFAS concentrations and mass emission rates. The analyte list includes the 49 compounds listed in the method focused on polar semi-volatile PFAS compounds including a core group of carboxylic and sulfonic acids such as PFOA and PFOS which have potentially significant environmental and health concerns as determined by EPA. The test runs were targeted to collect three dry standard cubic meters (NM^3) (105.9 cubic feet) of stack gas.

Test method quality control (QC) samples were collected including media blanks and a sample train proof blank. The sample train field blank was omitted since clean glassware was utilized for each of the three test runs.

Analytical data qualifiers or flags have been carried through to the final calculated test results. It is important to understand data flagging in the use of these test results. The flags associated with the total sample mass for a single test run may be from one or more of four analytical sample fractions. Additional discussion is provided in Section 4: Stack Test Procedures and Methods.

During each of the three runs, process samples including dry biosolids, biochar, and spent sorbent were collected. One sample each of process quench water and fresh sorbent were also collected. The process samples were analyzed for target PFAS compounds by EPA Method 537 modified. Process samples were also collected by Aries operators for wet biosolids, dry biosolids, and condensate, and analyzed for 40 target PFAS compounds by EPA Method 1633.

OTM-45 Samples were analyzed by the Eurofins Test America (Eurofins) laboratory in Knoxville, Tennessee. Process samples were analyzed by the Eurofins Test America (Eurofins) laboratory in Lancaster, Pennsylvania. Eurofins is a leader in analyzing mixed media samples for PFAS and has been working closely with the EPA Office of Research and Development (EPA ORD) in method development and revision to improve analytical effectiveness and outcomes.

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2 Results

Testing was performed on November 19-20, 2024 with the first test run completed on the 19th and the second and third completed on the 20th. Results of the test runs are summarized in Table 1. Low levels of ten PFAS compounds were measured consistently with one or more sample fractions above the laboratory reporting limit (RL) for all three stack test runs as shown below:

Table 2-1 Measured PFAS Compound Mass Emission Rates – Gasifier Stack

Parameter Test Methods EPA 1-4, OTM 45 Test Date	Gasifier Stack								
	Run 1 Date		Run 2 Date		Run 3 Date		Average	Flags	Detection Limit
Compound	Lb/hr	Flags	Lb/hr	Flags	Lb/hr	Flags			
Perfluorobutanoic acid (PFBA)	**4.1E-06**	H	**3.6E-06**	H	< **1.8E-06**	J H	< **3.1E-06**	H J	DLL
Perfluoropentanoic acid (PFPeA)	**7.8E-06**	H	**5.6E-06**	H	**2.6E-06**	H	**5.3E-06**	H	ADL
Perfluorohexanoic acid (PFHxA)	**2.6E-05**	B H	**2.1E-05**	B H	**9.0E-06**	B H J	**1.9E-05**	B H J	ADL
Perfluoroheptanoic acid (PFHpA)	**3.3E-06**	B H	**2.2E-06**	B H	**1.1E-06**	J B H	**2.2E-06**	B H J	ADL
Perfluorooctanoic acid (PFOA)	**5.3E-06**	H J x	**5.0E-06**	H x	**1.9E-06**	H J x	**4.1E-06**	H J x	ADL
Perfluorononanoic acid (PFNA)	**1.6E-06**	H J x	**1.2E-06**	H J x	**5.1E-07**	J H x	**1.1E-06**	H J x	ADL
Perfluorodecanoic acid (PFDA)	**1.5E-06**	H J	**1.5E-06**	H J	**5.1E-07**	H	**1.2E-06**	H J	ADL
Perfluoroundecanoic acid (PFUnA)	< **3.3E-07**	J H	**3.4E-07**	H J	**1.1E-07**	J H	< **2.6E-07**	J H	DLL
Perfluorododecanoic acid (PFDoA)	< **1.7E-07**	H	**2.2E-07**	H J	**6.2E-08**	J H	< **1.5E-07**	H J	DLL
Perfluoro-3-methoxypropanoic acid (PFMPA)	< 6.3E-08	H	**2.1E-07**	J H	< **7.7E-08**	H J	< **1.2E-07**	H J	DLL

Note: " < " indicates one or more fractions contributing to the total results are below analytical minimum detection level (MDL)
Bold indicates result or sum of results includes fraction with mass above the analytical reporting limit (RL)
Detection Limit Flags
ADL = Above detection limit, where each fraction has detected amounts of a target compound (9.5.1 OTM-45)
BDL = Below detection limit, where all fractions were at or below the detection limit for a target compound (9.5.2 OTM-45)
DLL = Detection limit limited, where at least one of the fractions is below detection limit and at least one fraction is above the detection limit (9.5.3 OTM-45)

The method analyte list includes 49 PFAS compounds as directed in the test method. Descriptions of the flags applied to the data are provided later in the report and in results Table 1 attached. Compound results in bold indicate that at least one of the OTM-45 sample fractions has a detected mass above the analytical reporting limit (RL). The less than symbol ("<") indicates one or more fractions of the sample fractions did not have mass greater than the analytical minimum detection limit (MDL) for that compound. An analytical reporting limit (RL) is the smallest concentration of an analyte that a laboratory can reliably report in a sample as determined by the method. At present time, there is no established regulatory limit for stack emissions.

Process samples were collected during each of the OTM-45 test runs by Barr personnel with the assistance of Aries operators for biochar, dry biosolids and spent sorbent, Barr collected single samples of fresh sorbent and process (quench) water. Barr stored these process samples separate from the stack test samples prior to submittal to Eurofins for analysis. Aries Operators took single samples of wet biosolids and condensate that were also submitted to Eurofins for analysis. PFAS analytical results of the process samples are provided in Tables 2 and 3 attached.

Barr performed mass balance calculations to assess the PFAS destruction and removal efficiency (DRE) of the gasification system. These results are summarized in Table 2-2.

Table 2-2 PFAS Destruction Removal Efficiency

	Run 1	Run 2	Run 3	Average
PFAS Destruction Removal Efficiency (measured)	95.0%	95.4%	97.3%	95.9%
PFAS Destruction Removal Efficiency (with potential future condensate treatment)	96.6%	97.0%	98.9%	97.5%

The input streams for the mass balance included wet biosolids, process quench water, and fresh sorbent. The output streams comprised spent sorbent, condensate, biochar, and stack emissions. Two evaluations were performed. The first evaluation included all input and output streams, resulting in an average DRE of 95.9% across three test runs. The second evaluation excluded the condensate stream from the outputs, recognizing that it could be treated for PFAS using commercially available technologies before discharge or disposal. This exclusion resulted in an average DRE of 97.5% across three test runs. Future treatment or disposal of the condensate stream will depend on feasibility analyses, both technical and economic.

Tables 4 and 5 attached provide the DRE of individual PFAS compounds with detected mass for the two cases, including and excluding the condensate output stream, respectively. The two PFAS mass balance tables also calculate the DRE of the gasification system for the total detected and summed mass of PFAS of the OTM-45 PFAS target analytes. Figures 1 and 2 attached illustrate the average PFAS mass rate of input and output streams in grams per hour (g/hr).

It was clear at the time of the test that the operation of the gasification system was most optimized in test run 3 as compared to the two previous runs. Test run 3 is most representative of the system operating at design conditions. Operating temperatures were highest during test run 3 as shown in the measured stack gas temperatures shown in Table 1 attached. A review of the process operating data in Appendix E shows production of a richer syngas from the gasifier with increased concentrations of hydrogen, methane and carbon monoxide during test run 3 implying more optimal operating conditions. The highest calculated PFAS DRE was 97.3% during test run 3 . Continued process runtime and optimization efforts have the potential to increase the PFAS destruction and removal efficiency.

3 Process Description

The Aries facility processes waste and provides waste management solutions through reduction of biosolids. The material receiving area of the facility involves the receipt and unloading of third-party biosolids. Wet biosolids are received by truck and transferred to enclosed storage tanks ready for introduction to the Aries system. The biosolids storage tanks are sized for storage of two days of material. The biosolids are then sent to the biosolids drying area which includes a 2-train drying system for drying of the wet biosolids from ~18-22% solids to 90% solids by weight, suitable for feeding to the gasification system. Two parallel rotary drum dryer trains are used in the facility using the thermal energy generated from the gasification process to dry the biosolids.

The fluidized bed gasifier is Aries proprietary technology. It is a refractory lined steel unit in which gasification reactions take place. During gasification, a controlled amount of heat is applied to the biosolids in an oxygen-starved environment operating at approximately 1,250°F. The biosolids are converted to molecules of methane, carbon monoxide, hydrogen, and other minor species to form a low energy producer gas. The residual solids, known as biochar and consisting of elemental carbon and ash, are elutriated through the top of the gasifier and captured in a cyclone. Air is injected into the bottom of the gasifier and serves to fluidize the bed of sand. Thermal decomposition of the carbonaceous fraction in the biosolids provides the heat for the gasification reactions and increases the gas flow through the gasifier.

From the gasifier, the producer gas is passed through the cyclone to remove entrained biochar. Approximately 5% of the total biosolids mass after gasification remains as biochar which becomes a value-added product that can be used as an ingredient in concrete. The gas flows through a duct from the cyclone to the thermal oxidizer where it is combusted and sent to heat exchangers that recover the thermal energy to transfer back to the dryers. The thermal oxidizer is designed for an operating temperature of 1,800°F with a residence time of at least 1 second.

An air emissions control system is used to reduce the NOx, SOx, HCl, and particulate emissions. The emission control equipment eliminates 99% of particulate matter (PM) and greater than 95% NOx, and SOx from the flue gas. The equipment consists of an enclosed Selective Catalytic Reduction system (SCR), dry sorbent injection, and a ceramic filter house. An induction fan installed on the downstream side of emissions control system provides a continuous induced flow of air within the flue gas duct work and ancillary emissions control equipment. The exhaust or discharge side of the induction fan is connected directly to the system exhaust stack.

4 Stack Testing Procedures and Methods

Testing was conducted from test ports that meet the test location criteria of Method 1. Drawings of the test port and sample point location are provided in Figures 3 and 4 attached.

Table 4-1 EPA Method 1 Acceptability Criteria

Location	Diameters to Upstream Disturbances	Diameters to Downstream Disturbances	Number of Ports	Number of Points	Average Yaw Angle, Degrees
Gasifier Stack	7.9	12.4	2	12	15

Method 2 was performed in conjunction with the OTM 45 PFAS method to determine stack air velocity and volumetric flowrate. An S-type pitot with a calibration of 0.84 is part of the sample probe assembly and was used to measure the stack gas velocity pressures with an oil manometer.

Stack gas oxygen and carbon dioxide concentrations were determined in accordance with EPA Method Modified 3A concurrent with the OTM-45 test. Bag samples were collected at a constant rate in a 10-liter Tedlar bag and analyzed after each run. A Quantek Model Q22 electrochemical oxygen analyzer and infrared carbon dioxide analyzer was used to determine concentrations.

Sample gas moisture content was determined by Method 4 procedures in conjunction with OTM 45. The moisture content determined at the Gasifier Stack followed Method 4.

PFAS concentrations and emission rates were determined following OTM-45 REV1 Measurement of Selected Per- and Polyfluorinated Alkyl Substances from Stationary Sources. Sample train glassware preparations followed the method including the baking procedure. Openings of cleaned glassware were covered with rinsed aluminum foil and placed in plastic sealed bags for transport to the test site. Eurofins laboratory provided the spiked XAD traps and the filter media, recovery solvent, screened de-ionized water and sample bottles.

Sample impinger trains were assembled in Barr's laboratory trailer prior to each test run, with complete train assembly performed at the test location. All openings of the train were covered with rinsed aluminum foil until connected to avoid contamination.

OTM-45 sample train recovery was completed in Barr's clean space in the laboratory trailer following the method procedures. Samples containers were stored in sealed plastic bags on ice in coolers until custody was transferred to the analytical laboratory.

QA samples were collected as described in the method which included a field media sampling blanks and a sample train proof blank. The sample train field blank was omitted as clean, unused glassware was used for all three runs.

All OTM-45 samples and process samples were transferred to the Eurofins Environment Testing (Eurofins) laboratory in Lancaster, Pennsylvania. OTM-45 samples were than couriered to the Eurofins Knoxville, Tennessee laboratory for analysis.

The OTM-45 samples were extracted and analyzed by Eurofins using their confidential standard operating procedures (SOP) KNOX-OP-0026 and KNOX-LC-0007. The results are reported in multiple laboratory reports.

- Eurofins Report 140-39657-1_REV1
- Eurofins Report 140-39662-1_REV1 OTM 45 QC Samples
- Eurofins Report 410-197832-1_REV1 Process Samples Results
- Eurofins Report 410-198490-1 Process Samples Results

Appendix C provides Barr's PFAS Laboratory Data Evaluation for the OTM 45 samples and the process sample reports. The analytical laboratory Level 4 and Level 2 reports are provided in Appendix D.

The OTM-45 sample analysis results in reporting of four discreet fractions of a PFAS sample train. Fraction 1 is the filter and probe rinse, Fraction 2 is the front sorbent trap (XAD and glassware rinses), Fraction 3 is the impinger catch and rinses, and Fraction 4 is the backup sorbent trap used to evaluate sample breakthrough. Compound sample mass is reported as the sum of the detected mass above the MDL or results at the minimum detection level (MDL) when applicable. The minimum detection limit is the lowest concentration of an analyte that can be reliably detected.

Barr has summarized the analytical results to combine the sample train detected mass fractions and mass reported at the MDL for each test run. Barr's data summaries include the prescribed OTM-45 flags regarding compound detections in the sample media, proof train blanks. These summaries are in Appendix C. The qualifiers and flags used in the summary include the project qualifiers and the laboratory assigned qualifiers. Qualifiers are applied to the total mass determined for the individual compound. Subsequent calculated results retain all qualifiers applied in the laboratory summaries. In addition, notation has been added to each run total pollutant mass as well as the test average calculated concentrations and mass emissions rates which indicate the nature of the result regarding laboratory MDL. The assignment of ADL (above detection limit) to a particular result indicates all fractions contributing to the total were reported above the MDL. Assignment of BDL (below detection limit) to a particular result indicates all fractions contributing to the total were below the MDL. Application of DLL is used to indicate there is a mix of detected masses and masses reported at the MDL contributing to the total.

The list of project qualifiers includes:

Detection Limit Flags

ADL = Above detection limit, where each fraction has detected amounts of a target compound (9.5.1 OTM-45)

BDL = Below detection limit, where all fractions were at or below the detection limit for a target compound (9.5.2 OTM-45)

DLL = Detection limit limited, where at least one of the fractions is below detection limit and at least one fraction is above the detection limit (9.5.3 OTM-45)

< = indicates values below minimum detection level (MDL)

A = >10% breakthrough to backup trap, mass included

Q = potential contamination in breakthrough trap, mass not included (9.1.6 OTM-45)

X = compound was above MDL in FSMB

Y = Proof Blank results is > 10% of total run compound mass

The list of analytical qualifiers includes:

*- = LCS and/or LCSD is outside acceptance limits, low biased.
*+ = LCS and/or LCSD is outside acceptance limits, high biased.
*1 = LCS/LCSD RPD exceeds control limits.
B = Compound was found in blank and sample.
H= Sample was prepped or analyzed beyond the specified holding time.
I = Value is EMPC (estimated maximum possible concentration).
J = Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

It is important to note that Method OTM-45REV 1 is a draft method under evaluation as described by the EPA method. The analytical results provided are a product of the sampling method and standard operating procedures established by the laboratory utilized for the analysis. There are ongoing development efforts to update OTM-45 to address issues with analytical performance.

5 Conclusion

Given the mass balance results of the testing at the Aries Linden facility, it appears that Aries can achieve effective PFAS destruction and removal with their gasification system at levels up to 97.3%. It is reasonable to expect that even greater PFAS destruction can be achieved with continued process optimization. There is also potential to improve removal by treating the condensate stream for PFAS, which may be implemented in the future, pending technical and economic evaluations. This conclusion can be verified with further stack emission and mass balance results obtained during facility operations at the design standard.

Tables

TABLE 1

EPA OTM - 45 TEST RESULTS SUMMARY

Gasifier Stack

Parameter	Run 1	Run 2	Run 3	Average
Test Date	11/19/2024	11/20/2024	11/20/2024	---
Test Period	1725 - 1835	935 - 1138	1143 - 1336	---
Test Duration, min	70	120	110	100
Average Stack Temperature, °F	273	393	423	363
Average Moisture Content, %V/V	15.5	15.4	16.1	15.7
Air Flow Rate				
acfm	40,300	48,700	50,500	46,500
scfm	29,000	30,100	30,100	29,700
dscfm	24,500	25,400	25,300	25,100
Sample Volume				
acf	60.70	106.30	98.12	88.37
dscf	60.03	106.26	97.17	87.82
dscm	1.70	3.01	2.75	2.49
Isokinetic Variation, %	101.4	100.8	101.2	101.1

TABLE 1 Continued

EPA OTM - 45 TEST RESULTS SUMMARY

Gasifier Stack

Pollutant Concentration, lb/dscf	Run 1	Flag	Detection Level	Run 2	Flag	Detection Level	Run 3	Flag	Detection Level	Average	Flag	Detection Level
Perfluorobutanoic acid (PFBA)	**2.8E-12**	H	ADL	**2.3E-12**	H	ADL	< **1.2E-12**	J H	DLL	< **2.1E-12**	H J	DLL
Perfluoropentanoic acid (PFPeA)	**5.3E-12**	H	ADL	**3.7E-12**	H	ADL	**1.7E-12**	H	ADL	**3.6E-12**	H	ADL
Perfluorohexanoic acid (PFHxA)	**1.8E-11**	B H	ADL	**1.4E-11**	B H	ADL	**5.9E-12**	B H J	ADL	**1.3E-11**	B H J	ADL
Perfluoroheptanoic acid (PFHpA)	**2.3E-12**	B H	ADL	**1.5E-12**	B H	ADL	**7.1E-13**	J B H	ADL	**1.5E-12**	B H J	ADL
Perfluorooctanoic acid (PFOA)	**3.6E-12**	H J x	ADL	**3.3E-12**	H x	ADL	**1.3E-12**	H J x	ADL	**2.7E-12**	H J x	ADL
Perfluorononanoic acid (PFNA)	**1.1E-12**	H J x	ADL	**7.8E-13**	H J x	ADL	**3.4E-13**	J H x	ADL	**7.4E-13**	H J x	ADL
Perfluorodecanoic acid (PFDA)	**1.0E-12**	H J	ADL	**9.7E-13**	H J	ADL	**3.4E-13**	H	ADL	**7.8E-13**	H J	ADL
Perfluoroundecanoic acid (PFUnA)	< **2.3E-13**	J H	DLL	**2.2E-13**	H J	ADL	**7.3E-14**	J H	ADL	< **1.7E-13**	J H	DLL
Perfluorododecanoic acid (PFDoA)	< **1.1E-13**	H	DLL	**1.4E-13**	H J	ADL	**4.1E-14**	J H	ADL	< **9.9E-14**	H J	DLL
Perfluorotridecanoic acid (PFTriA)	< 3.4E-14	J *+ H	DLL	< 4.0E-14	J *+ H	DLL	< 1.3E-14	*+ H	BDL	< 2.9E-14	J *+ H	DLL
Perfluorotetradecanoic acid (PFTeA)	< 3.1E-14	H	BDL	< 4.2E-14	J H	DLL	< 1.8E-14	J H	DLL	< 3.0E-14	H J	DLL
Perfluorobutanesulfonic acid (PFBS)	< 9.3E-14	H J I	DLL	< 4.1E-14	H	BDL	< 3.4E-14	H	BDL	< 5.6E-14	H J I	DLL
Perfluorohexanesulfonic acid (PFHxS)	< 1.7E-14	H	BDL	< 2.1E-14	H	BDL	< 8.8E-15	H	BDL	< 1.5E-14	H	BDL
Perfluoroheptanesulfonic acid (PFHpS)	< 3.3E-14	H *+	BDL	< 4.3E-14	H *+	BDL	< 1.9E-14	H *+	BDL	< 3.2E-14	H *+	BDL
Perfluorooctanesulfonic acid (PFOS)	< 5.1E-14	H J	DLL	< 4.1E-14	J I H	DLL	< 2.8E-14	J I H	DLL	< 4.0E-14	H J I	DLL
Perfluorodecanesulfonic acid (PFDS)	< 2.6E-14	H *-	BDL	< 3.1E-14	H *-	BDL	< 1.5E-14	H *-	BDL	< 2.4E-14	H *-	BDL
Perfluorooctanesulfonamide (FOSA)	< 2.0E-14	H	BDL	< 2.3E-14	H	BDL	< 1.1E-14	H	BDL	< 1.8E-14	H	BDL
Perfluoropentanesulfonic acid (PFPeS)	< 1.5E-14	H	BDL	< 2.0E-14	H	BDL	< 7.5E-15	H	BDL	< 1.4E-14	H	BDL
Perfluorononanesulfonic acid (PFNS)	< 1.7E-14	H *-	BDL	< 1.6E-14	H *-	BDL	< 8.1E-15	H *-	BDL	< 1.3E-14	H *-	BDL
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	< 2.4E-14	H	BDL	< 3.5E-14	H	BDL	< 1.3E-14	H	BDL	< 2.4E-14	H	BDL
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	< 2.3E-14	H	BDL	< 2.7E-14	H	BDL	< 1.2E-14	H	BDL	< 2.1E-14	H	BDL
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	< 1.4E-14	H	BDL	< 1.9E-14	H	BDL	< 7.5E-15	H	BDL	< 1.4E-14	H	BDL
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	< 3.2E-13	H	BDL	< 1.6E-13	H	BDL	< 1.1E-13	H	BDL	< 2.0E-13	H	BDL
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	< 2.5E-14	H	BDL	< 4.1E-14	H	BDL	< 1.4E-14	H	BDL	< 2.7E-14	H	BDL
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	< 4.6E-13	H J x	DLL	< 2.1E-13	H x	BDL	< 1.7E-13	H J x	DLL	< 2.8E-13	H J x	DLL
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	< 1.6E-14	H	BDL	< 2.2E-14	H	BDL	< 8.7E-15	H	BDL	< 1.6E-14	H	BDL
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	< 3.3E-14	H *-	BDL	< 3.1E-14	H *-	BDL	< 1.7E-14	H *-	BDL	< 2.7E-14	H *-	BDL
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	< 6.1E-14	H *+	BDL	< 6.4E-14	H *+	BDL	< 3.6E-14	H *+	BDL	< 5.4E-14	H *+	BDL
1H,1H,2H,2H-Perfluorododecane sulfonic acid (10:2 FTS)	< 4.0E-14	H *1	BDL	< 4.1E-14	H *1	BDL	< 1.9E-14	H *1	BDL	< 3.3E-14	H *1	BDL
2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	< 2.8E-14	H	BDL	< 3.0E-14	H	BDL	< 1.6E-14	H	BDL	< 2.5E-14	H	BDL
Perfluoro-n-octadecanoic acid (PFODA)	< 3.1E-14	H	BDL	< 4.3E-14	H	BDL	< 1.6E-14	H	BDL	< 3.0E-14	H	BDL
2-(N-methylperfluoro-1-octanesulfonamido) ethanol	< 3.8E-13	J H	DLL	< 1.5E-13	J H	DLL	< 1.2E-13	J H	DLL	< 2.2E-13	J H	DLL
N-methylperfluorooctane sulfonamide (NMeFOSA)	< 3.0E-14	H	BDL	< 3.3E-14	H	BDL	< 1.6E-14	H	BDL	< 2.7E-14	H	BDL
N-ethylperfluorooctane sulfonamide (NEtFOSA)	< 3.3E-14	H	BDL	< 4.7E-14	H	BDL	< 1.9E-14	H	BDL	< 3.3E-14	H	BDL
Perfluoro-n-hexadecanoic acid (PFHxDA)	< 3.8E-14	H	BDL	< 4.9E-14	H	BDL	< 1.9E-14	H	BDL	< 3.5E-14	H	BDL
Perfluorododecanesulfonic acid (PFDoS)	< 3.5E-14	H *-	BDL	< 3.6E-14	H *-	BDL	< 2.0E-14	H *-	BDL	< 3.0E-14	H *-	BDL
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	< 2.9E-14	H	BDL	< 4.6E-14	H	BDL	< 1.6E-14	H	BDL	< 3.0E-14	H	BDL
10:2 Fluorotelomer carboxylic acid	< 8.7E-14	H	BDL	< 1.1E-13	H	BDL	< 4.8E-14	H	BDL	< 8.2E-14	H	BDL
6:2 Fluorotelomer carboxylic acid	< 8.0E-14	H	BDL	< 1.1E-13	H	BDL	< 4.3E-14	H	BDL	< 7.6E-14	H	BDL
7:3 Fluorotelomer carboxylic acid	< 5.4E-14	*+ H	BDL	< 6.9E-14	*+ H	BDL	< 2.8E-14	*+ H	BDL	< 5.0E-14	*+ H	BDL
6:2 Fluorotelemer unsaturated acid	< 2.1E-14	H	BDL	< 2.9E-14	H	BDL	< 1.1E-14	H	BDL	< 2.0E-14	H	BDL
8:2 Fluorotelomer carboxylic acid	< 7.1E-14	H	BDL	< 1.1E-13	H	BDL	< 4.0E-14	H	BDL	< 7.3E-14	H	BDL
8:2 Fluorotelemer unsaturated acid	< 3.6E-14	H	BDL	< 6.2E-14	H	BDL	< 2.0E-14	H	BDL	< 3.9E-14	H	BDL
5:3 Fluorotelomer carboxylic acid	< 7.1E-14	*+ J H	DLL	< 9.9E-14	*+ H	BDL	< 3.6E-14	*+ H	BDL	< 6.9E-14	*+ J H	DLL
3-Perfluoropropylpropanoic acid	< 4.8E-14	H	BDL	< 7.2E-14	H	BDL	< 2.6E-14	H	BDL	< 4.8E-14	H	BDL
Perfluoro-3-methoxypropanoic acid (PFMPA)	< 4.3E-14	H	BDL	**1.4E-13**	J H	ADL	< **5.1E-14**	H J	DLL	< **7.7E-14**	H J	DLL
Perfluoro-4-methoxybutanoic acid (PFMBA)	< 3.3E-14	H	BDL	< 6.3E-14	J H	DLL	< 1.8E-14	H	BDL	< 3.8E-14	H J	DLL
Perfluoro-4-ethylcyclohexanesulfonic acid	< 3.6E-14	*+ H	BDL	< 5.2E-14	*+ H	BDL	< 1.9E-14	*+ H	BDL	< 3.6E-14	*+ H	BDL
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	< 2.3E-14	H	BDL	< 3.9E-14	H	BDL	< 1.3E-14	H	BDL	< 2.5E-14	H	BDL

TABLE 1 Continued

EPA OTM - 45 TEST RESULTS SUMMARY

Gasifier Stack

Pollutant Emission Rate, lb/hr	Run 1	Flag	Detection Level	Run 2	Flag	Detection Level	Run 3	Flag	Detection Level	Average	Flag	Detection Level
Perfluorobutanoic acid (PFBA)	**4.1E-06**	H	ADL	**3.6E-06**	H	ADL	< **1.8E-06**	J H	DLL	< **3.1E-06**	H J	DLL
Perfluoropentanoic acid (PFPeA)	**7.8E-06**	H	ADL	**5.6E-06**	H	ADL	**2.6E-06**	H	ADL	**5.3E-06**	H	ADL
Perfluorohexanoic acid (PFHxA)	**2.6E-05**	B H	ADL	**2.1E-05**	B H	ADL	**9.0E-06**	B H J	ADL	**1.9E-05**	B H J	ADL
Perfluoroheptanoic acid (PFHpA)	**3.3E-06**	B H	ADL	**2.2E-06**	B H	ADL	**1.1E-06**	J B H	ADL	**2.2E-06**	B H J	ADL
Perfluorooctanoic acid (PFOA)	**5.3E-06**	H J x	ADL	**5.0E-06**	H x	ADL	**1.9E-06**	H J x	ADL	**4.1E-06**	H J x	ADL
Perfluorononanoic acid (PFNA)	**1.6E-06**	H J x	ADL	**1.2E-06**	H J x	ADL	**5.1E-07**	J H x	ADL	**1.1E-06**	H J x	ADL
Perfluorodecanoic acid (PFDA)	**1.5E-06**	H J	ADL	**1.5E-06**	H J	ADL	**5.1E-07**	H	ADL	**1.2E-06**	H J	ADL
Perfluoroundecanoic acid (PFUnA)	< **3.3E-07**	J H	DLL	**3.4E-07**	H J	ADL	**1.1E-07**	J H	ADL	< **2.6E-07**	J H	DLL
Perfluorododecanoic acid (PFDoA)	< **1.7E-07**	H	DLL	**2.2E-07**	H J	ADL	**6.2E-08**	J H	ADL	< **1.5E-07**	H J	DLL
Perfluorotridecanoic acid (PFTriA)	< 5.0E-08	J *+ H	DLL	< 6.1E-08	J *+ H	DLL	< 2.0E-08	*+ H	BDL	< 4.4E-08	J *+ H	DLL
Perfluorotetradecanoic acid (PFTeA)	< 4.6E-08	H	BDL	< 6.4E-08	J H	DLL	< 2.7E-08	J H	DLL	< 4.6E-08	H J	DLL
Perfluorobutanesulfonic acid (PFBS)	< 1.4E-07	H J I	DLL	< 6.3E-08	H	BDL	< 5.1E-08	H	BDL	< 8.4E-08	H J I	DLL
Perfluorohexanesulfonic acid (PFHxS)	< 2.5E-08	H	BDL	< 3.1E-08	H	BDL	< 1.3E-08	H	BDL	< 2.3E-08	H	BDL
Perfluoroheptanesulfonic acid (PFHpS)	< 4.8E-08	H *+	BDL	< 6.5E-08	H *+	BDL	< 2.9E-08	H *+	BDL	< 4.7E-08	H *+	BDL
Perfluorooctanesulfonic acid (PFOS)	< 7.5E-08	H J	DLL	< 6.3E-08	J I H	DLL	< 4.2E-08	J I H	DLL	< 6.0E-08	H J I	DLL
Perfluorodecanesulfonic acid (PFDS)	< 3.8E-08	H *-	BDL	< 4.8E-08	H *-	BDL	< 2.2E-08	H *-	BDL	< 3.6E-08	H *-	BDL
Perfluorooctanesulfonamide (FOSA)	< 3.0E-08	H	BDL	< 3.5E-08	H	BDL	< 1.7E-08	H	BDL	< 2.7E-08	H	BDL
Perfluoropentanesulfonic acid (PFPeS)	< 2.3E-08	H	BDL	< 3.1E-08	H	BDL	< 1.1E-08	H	BDL	< 2.1E-08	H	BDL
Perfluorononanesulfonic acid (PFNS)	< 2.5E-08	H *-	BDL	< 2.4E-08	H *-	BDL	< 1.2E-08	H *-	BDL	< 2.0E-08	H *-	BDL
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	< 3.5E-08	H	BDL	< 5.3E-08	H	BDL	< 2.0E-08	H	BDL	< 3.6E-08	H	BDL
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	< 3.3E-08	H	BDL	< 4.2E-08	H	BDL	< 1.8E-08	H	BDL	< 3.1E-08	H	BDL
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	< 2.1E-08	H	BDL	< 3.0E-08	H	BDL	< 1.1E-08	H	BDL	< 2.1E-08	H	BDL
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	< 4.7E-07	H	BDL	< 2.5E-07	H	BDL	< 1.7E-07	H	BDL	< 3.0E-07	H	BDL
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	< 3.7E-08	H	BDL	< 6.3E-08	H	BDL	< 2.1E-08	H	BDL	< 4.0E-08	H	BDL
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	< 6.7E-07	H J x	DLL	< 3.2E-07	H x	BDL	< 2.6E-07	H J x	DLL	< 4.2E-07	H J x	DLL
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	< 2.4E-08	H	BDL	< 3.4E-08	H	BDL	< 1.3E-08	H	BDL	< 2.4E-08	H	BDL
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	< 4.9E-08	H *-	BDL	< 4.7E-08	H *-	BDL	< 2.5E-08	H *-	BDL	< 4.0E-08	H *-	BDL
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	< 9.0E-08	H *+	BDL	< 9.7E-08	H *+	BDL	< 5.5E-08	H *+	BDL	< 8.1E-08	H *+	BDL
1H,1H,2H,2H-Perfluorododecane sulfonic acid (10:2 FTS)	< 5.8E-08	H *1	BDL	< 6.2E-08	H *1	BDL	< 2.8E-08	H *1	BDL	< 5.0E-08	H *1	BDL
2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	< 4.2E-08	H	BDL	< 4.6E-08	H	BDL	< 2.4E-08	H	BDL	< 3.7E-08	H	BDL
Perfluoro-n-octadecanoic acid (PFODA)	< 4.6E-08	H	BDL	< 6.5E-08	H	BDL	< 2.4E-08	H	BDL	< 4.5E-08	H	BDL
2-(N-methylperfluoro-1-octanesulfonamido) ethanol	< 5.6E-07	J H	DLL	< 2.2E-07	J H	DLL	< 1.9E-07	J H	DLL	< 3.2E-07	J H	DLL
N-methylperfluorooctane sulfonamide (NMeFOSA)	< 4.4E-08	H	BDL	< 5.1E-08	H	BDL	< 2.5E-08	H	BDL	< 4.0E-08	H	BDL
N-ethylperfluorooctane sulfonamide (NEtFOSA)	< 4.9E-08	H	BDL	< 7.1E-08	H	BDL	< 2.8E-08	H	BDL	< 5.0E-08	H	BDL
Perfluoro-n-hexadecanoic acid (PFHxDA)	< 5.6E-08	H	BDL	< 7.4E-08	H	BDL	< 2.9E-08	H	BDL	< 5.3E-08	H	BDL
Perfluorododecanesulfonic acid (PFDoS)	< 5.1E-08	H *-	BDL	< 5.5E-08	H *-	BDL	< 3.1E-08	H *-	BDL	< 4.5E-08	H *-	BDL
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	< 4.2E-08	H	BDL	< 7.1E-08	H	BDL	< 2.4E-08	H	BDL	< 4.6E-08	H	BDL
10:2 Fluorotelomer carboxylic acid	< 1.3E-07	H	BDL	< 1.7E-07	H	BDL	< 7.3E-08	H	BDL	< 1.2E-07	H	BDL
6:2 Fluorotelomer carboxylic acid	< 1.2E-07	H	BDL	< 1.6E-07	H	BDL	< 6.6E-08	H	BDL	< 1.1E-07	H	BDL
7:3 Fluorotelomer carboxylic acid	< 8.0E-08	*+ H	BDL	< 1.1E-07	*+ H	BDL	< 4.2E-08	*+ H	BDL	< 7.6E-08	*+ H	BDL
6:2 Fluorotelemer unsaturated acid	< 3.0E-08	H	BDL	< 4.5E-08	H	BDL	< 1.6E-08	H	BDL	< 3.0E-08	H	BDL
8:2 Fluorotelomer carboxylic acid	< 1.1E-07	H	BDL	< 1.6E-07	H	BDL	< 6.1E-08	H	BDL	< 1.1E-07	H	BDL
8:2 Fluorotelemer unsaturated acid	< 5.3E-08	H	BDL	< 9.4E-08	H	BDL	< 3.0E-08	H	BDL	< 5.9E-08	H	BDL
5:3 Fluorotelomer carboxylic acid	< 1.0E-07	*+ J H	DLL	< 1.5E-07	*+ H	BDL	< 5.4E-08	*+ H	BDL	< 1.0E-07	*+ J H	DLL
3-Perfluoropropylpropanoic acid	< 7.0E-08	H	BDL	< 1.1E-07	H	BDL	< 3.9E-08	H	BDL	< 7.3E-08	H	BDL
Perfluoro-3-methoxypropanoic acid (PFMPA)	< 6.3E-08	H	BDL	**2.1E-07**	J H	ADL	< **7.7E-08**	H J	DLL	< **1.2E-07**	H J	DLL
Perfluoro-4-methoxybutanoic acid (PFMBA)	< 4.8E-08	H	BDL	< 9.6E-08	J H	DLL	< 2.7E-08	H	BDL	< 5.7E-08	H J	DLL
Perfluoro-4-ethylcyclohexanesulfonic acid	< 5.2E-08	*+ H	BDL	< 8.0E-08	*+ H	BDL	< 2.9E-08	*+ H	BDL	< 5.4E-08	*+ H	BDL
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	< 3.4E-08	H	BDL	< 6.0E-08	H	BDL	< 1.9E-08	H	BDL	< 3.8E-08	H	BDL

TABLE 1 Continued

EPA OTM - 45 TEST RESULTS SUMMARY

Gasifier Stack

Note: " < " indicates one or more fractions contributing to the total results are below analytical minimum detection level (MDL)
Bold indicates result or sum of results includes fraction with mass above the analyitical reporting limit (RL)
Detection Limit Flags

- ADL = Above detection limit, where each fraction has detected amounts of a target compound (9.5.1 OTM-45)
- BDL = Below detection limit, where all fractions were at or below the detection limit for a target compound (9.5.2 OTM-45)
- DLL = Detection limit limited, where at least one of the fractions is below detection limit and at least one fraction is above the detection limit (9.5.3 OTM-45)

Project Analytical Flags

- A = >10% breakthrough to backup trap, mass included.
- Q = potential contamination in breakthrough trap, mass not included (9.1.6 OTM-45)
- X = compound was above MDL in FMSB
- Y = Proof Blank results is > 10% of total run compound mass

Lab Qualifiers

- *- = LCS and/or LCSD is outside acceptance limits, low biased.
- *+ = LCS and/or LCSD is outside acceptance limits, high biased.
- *1 = LCS/LCSD RPD exceeds control limits.
- B = Compound was found in blank and sample.
- H= Sample was prepped or analyzed beyond the specified holding time.
- I = Value is EMPC (estimated maximum possible concentration).
- J = Result is less than the RL but greater than or equal to the MDL and the concentration is an approximate value.

TABLE 2

Process Sample Analysis Results

Biosolids Gasification Process

Sample		BC-01	BC-02	BC-03	BS-01	BS-02	BS-03	FS-00	SS-01	SS-02	SS-03		CW-00
Sample Type		Biochar	Biochar	Biochar	Dry Biosolids	Dry Biosolids	Dry Biosolids	Fresh Solvent	Spent Solvent	Spent Solvent	Spent Solvent		Quench Water
Date		11/19/2024	11/20/2024	11/20/2024	11/19/2024	11/20/2024	11/20/2024	11/20/2024	11/19/2024	11/20/2024	11/20/2024		11/19/2024
Sample Matrix		Solid	Solid	Solid	Solid	Solid	Solid	Solid	Solid	Solid	Solid		Process Water
Parameter	Units											Units	
Per- and Polyfluoroalkyl Substances													
10:2 Fluorotelemer unsaturated acid (10:2 FTUCA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	**0.18 J**	**0.12 J**	< 0.20 UJ	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.37 U
10:2 Fluorotelomer carboxylic acid (10:2 FTCA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 UJ	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.46 U
10:2 Fluorotelomer sulfonate (10:2 FTS)	ng/g	< 0.59 U	< 0.59 U	< 0.57 U	< 0.31 U	< 0.32 U	< 0.31 U	< 0.59 U	< 0.59 UJ	< 0.55 UJ	< 0.59 UJ	ng/l	< 0.74 U
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.46 U
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid (8:2 FTS)	ng/g	< 0.59 U	< 0.59 U	< 0.57 U	**0.35 J**	**0.32 J**	< 0.31 U	< 0.59 U	< 0.59 UJ	< 0.55 UJ	< 0.59 UJ	ng/l	< 0.55 U
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid (4:2 FTS)	ng/g	< 0.59 U	< 0.59 U	< 0.57 U	< 0.31 U	< 0.32 U	< 0.31 U	< 0.59 U	< 0.59 UJ	< 0.55 UJ	< 0.59 UJ	ng/l	< 0.46 U
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid (6:2 FTS)	ng/g	< 0.59 U	< 0.59 U	< 0.57 U	**1.7 J**	**1.2 J**	**1.3 J**	< 0.59 U	< 0.59 UJ	< 0.55 UJ	< 0.59 UJ	ng/l	< 1.0 U
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol (N-EtFOSE)	ng/g	< 0.50 U	< 0.49 U	< 0.47 U	**0.63 J**	**0.74 J**	**0.94 J**	< 0.49 U	< 0.49 U	< 0.46 U	< 0.50 U	ng/l	< 0.37 U
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol (N-MeFOSE)	ng/g	< 0.50 U	< 0.49 U	< 0.47 U	**2.0**	**3.8**	**3.1**	< 0.49 U	< 0.49 U	< 0.46 U	< 0.50 U	ng/l	< 0.37 U
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**4.9**	**3.9**	**3.5**	R	< 0.20 U	**0.22 J**	< 0.20 U	ng/l	< 1.0 U
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**27**	**26**	**24**	< 0.20 U	**2.5 J**	**11 J**	**2.1 J**	ng/l	< 0.46 U
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**0.82**	**0.82**	**0.64**	< 0.20 UJ	< 0.20 UJ	< 0.18 UJ	< 0.20 UJ	ng/l	< 0.46 U
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 UJ	< 0.18 UJ	< 0.20 UJ	ng/l	< 0.46 U
6:2 Fluorotelemer unsaturated acid (6:2 FTUCA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**0.50**	**0.37**	**0.37**	R	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.37 U
6:2 Fluorotelomer carboxylic acid (6:2 FTCA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**0.50**	**0.26 J**	**0.42**	R	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.64 U
8:2 Fluorotelemer unsaturated acid (8:2 FTUCA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**0.41**	**0.29 J**	**0.25 J**	R	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.37 U
8:2 Fluorotelomer carboxylic acid (8:2 FTCA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**0.22 J**	< 0.11 U	< 0.10 U	R	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.37 U
9-Chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.46 U
Hexafluoropropylene oxide dimer acid (HFPO-DA)	ng/g	< 0.99 U	< 0.98 U	< 0.94 U	< 1.0 U	< 1.1 U	< 1.0 U	**2.6 J**	< 0.98 U	**1.2 J**	< 0.99 U	ng/l	< 1.5 U
Methylperfluoro-1-octanesulfonamide (N-MEFOSA)	ng/g	< 0.50 U	< 0.49 U	< 0.47 U	< 0.26 U	< 0.27 U	< 0.26 U	< 0.49 U	< 0.49 U	< 0.46 U	< 0.50 U	ng/l	< 0.64 U
n-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**4.5**	**3.8**	**3.5**	< 0.20 UJ	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.46 U
n-Ethylperfluoroctansulfonamide (N-EtFOSA)	ng/g	< 0.50 U	< 0.49 U	< 0.47 U	< 0.26 U	< 0.27 U	< 0.26 U	< 0.49 U	< 0.49 U	< 0.46 U	< 0.50 U	ng/l	< 0.37 U
n-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**4.1**	**3.8 J**	**3.3 J**	< 0.20 UJ	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.37 U
Nonafluoro-3, 6-dioxaheptanoic acid (NFDHA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.28 U
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.28 U
Perfluoro-3-methoxypropanoic acid (PFMPA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 UJ	< 0.20 UJ	< 0.18 UJ	< 0.20 UJ	ng/l	< 0.28 U
Perfluoro-4-ethylcyclohexanesulfonic acid (PFecHS)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**0.11 J**	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.28 U
Perfluoro-4-methoxybutanoic acid (PFMBA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 UJ	< 0.20 U	ng/l	< 0.28 U
Perfluorobutanesulfonic acid (PFBS)	ng/g	< 0.40 U	< 0.39 U	< 0.38 U	**3.1 J**	**2.4 J**	**1.8 J**	< 0.40 U	< 0.39 U	< 0.37 U	< 0.40 U	ng/l	**1.8**
Perfluorobutanoic acid (PFBA)	ng/g	< 0.79 U	< 0.78 U	< 0.75 U	< 0.42 U	**0.53 J**	< 0.42 U	< 0.79 UJ	< 0.78 UJ	< 0.73 UJ	< 0.79 UJ	ng/l	**2.7**
Perfluorodecanesulfonic acid (PFDS)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.28 U
Perfluorodecanoic acid (PFDA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**3.5**	**2.8**	< 0.10 U	< 0.20 UJ	< 0.20 UJ	< 0.18 UJ	< 0.20 UJ	ng/l	< 0.28 U
Perfluorododecanesulfonic acid (PFDOS)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.28 U
Perfluorododecanoic acid (PFDoA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 UJ	< 0.20 U	ng/l	< 0.37 U
Perfluoroheptanesulfonic acid (PFHpS)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.28 U
Perfluoroheptanoic acid (PFHpA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**0.90**	**0.62**	**0.56**	< 0.20 U	< 0.20 UJ	< 0.18 UJ	< 0.20 UJ	ng/l	**1.4 J**
Perfluorohexadecanoic Acid (PFHxDA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 UJ	< 0.18 UJ	< 0.20 U	ng/l	< 0.46 U
Perfluorohexanesulfonic acid (PFHxS)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**0.61**	**0.46**	**0.38**	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	**0.94 J**
Perfluorohexanoic acid (PFHxA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**5.8**	**5.5**	**4.9**	< 0.20 UJ	< 0.20 UJ	< 0.18 UJ	< 0.20 UJ	ng/l	**2.9**
Perfluorononanesulfonic acid (PFNS)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.28 U
Perfluorononanoic acid (PFNA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**1.4**	**1.0**	**0.93**	< 0.20 UJ	< 0.20 UJ	< 0.18 UJ	< 0.20 UJ	ng/l	**0.58 J**
Perfluorooctadecanoic Acid (PFOCDA / PFODA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 UJ	< 0.18 UJ	< 0.20 U	ng/l	< 0.46 U
Perfluorooctanesulfonamide (PFOSA / FOSA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**0.25 J**	**0.26 J**	**0.26 J**	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	**5.5**
Perfluorooctanesulfonic acid (PFOS)	ng/g	< 0.20 U	< 0.20 U	**0.21 J**	**3.6 J**	**9.0**	**3.3 J**	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	**2.2**
Perfluorooctanoic acid (PFOA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**3.2**	**2.3**	**2.0**	< 0.20 UJ	< 0.20 UJ	< 0.18 UJ	**0.34 J**	ng/l	**4.5**
Perfluoropentanesulfonic acid (PFPeS)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 U	< 0.20 U	ng/l	< 0.28 U
Perfluoropentanoic acid (PFPeA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	**0.29 J**	< 0.20 UJ	< 0.18 UJ	< 0.20 UJ	ng/l	**3.1**
Perfluoropropanesulfonic acid (PFPrS)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	**4.3**	< 0.10 U	< 0.20 UJ	< 0.20 UJ	< 0.18 UJ	< 0.20 UJ	ng/l	< 0.37 U
Perfluorotetradecanoic acid (PFTA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**0.41**	**0.35**	**0.34**	< 0.20 U	< 0.20 UJ	< 0.18 UJ	< 0.20 U	ng/l	< 0.37 U
Perfluorotridecanoic acid (PFTrDA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	< 0.10 U	< 0.11 U	< 0.10 U	< 0.20 U	< 0.20 U	< 0.18 UJ	< 0.20 U	ng/l	< 0.37 U
Perfluoroundecanoic acid (PFUnA)	ng/g	< 0.20 U	< 0.20 U	< 0.19 U	**1.2**	**1.1**	**0.98**	< 0.20 U	< 0.20 U	< 0.18 UJ	< 0.20 U	ng/l	< 0.28 U

Note: " < " indicates one or more fractions contributing to the total results are below analytical minimum detection level (MDL)
Bold indicates result or sum of results includes fraction with mass above the analyitical reporting limit (RL)

Lab Qualifiers

-- = Not analyzed/Not available.
N = Sample Type: Normal
J = Estimated detected value. Either certain QC criteria were not met or the concentration is between the laboratory's detection and quantitation limits.
R = The data are unusable. The samples results are rejected due to serious deficiencies in meeting QC criteria. The analyte may or may not be present in the sample.
U = The analyte was analyzed for, but was not detected.
H= Sample was prepped or analyzed beyond the specified holding time.

TABLE 3

Process Sample Analysis Results

Biosolids Gasifier Process

Sample		BS-2	SL-2		W-(1-4)
Sample Type		Dry Biosolids	Sludge		Process Water
Date		11/19/2024	11/19/2024		11/19/2024
Sample Matrix		Solid	Solid		Water
Parameter	Units			Units	
General Parameters					
Moisture	%	**5.0**	**82.4**	--	--
Per- and Polyfluoroalkyl Substances					
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (11Cl-PF3OUdS)	ng/g	< 0.69 UHJ	< 2.1 UH	ng/l	< 1.7 UH
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid (8:2 FTS)	ng/g	< 1.4 UH	< 4.3 UH	ng/l	< 33 UH
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid (4:2 FTS)	ng/g	< 1.4 UHJ	< 4.3 UH	ng/l	< 3.3 UH
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid (6:2 FTS)	ng/g	**2.0 H**	< 4.3 UH	ng/l	**7.8 HJ**
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol (N-EtFOSE)	ng/g	< 3.5 UH	**4.7 HJ**	ng/l	< 8.3 UH
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol (N-MeFOSE)	ng/g	< 3.5 UHJ	**10 HJ**	ng/l	< 8.3 UH
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	ng/g	**120 HJ**	**41 H**	ng/l	**35 H**
3-Perfluoropentylpropanoic acid (5:3 FTCA)	ng/g	**180 HJ**	**280 H**	ng/l	**680 H**
3-Perfluoropropylpropanoic acid (3:3 FTCA)	ng/g	< 1.4 UHJ	< 4.3 UH	ng/l	**7.9 H**
4,8-dioxa-3H-perfluorononanoic acid (ADONA)	ng/g	< 0.69 UHJ	< 2.1 UH	ng/l	< 1.7 UH
9-Chlorohexadecafluoro-3-oxanone-1-sulfonic acid (9Cl-PF3ONS)	ng/g	< 0.69 UHJ	< 2.1 UH	ng/l	< 1.7 UH
Hexafluoropropylene oxide dimer acid (HFPO-DA)	ng/g	< 0.69 UHJ	< 2.1 UH	ng/l	< 3.3 UH
Methylperfluoro-1-octanesulfonamide (N-MEFOSA)	ng/g	< 0.69 UH	< 2.1 UH	ng/l	< 1.7 UH
n-Ethyl perfluorooctanesulfonamidoacetic acid (NEtFOSAA)	ng/g	**3.5 H**	**4.8 H**	ng/l	< 1.7 UH
n-Ethylperfluoroctansulfonamide (N-EtFOSA)	ng/g	< 0.69 UH	< 2.1 UH	ng/l	< 1.7 UH
n-Methyl perfluorooctanesulfonamidoacetic acid (NMeFOSAA)	ng/g	**4.5 H**	**5.2 H**	ng/l	**0.95 HJ**
Nonafluoro-3, 6-dioxaheptanoic acid (NFDHA)	ng/g	< 0.69 UHJ	< 2.1 UH	ng/l	< 1.7 UH
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	ng/g	< 0.69 UHJ	< 2.1 UH	ng/l	< 1.7 UH
Perfluoro-3-methoxypropanoic acid (PFMPA)	ng/g	< 0.69 UHJ	< 2.1 UH	ng/l	**52 H**
Perfluoro-4-methoxybutanoic acid (PFMBA)	ng/g	< 0.69 UHJ	< 2.1 UH	ng/l	< 1.7 UH
Perfluorobutanesulfonic acid (PFBS)	ng/g	**3.9 HJ**	< 13 UH	ng/l	**25 H**
Perfluorobutanoic acid (PFBA)	ng/g	< 1.4 UHJ	< 4.3 UH	ng/l	< 3.3 UH
Perfluorodecanesulfonic acid (PFDS)	ng/g	**0.87 H**	**0.97 HJ**	ng/l	< 1.7 UH
Perfluorodecanoic acid (PFDA)	ng/g	**5.0 HJ**	**3.9 HJ**	ng/l	**4.9 H**
Perfluorododecanesulfonic acid (PFDOS)	ng/g	< 0.69 UH	< 2.1 UH	ng/l	< 1.7 UH
Perfluorododecanoic acid (PFDoA)	ng/g	**2.0 H**	**2.3 HJ**	ng/l	< 1.7 UH
Perfluoroheptanesulfonic acid (PFHpS)	ng/g	< 0.69 UH	< 2.1 UH	ng/l	< 1.7 UH
Perfluoroheptanoic acid (PFHpA)	ng/g	**1.1 HJ**	< 2.7 UH	ng/l	**25 HJ**
Perfluorohexanesulfonic acid (PFHxS)	ng/g	< 0.69 UHJ	< 2.1 UH	ng/l	**3.3 H**
Perfluorohexanoic acid (PFHxA)	ng/g	**9.2 HJ**	**3.4 H**	ng/l	**130 H**
Perfluorononanesulfonic acid (PFNS)	ng/g	< 0.69 UH	< 2.1 UH	ng/l	< 1.7 UH
Perfluorononanoic acid (PFNA)	ng/g	**1.9 H**	**2.2 HJ**	ng/l	**7.4 H**
Perfluorooctanesulfonamide (PFOSA / FOSA)	ng/g	< 0.69 UHJ	< 2.1 UHJ	ng/l	< 1.7 UH
Perfluorooctanesulfonic acid (PFOS)	ng/g	**13 H**	**9.0 H**	ng/l	**7.5 H**
Perfluorooctanoic acid (PFOA)	ng/g	**5.1 HJ**	**3.7 H**	ng/l	**41 H**
Perfluoropentanesulfonic acid (PFPeS)	ng/g	< 0.69 UHJ	< 2.1 UH	ng/l	< 1.7 UH
Perfluoropentanoic acid (PFPeA)	ng/g	**2.2 HJ**	< 2.1 UH	ng/l	**67 H**
Perfluorotetradecanoic acid (PFTA)	ng/g	< 0.69 UH	< 2.1 UH	ng/l	< 1.7 UH
Perfluorotridecanoic acid (PFTrDA)	ng/g	< 0.69 UH	< 2.1 UH	ng/l	< 1.7 UH
Perfluoroundecanoic acid (PFUnA)	ng/g	< 2.6 UH	< 2.7 UH	ng/l	< 0.63 UH

Note: " < " indicates one or more fractions contributing to the total results are below analytical minimum detection level (MDL)
Bold indicates result or sum of results includes fraction with mass above the analyitical reporting limit (RL)

Lab Qualifiers

- -- = Not analyzed/Not available.
- N = Sample Type: Normal
- J = Estimated detected value. Either certain QC criteria were not met or the concentration is between the laboratory's detection and quantitation limits.
- R = The data are unusable. The samples results are rejected due to serious deficiencies in meeting QC criteria. The analyte may or may not be present in the sample.
- U = The analyte was analyzed for, but was not detected.
- H= Sample was prepped or analyzed beyond the specified holding time.

TABLE 4

PFAS Mass Balance
Destruction Removal Efficiency with Condensate

Biosolids Gasifier Process

PFAS Compounds	Run 1	Run 2	Run 3	Average DRE, %
Perfluorobutanoic acid (PFBA)	*	*	*	*
Perfluoropentanoic acid (PFPeA)	*	*	*	*
Perfluorohexanoic acid (PFHxA)	*	*	24.3%	24.3%
Perfluoroheptanoic acid (PFHpA)	*	*	*	*
Perfluorooctanoic acid (PFOA)	60.4%	63.7%	81.8%	68.6%
Perfluorononanoic acid (PFNA)	81.0%	86.1%	93.3%	86.8%
Perfluorodecanoic acid (PFDA)	90.0%	90.8%	96.6%	92.5%
Perfluoroundecanoic acid (PFUnA)	*	*	*	*
Perfluorododecanoic acid (PFDoA)	98.3%	97.9%	99.4%	98.5%
Perfluorotridecanoic acid (PFTriA)	*	*	-	*
Perfluorotetradecanoic acid (PFTeA)	*	*	*	*
Perfluorobutanesulfonic acid (PFBS)	*	*	*	*
Perfluorohexanesulfonic acid (PFHxS)	*	*	*	*
Perfluoroheptanesulfonic acid (PFHpS)	-	-	-	-
Perfluorooctanesulfonic acid (PFOS)	99.3%	99.4%	99.4%	99.4%
Perfluorodecanesulfonic acid (PFDS)	100.0%	100.0%	100.0%	100.0%
Perfluorooctanesulfonamide (FOSA)	100.0%	100.0%	100.0%	100.0%
Perfluoropentanesulfonic acid (PFPeS)	-	-	-	-
Perfluorononanesulfonic acid (PFNS)	-	-	-	-
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	99.9%	99.9%	99.9%	99.9%
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	100.0%	100.0%	100.0%	100.0%
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	-	-	-	-
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	*	*	*	*
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	-	-	-	-
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	61.6%	53.8%	85.0%	66.8%
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	-	-	-	-
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	-	-	-	-
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	-	-	-	-
1H,1H,2H,2H-Perfluorododecane sulfonic acid (10:2 FTS)	-	-	-	-
2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	100.0%	100.0%	100.0%	100.0%
Perfluoro-n-octadecanoic acid (PFODA)	-	-	-	-
2-(N-methylperfluoro-1-octanesulfonamido) ethanol	98.7%	99.5%	99.6%	99.3%
N-methylperfluorooctane sulfonamide (NMeFOSA)	-	-	-	-
N-ethylperfluorooctane sulfonamide (NEtFOSA)	-	-	-	-
Perfluoro-n-hexadecanoic acid (PFHxDA)	-	-	-	-
Perfluorododecanesulfonic acid (PFDoS)	-	-	-	-
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	-	-	-	-
10:2 Fluorotelomer carboxylic acid	-	-	-	-
6:2 Fluorotelomer carboxylic acid	-	-	-	-
7:3 Fluorotelomer carboxylic acid	99.5%	99.5%	99.5%	99.5%
6:2 Fluorotelemer unsaturated acid	-	-	-	-
8:2 Fluorotelomer carboxylic acid	-	-	-	-
8:2 Fluorotelemer unsaturated acid	-	-	-	-
5:3 Fluorotelomer carboxylic acid	98.5%	98.1%	98.5%	98.4%
3-Perfluoropropylpropanoic acid	*	*	*	*
Perfluoro-3-methoxypropanoic acid (PFMPA)	*	*	*	*
Perfluoro-4-methoxybutanoic acid (PFMBA)	-	*	-	*
Perfluoro-4-ethylcyclohexanesulfonic acid	-	-	-	-
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	-	-	-	-
Total PFAS Removal Efficiency (with Condensate)	**95.0%**	**95.4%**	**97.3%**	**95.9%**

* Indicates that more PFAS is in the sum of outputs than the sum of inputs for that compound indicating a possible product of incomplete combustion or destruction (PIC or PID) or an existing unknown compound formation mechanism

- Indicates the analyte was analyzed for but not detected in the solid or air samples

TABLE 5

PFAS Mass Balance
Destruction Removal Efficiency without Condensate

Biosolids Gasifier Process

PFAS Compounds	Run 1	Run 2	Run 3	Average DRE, %
Perfluorobutanoic acid (PFBA)	*	*	*	*
Perfluoropentanoic acid (PFPeA)	*	*	*	*
Perfluorohexanoic acid (PFHxA)	*	*	45.6%	45.6%
Perfluoroheptanoic acid (PFHpA)	*	*	*	*
Perfluorooctanoic acid (PFOA)	66.5%	69.6%	88.0%	74.7%
Perfluorononanoic acid (PFNA)	82.8%	87.9%	95.2%	88.6%
Perfluorodecanoic acid (PFDA)	90.7%	91.5%	97.3%	93.2%
Perfluoroundecanoic acid (PFUnA)	*	*	*	*
Perfluorododecanoic acid (PFDoA)	98.3%	97.9%	99.4%	98.5%
Perfluorotridecanoic acid (PFTriA)	*	*	-	*
Perfluorotetradecanoic acid (PFTeA)	*	*	*	*
Perfluorobutanesulfonic acid (PFBS)	*	100.0%	100.0%	100.0%
Perfluorohexanesulfonic acid (PFHxS)	100.0%	100.0%	100.0%	100.0%
Perfluoroheptanesulfonic acid (PFHpS)	-	-	-	-
Perfluorooctanesulfonic acid (PFOS)	99.8%	99.8%	99.9%	99.9%
Perfluorodecanesulfonic acid (PFDS)	100.0%	100.0%	100.0%	100.0%
Perfluorooctanesulfonamide (FOSA)	100.0%	100.0%	100.0%	100.0%
Perfluoropentanesulfonic acid (PFPeS)	-	-	-	-
Perfluorononanesulfonic acid (PFNS)	-	-	-	-
N-methylperfluorooctanesulfonamidoacetic acid (NMeFOSAA)	100.0%	100.0%	100.0%	100.0%
N-ethylperfluorooctanesulfonamidoacetic acid (NEtFOSAA)	100.0%	100.0%	100.0%	100.0%
1H,1H,2H,2H-Perfluorohexane sulfonic acid (4:2 FTS)	-	-	-	-
1H,1H,2H,2H-Perfluorooctane sulfonic acid (6:2 FTS)	-	-	-	-
1H,1H,2H,2H-Perfluorodecane sulfonic acid (8:2 FTS)	-	-	-	-
Hexafluoropropylene Oxide Dimer Acid (HFPO-DA)	61.6%	53.8%	85.0%	66.8%
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid	-	-	-	-
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid	-	-	-	-
4,8-Dioxa-3H-perfluorononanoic acid (ADONA)	-	-	-	-
1H,1H,2H,2H-Perfluorododecane sulfonic acid (10:2 FTS)	-	-	-	-
2-(N-ethylperfluoro-1-octanesulfonamido) ethanol	100.0%	100.0%	100.0%	100.0%
Perfluoro-n-octadecanoic acid (PFODA)	-	-	-	-
2-(N-methylperfluoro-1-octanesulfonamido) ethanol	98.7%	99.5%	99.6%	99.3%
N-methylperfluorooctane sulfonamide (NMeFOSA)	-	-	-	-
N-ethylperfluorooctane sulfonamide (NEtFOSA)	-	-	-	-
Perfluoro-n-hexadecanoic acid (PFHxDA)	-	-	-	-
Perfluorododecanesulfonic acid (PFDoS)	-	-	-	-
Nonafluoro-3,6-dioxaheptanoic acid (NFDHA)	-	-	-	-
10:2 Fluorotelomer carboxylic acid	-	-	-	-
6:2 Fluorotelomer carboxylic acid	-	-	-	-
7:3 Fluorotelomer carboxylic acid	100.0%	99.9%	100.0%	100.0%
6:2 Fluorotelemer unsaturated acid	-	-	-	-
8:2 Fluorotelomer carboxylic acid	-	-	-	-
8:2 Fluorotelemer unsaturated acid	-	-	-	-
5:3 Fluorotelomer carboxylic acid	99.8%	99.4%	99.9%	99.7%
3-Perfluoropropylpropanoic acid	-	-	-	*
Perfluoro-3-methoxypropanoic acid (PFMPA)	-	*	*	*
Perfluoro-4-methoxybutanoic acid (PFMBA)	-	*	-	*
Perfluoro-4-ethylcyclohexanesulfonic acid	-	-	-	-
Perfluoro (2-ethoxyethane) sulfonic acid (PFEESA)	-	-	-	-
Total PFAS Removal Efficiency (no Condensate)	**96.6%**	**97.0%**	**98.9%**	**97.5%**

* Indicates that more PFAS is in the sum of outputs than the sum of inputs for that compound indicating a possible product of incomplete combustion or destruction (PIC or PID) or an existing unknown compound formation mechanism

- Indicates the analyte was analyzed for but not detected in the solid or air samples

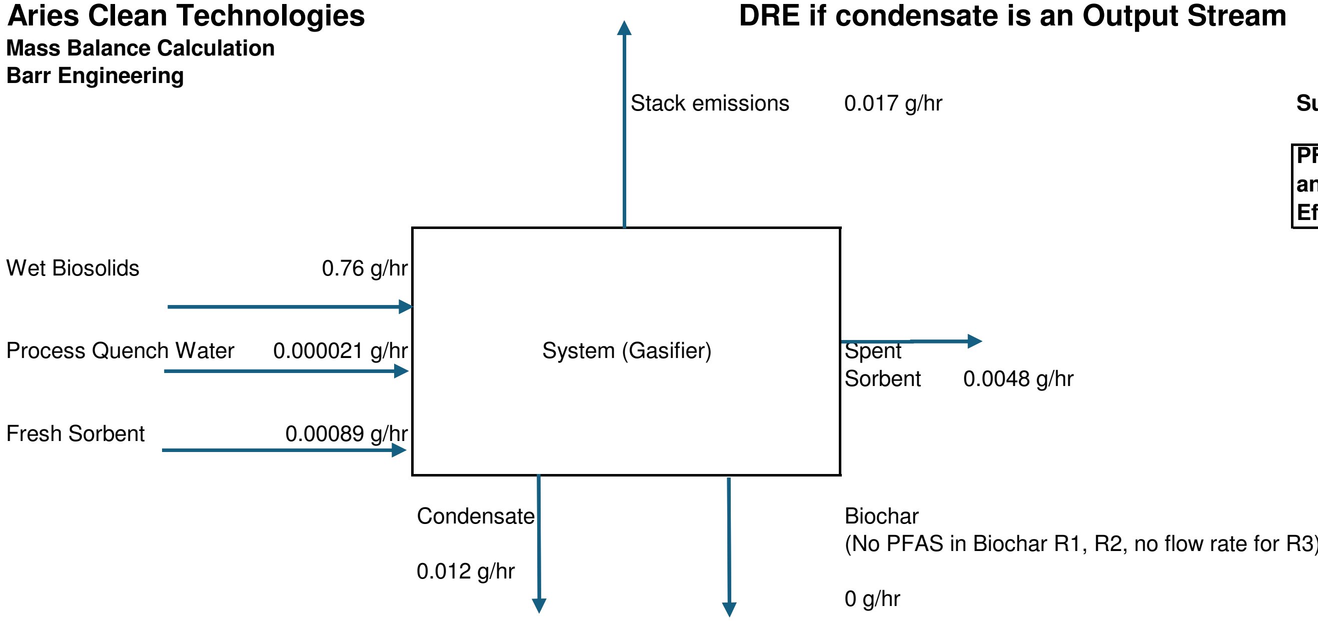
Figures

FIGURE 1

Aries Clean Technologies

Mass Balance Calculation
Barr Engineering

DRE if condensate is an Output Stream



Summary

	Run 1	Run 2	Run 3
PFAS Destruction and Removal Efficiency (DRE)	95.0%	95.4%	97.3%

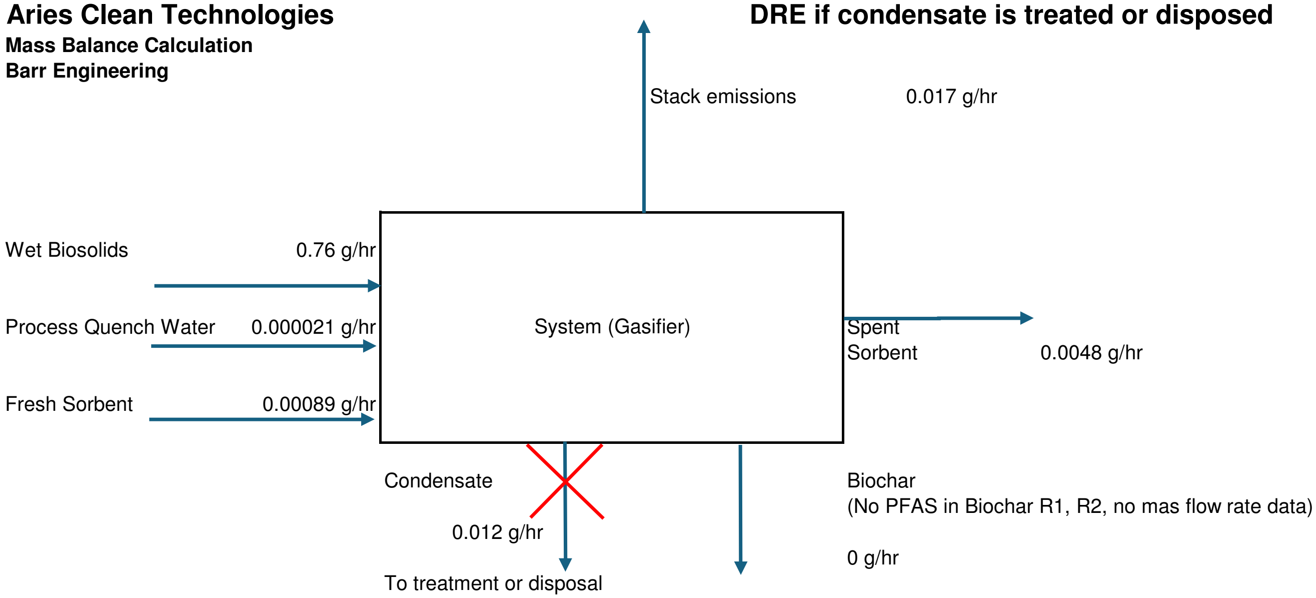
Total detected mass of analyzed PFAS compounds incorporated into this mass balance for each input and output stream

FIGURE 2

Aries Clean Technologies

Mass Balance Calculation
Barr Engineering

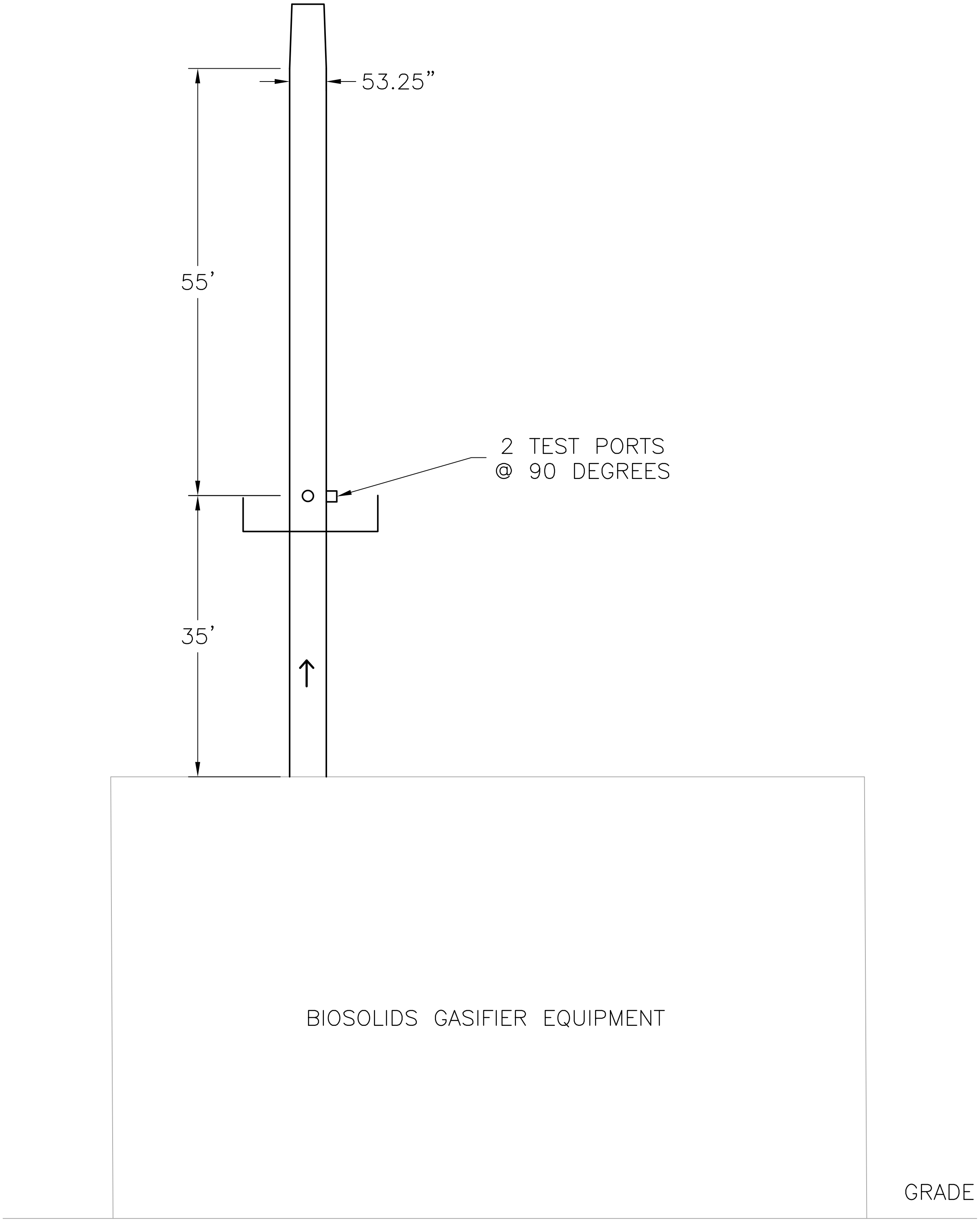
DRE if condensate is treated or disposed



Summary

	Run 1	Run 2	Run 3
PFAS Destruction and Removal Efficiency (DRE)	96.6%	97.0%	98.9%

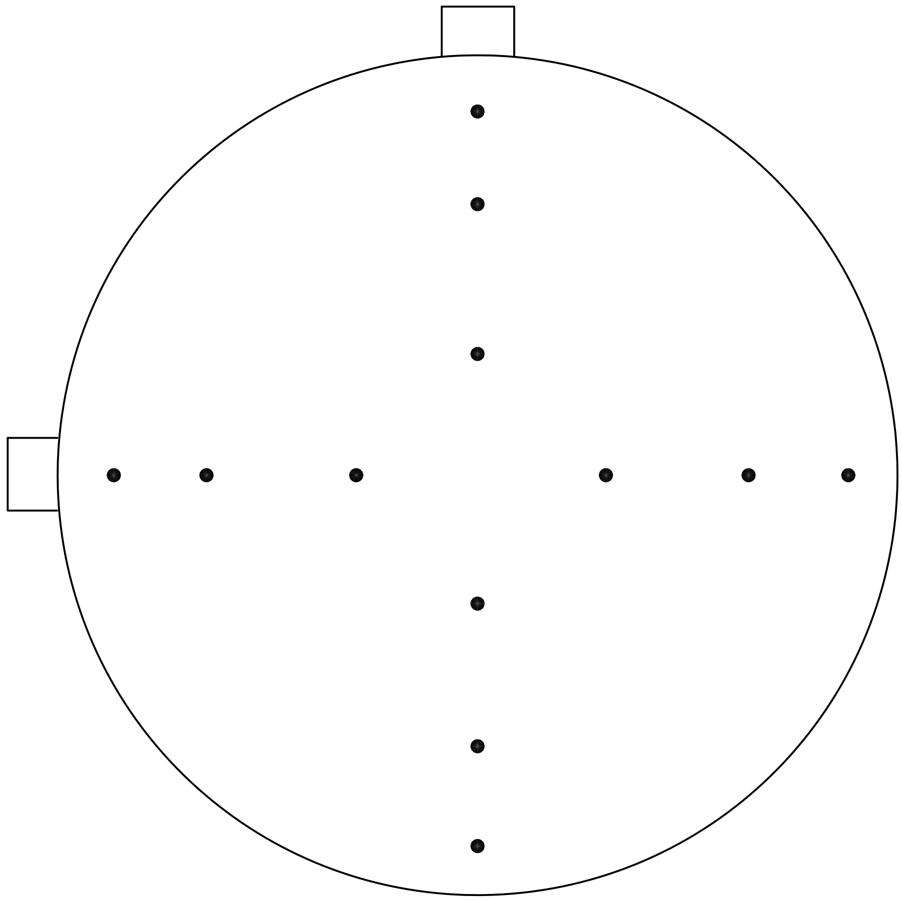
Total detected mass of analyzed PFAS compounds incorporated into this mass balance for each input and output stream



TEST PORT LOCATION
ARIES CLEAN TECHNOLOGIES
LINDEN, NEW JERSEY
GASIFIER STACK

FIGURE 3

NOT TO SCALE



NO. OF TEST PORTS	2
PORT LENGTH	10.00"
PORT DIAMETER	6"
NO. OF TRAVERSE POINTS	12
DUCT DIAMETER	53.25"

POINT	INSERTION DEPTH IN "
1	2.32
2	7.80
3	15.76
4	37.49
5	45.45
6	50.93

TRAVERSE POINT LOCATION
ARIES CLEAN TECHNOLOGIES
LINDEN, NEW JERSEY
GASIFIER STACK

FIGURE 4

NOT TO SCALE

Attachment I

Air Emission Control System Literature

Tri-Mer Corporation
Catalytic Ceramic Filter Systems

Aires Energy

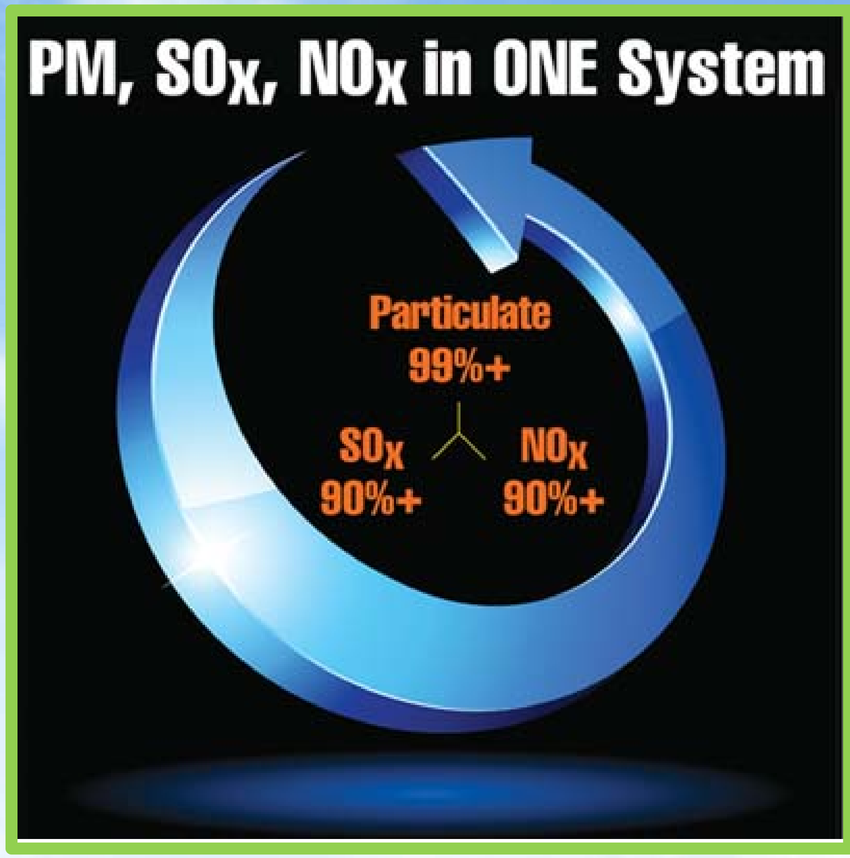
January 2019

Rod Gravley
Technology Director

Kevin Moss
Business Development Director

Tri-Mer Overview

Catalytic Ceramic Filters for Multi-Pollutant Control



Tri-Mer is the Largest Supplier of Ceramic Filter Systems in the World

Presentation Outline

- **Tri-Mer Overview**
- Filter Elements
- NOx Control
- PM Control
- Acid Gas Control
- Filter Systems
- Technical Services
- Aries Discussion

Tri-Mer Installed Base (Page 1 of 3)

	Project	Type	ACFM	Product & Emissions	Operational
1.	Porocel, AR	Catalyst Manufacturing	1,200	UltraTemp -- PM	Q2 2011
2.	Plasma Power, FL	Syngas R&D	2,000	UltraTemp -- PM	Q3 2011
3.	University of Iowa, IA	Biomass Boiler	15,600	UltraCat - PM, NOx + CO unit	Q4 2011
4.	Illumina, CA	RTO Exhaust Biotechnology Process	13,500	UltraCat - PM, HCl, NOx	Q1 2012
5.	Intel, NM	RTO Exhaust, Semiconductor	3,500	UltraCat - PM, HCl, NOx	Q1 2012
6.	Durand Glass, NJ	Glass Furnaces, Tableware	100,000	UltraCat - PM, SO2, HCl, NOx	Q1 2012
7.	Anchor Hocking, PA	Glass Furnace, Tableware	30,000	UltraCat - PM, SO2, HCl, NOx	Q3 2012
8.	Imerys, GA	Ceramic Proppants for Oil/Gas Fracking	324,000	UltraCat - PM, SO2, SO3, HCl, HF, NOx	Q1 2013
9.	AGC Glass, TN	Glass Furnace, Float	165,000	UltraCat - PM, SOx, HCl, NOx	Q4 2012
10.	Porocel, AR	Catalyst Manufacturing	6,000	UltraCat - PM, NOx	Q2 2012
11.	Calgon Carbon, AZ	Reactivation Furnace	25,000	UltraCat - PM, SO2, HCl	Q4 2012
12.	Gallo Glass, CA	Glass Furnace, Container	In stages	UltraTemp - PM, SO2, HCl	Q1 2013
13.	AGC Glass, KS	Glass Furnace, Float	172,000	UltraCat - PM, SOx, HCl, NOx	Q3 2013
14.	Kohler, WI	Specialty Glass Melting	10,000	UltraCat - PM, HF, NOx	Q4 2014
15.	Ardagh, IL	Container Glass	140,000	UltraCat - PM, SOx, HCl, NOx	Q3 2014
16.	Graymont Lime	Lime Kiln Exhaust Pilot	1,000	UltraCat - PM, NOx, SOx, Organic HAPS VOC	Q2 2015

Tri-Mer Installed Base (Page 2 of 3)

	Project	Type	ACFM	Product & Emissions	Operational
17.	CAEM METS-1, CA	Ship Diesel Exhaust	11,000	UltraCat - PM, NOx	Q2 2014
18.	3M, MN	Production	5,000	UltraCat - PM, NOx	Q3 2013
19.	3M, MN	Production	20,000	UltraCat - PM, NOx	Q1 2014
20.	Fort Irwin, CA	Dirty Syngas Boiler	20,000	UltraCat - PM, SO2, NOx	Q3 2014
21.	Powder Processing, IN	Test Kiln	5,000	UltraCat - PM, NOx	Q2 2015
22.	Guardian Glass, MI	Float Glass	175,000	UltraCat - PM, SOx, HCl, NOx	Q2 2015
23.	PQ Corporation, CA	Glass Materials Supplier	30,000	UltraCat - PM, SOx, NOx	Q2 2017
24.	Cardinal Glass, OK	Float Glass	152,000	UltraCat - PM, SOX, HCl, NOx	Q2 2017
25.	Cardinal Glass, NC	Float Glass	149,000	UltraCat - PM, SOX, HCl, NOx	Q2 2017
26.	O-I Owens Brockway, CA	Container Glass	96,000	UltraCat - PM, SOX, HCl, NOx	Q4 2017
27.	Fuyao Glass, IL	Float Glass	120,000	UltraCat - PM, SOX, HCl, NOx	Q3 2017
28.	CAEM ShoreCat, CA	Ship Diesel Exhaust	10,000	UltraCat - PM, NOx	Q3 2017
29.	Fiberglass A1, OR	Fiberglass	Large	UltraTemp	Q1 2018
30.	Fiberglass A2, GA	Fiberglass	Large	UltraTemp	Q2 2018
31.	O-I, IL	Container glass		UltraCat - PM, SOX, HCl, NOx	Q4 2018
32.	Jushi USA, SC	Fiberglass		UltraTemp - PM, SO2, HCl, HF, NOx	Q4 2018

Tri-Mer Installed Base (Page 3 of 3)

	Project	Type	ACFM	Product & Emissions	Operational
33.	Durand Glass, NJ	Tableware Glass	37,000	UltraCat - PM, SO2, HCl, NOx	Q1 2019
34.	O-I/ RMBC	Container Glass	70,000	UltraTemp – PM, SO2, HCl	Q1 2019
35.	Jushi USA, SC	Fiberglass	114,000	UCF - PM, SO2, HCl, HF, NOx	Q4 2018
36.	Arglass, GA	Container Glass	43,000	UltraTemp – PM, SO2, HCl	Q3 2019
37.	Gallo Glass, CA	Container Glass	114,000	UltraTemp - PM, SO2, HCl	Q2 2019
38.	Republic Metals	Product Recovery	3,500	UltraTemp – PM	Q3 2018
39.	Guardian Glass	Float Gass	202,000	UltraCat – PM, SOx, HCl, NOx	Q2 2019

Offices, Fabrication, Finishing, Assembly, and Warehousing

Tri-Mer Overview

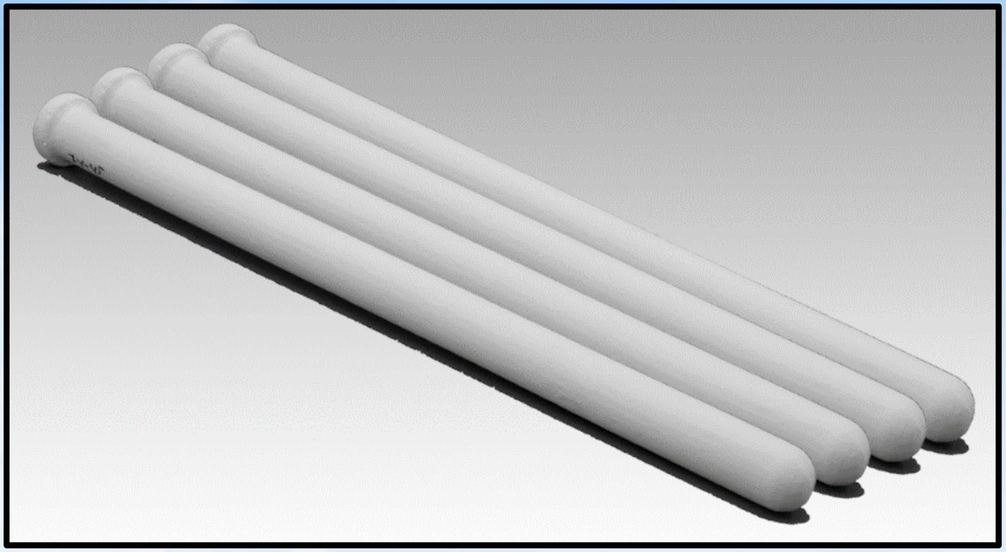
250,000 ft^2 of Engineering Offices and Manufacturing

Tri-Mer Corp – Turnkey Project Execution

- Regulatory Agency Support
- Pilot Testing (if required)
- Pollution System Design (process, structural, mechanical, electrical, controls, & civil)
- Fabrication of an Integrated Catalytic Ceramic Filter System
  1. Base System of Filter Elements and Housings
  2. Sorbent Storage and Injection
  3. Ammonia Storage and Injection
  4. Waste Handling and Storage
  5. Integrated Controls and Data Management
  6. Fan Systems
  7. CEMS
- Installation (civil, mech, and electrical)
- Commissioning and Training
- Performance Guarantees
- Technical Services Group

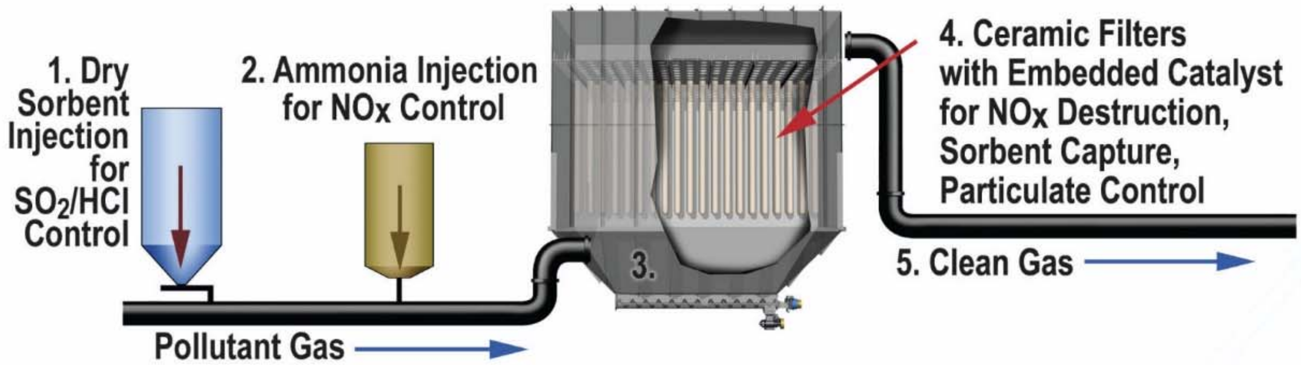
Presentation Outline

- Tri-Mer Overview
- **Filter Elements**
- NOx Control
- PM Control
- Acid Gas Control
- Filter Systems



Catalytic Ceramic Filter Systems

Tri-Mer System – Typical Installation

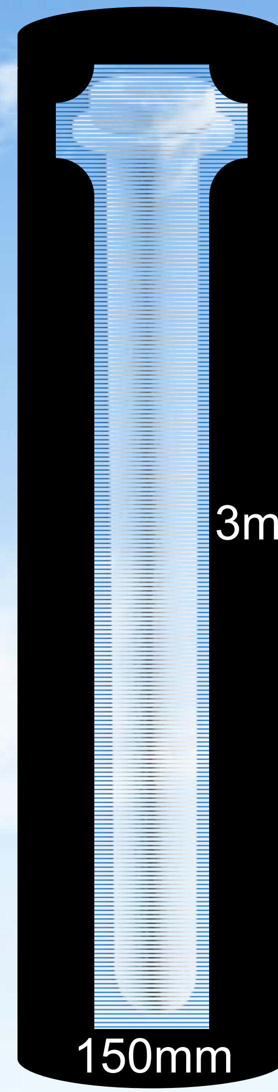


1. Dry powdered sorbent – bicarb, trona, or lime – is injected into the duct. It immediately starts to react with the SO_2, SO_3, and HCl to form solid particles that will be captured by the ceramic filter.
2. Non-hazardous 19% aqueous ammonia is atomized and sprayed into the duct. It immediately turns into a gas and mixes with NO_X. This mixing is not affected by the process PM or sorbent PM.
3. The gas stream goes into the filter housing, and the particulate from the process and sorbent is captured on the outside surface of the filters. Filters are periodically cleaned (about twice a day for many applications) with a burst of compressed air while filter housings remain on-line.
4. The NO_X and ammonia mixture react on the enormous surface area of the nano-catalysts embedded in the filter walls. The mixture is free from particulate that can blind or poison the catalyst, so the reaction can occur more efficiently and across a much wider temperature range. NO_X is broken down into harmless N_2 and water vapor. There is minimal ammonia slip.
5. Treated air exits the ceramic filter system, drawn by an induction fan to the stack.

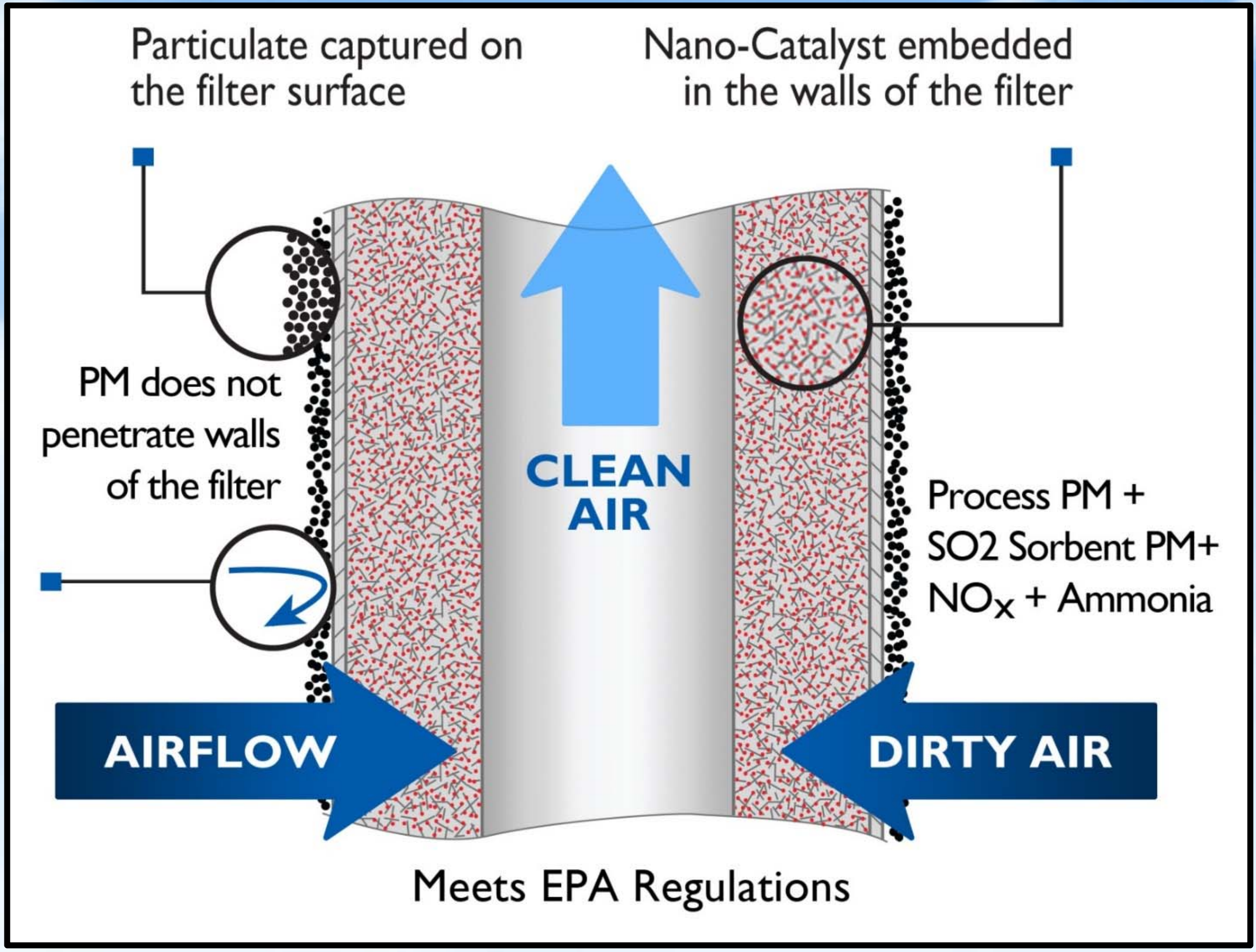
UltraCat Ceramic Filter Elements

CHARACTERISTICS OF (LOW-DENSITY) CERAMIC ELEMENTS	
Form	Monolithic rigid tube
Composition	Refractory fibers plus organic and inorganic binding agents
Porosity	About 80-90%
Density	About 0.3 - 0.4 g/cc
Support	Self supporting from integral flange
Geometry	Outer diameter up to 150 mm; Length up to 3 m

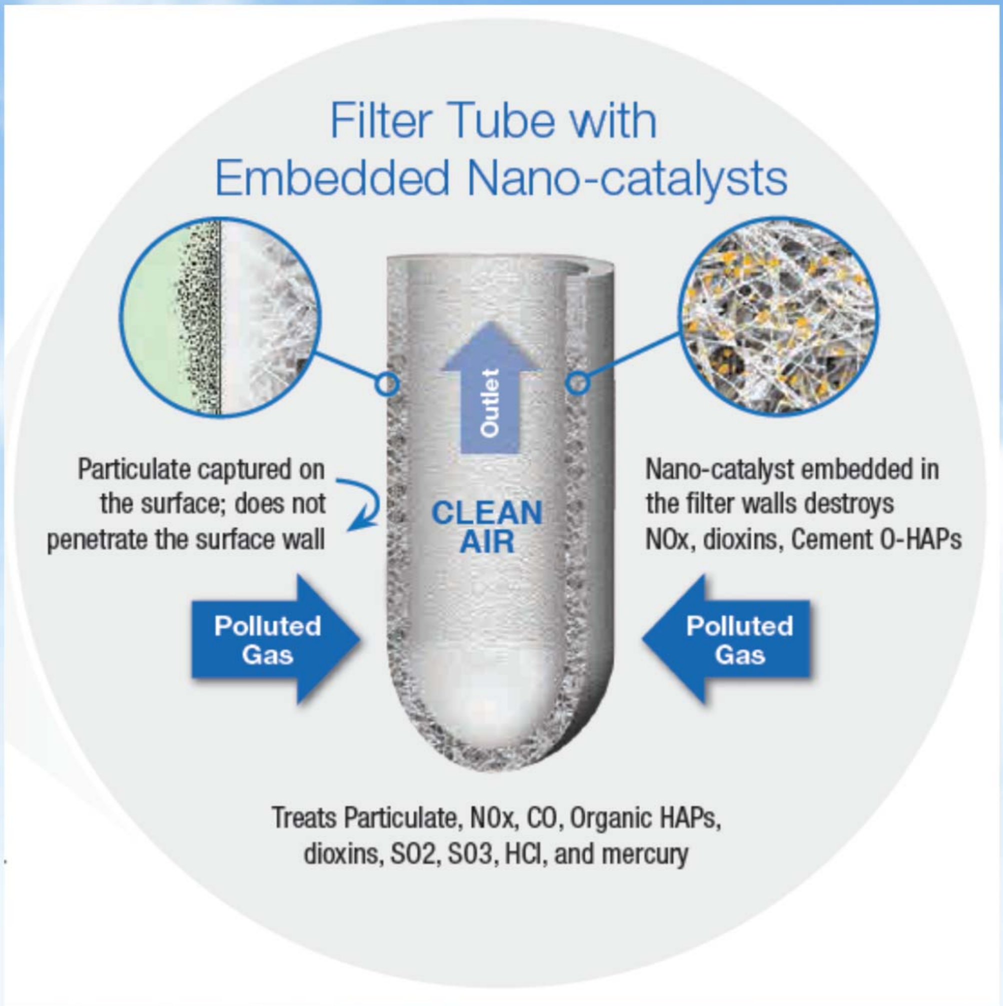
10 feet by 6 inches
(3 meters by 150mm)
strong, lightweight
ceramic fiber filter



Protection from Catalyst PM Blinding and Poisoning



Protection from Catalyst PM Blinding and Poisoning



- Catalyst is inside the filter walls, evenly distributed
- Particulate (PM) is captured on the surface of the filter
- Catalyst is protected from blinding and poisoning by particulate
- Very long catalyst life
- Over 90% NOx removal at 450º F.

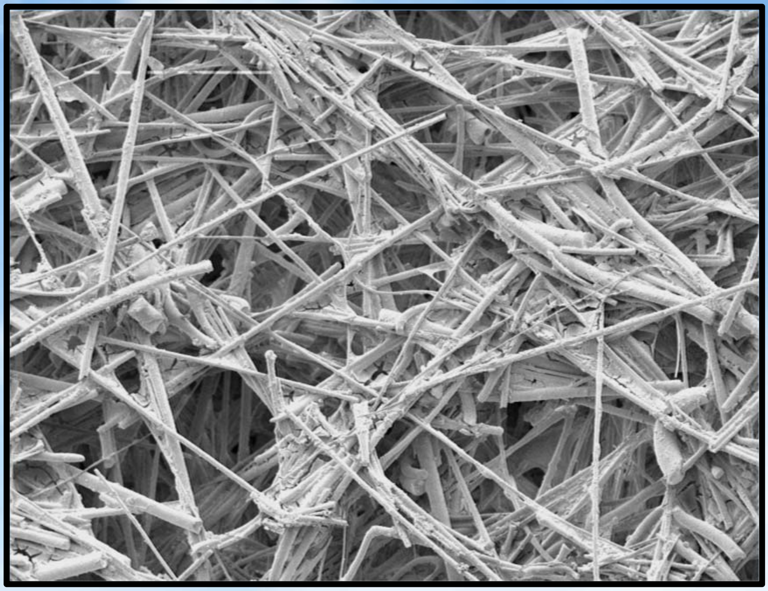
Filter Elements Operating Temperatures

PM + Acids + NO_x 280 → 750 °F	Low temp applications might require second stage of catalyst
PM + Acids 200 → 1200 °F	Acids Include: SO_2, HCl, HF, SO_3
PM only 200 → 1,650 °F	

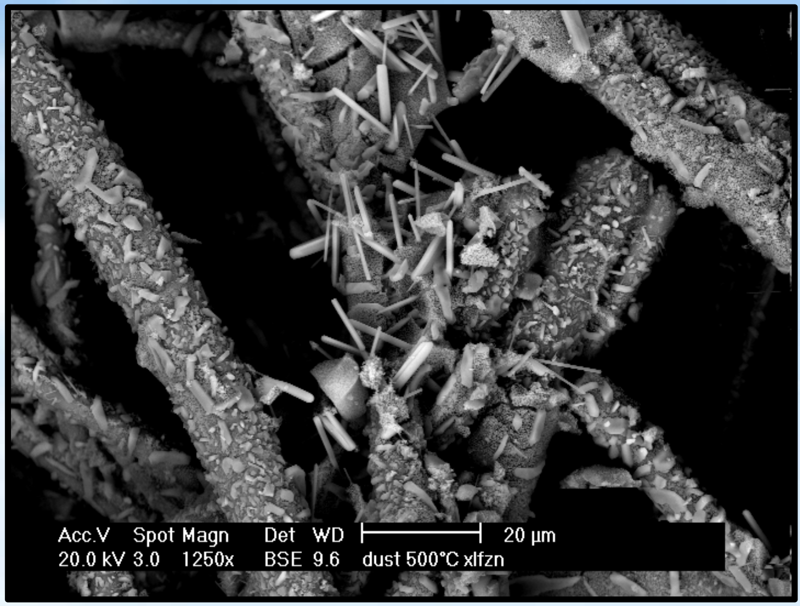
200 °F — Temperature Scale — 1,650 °F

Filter Elements

UltraCat Ceramic Filter Element Construction

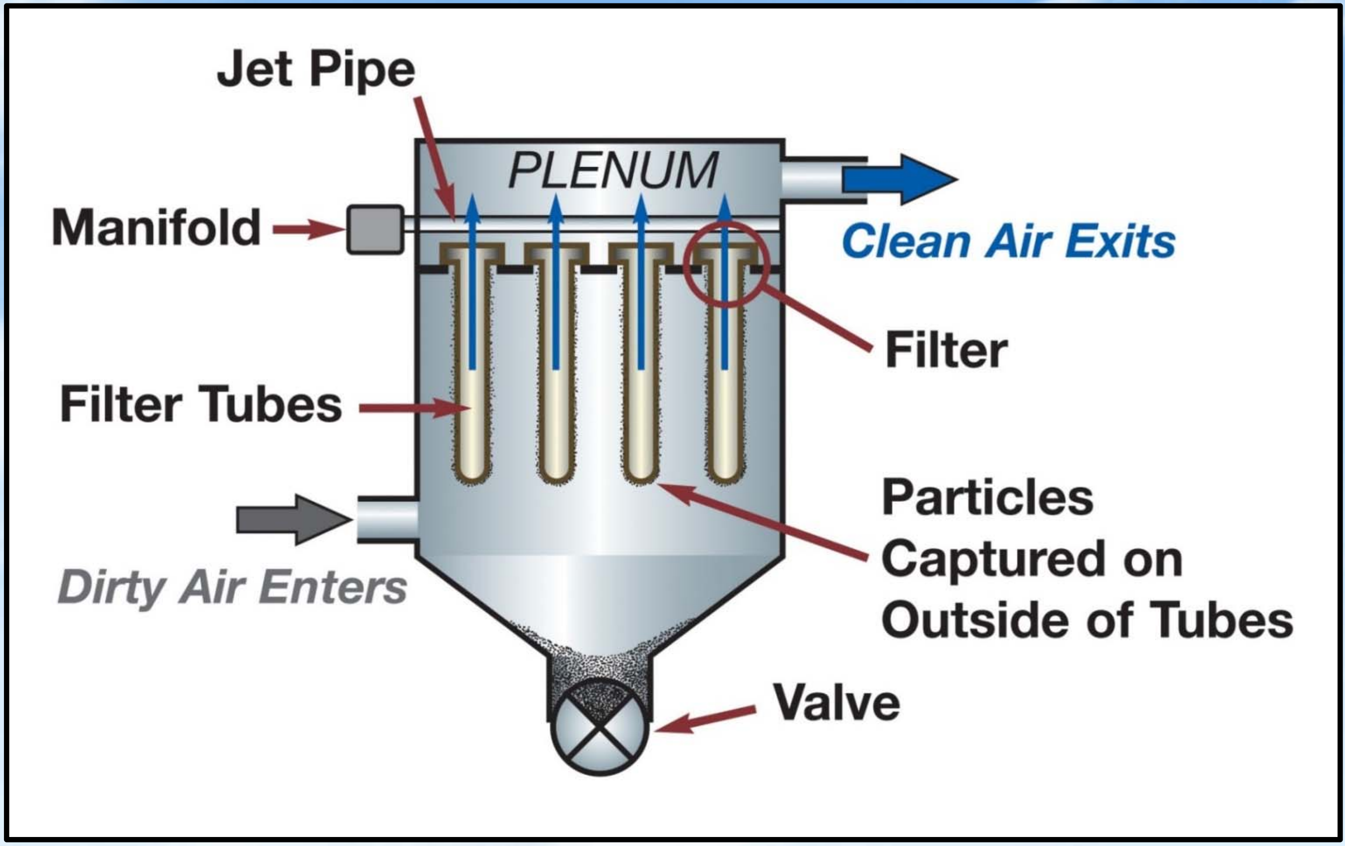


Outer Surface



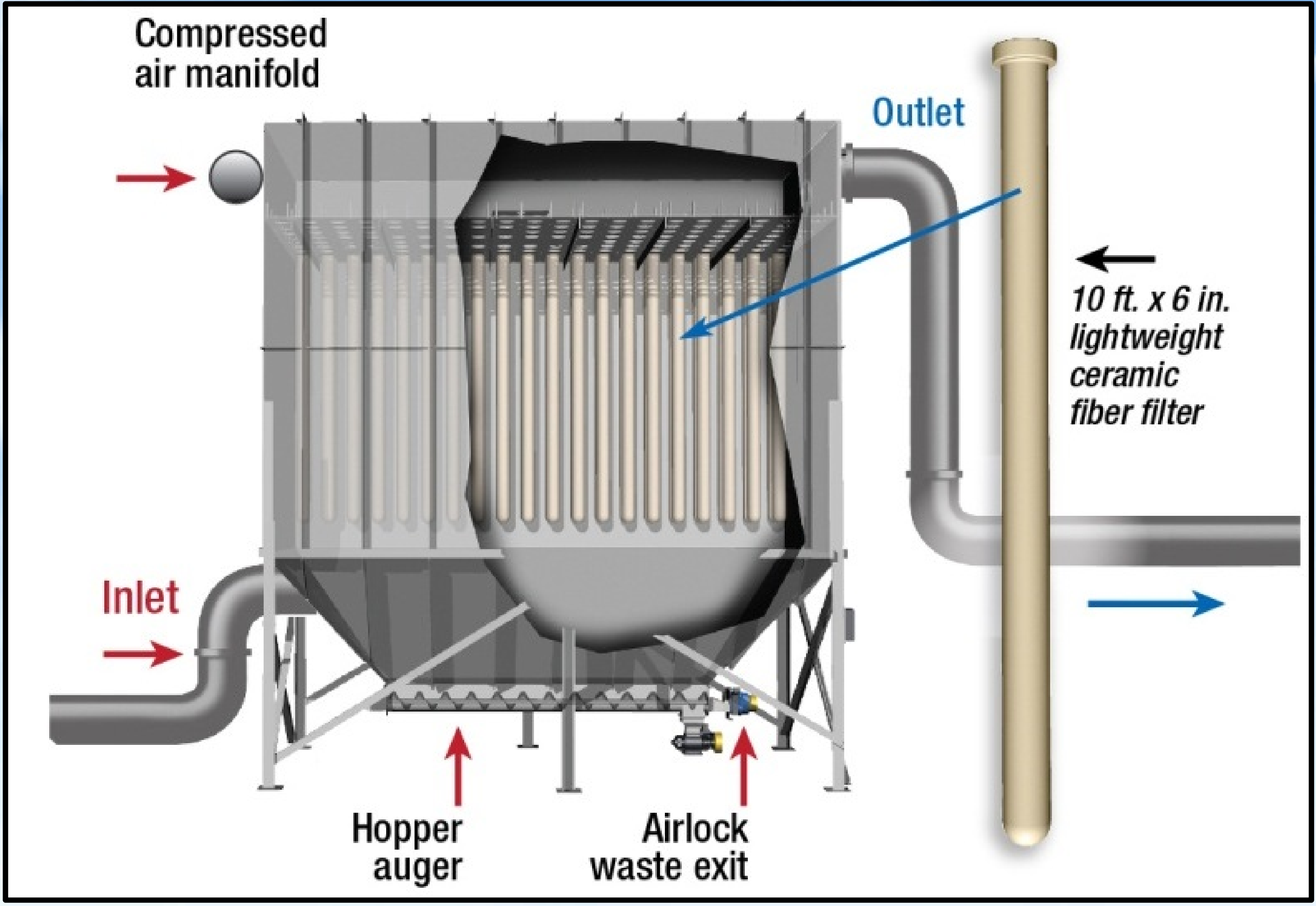
Inner Surface with Catalyst

Basic Operations

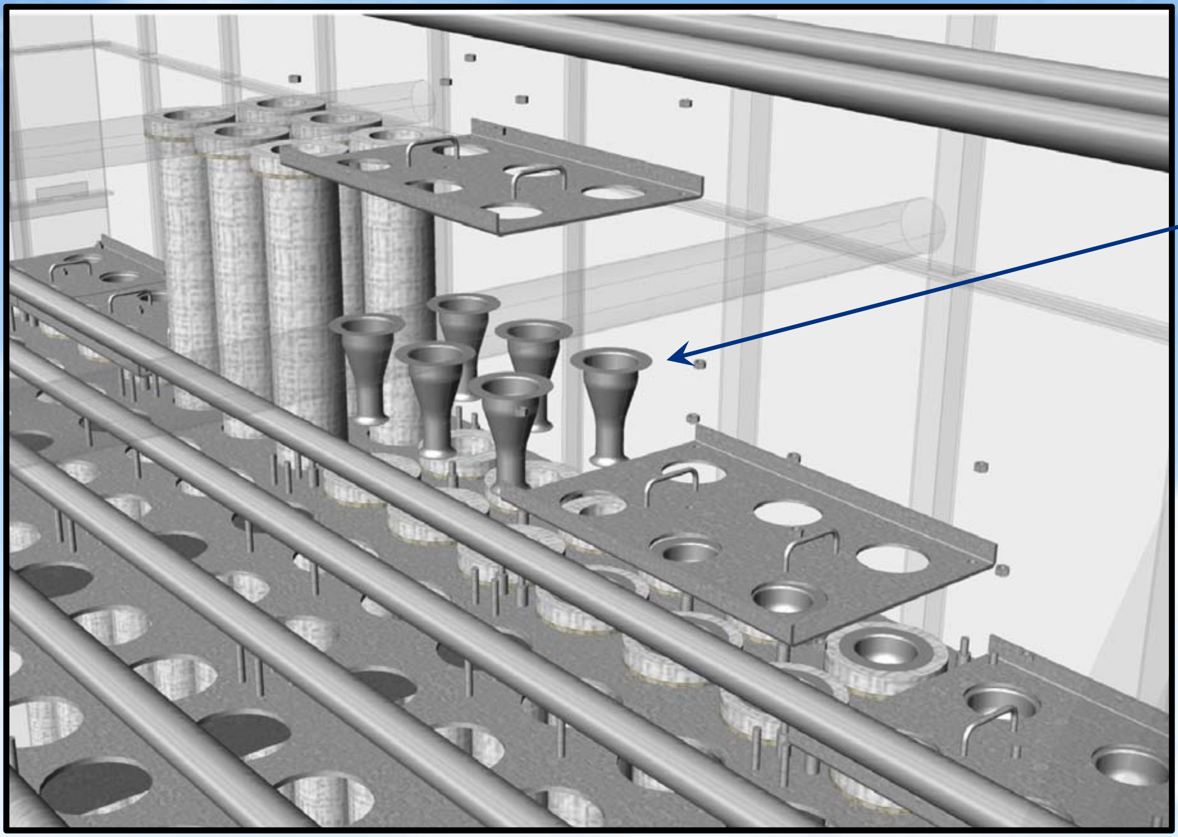


The UCF system requires 70 psi of clean, dry, and oil-free air preferably filtered to 0.1 microns with a dew point of -20°C.

Tri-Mer UltraCat Catalyst Filter & Housing



UltraCat Ceramic Filters for Multi-Pollutant Control

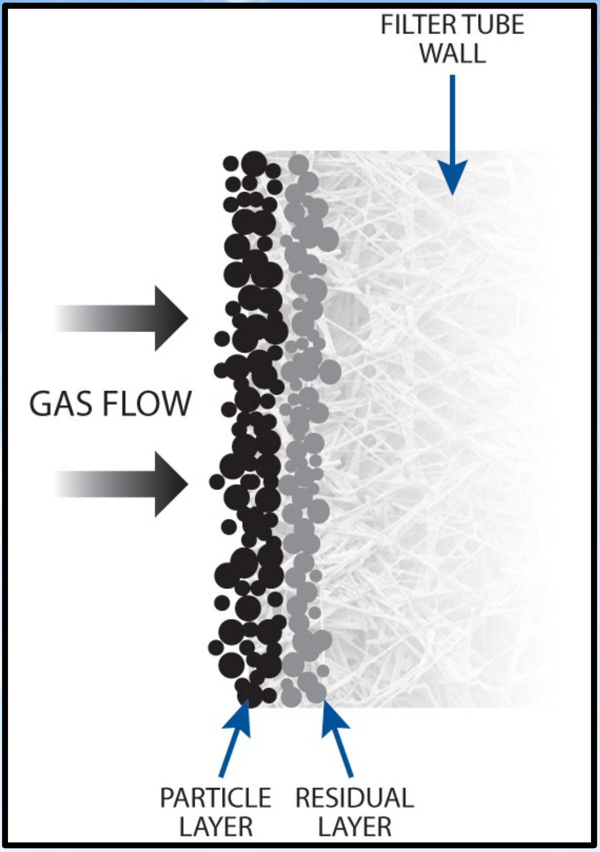


Venturis direct the "pulse" of air into the filter element. This causes a momentary disruption of flow through the element, which allows the accumulated filter cake to fall into the hopper.

Barrier Filter Effective on All Particle Sizes

- Dust cake builds upon the residual layer, does not penetrate into filter body
- Cake is periodically removed with a reverse pulse of air, a brief low volume shockwave
- Can handle variable loading conditions
- Tube does not flex like a Fabric Filter bag,

  No mechanical wear = long filter life



This is a classic example of a “barrier filter.”
There is no “mesh size” or “average pore size.”
UltraCat filters are effective on all particle sizes, including PM2.5 and Submicron.

Filter Elements

Pressure Drop Remains Virtually the Same

- Initial pressure drop approx. 1.0–1.5 kPa, 4 – 6 in. wg.
- Over 8 year period, no significant pressure drop increase.

Estimated filter life is over 10 years

Catalyst Does Not Deactive, Maintains Initial Performance

- Catalyst does not deactivate, it is protected within the filter
- Filter are NOT changed because catalyst goes bad
- NOx performance stays the same
- PM, SO2, HCl, HF performance always same as new filter

Estimated filter life is over 10 years

Tri-Mer has the Largest Inventory of Ceramic Filters

- Largest continuous inventory, over 3000 filters
- Reserve for natural disasters
- Accelerated project schedules
- Spare parts management for customers

Presentation Outline

- Tri-Mer Overview
- Filter Elements
- **NOx Control**
- PM Control
- Acid Gas Control
- Filter Systems

NOx Control

UltraCat Utilizes Standard SCR Chemistry

Selective Catalytic Reduction (SCR)

$$4\,NO_{gas} + 4NH_{3\,gas} + O_{2\,gas} \xrightarrow{catalyst} 4N_{2\,gas} + 6H_2O_{gas}$$

NOx is converted to the harmless basic constituents of our atmosphere, nitrogen and water vapor.

NOx Removal Approach

Typical SCR Block Catalyst

Typical temperature range
600 F – 1,100 F

Removal efficiency: up to 90%

Blinding and poisoning the catalyst are the greatest drawbacks.

Typical Catalyst Deactivation Rates

• 100% straw	50% per 10,000 h
• Wood-fired PF fired boiler	60% per 10,000 h
• Wood-fired CFB boiler	45% per 10,000 h
• Wood, grate-fired boiler	25% per 10,000 h
• Peat-fired boiler	60% per 10,000 h
• Coal-fired boiler	12% per 10,000 h
• Coal / 20% biomass	12% per 10,000 h
• Gas-fired boiler	2% per 10,000 h

Conventional Block SCR

High Removal at 650 F. and hotter

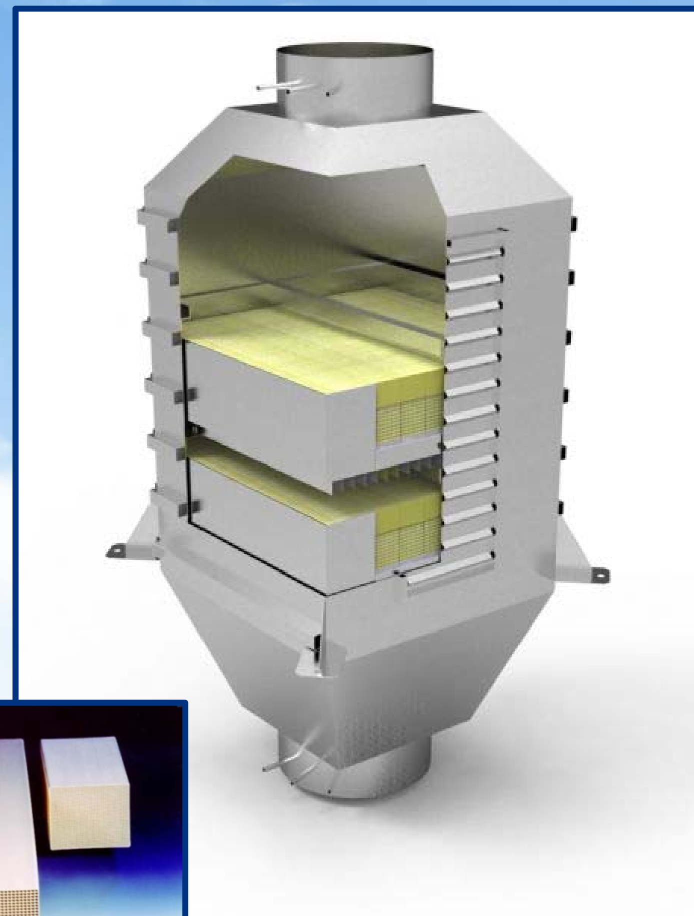
Blinding and poisoning the catalyst are the greatest drawbacks.

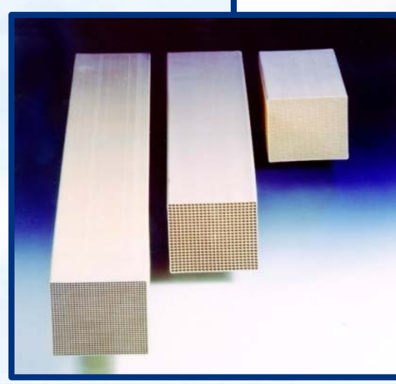
“Hot side”

Reactor placed before
any PM or other pollutant removal

“Cold side”

Reactor placed after electrostatic precipitator or fabric baghouse for PM control.





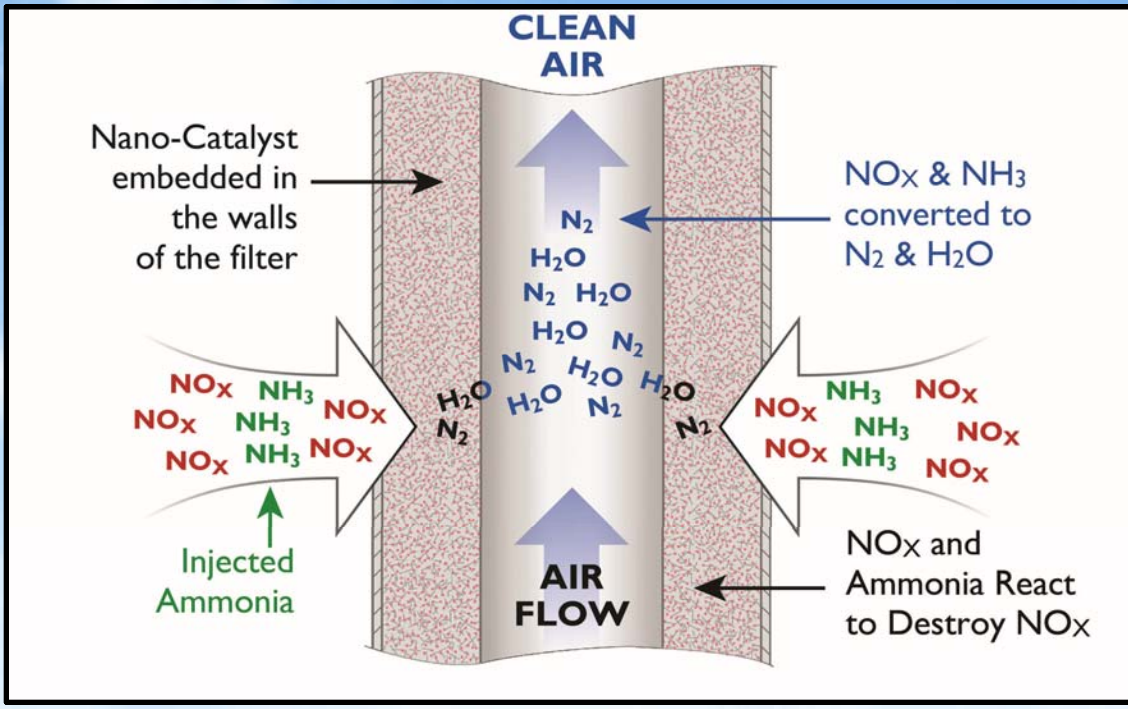
NOx Removal Approach

The combination of two well established technologies

Standard filter tube
+ SCR catalyst

NOx Control

Principle of Operation



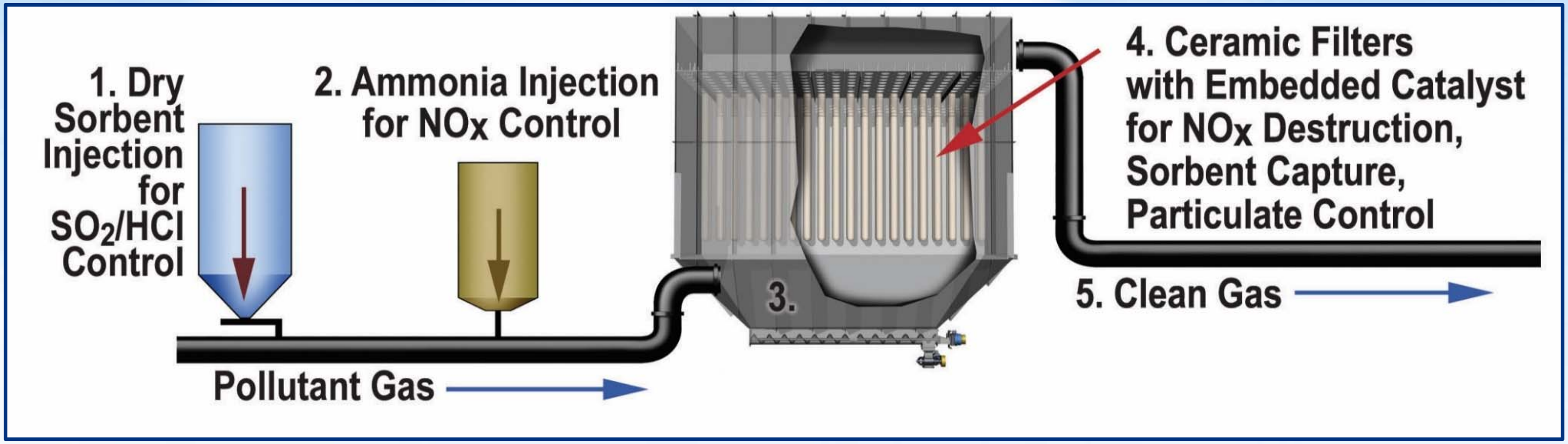
Utilization is virtually 100%, compared to 15% for traditional SCR
– Haldor Topsoe, P. Schoubye paper 2006

Lower temperatures achieve higher removal efficiency-- 60-70% starting at 350 F, and over 90% approaching 450 F. Traditional block SCR usually requires 650 F to reach 90%.

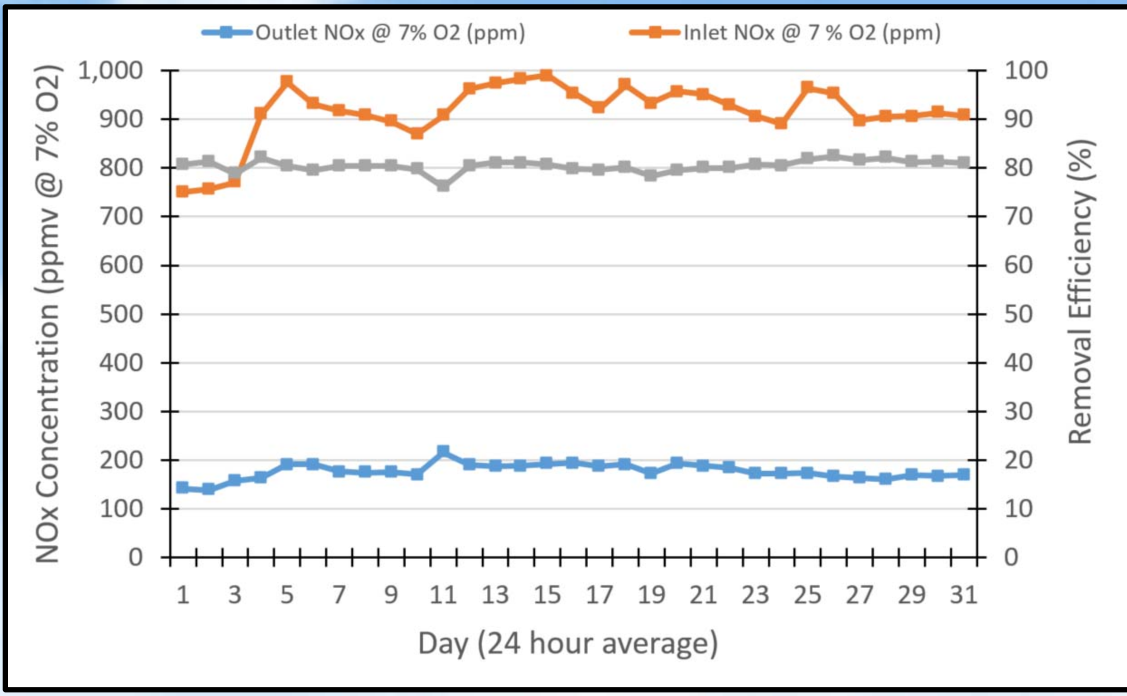
Tri-Mer® CORPORATION Technology Leader *air pollution control*

System Configuration

- Catalytic Ceramic Filter Systems can meet all Federal and State requirements for NOx reduction.
- Aqua ammonia injection and control is included as part of an integrated system.
- Operating temperature range 350 F – 750 F.
- Filter expected life is more than 10 years of continuous operation.
- Catalyst formulation is proprietary, and minimizes SO2→SO3 conversion.



Tri-Mer Actual System Performance



- Compliance Requirement is 80% Reduction
- Average Reduction = 80.5%
- Ammonia Slip <5 ppmv as Measured by Insitu IR
- Precise Control Minimizes Ammonia Consumption
- Filter Operating Temp = 690F
- Average Inlet NOx = 915 ppmv
- Average Outlet NOx = 177 ppmv

Presentation Outline

- Tri-Mer Overview
- Filter Elements
- NOx Control
- **PM Control**
- Acid Gas Control
- Filter Systems

Particulate Control

- PM removal guaranteed to below 10 mg/Nm3
- PM performance has been verified by EPA Method 5/201/202 on all installed systems.
- Systems meet all EPA and State requirements for all manufacturing facilities to date.

PM Control

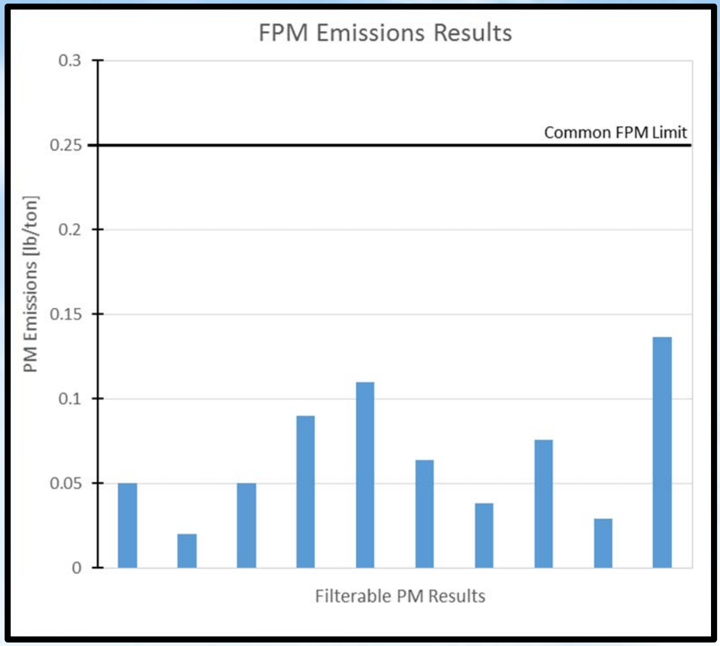
Particulate Control, Chrome – Including Hexavalent

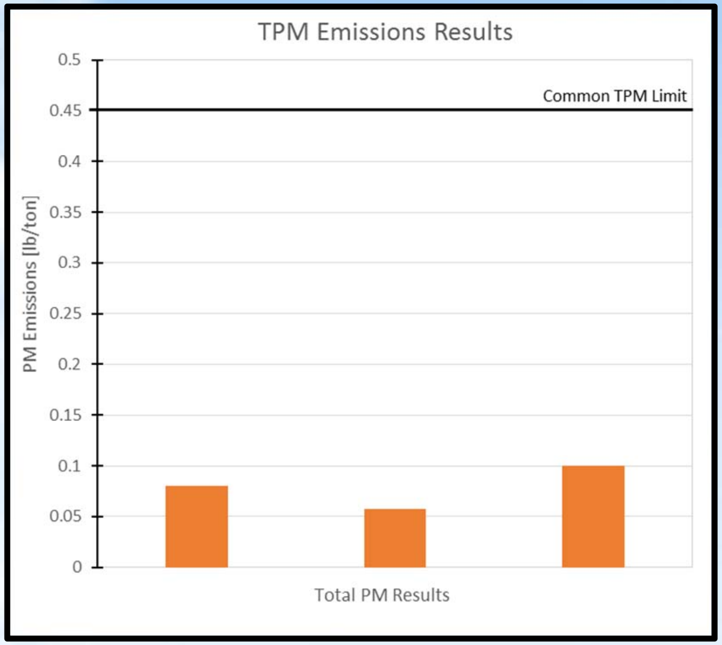
Tri-Mer® CORPORATION

Technology Leader *air pollution control*

PM Reduction on Various Glass Furnaces

Each bar shown in the graphs below is a result from a different glass furnace utilizing a Tri-Mer Catalytic Ceramic Filter (CCF) System





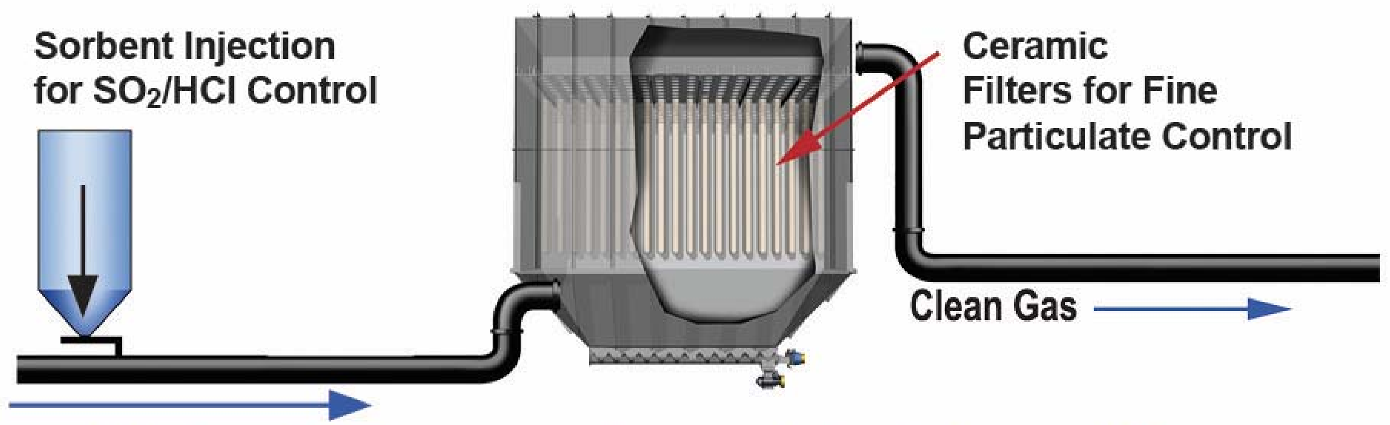
Presentation Outline

- Tri-Mer Overview
- Filter Elements
- NOx Control
- PM Control
- **Acid Gas Control**
- Filter Systems

Acid Gas Control

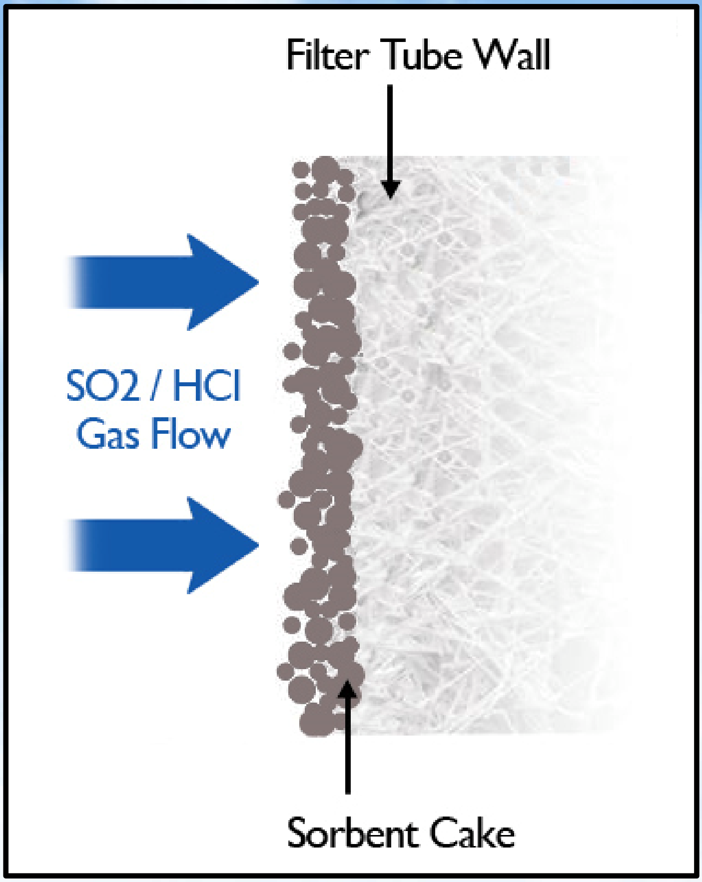
SO_x, HCl, and HF – Dry Sorbent Injection

- Hydrated Lime is used on all Tri-Mer CCF Systems
  - Engineered hydrates are more cost effective than sodium based sorbents, including trona.
  - Hydrates are easier to transport and can be land filled if required
  - Hydrates capture selenium better than sodium based sorbents
- Operating Temperatures 350 F – 1600 F
- Meets all EPA and State Regulations



UltraTemp Filtration system for control of particulate and SO_2

In-Duct Reaction PLUS Sorbent Cake on the Filter



Sorbent injection chemistry

$Ca(OH)_2$ (powder) + SO_2 (flue gas)

+ O_2 (gas from ambient air)

=>

$CaSO_4$ (powder)+ H_2O (gas)

Sorbacal SP by Lhoist – Tri-Mer's Partner In Performance

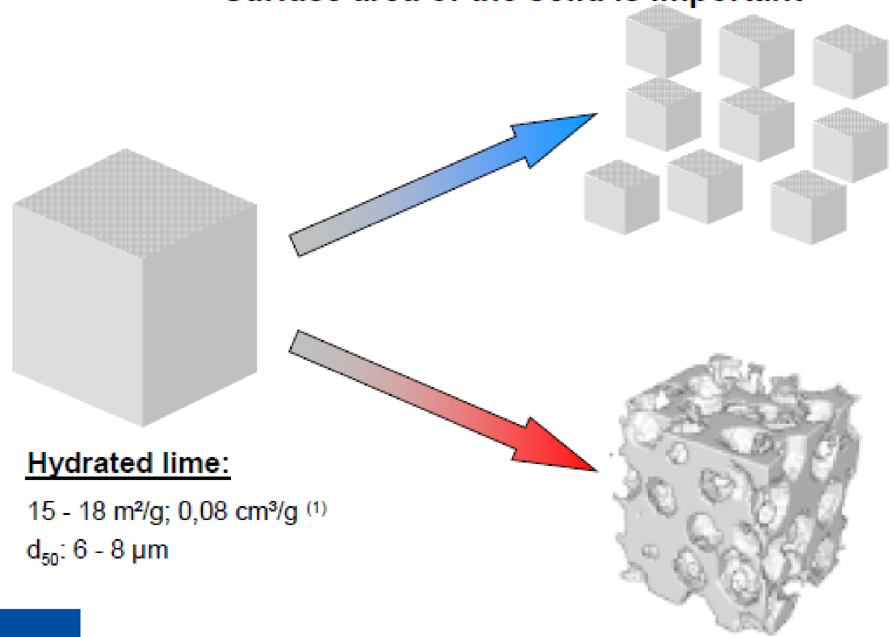
Sorbacal®

Product development highly reactive hydrate ($Ca(OH)_2$):

Reaction of $Ca(OH)_2$ and acid flue gas components:

Acid – base reaction by gas – solid contact

=> Surface area of the solid is important



Sorbacal® A:

35 - 38 m²/g; 0,13 cm³/g

d_{50}: **2 - 3 µm**

Hydrated lime:

15 - 18 m²/g; 0,08 cm³/g (1)

d_{50}: 6 - 8 µm

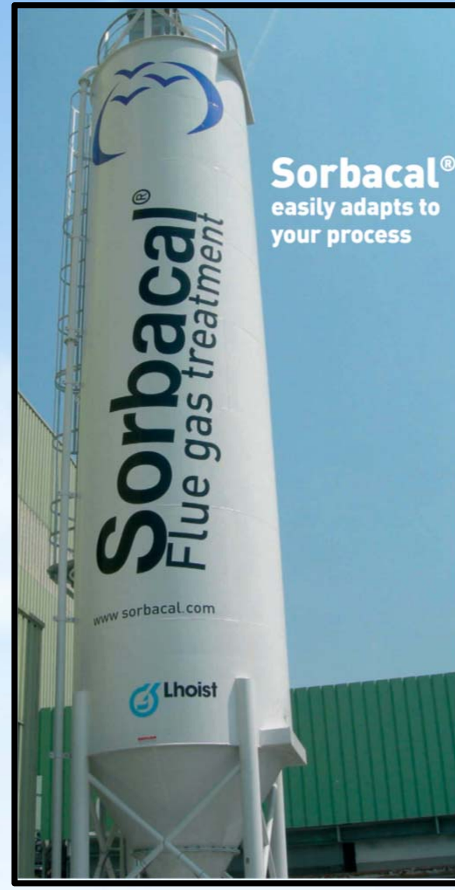
Sorbacal® SP:

42 - 45 m²/g; 0,25 cm³/g

d_{50}: 6 - 8 µm

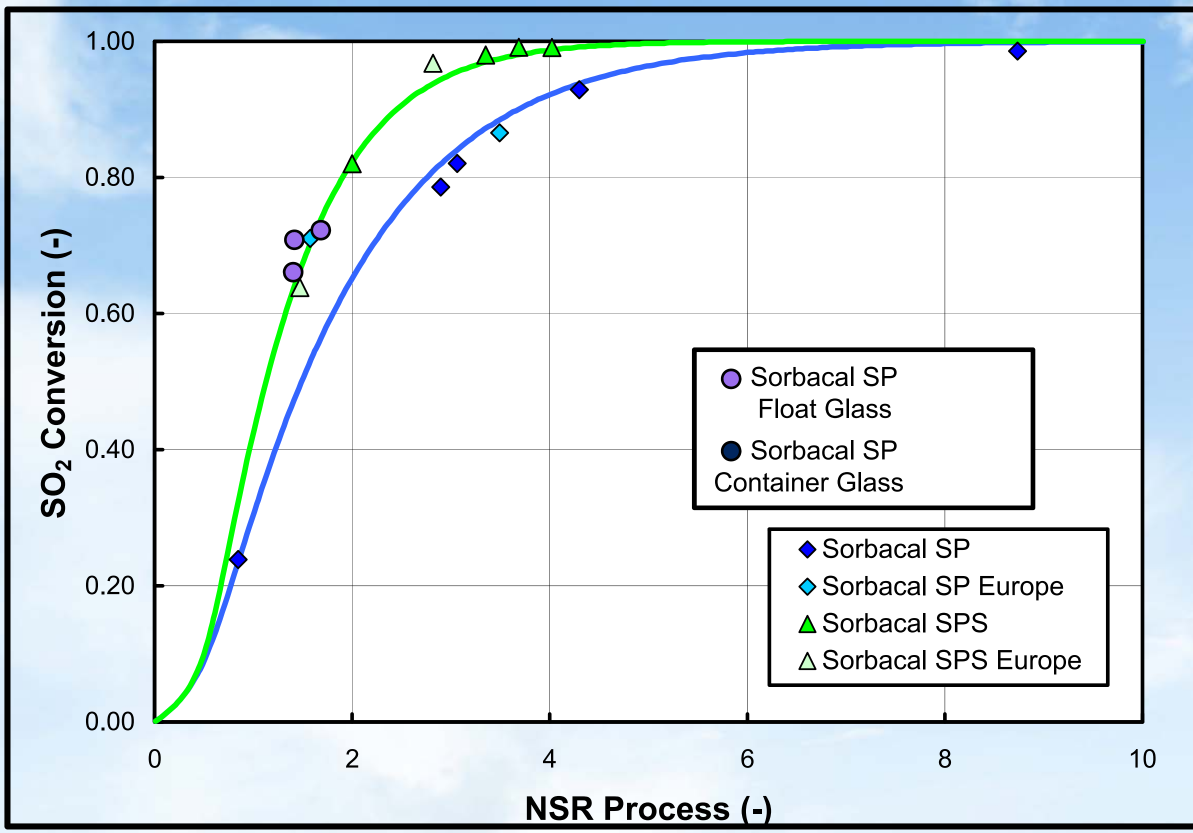
At the moment developing (Sorbacal® SPS for > 160°C)

(1): spec. surface area/ pore volume



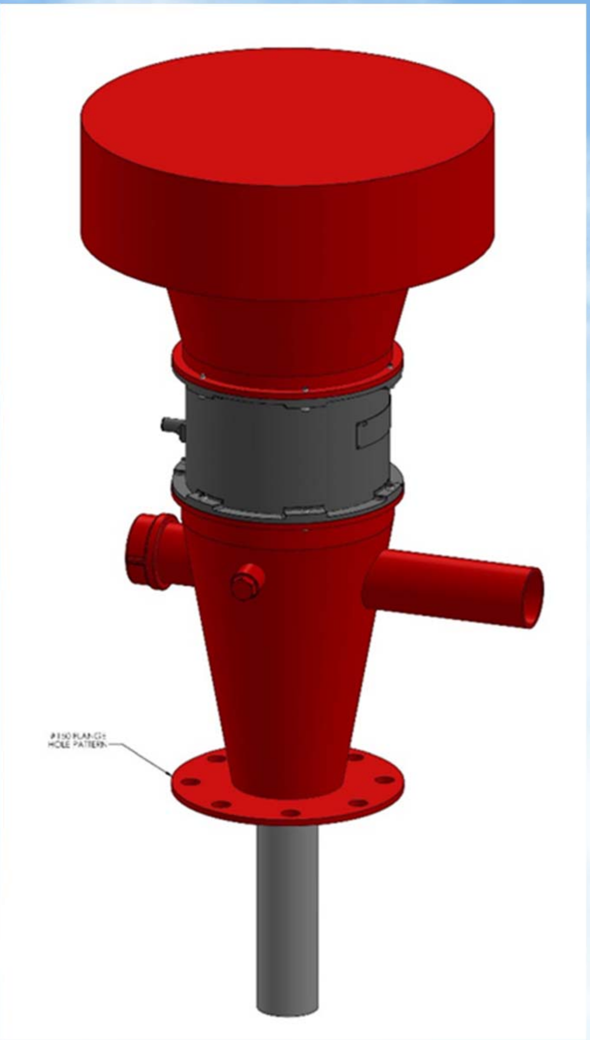
Acid Gas Control

SO2 Reduction on Various Glass Furnace Applications



Sorbent Optimization

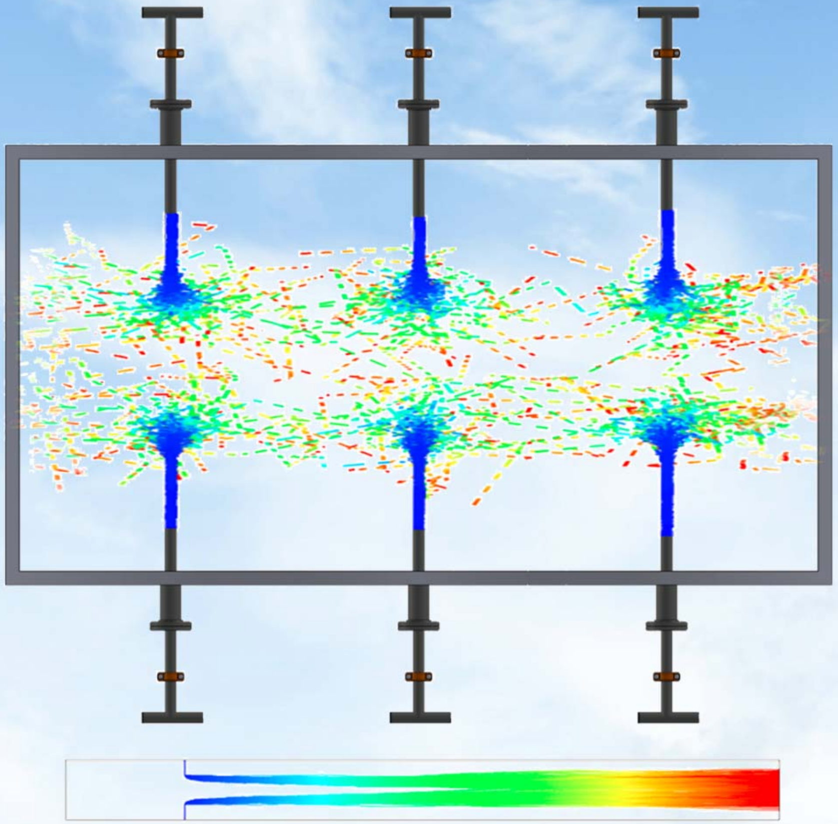
Tri-Mer Injection System – Exclusive Technology



Tri-Mer Injector installed in UCF system duct

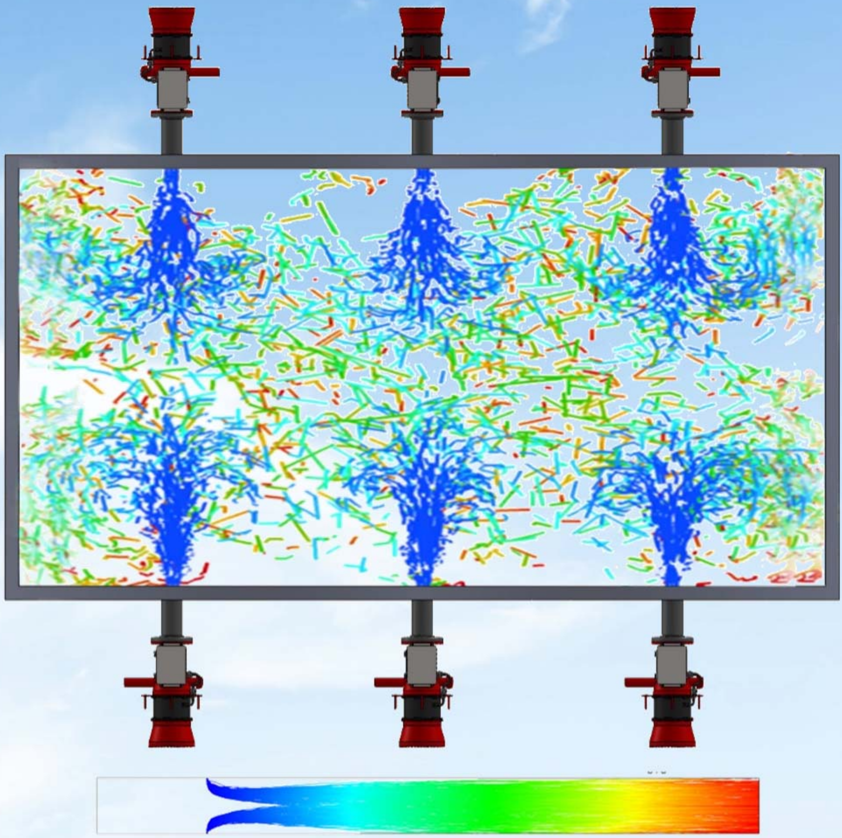
Tri-Mer Injection System

Traditional Lances



Residence time profile

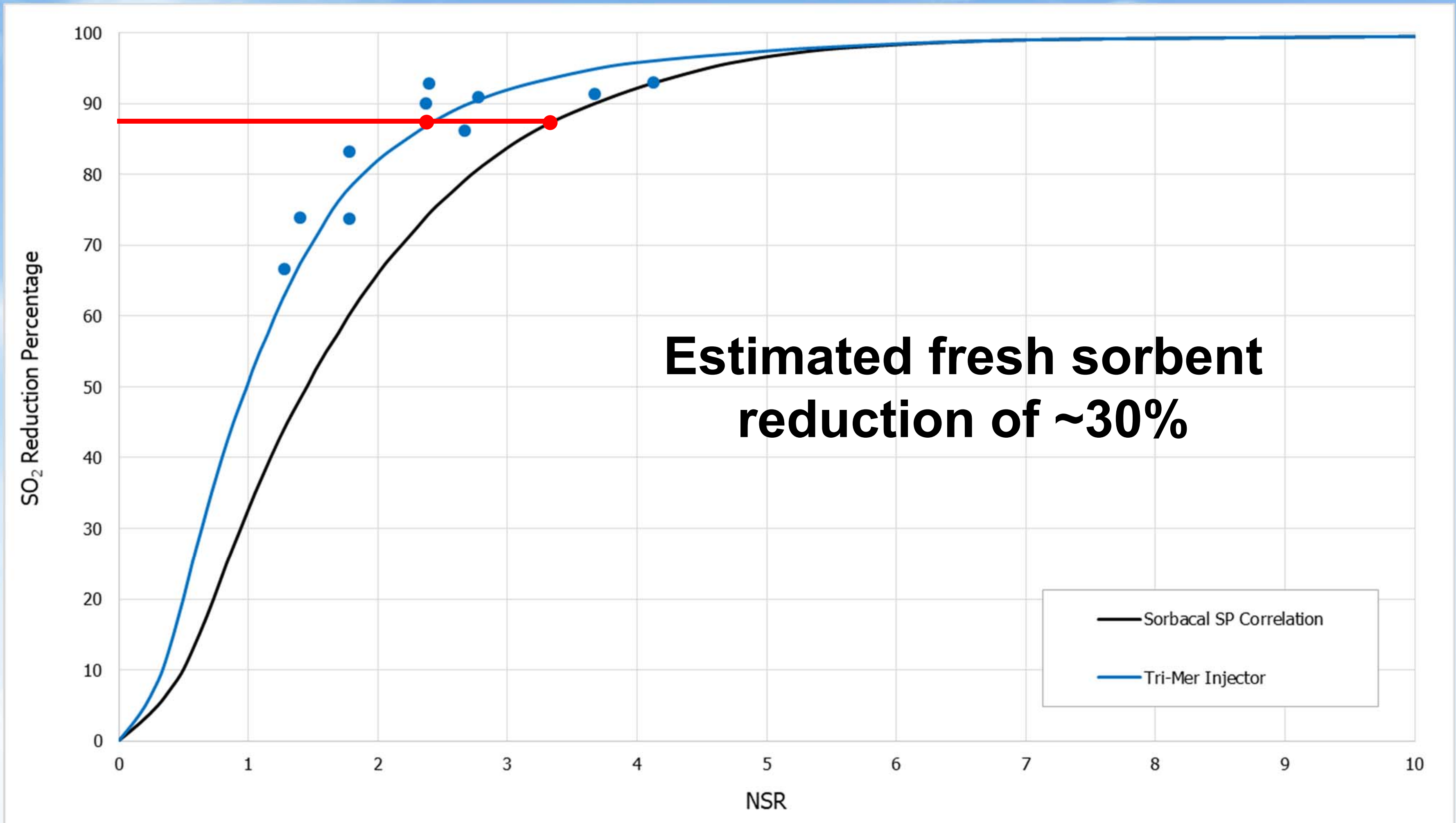
Tri-Mer Injection



Residence time profile

Sorbent Optimization

Tri-Mer Injection System Performance



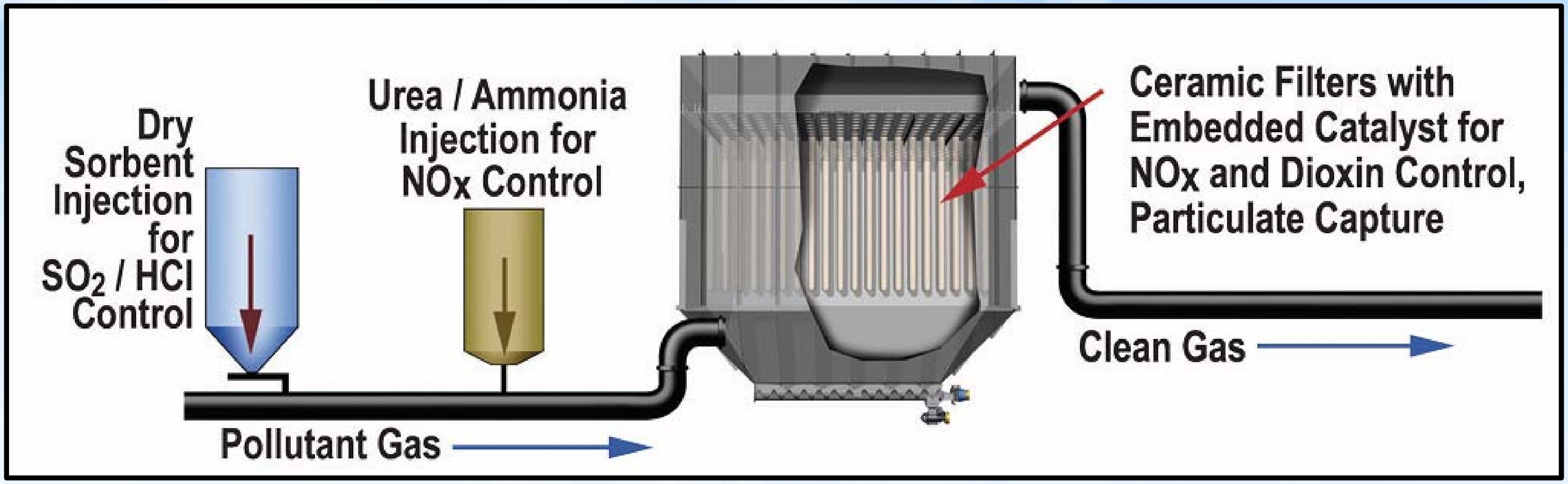
Estimated fresh sorbent reduction of ~30%

Presentation Outline

- Tri-Mer Overview
- Filter Elements
- NOx Control
- PM Control
- Acid Gases
- **Filter Systems**

Typical System Configuration

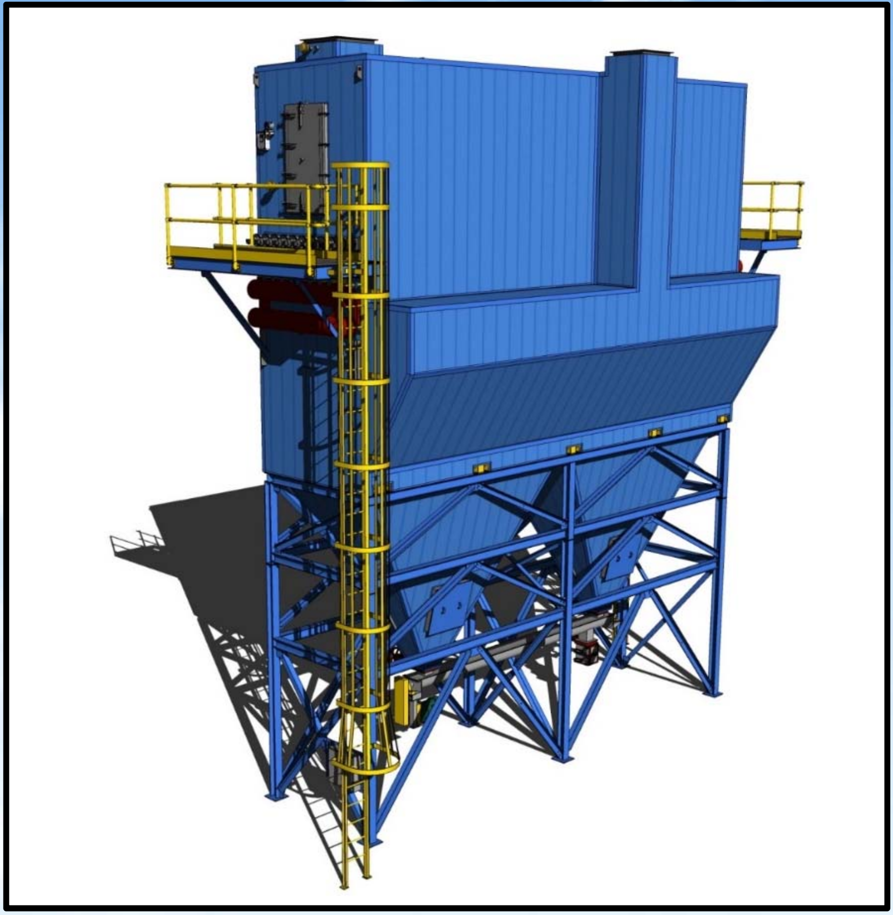
1. If necessary, condition incoming gas to <750ºF
2. Add sorbent to control acid gases and Hg.
3. Add aqua ammonia for NOx reaction.
4. Remove solid waste.



Filter Systems

Single Housing Configuration

1. Maximum of 500 filters per housing.
2. No limit to housings operating in parallel
3. Single Housing Height 34’
4. Single Housing Width 11’
5. Single Housing Length 11’ to 38’ depending on filter count
6. Fully Insulated
7. Indoor/Outdoor



Constructed in Four Sections

1. Walk-in plenum
2. Tube Sheet
3. Hopper
4. Support Frame

Shipped in four pieces

Simple installation with a crane

Filter elements installed in the field by Tri-Mer personnel.

One Day Installation Per Filter Housing

Filter Systems

Array of Filter Housings in Place with a Week

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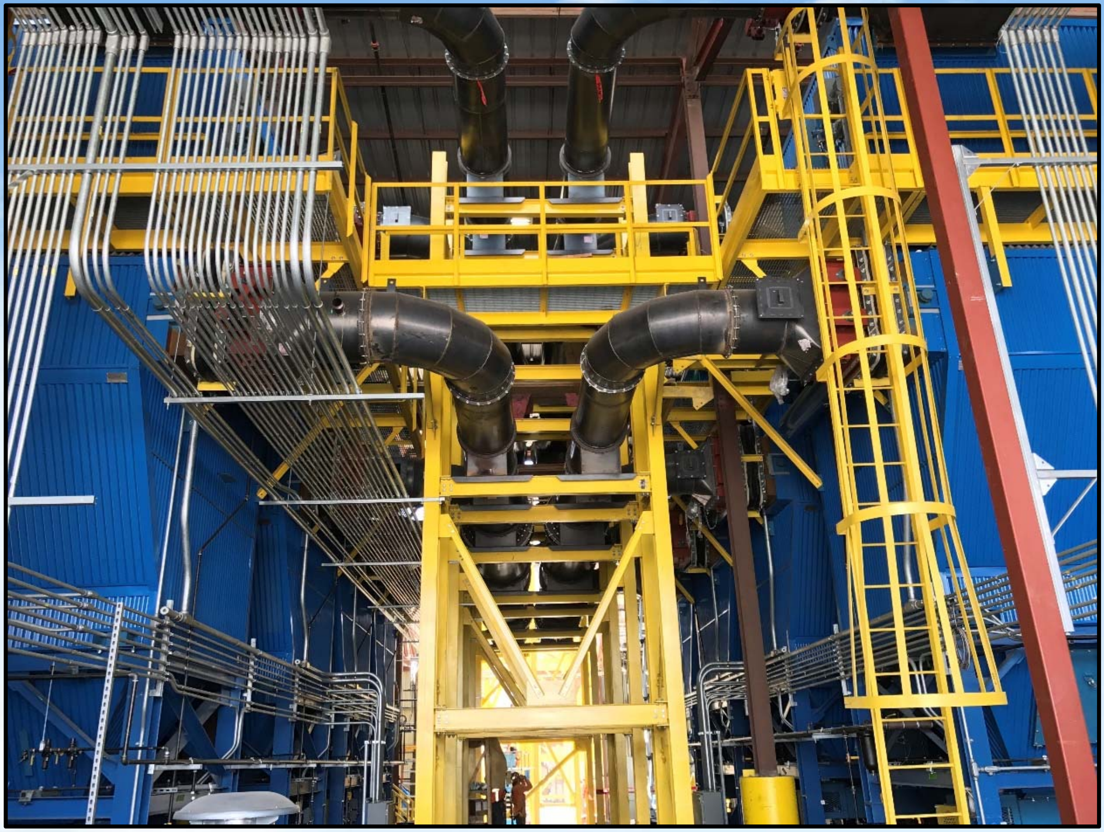
The Tri-Mer Equipment Does not Interfere with Making Glass

With 3 or more modules, if a module needs to be serviced its dampers are closed and it is cooled by opening the service doors. The other modules temporarily take all the flow and operate at a higher pressure with very minimal change in performance.

Filters fail at a rate of less than 1 per 500 annually for average applications. Changing a filter requires 4 to 6 hours, most of that in cool down time. After service gradual heat-up is unnecessary.

Container Glass – California

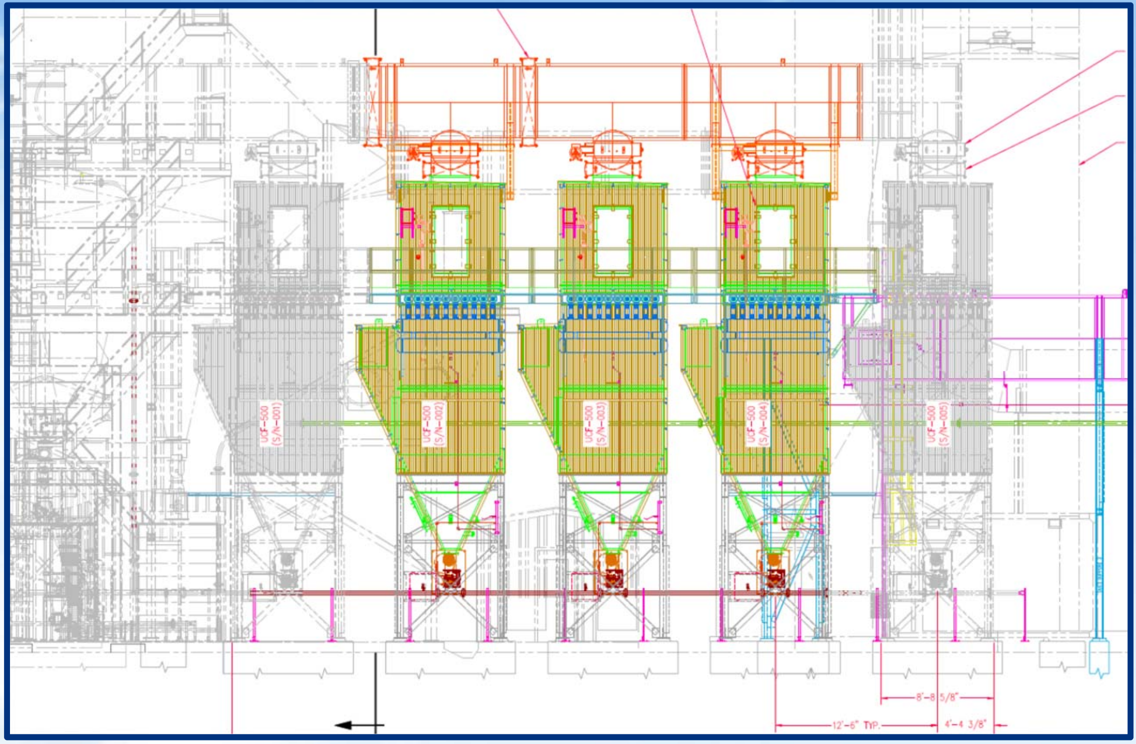
- 780 tpd (clear)
- Two Furnaces
- Oxy/Fuel
- PM, NOx, & SO2
- Full Turnkey w/ civil
- Start-up Oct 2017



Filter Systems

Container Glass – California

- Five Furnaces
- Oxy
- PM, SO2, NOx option
- Full Turnkey
- Completion 2019



Filter Systems

Sodium Silicate – California

- 220 tpd
- Single Furnace
- Air/Fuel
- PM & NOx
- Full Turnkey
- Start-up May 2017
- Compliance Verified

Highest NOx Reduction – Stationary Diesel Emissions

Systems for treating diesel exhaust from ships at berth are comprised of 2 principal components.

1 Capture System

Stack adaptor and exhaust shuttle connected to stack of auxiliary engine

2 Treatment System

Catalytic ceramic filter system configured for treating PM, SO_x, NO_x

Filter Systems

Fiberglass – Oregon, Georgia

- Customer has not authorized us to share project information.
- First of two projects.

- Very extensive testing was done over a very long time.
- This is a very large project.
- In compliance with US EPA and State regulations.

H&V Oregon – Multiple housings, Fiberglass

- H&V has not authorized us to share project information. Very sorry.
- Much public information is available to your US consultant, SM&E.

- Very extensive testing was done over a very long time.
- This is a very large project.
- In will be complete in 2017.
- Will comply with US EPA and State of Oregon, City of Corvallis (a special hard city.)

H&V Georgia – Multiple housings, Fiberglass

- H&V has not authorized us to share project information. Very sorry.
- Much public information is available to your US consultant, SM&E.
- This is a very large project. Will have a large expansion.
- It will be complete in 2018.
- Will comply with US EPA and State of Georgia. Regulations are easier in southern United States, like in South Carolina.

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Tri-Mer Profile for Jushi USA, Columbia, South Carolina

JUSHIUSA

- Location: Columbia, South Carolina
- Air/fuel combustion

- Air flow: Proprietary Am^3/hr
- Initial temperature: 750 C
- Temperature after cooling with ambient air: 370 C

- Operational date: summer 2018
- Will be compliance verified (tested) with performance guarantees
- Will meet US EPA regulations and State of South Carolina permit

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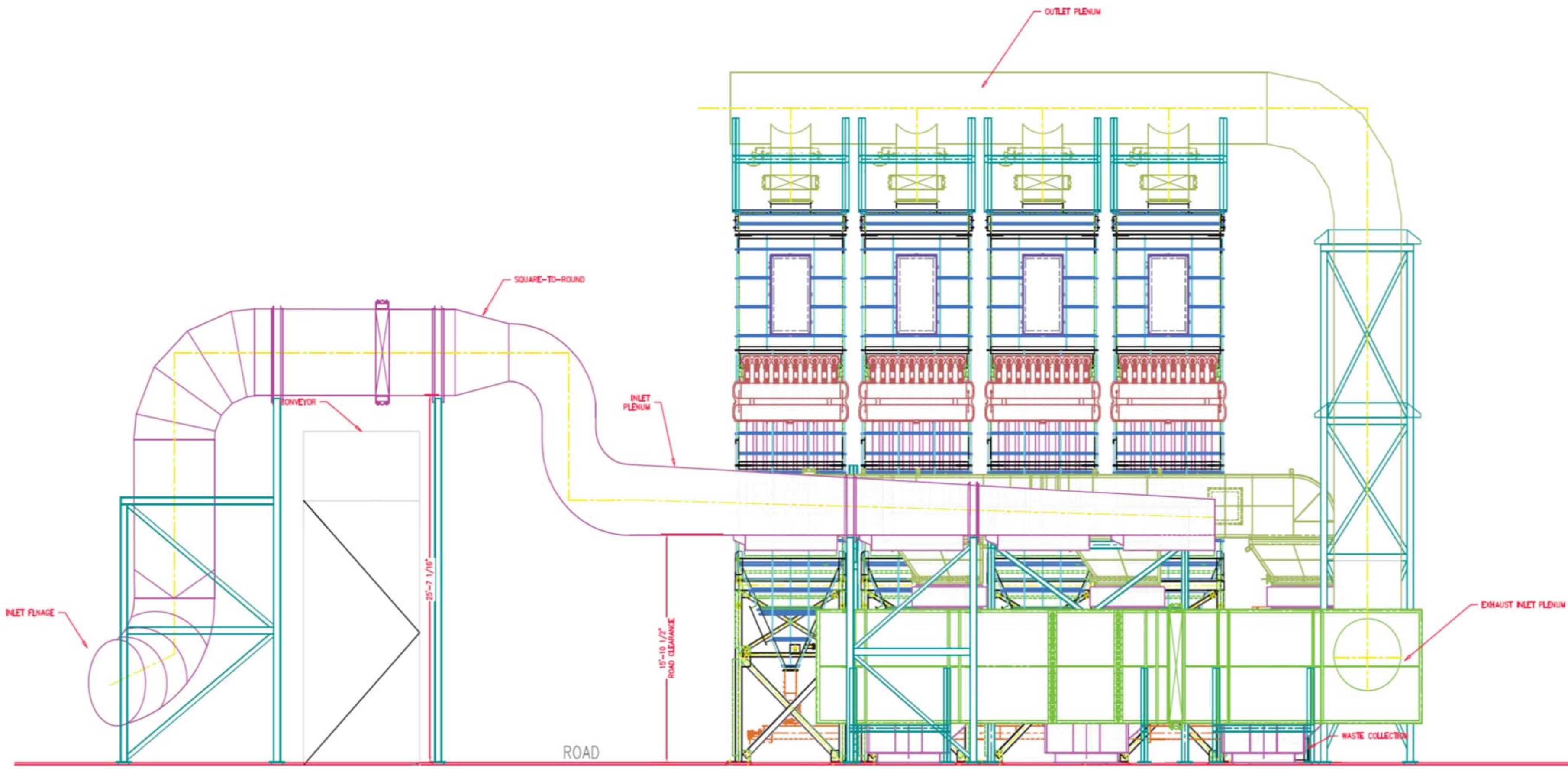
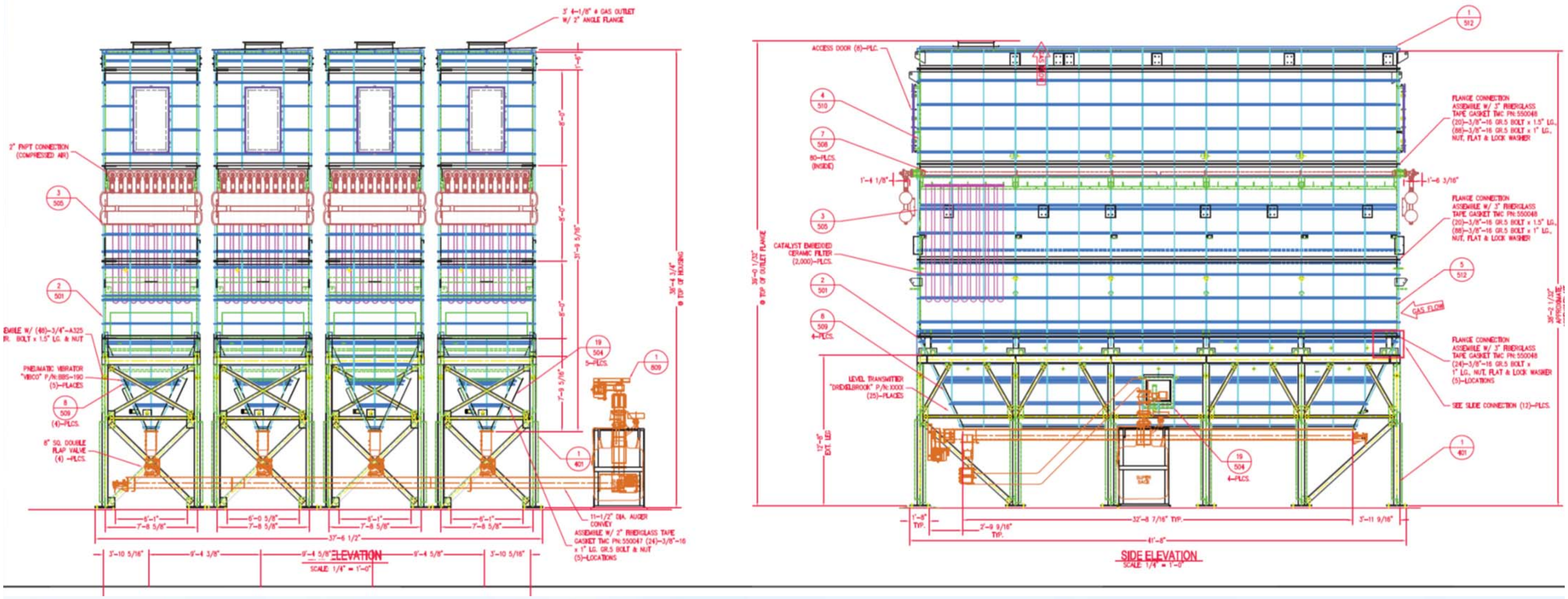
Jushi USA, Conceptual Only



Jushi USA, Conceptual Only



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Filter Systems

Float Glass - Michigan

- 640 tpd (clear & tint)
- Single Furnace
- Air/Fuel
- PM, NOx, SO2, Metals
- Full Turnkey – Civil & CEMS
- Start-up April 2015
- Fast Track Schedule (9 months)

Filter Systems

Float Glass – North Carolina, Oklahoma

- 700 tpd (clear)
- Single Furnace
- Air/Fuel
- PM, NOx, & SO2
- Full Turnkey w/ civil
- Start-up April 2017
- Compliance Verified

12 Housings – Ceramics Kiln (PM, SO2, NOx)

- Ceramic fracking proppants
- 2 kilns
- Operational Q1 2013
- Compliance verified

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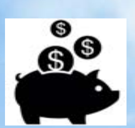
Presentation Outline

- Tri-Mer Overview
- Filter Elements
- NOx Control
- PM Control
- Acid Gases
- Filter Systems
- **Technical Field Services**

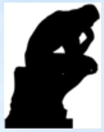
Technical Field Services – A Pro-Active Approach



- Cost Savings

- Reduce Downtime

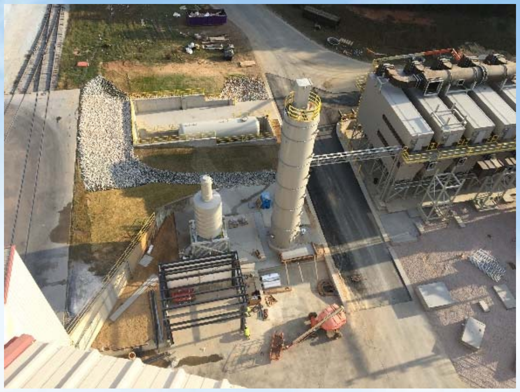
- Extended Life



- Continuous Improvement

Onsite Supervision

- Onsite Supervision - Experienced Trained Professionals
  - Construction Managers
  - Quality Control
  - Trusted Contractors
  - Proven Approach



System Start-up and Training

- Approach – Lead with Confidence
  - Technicians
  - Tools
  - Documentation
  - Technology
  - Advancement
  - Tri-Mer Operators

Technical Field Service – The Manufacture Advantage

- **Continuous Training**
  Every visit from Tri-Mer presents opportunities for onsite training.

- **Constant Review**
  Engineering review from Tri-Mer Process Group is an effective tool

- **Consistent Operation**
  Not a vague goal…a Reality to be achieved with the right plan, based on multiple glass installs.

- **Continuous Improvement**
  Engineering and optimization to remain on the leading edge can be reflected to existing systems.

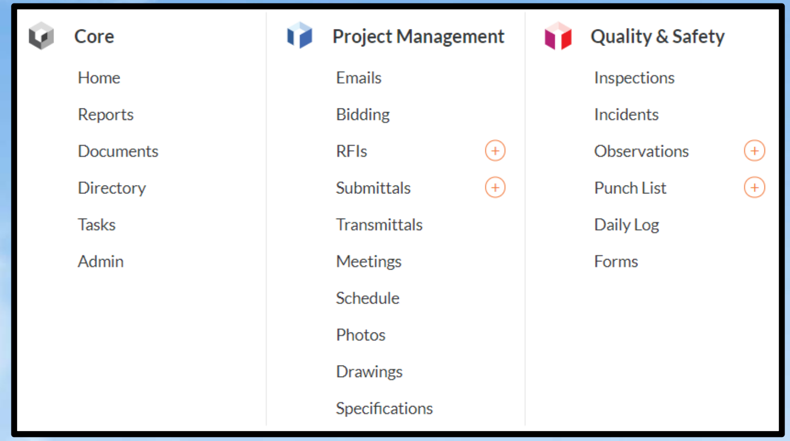
- **Spare Parts**
  Parts in stock. Constant review/improvement of parts used.

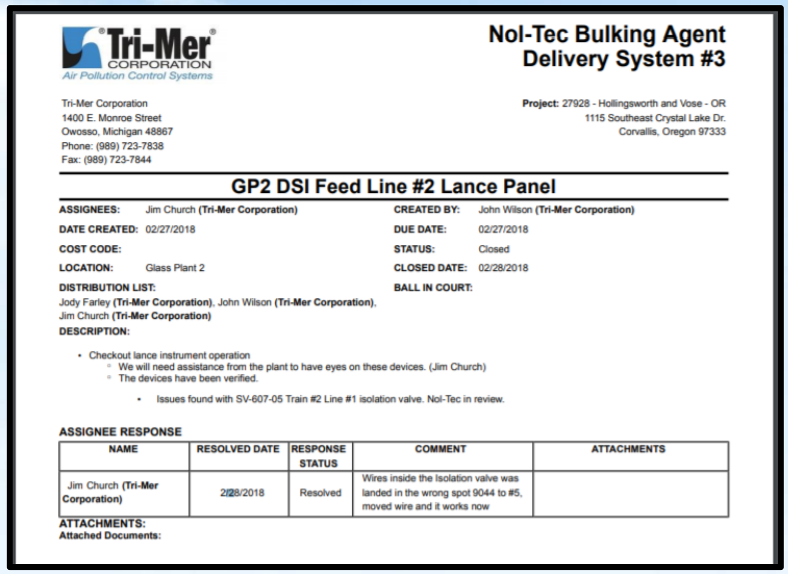
Tri-Mer Technical Field Services

Project Management

Controlling Documents, work requests, vendor and customer communications, can easily get out of control….but it can be prevented

- Cloud based Project Tools maintain control.
- Useable on all platforms and devices
- Features Include
  1. Document Management
  2. Email Management
  3. Scheduling
  4. Status Tracking
  5. Photo Management
  6. Financial Management





Tri-Mer CORPORATION Air Pollution Control Systems

Nol-Tec Bulking Agent Delivery System #3

Tri-Mer Corporation
1400 E. Monroe Street
Owosso, Michigan 48867
Phone: (989) 723-7838
Fax: (989) 723-7844

Project: 27928 - Hollingsworth and Vose - OR
1115 Southeast Crystal Lake Dr.
Corvallis, Oregon 97333

GP2 DSI Feed Line #2 Lance Panel

ASSIGNEES: Jim Church **(Tri-Mer Corporation)**
CREATED BY: John Wilson **(Tri-Mer Corporation)**
DATE CREATED: 02/27/2018
DUE DATE: 02/27/2018
COST CODE:
STATUS: Closed
LOCATION: Glass Plant 2
CLOSED DATE: 02/28/2018
DISTRIBUTION LIST:
Jody Farley **(Tri-Mer Corporation)**, John Wilson **(Tri-Mer Corporation)**, Jim Church **(Tri-Mer Corporation)**
BALL IN COURT:
DESCRIPTION:

- Checkout lance instrument operation
  - We will need assistance from the plant to have eyes on these devices. (Jim Church)
  - The devices have been verified.
    - Issues found with SV-607-05 Train #2 Line #1 isolation valve. Nol-Tec in review.

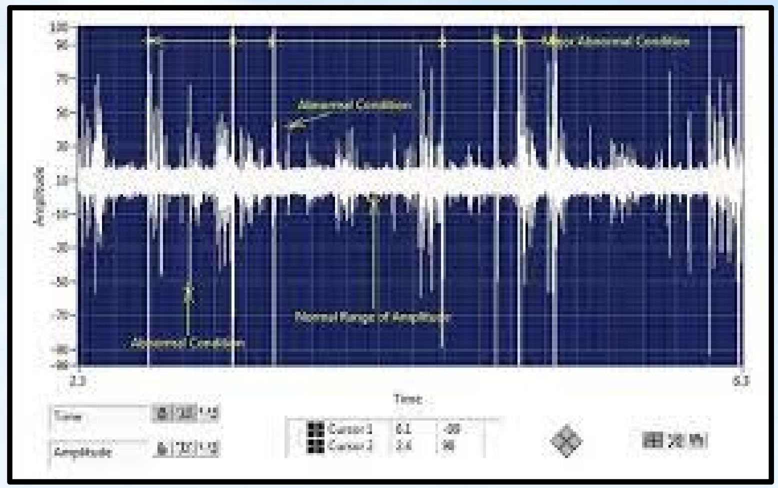
ASSIGNEE RESPONSE

NAME	RESOLVED DATE	RESPONSE STATUS	COMMENT	ATTACHMENTS
Jim Church **(Tri-Mer Corporation)**	2/28/2018	Resolved	Wires inside the Isolation valve was landed in the wrong spot 9044 to #5, moved wire and it works now	

ATTACHMENTS:
Attached Documents:

Tools - Fan and Bearing Monitoring

- Consistent fan operation is of upmost importance to production
- Our Techs are Trained
- Our Techs have Tools
- Remote Alerts for bearing temperatures, fan vibrations, airflow inconsistencies, VFD amperage…
- Follow-up and Resolve

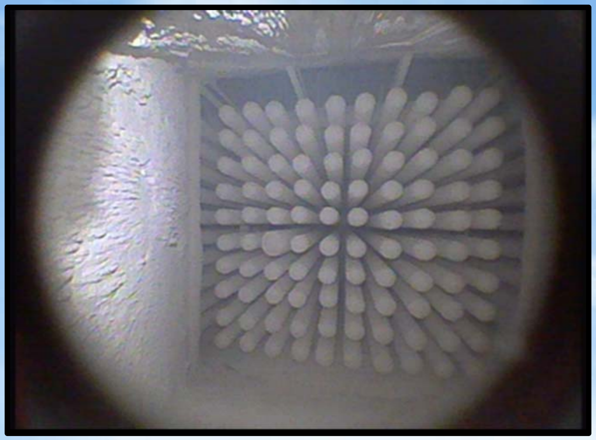


High Temperature Inspection Camera

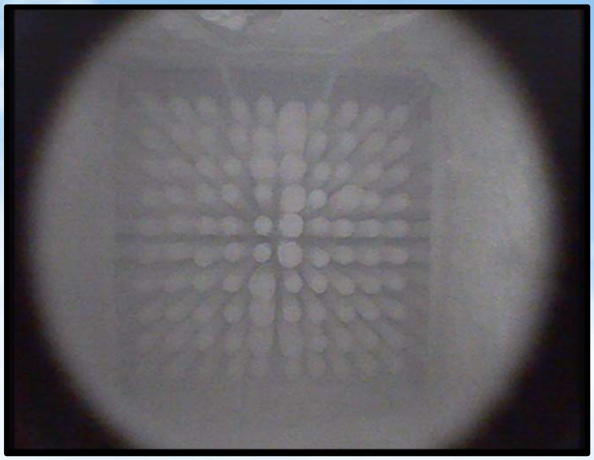
Suggested Camera Inspection Approach

- Preventative Maintenance – Weekly Hopper and Filter Inspection
- Preventative Maintenance – Quarterly Ducts, Dampers, and Lance Inspection
- Permit Compliance – Weekly Hopper Inspection
- Troubleshooting – Hoppers, Lances, Ducts, and Dampers as Required

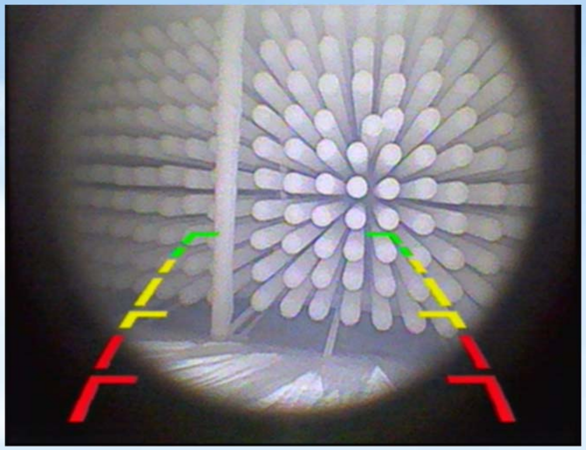
On-Line Filter Inspection Camera - Results



Elements Intact



Inoperable Pulse Valve

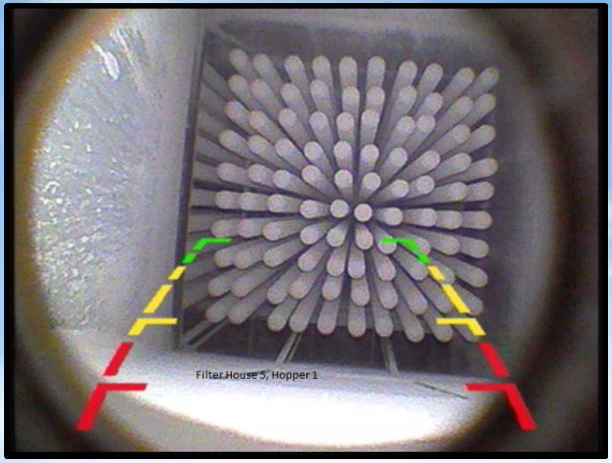


Broken Element

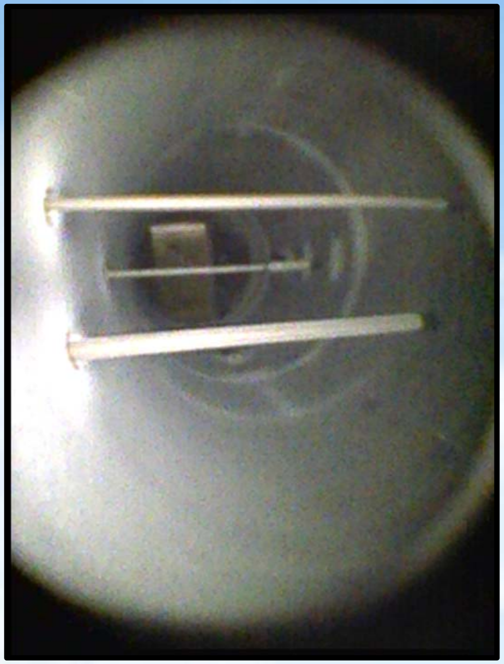
- Changing a filter requires 4 to 6 hours, most of which is cool down time.
- After service gradual heat-up is not required.

Tri-Mer Technical Field Services

Examples of Utilizing the High Temp Camera for Maintenance



Filter Element Inspection



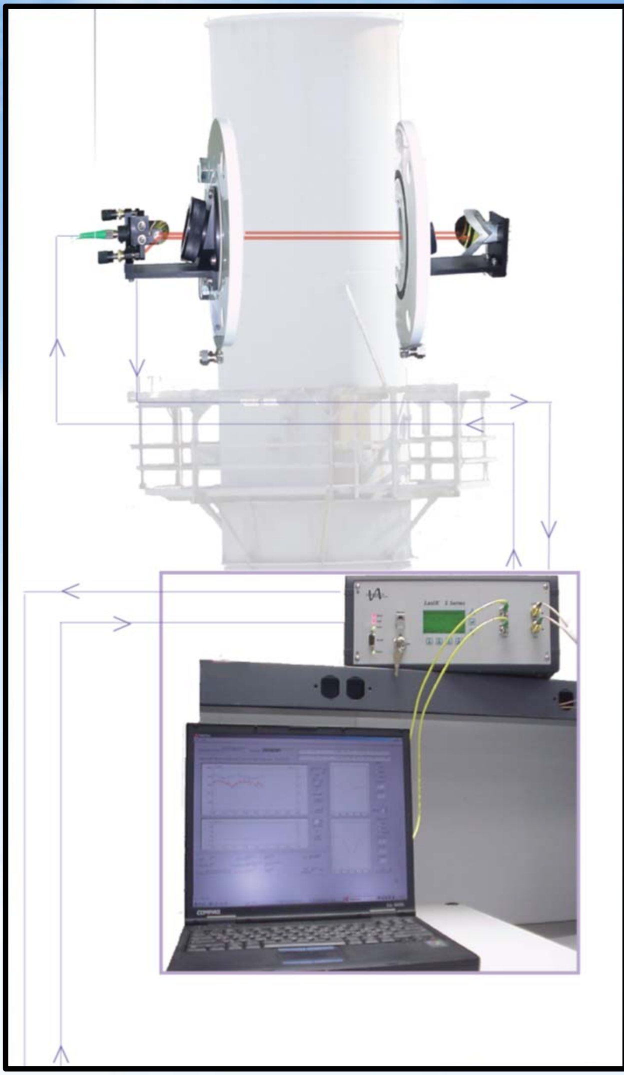
Duct Inspection

Damper Inspection

Technical Field Service has Unique Tools and Methods

- Traditional broken bag detection has been abandoned for the following reasons.
  - Lack of sensitivity for both glass process PM and hydrated lime
  - Initial cost for both equipment and install
  - Ongoing service and maintenance costs
  - Reliability
- Alternative method has been developed and accepted by the various state agencies, per the provision of alternate methods in the federal regulations.

Tri-Mer Broken Filter Detection, Approved by EPA



- **Ammonia slip or stack PM detector is used to monitor broken bag status**
  - **PM emissions can be accurately estimated based on broken filter count**
  - **Broken filter count can be accurately estimated based on ammonia slip**
- **Ammonia slip and PM detection can be reliably monitored**
  - **For ammonia, Insitu, laser based IR by Unisearch**
  - **< 0.5 ppmv sensitivity**
  - **95% Nox reduction with < 1 ppmv slip**
  - **PM detector more sensitive than opacity monitor but not a PM CEMS**
- **Broken bag status is verified with inspection camera.**

Broken Filters are Easy to Locate

1. The Ammonia Slip Method indicates a broken filter.
2. A camera inspection quickly locates which filter housing.
3. The broken filter location is obvious when the housing is opened because of the sorbent ring.

Tri-Link

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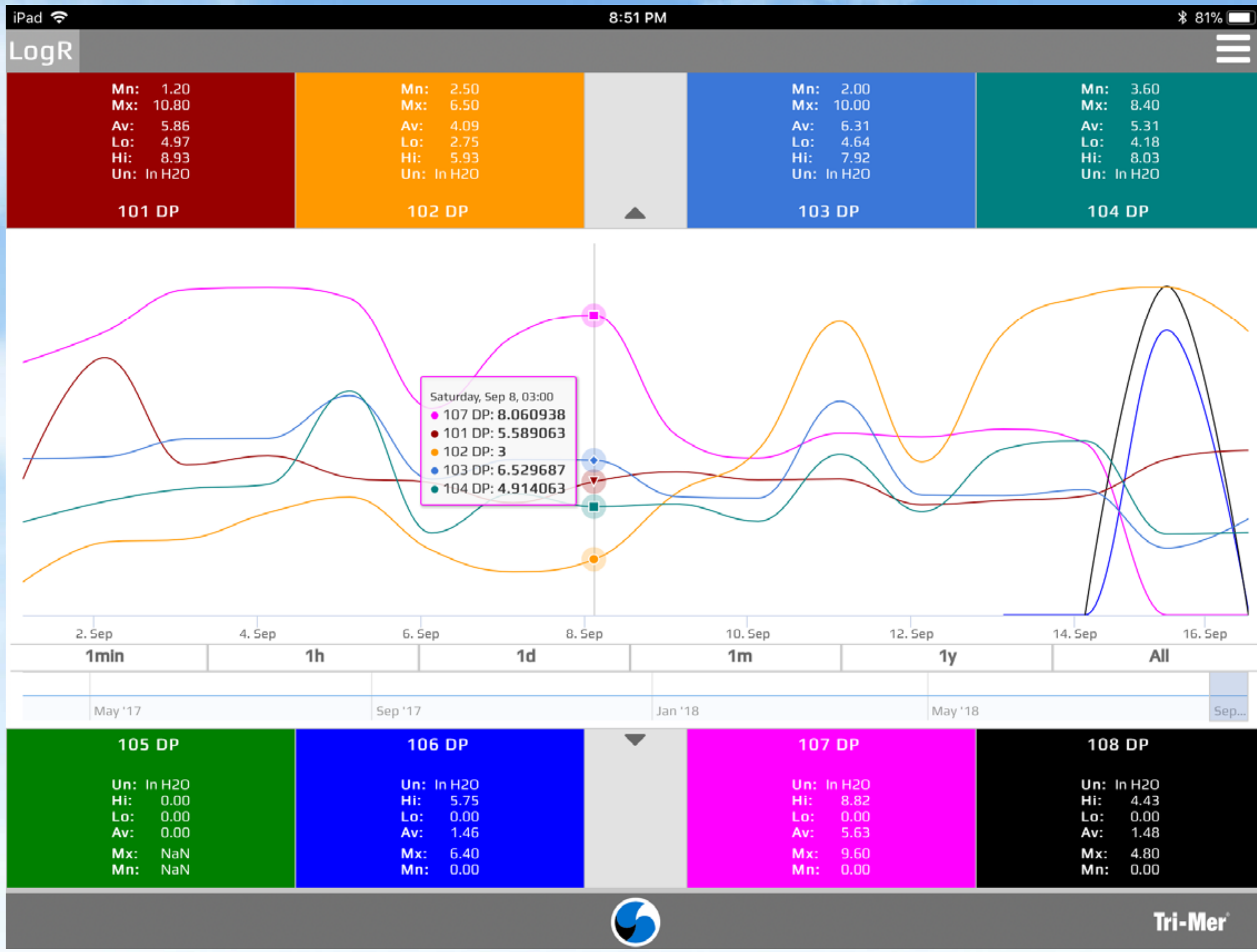
Tri-Mer Technical Field Services

Tri-Link



Thank You

Kevin Moss
Business Development Director
(989) 321-2991
kevin.moss@tri-mer.com

www.tri-mer.com

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Attachment J

Documentation of Public Notice

SPORTS *notes*

Compiled by Carolyn Cadigan

Photo: Henning Schlottmann via Creative Commons

Deadline for SSYAA lax sign-up is looming: It's time to sign up for lacrosse through the Sanford-Springvale Youth Athletic Association. The organization offers a grade 1 - 2 co-ed team, grade 3 - 4 girls and boys teams, and grade 5 - 6 girls and boys teams. Registration ends Saturday, Jan. 31, so don't delay. The cost is $90 per person. To register, go here: https://www.ssyaa.org/registration

SMS Spring and Winter Two sports registration is open: The Sanford Middle School Winter Two season is open for registration, offering Girls Volleyball for grades 7 and 8 and Wrestling for grades 6, 7 and 8. Registrations should be completed for volleyball by Friday, Feb. 6, and for wrestling by Friday, Feb. 13, along with having a current sports physical on file with the SMS nurse's office.

The Sanford High School Spring season is also open for registration, offering Boys and Girls Tennis, Boys and Girls Lacrosse, Boys and Girls Outdoor Track, Baseball, and Softball. Registrations should be completed before Monday, March 30. A current sports physical on file with the athletic office is required.

Registration links for both SMS and SHS teams can be found here: https://www.sanford.org/article/2638224

SSYAA high school hoops sign-up: The High School Basketball season through the Sanford-Springvale Youth Athletic Association begins March 14 and will run for 8 weeks, with games held on Saturday mornings at Nasson Gym. The cost is $95 per person. Registration closes on Friday, Feb. 13. Spots are limited. To register, go here: https://www.ssyaa.org/registration ●

Double-Shot Weekend at SPAC

When winter settles in and cabin fever sets in, Sanford Performing Arts Center turns up the heat with a double-shot weekend of live shows on Saturday February 7 and Sunday, February 8.

Seamlessly blending illusion, acrobatics, magic, and whimsy, MOMIX sends audiences flying down the rabbit hole in Moses Pendleton's newest creation, ALICE, set to take the stage at Sanford Performing Arts Center at 7 p.m. Saturday, Feb. 7. And on Sunday, Feb. 8, internationally acclaimed pianist Ilya Yakushev entertains with breathtaking power, lyrical beauty and moments of pure musical magic for a 3 p.m. show.

Inspired by Lewis Carroll's classic "Alice in Wonderland," the show is a mind-bending adventure, as Alice encounters time-honored characters including the undulating Caterpillar, a lobster quadrille, frenzied White Rabbits, a mad Queen of Hearts, and a variety of other surprises. Tickets are $35-$79.

Known for his brilliant interpretations of Rachmaninoff, Prokofiev and Beethoven, Yakushev has earned a reputation as one of the most electrifying performers of his generation. He blends impeccable artistry with sheer virtuosity, making each performance an unforgettable experience. Tickets are $20-$35.

Ilya Yakushev
Photo: SPAC

For information, including discounts for subscribers, students, seniors and military veterans. visit sanfordpac.org or call the box office at (207) 206-1126, or visit the box office in person Tuesdays and Thursdays from 9 a.m.-noon.

PUBLIC NOTICE OF INTENT TO FILE

Please take notice that: **Aries Pine Tree LLC**
4037 Rural Plains Circle, Suite 290, Franklin, TN 37064
mark.lyons@ariescleantech.com (603) 498-6525
intends to file an Air Emission License application with the Maine Department of Environmental Protection (DEP) pursuant to the provisions of 38 M.R.S., Section 590 on or about January 28, 2026.

The application is for a biosolids gasification facility, which will increase the region's biosolids disposal capacity and provide an alternative to landfilling and long-haul disposal. In brief: biosolids (sometimes referred to as sludge) from regionally located municipal wastewater treatment facilities will be accepted by truck primarily from Maine, Southern New Hampshire and Eastern Massachusetts; after being dried, the biosolids are then gasified using a using a proprietary fluidized bed process, which reduces the biosolids to a useful biochar (collected by truck for off-site use or disposal) and a producer gas (combusted on-site using a thermal oxidizer, which removes pollutants and produces useful heat that is recycled within the facility.) The facility is to be located at Cyro Road Lot 4, Sanford ME 04073.

According to Department regulations, interested parties must be publicly notified, written comments invited, and if justified, an opportunity for public hearing given. A request for a public hearing must be received by the Department, in writing, no later than 20 days after the application is accepted by the Department as complete for processing. The application and supporting documentation will be made available for review by contacting the DEP Bureau of Air Quality offices in Augusta, 207 287-7688, during normal working hours. A copy of the application and supporting documentation may also be available at the municipal office in Sanford, Maine. Written public comments may be sent to Jane Gilbert at the Bureau of Air Quality, State House Station #17, Augusta, Maine 04333.