

# Report on Quality of Hydrogen from H70 Nozzles of CSU LA H<sub>2</sub> Station on November 12, 2014

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## Executive Summary

All the non-hydrogen constituents are below the limits listed in “TABLE 1 - HYDROGEN FUEL QUALITY SPECIFICATION of SAE J2719”.

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# Summary of Quality of Hydrogen at **CSU H70** Nozzle

Smart Chemistry Number: 14CSU007 sampled on 11/12/2014

Constituent	SAE Limits ( $\mu\text{mol/mol}$ )	Smart Chemistry Detection Limits ( $\mu\text{mol/mol}$ )	Concentration ( $\mu\text{mol/mol}$ )	Analytical Method
Water	5	1	< 1	ASTM D7649-10
Total Hydrocarbons ( <b>C<sub>1</sub> Basis</b> )	2	1	<b>0.021</b>	ASTM WK34574
Methane		0.001	<b>0.016</b>	
Isopropyl Alcohol			<b>0.0054</b>	
Oxygen	5	2	< 2	ASTM D7649-10
Helium	300	4	<b>4.0</b>	ASTM D1946
Nitrogen, Argon	100		<b>25</b>	
Nitrogen		5	<b>25</b>	ASTM D7649-10
Argon		0.5	< 0.5	ASTM D7649-10
Carbon Dioxide	2	0.5	< 0.5	ASTM D7649-10
Carbon Monoxide	0.2	0.0008	<b>0.0010</b>	ASTM D5466
Total Sulfur	0.004	0.0001	< 0.0001	ASTM D7652-11
Hydrogen Sulfide		0.00001	< 0.00001	ASTM D7652-11
Carbonyl Sulfide		0.00001	< 0.00001	ASTM D7652-11
Methyl Mercaptan (MTM)		0.00002	< 0.00002	ASTM D7652-11
Ethyl Mercaptan (ETM)		0.00002	< 0.00002	ASTM D7652-11
Dimethyl Sulfide (DMS)		0.00001	< 0.00001	ASTM D7652-11
Carbon Disulfide		0.00002	< 0.00002	ASTM D7652-11
Isopropyl Mercaptan (IPM)		0.00002	< 0.00002	ASTM D7652-11
Tert-Butyl Mercaptan (TBM)		0.00002	< 0.00002	ASTM D7652-11
n-Propyl Mercaptan		0.00002	< 0.00002	ASTM D7652-11
n-Butyl Mercaptan		0.00002	< 0.00002	ASTM D7652-11
Tetrahydrothiophene (THT)		0.00002	< 0.00002	ASTM D7652-11
Formaldehyde	0.01	0.001	< 0.001	ASTM WK34574
Formic Acid	0.2	0.005	< 0.005	ASTM D5466
Ammonia	0.1	0.001	< 0.001	ASTM D5466
Total halogenates	0.05		< 0.02	
Chlorine		0.001	< 0.001	ASTM D5466
Hydrogen Chloride		0.007	< 0.007	ASTM D5466
Hydrogen Bromide		0.010	< 0.01	ASTM D5466
Organic Halides (32 compounds in red and bold listed in "Other Hydrocarbons"). Smart Chemistry limit is for each individual organic halide.		0.001	< 0.001	ASTM WK34574

## Particulate

Concentration	1mg/Kg	<b>0.11 mg/kg</b>	ASTM D7651-10
Size (ASTM D7634-10) - Images of particulates found is in Table 1		<b>Only one 0.05mm particulate found in the center of the filter.</b>	

## Hydrogen Fuel Index The

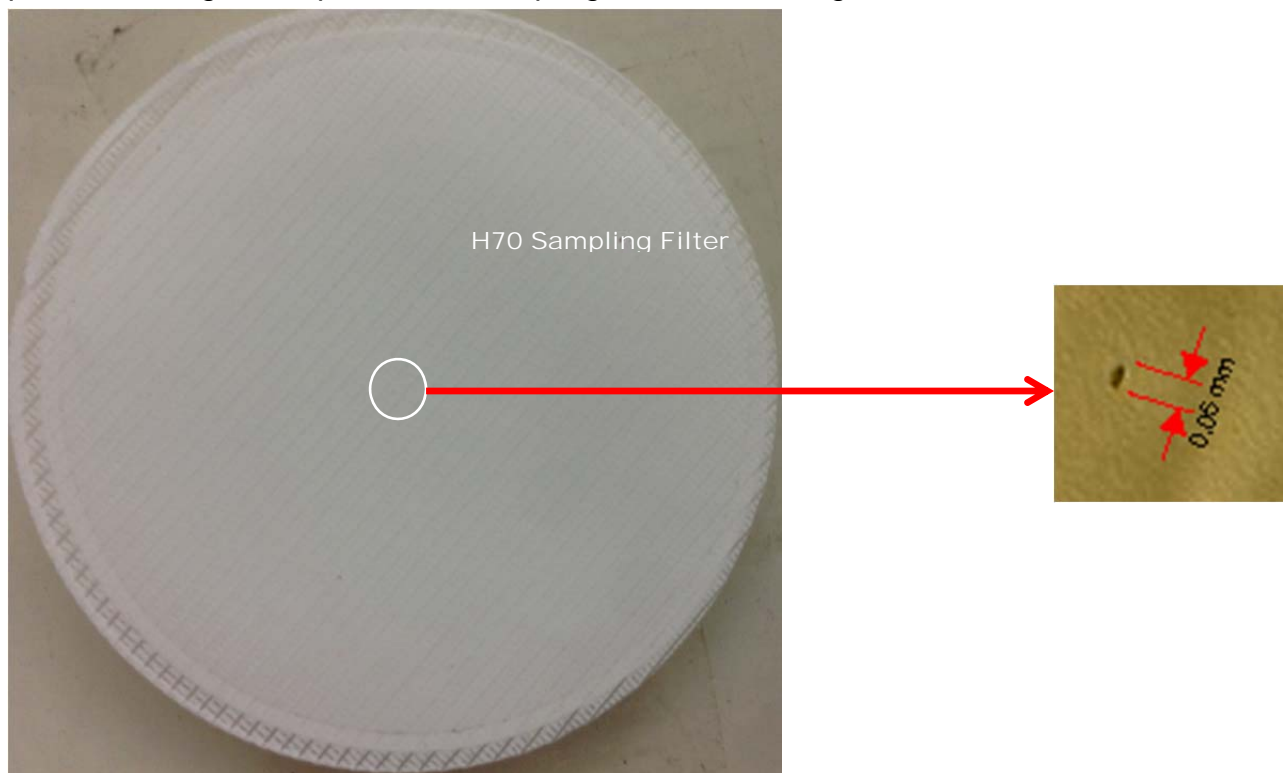
hydrogen fuel index is the value obtained when the amount of aggregate impurities, as, expressed as percent ( $\mu\text{mole}/\mu\text{mole}$ ), is subtracted from 100%. (Section 3.5 of SAE J2719)

**99.9971%**



## Table I Particulate Filter, Size and Concentration - ASTM D7651-10

This is 0.2 $\mu$ m Teflon particulate filter after ASTM D7650-10 particulate sampling at H70 nozzle of CSU LA hydrogen fueling station without any flow regulation. The particulate concentration of the sample from H70, 14CSU007-01, is 0.11 mg/kg, in which an amount of 0.218 mg particulates is found in 2.0 kilogram H<sub>2</sub> with average sampling flow rate 67g per second. The Teflon filter shows no pinhole damage after particulate sampling. Sizes and images of Particulates are shown in Table II & III.





## Table II Particulate Concentration Calculation Sheet

Weight of Particulates Collected on Teflon Filter				
Date	WMF (Weight Monitoring Filter) Weight (g)	WMF (Filter#88) (Weight Monitoring Filter) Weight (g)	#152 Filter Weight (g) - Before Sampling	#152 Filter Weight (g) - After Sampling
2014-11-10time 15.29.40	0.09608		0.10007 0.10007 0.10008 0.10007 0.10009 0.10011 0.1001 0.10008 0.10011 0.1001	
2014-11-10time 17.08.39		0.09261		
2014-11-17time 16.01.11	0.09606			0.10028 0.10032 0.10029 0.10031 0.1003 0.1003 0.10034 0.10032 0.1003 0.1003
2014-11-17time 17.45.07		0.09269		
Number of Measurement	2	2	10	10
Average Filter Weight	0.09607	0.09265	0.10009	0.10031
Average Standard Deviation of Weight (g)	1.41E-05	5.66E-05	1.62E-05	1.71E-05
Relative Standard Deviation of Weight (g)	0.0147%	0.0611%	0.0162%	0.0171%
Average Weight of Particulates (g) on Filter				0.000218

Sampling			
Event	Sampling Duration (second)	Sampling Flow Rate (g/sec)	Hydrogen Sampled (kg)
Particulate Sampling	30	66.7	2.0
H <sub>2</sub> Sampled for Particulate (m <sup>3</sup> )			24.4

Particulate Concentration	
Average Particulate Concentration (mg/kg)	0.11 mg/kg
Average Particulate Concentration (µg/L)	0.0089 µg/Liter



## Sampling Summary

The hydrogen sampling is performed on November 12, 2014 at CSU LA Hydrogen fueling Station with the sampling parameters listed in Table III, the sampling procedures for particulate and gaseous sample in Table IV & V, respectively.

The particulate sampling by ASTM D7650-10 is implemented, in which the particulate sampling assembly (PSA) with a pre-weighed 0.2µm PTFE filter is employed. A total of approximate 2 kg of hydrogen from the H70 nozzle passes through the 0.2µm Teflon filter of PSA without either regulator or orifice in between. The Teflon filter shows no pinhole damage under microscope. The particulate concentrations and size measurements follow ASTM D7651-10 and D7634-10, respectively.

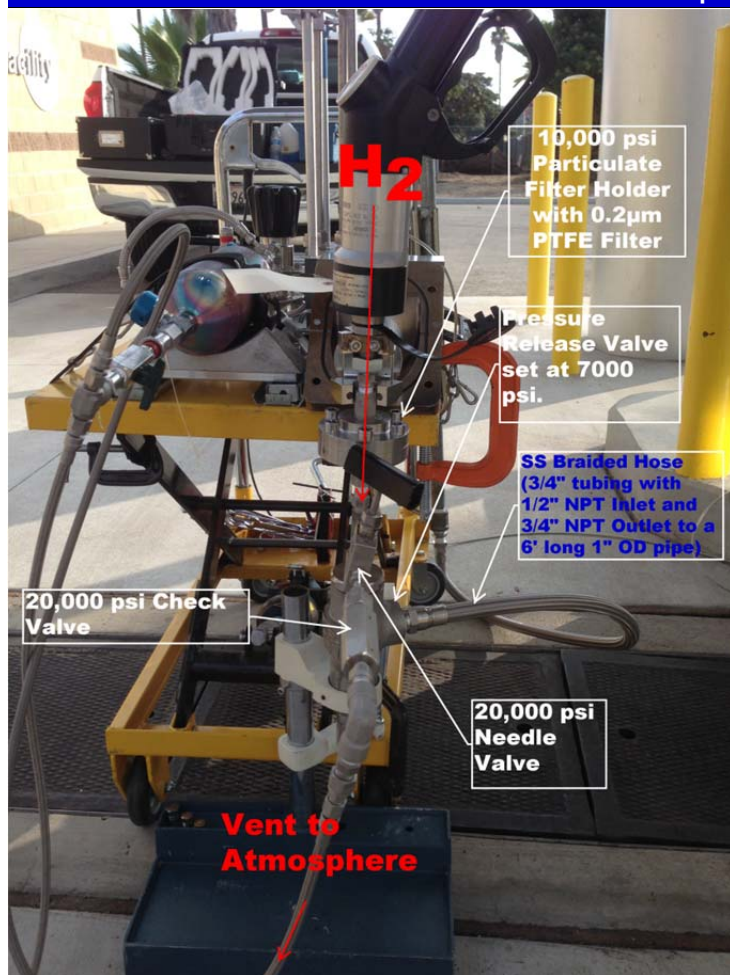
The gaseous sampling by ASTM D7606 is to regulate the hydrogen fuel from the H70 fueling nozzle to 1000 psi before flowing approximate 1 kg hydrogen fuel through a 1-Liter 1800 psi pressure proof sample container to obtain representative gaseous sample. Three gaseous hydrogen samples are collected from each nozzle using the procedures shown in the following section - Gaseous Sampling Procedure – ASTM D7606.

**Table III      Particulate and Gaseous Sampling Parameters**

Event	Sampling Time	Duration (second)	Hydrogen Sampled (kg)	Flow Rate (g/second)	Hydrogen Inlet Pressure (psi)
Particulate Sampling at H70 Nozzle	11/12/2014 15:20	30	2	67	5000
1st Gaseous Sampling at H70 Nozzle	11/12/2014 15:34	67	1	15	10000
2nd Gaseous Sampling at H70 Nozzle	11/12/2014 15:38	55	1	18	10000
3rd Gaseous Sampling at H70 Nozzle	11/12/2014 15:51	65	1	15	10000



## Table IV Particulate Sampling Procedure – ASTM D7650-10

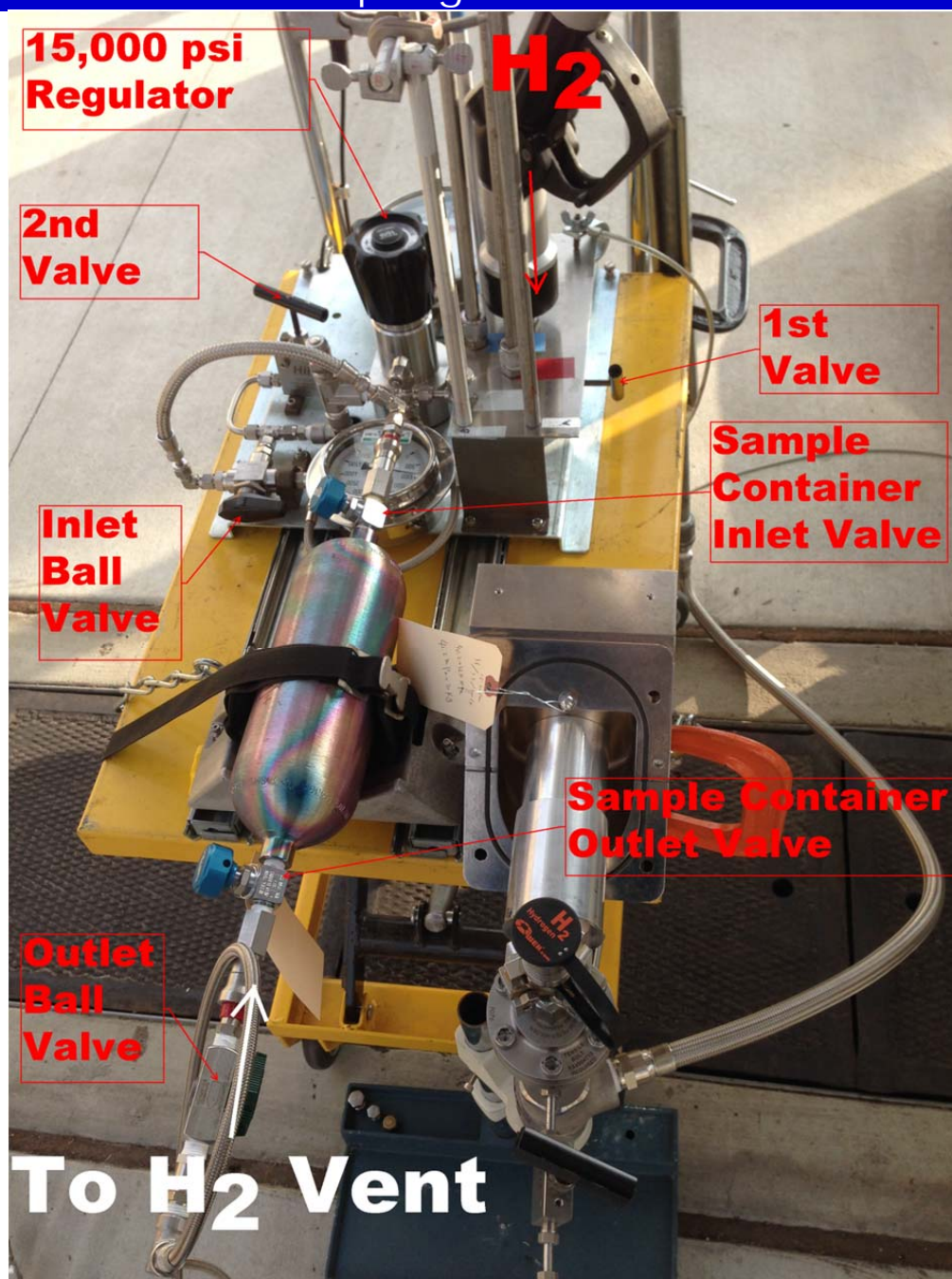


1. **ALWAYS GROUND THE SAMPLING SETUP FIRST.**
2. In Lab, a 47mm OD pre-weighed 0.2 Teflon filter is installed into a 10,000 psi pressure proof filter holder of a particulate sampling assembly (PSA) inside a glove box.
3. Before particulate sampling, the particulate sampling assembly (PSA) is secured physically as shown left; the fueling nozzle is then attached to the PSA.
4. Make sure the hydrogen to be sampled passes through the cooling unit.
5. Open the needle valve to allow approximate 2kg of hydrogen flow through. The nozzle is then removed and the needle valve closed.

Transport the particulate filter to Smart Chemistry for particulate concentration (ASTM D7651-10) and particulate size measurements (ASTM D7634-10).



## Table V Gaseous Sampling Procedure – ASTM D7606-11



1. Assemble the gaseous sampling as above.
2. Attach the station suspensor nozzle to the receptacle. With the 1<sup>st</sup> valve closed and hydrogen fueling started by station personnel, use a hand held hydrogen detector to check for hydrogen leaks around the connections from J2799 nozzle to receptacle and receptacle to 1<sup>st</sup> valve. If no leak and 2<sup>nd</sup> valve closed, open the 1<sup>st</sup> valve and read the hydrogen pressure from 20,000 psi inlet gauge.
3. Regulate the **pressure of hydrogen fuel at 1000 PSI**. Check the hydrogen leak along hydrogen pass way from the 1<sup>st</sup> valve to the 2<sup>nd</sup> valve. If no leak is found, open all the valves downwards from 2<sup>nd</sup> valve, except the outlet ball valve after sample container outlet valve. Check for leak from 2<sup>nd</sup> valve to the outlet ball valve, especially sample container.
4. Let approximate 1 kg hydrogen fuel in pulses flowing through the sample container by opening the outlet ball valve, record the time duration and inlet pressure. Close in sequence the sample container outlet, inlet valves and the 2<sup>nd</sup> valve, while the hydrogen fueling is ongoing. After sampling of a sample container, the high hydrogen pressure in the inlet end to the sample container must be released through the inlet ball valve before a new sample container attached to the inlet end quick connection.



## Analytical Data for Non-Hydrogen Gaseous Constituents

The analytical data is tabulated for each non-hydrogen gaseous constituent in SAE J2719. The analytical data includes calibration standards, detection limit study, sample analysis, spike, or duplicate.

<b>Non-Hydrogen Gaseous Constituents</b>	
1.	Water
2.	Total Hydrocarbons
2.1	Methane
2.2	Non-Methane Hydrocarbons
3.	Oxygen
4.	Helium
5.	Nitrogen
6.	Argon
7.	Carbon Dioxide
8.	Carbon Monoxide
9.	Sulfur
9.1	H <sub>2</sub> S, COS, CH <sub>3</sub> SH, CH <sub>3</sub> CH <sub>2</sub> SH, CH <sub>3</sub> SCH <sub>3</sub> , CS <sub>2</sub> , (CH <sub>3</sub> ) <sub>2</sub> HCSH, (CH <sub>3</sub> ) <sub>3</sub> CSH, CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> HCSH, CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> HCSH and Tetrahydrothiophene.
9.2	Total Sulfurs – The sum of the concentrations of H <sub>2</sub> S, COS, CH <sub>3</sub> SH, CH <sub>3</sub> CH <sub>2</sub> SH, , CH <sub>3</sub> SCH <sub>3</sub> , CS <sub>2</sub> , (CH <sub>3</sub> ) <sub>2</sub> HCSH, (CH <sub>3</sub> ) <sub>3</sub> CSH, CH <sub>3</sub> (CH <sub>2</sub> ) <sub>2</sub> HCSH, CH <sub>3</sub> (CH <sub>2</sub> ) <sub>3</sub> HCSH and Tetrahydrothiophene.
10.	Formaldehyde
11.	Formic Acid
12.	Ammonia
13.	Total Organic Halogenates
13.1	Chlorine
13.2	Hydrogen Chloride
13.3	Hydrogen Bromide
13.4	Organic Halides (32 compounds in red and bold listed in "Non-Methane Hydrocarbons")



Analytical Data	1. H <sub>2</sub> O      ASTM 7649-10						
File Name, Sample, Sample Loop Pressure (psi)	H2O Sample RT or BAD RF in Pink	H2O Sample Area	Co-Injected Peak RT	Co-Injected Peak AREA	Conc. (PPMV) of H2O in G0793	RF	H2O CONC. (ppmv)
411113B.D - PRAXAIR UHP H2 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 252.5	0.00	0	0 0 0	2206783 1309075 452454	0 0 0	1.1E-09 9.4E-10 1.1E-09	0
14111301.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 262.3	0.00	0	0 0 0	2390789 1217218 440531	0 0 0	1.0E-09 1.0E-09 1.1E-09	0
14111302.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 259.7	0.00	0	0 0 0	2543320 1348925 457882	0 0 0	9.7E-10 9.1E-10 1.1E-09	0
14111303.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 244.2	0.00	0	0 0 0	2370080 1245481 431955	0 0 0	1.0E-09 9.9E-10 1.1E-09	0
14111304.D - PRAXAIR UHP H2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 246.2	0.00	0	0 0 0	2486400 1289959 495774	0 0 0	9.9E-10 9.6E-10 9.9E-10	0
14111305.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 120.2	0.00	0	0 0 0	2369422 1337608 468469	0 0 0	1.0E-09 9.2E-10 1.1E-09	0
14111306.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 138	0.00	0	0 0 0	2325599 1404403 553245	0 0 0	1.1E-09 8.8E-10 8.9E-10	0
14111307.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 136.2	0.00	0	0 0 0	2282435 1294979 381244	0 0 0	1.1E-09 9.5E-10 1.3E-09	0



Date: 11/14/2014 - File Name	<h1>Analytical Data</h1> <p>Injection</p>	<div>2.1 CH<sub>4</sub></div> <div>Standard Conc. (PPMV)      Volume of CH<sub>4</sub> in Standard (μL)      Ret. Time (MIN) of CH<sub>4</sub>      Area of CH<sub>4</sub>      CH<sub>4</sub> Response Factor or Conc in ppmv</div>				
001F0101.D	G0991,6.0PPMV CO & 4.8PPMV CH4 (SYSTEM:65MTORR) [1L:40TORR] [R20] [FCTV=35,TT@20=106SC]] (AT=766.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	4.8	0.250522	5.617	678989	3.7E-07
001F0201.D	G0986,0.018PPMV CO & 0.014PPMV CH4 (SYSTEM:45MTORR) [1L:36TORR] [R20] [FCTV=33.4,TT@20=104SC]] (AT=766.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	0.014	0.000658	5.629	79085	0.62
001F0301.D	14CSU007-01#1,CSU 70MPA H2,SR141112. (SYSTEM:43MTORR) [1L:181TORR] [R20] [FCTV=180,TT@20=5514SC]] (AT=766.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)			5.619	10083	0.016
001F0401.D	G0986,0.018PPMV CO & 0.014PPMV CH4 (SYSTEM:40MTORR) [1L:38TORR] [R20] [FCTV=35.5,TT@20=104SC]] (AT=766.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	0.014	0.000694	5.625	89483	0.67



## 2.2 Analytical Laboratory Report for "Non-Methane Hydrocarbons (ASTM WK34574)"

Client: CSU, LA

Field ID #: 400ML 14CSU007-01#1, CSU 70BAR H2, SR141112

Hydrogen Station at: CSU, LA

Lab Sample ID: 14CSU00701

Sample Type: Hydrogen Fuel

Concentration Units: PPBV

Date Sampled: 11122014, 15:34

Date File Location 14CSU007TPH.pdf

Date Received: 11122014

Data Filename: 14111303.D

Date Analyzed: 11132014

Dilution Factor: 1.0

Time Analyzed: 3:51 pm

Analytes	MW	CASNUM	MQL (PPBV)	Results (PPBV)	Qualifier	MQL (ug/L)	Results (ug/L)	Carbon Number	Results (C1 Basis, PPMV)
1,1,1-Trichloroethane	132	71-55-6	1	0	U	0.005	0	2	
1,1,2,2-Tetrachloroethane	166	79-34-5	1	0	U	0.007	0	3	
1,1,2-Trichloroethane	132	79-00-5	1	0	U	0.005	0	2	
1,2-Dibromoethane	186	106-93-4	1	0	U	0.008	0	2	
1,1-Dichloroethane	98	75-34-3	1	0	U	0.004	0	2	
1,1-Dichloroethene	96	75-35-4	1	0	U	0.004	0	2	
1,2,4-Trichlorobenzene	180	120-82-1	1	0	U	0.007	0	6	
1,2,4-Trimethylbenzene	120	95-63-6	1	0	U	0.005	0	9	
1,2-Dichloroethane	98	107-06-2	1	0	U	0.004	0	2	
1,2-Dichloropropane	112	78-87-5	1	0	U	0.005	0	3	
1,3,5-Trimethylbenzene	120	108-67-8	1	0	U	0.005	0	9	
1,3-Butadiene	54	106-99-0	1	0	U	0.002	0	4	
1,2-Dichlorobenzene	146	95-50-1	1	0	U	0.006	0	6	
1,3-Dichlorobenzene	146	541-73-1	1	0	U	0.006	0	6	
1,4-Dichlorobenzene	146	106-46-7	1	0	U	0.006	0	6	
1,4-Dioxane	88	123-91-1	1	0	U	0.004	0	4	
2-Butanone	72	78-93-3	1	0	U	0.003	0	4	
2-Hexanone	100	591-78-6	1	0	U	0.004	0	6	
4-Ethyltoluene	120	622-96-8	1	0	U	0.005	0	8	
4-Methyl-2-Pentanone	100	108-10-1	1	0	U	0.004	0	6	
Acetone	58	67-64-1	1	0	U	0.002	0	3	
Acetylene/Ethene	28	9002-88-4	2	0	U	0.002	0	2	
Aldehyde	44	75-07-0	1	0	U	0.002	0	2	
Benzene	78	71-43-2	1	0	U	0.003	0	6	
Benzyl Chloride	126	100-44-7	1	0	U	0.005	0	6	
Bromodichloromethane	162	75-27-4	1	0	U	0.007	0	1	
Bromoform	250	75-25-2	1	0	U	0.01	0	1	
Bromomethane	94	74-83-9	1	0	U	0.004	0	1	
Carbon Disulfide	76	75-15-0	1	0	U	0.003	0	1	
Carbon tetrachloride	152	56-23-5	1	0	U	0.006	0	1	
Chlorobenzene	112	108-90-7	1	0	U	0.005	0	6	
Chloroethane	64	75-00-3	1	0	U	0.003	0	2	
Chloroform	118	67-66-3	1	0	U	0.005	0	1	
Chloromethane	50	74-87-3	1	0	U	0.002	0	1	
cis-1,2-dichloroethene	96	156-59-2	1	0	U	0.004	0	2	
cis-1,3-Dichloropropene	110	10061-01-5	1	0	U	0.005	0	3	
Cyclohexane	84	110-82-7	1	0	U	0.003	0	6	
Dibromochloromethane	206	124-48-1	1	0	U	0.008	0	1	
Dichlorodifluoromethane	120	75-71-8	1	0	U	0.005	0	1	
Ethane	30	74-84-0	4	0	U	0.005	0	2	
Ethanol	46	64-17-5	2	0	U	0.004	0	2	
Ethyl Acetate	88	141-78-6	1	0	U	0.004	0	4	
Ethylbenzene	106	100-41-4	1	0	U	0.004	0	8	
Formaldehyde	30	50-00-0	1	0	U	0.001	0	1	
Freon113	186	76-13-1	1	0	U	0.008	0	2	
Freon114	170	76-14-2	1	0	U	0.007	0	2	
Heptane	100	142-82-5	1	0	U	0.004	0	7	
Hexane	86	110-54-3	1	0	U	0.004	0	6	
Hexachlorobutadiene	258	87-68-3	1	0	U	0.01	0	4	
Isopropyl Alcohol	60	67-63-0	1	1.8	=	0.002	0.0044	3	0.0054
Methylene chloride	84	75-09-2	1	0	U	0.003	0	1	
Methyl tert-Butyl Ether	88	1634-04-4	1	0	U	0.004	0	5	
Propane	44	74-98-6	2	0	U	0.004	0	3	
Propene	36	115-07-1	1	0	U	0.001	0	3	
Styrene	104	100-42-5	1	0	U	0.004	0	8	
Tetrachloroethene	164	127-18-4	1	0	U	0.007	0	2	
Tetrahydrofuran	72	109-99-9	1	0	U	0.003	0	4	
Toluene	92	108-88-3	1	0	U	0.004	0	7	
trans-1,2-dichloroethene	96	156-60-5	1	0	U	0.004	0	2	
trans-1,3-Dichloropropene	110	10061-02-6	1	0	U	0.005	0	3	
Trichloroethene	130	79-01-6	1	0	U	0.005	0	2	
Trichlorofluoromethane	136	75-69-4	1	0	U	0.006	0	1	
Vinyl acetate	86	108-05-4	1	0	U	0.004	0	4	
Vinyl chloride	62	75-01-4	1	0	U	0.003	0	2	
Xylenes, m&p-	106	106-38-3 & 106-42-3	1	0	U	0.004	0	8	
Xylenes, o-	106	95-47-6	1	0	U	0.004	0	8	
1,2,3,4-Tetrachloro-hexafluorobutane	334	423-38-1	1	0	U	0.01	0	4	
Bromochloromethane (surrogate), %recd	128	74-97-5		96	=				
4-BFB(surrogate), %recovery	174	460-00-4		105	=				

## NOTES:

U - Analytes not detected at, or above the stated detection limit.

0 - A result of zero represents an undetected result at the MQL reported and does not imply an actual value.

PPBV - Parts per billion volume.

MQL - Method quantitation limit.

Surrogate results are in units of percent recovery with control limits: 65 to 135%.

The compounds in red and bold are organic halides.

Tentatively Identified Compound Estimated Concentration (PPBV)

Total Hydrocarbon (PPMV) 1.800

14CSU007.xlsm

Total Hydrocarbon (C1 Basis, PPMV) 0.005



Analytical Data		3. O <sub>2</sub> ASTM 7649-10						
File Name, Sample, Sample Loop Pressure (psi)	O2 Sample RT OR Appraent Injection Vol. (uL)	O2 Sample Area	Co-Injected Peak RT, or O2 Conc. (ppmv) in P0136	Co-Injected Peak AREA	O2 RF at Low Conc.	O2 RF at High Conc.	O2 CONC. (ppmv)	Appraent Injection Vol. (uL)
411113B.D - PRAXAIR UHP H2 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 252.5	0.00	0	137362 124549 130781	1581051 849966 321003	1.5E-08 1.7E-08 1.6E-08	2.5E-08 2.3E-08 2.5E-08	0.0	
14111301.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 262.3	0.74	39784	133354 139060 124047	1605100 855912 312033	1.5E-08 1.5E-08 1.7E-08	2.5E-08 2.3E-08 2.5E-08	7.9	90
14111302.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 259.7	0.74	37797	124872 134319 122062	1536854 857633 308532	1.7E-08 1.5E-08 1.7E-08	2.6E-08 2.3E-08 2.6E-08	7.5	86
14111303.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 244.2	0.75	30864	132902 119861 125441	1506622 810470 312933	1.6E-08 1.7E-08 1.6E-08	2.6E-08 2.4E-08 2.5E-08	6.1	70
14111304.D - PRAXAIR UHP H2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 246.2	0.00	0	133436 115795 123244	1516272 815209 320586	1.5E-08 1.8E-08 1.7E-08	2.6E-08 2.4E-08 2.5E-08	0	
14111305.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 120.2	0.00	0	125649 116860 125514	1480618 834490 309843	1.6E-08 1.8E-08 1.6E-08	2.7E-08 2.4E-08 2.6E-08	0	
14111306.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 138	0.00	0	134071 130313 125840	1489142 828999 321794	1.5E-08 1.6E-08 1.6E-08	2.7E-08 2.4E-08 2.5E-08	0	
14111307.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 136.2	0.00	0	119435 122614 116162	1487346 810412 287920	1.7E-08 1.7E-08 1.8E-08	2.7E-08 2.4E-08 2.8E-08	0	



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## Analytical Data

4. He

Date of  
Analysis

11/14/2014

Instrumentation

GC/TCD

File Name	Helium Retention Time (min)	Helium Retention Time (min)	Helium Standard Conc. (PPMV)	Area	Response Factor (RF)	Sample Concentration (PPMV)
001F0101.D	G0812 (164.2 PPMV HE IN HYDROGEN). OT=40C.	3.795	164.2	14.61	11.2	
001F0201.D	G0973 (72.3 PPMV HE IN HYDROGEN). OT=40C.	3.83	72.3	7.12	10.2	
001F0301.D	G0634 (9.2 PPMV HE IN HYDROGEN). OT=40C.	3.892	9.2	1.28	7.2	
001F0401.D	14LIN007-01#1,LINDE WEST SAC 70MPA H2,SR141103.	3.983		0.54		4.0
001F0501.D	G0634 (9.2 PPMV HE IN HYDROGEN). OT=40C.	3.892	9.2	1.19	7.7	



## Analytical Data

5. N<sub>2</sub> ASTM 7649-10

File Name, Sample, Sample Loop Pressure (psi)	N2 Sample RT OR Appraent Injection Vol. (uL)	N2 Peak 1 Area	Co-Injected Peak RT	Co-Injected Peak AREA	N2 RF at Low Conc.	N2 RF at High Conc.	N2 CONC. (ppmv)
411113B.D - PRAXAIR UHP H2 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 252.5	0.76	17726	544054 493049 509662	10070127 5846703 2392998	3.8E-09 4.2E-09 4.1E-09	1.5E-08 1.3E-08 1.2E-08	1.3
14111301.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 262.3	0.76	97352	514734 578548 513833	10421886 6083334 2368559	4.0E-09 3.6E-09 4.0E-09	1.4E-08 1.2E-08 1.2E-08	7.2
14111302.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 259.7	0.75	100675	515856 549055 498149	10313410 6136516 2430376	4.0E-09 3.8E-09 4.1E-09	1.4E-08 1.2E-08 1.2E-08	7.5
14111303.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 244.2	0.74	92139	525579 468558 479958	10189122 6015401 2445382	3.9E-09 4.4E-09 4.3E-09	1.4E-08 1.2E-08 1.2E-08	6.9
14111304.D - PRAXAIR UHP H2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 246.2	0.00	0	484997 441685 544097	10328477 6039450 2502843	4.3E-09 4.7E-09 3.8E-09	1.4E-08 1.2E-08 1.2E-08	0
14111305.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 120.2	0.74	345426	503337 455661 531829	10119918 6165754 2427654	4.1E-09 4.5E-09 3.9E-09	1.5E-08 1.2E-08 1.2E-08	26
14111306.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 138	0.75	333406.259	543778 472986 518061	10284675 6162752 2602650	3.8E-09 4.4E-09 4.0E-09	1.4E-08 1.2E-08 1.1E-08	25
14111307.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 136.2	0.75	337709	505647 498842 450122	10226931 6074813 2366459	4.1E-09 4.1E-09 4.6E-09	1.4E-08 1.2E-08 1.2E-08	25



Analytical Data		6. Ar ASTM 7649-10 Date of Analysis 11/13/2014						
File Name, Sample, Sample Loop Pressure (psi)	Ar Sample RT or BAD RF	Ar Sample Area	Co-Injected Peak RT	Co-Injected Peak AREA	RF	RF	Ar CONC. (ppmv)	Appraent Injection Vol. (uL)
41113B.D - PRAXAIR UHP H2 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 252.5	0.00	0	68829.88 67830.90 70749.11	192114 103928 43981	7.5E-09 7.6E-09 7.3E-09	9.2E-09 8.5E-09 8.0E-09	0	
14111301.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 262.3	0.76	23186	72341.79 73761.75 69127.14	192722 107365 37415	7.1E-09 7.0E-09 7.4E-09	9.2E-09 8.2E-09 9.4E-09	1.8	93
14111302.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 259.7	0.74	21834	71075.25 72776.15 68445.56	186159 105225 39474	7.2E-09 7.1E-09 7.5E-09	9.5E-09 8.4E-09 8.9E-09	1.7	87
14111303.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 244.2	0.74	22883	72833.32 71215.84 71933.64	192628 105365 43596	7.1E-09 7.2E-09 7.1E-09	9.2E-09 8.4E-09 8.1E-09	1.8	92
14111304.D - PRAXAIR UHP H2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 246.2	0.00	0	70205.85 71122.75 71031.10	191682 106113 41961	7.3E-09 7.2E-09 7.2E-09	9.2E-09 8.3E-09 8.4E-09	0	
14111305.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 120.2	0.00	0	74796 69764 68231	187071 108744 43440	6.9E-09 7.4E-09 7.5E-09	9.4E-09 8.1E-09 8.1E-09	0	
14111306.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 138	0.75	1670.258	72313 72704 71498	185553 107896 45144	7.1E-09 7.1E-09 7.2E-09	9.5E-09 8.2E-09 7.8E-09	0	
14111307.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 136.2	0.00	0	74826 73630 69269	187193 106514 37798	6.9E-09 7.0E-09 7.4E-09	9.4E-09 8.3E-09 9.3E-09	0	



Analytical Data		7. CO <sub>2</sub> ASTM 7649-10 Date of Analysis 11/13/2014						
File Name, Sample, Sample Loop Pressure (psi)	CO2 Sample RT	CO2 Sample Area	Co-Injected Peak RT	Co-Injected Peak AREA	RF	Conc. CO2 in Air (PPMV)	CO2 CONC. (ppmv)	Appraent Injection Vol. (uL)
411113B.D - PRAXAIR UHP H2 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 252.5	0.00	0	215435 221040 226957	122948 33669 10090	2.4E-09 2.3E-09 2.3E-09	27 15 11	0	
14111301.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 262.3	0.75	84663	225521 231239 229558	67083 22870 7979	2.3E-09 2.2E-09 2.2E-09	15 10 9	1.8	104
14111302.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 259.7	0.74	87611	233169 235259 236761	56237 23530 6519	2.2E-09 2.2E-09 2.2E-09	12 10 7	1.9	107
14111303.D - G1028, 1.8PPMV CO2&AR, 7.2PPMV N2&O2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 244.2	0.74	80990	236301 240744 240228	57980 20871 7915	2.2E-09 2.1E-09 2.1E-09	13 9 9	1.7	99
14111304.D - PRAXAIR UHP H2;ES0.01 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 246.2	0.00	0	233892 236527 227704	88955 24313 8256	2.2E-09 2.2E-09 2.3E-09	20 11 9	0	
14111305.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 120.2	0.00	0	238675 235252 236970	64423 20475 13149	2.2E-09 2.2E-09 2.2E-09	14 9 14	0	
14111306.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 138	0.00	0	231940 235896 237118	85874 20071 7331	2.2E-09 2.2E-09 2.2E-09	19 9 8	0	
14111307.D - 14CSU007-01#1,CSU,LA 70MP H2,SR141112 3 10UL G1027 1.1% N2&O2, 0.27;ES1:100;CF1.5MM 136.2	0.00	0	243409 239566 232955	63618 21319 7876	2.1E-09 2.1E-09 2.2E-09	14 9 9	0	



Date: 11/14/2014 - File Name	<h1>Analytical Data</h1> Injection	<div> <div>8. CO</div> <div>Ret.</div> <div>CO Response Factor</div> </div> <div> <div>Time (MIN) of CO</div> <div>Area of CO</div> <div>or Conc in ppmv</div> </div>
001F0101.D	G0991,6.0PPMV CO & 4.8PPMV CH4 (SYSTEM:65MTORR) [1L:40TORR] [R20] [FCTV=35,TT@20=106SC]] (AT=766.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	<div>8.37</div> <div>469914</div> <div>6.7E-07</div>
001F0201.D	G0986,0.018PPMV CO & 0.014PPMV CH4 (SYSTEM:45MTORR) [1L:36TORR] [R20] [FCTV=33.4,TT@20=104SC]] (AT=766.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	<div>8.444</div> <div>1370</div> <div>6.2E-07</div>
001F0301.D	14CSU007-01#1,CSU 70MPA H2,SR141112. (SYSTEM:43MTORR) [1L:181TORR] [R20] [FCTV=180,TT@20=5514SC]] (AT=766.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	<div>8.469</div> <div>391</div> <div>0.0010</div>
001F0401.D	G0986,0.018PPMV CO & 0.014PPMV CH4 (SYSTEM:40MTORR) [1L:38TORR] [R20] [FCTV=35.5,TT@20=104SC]] (AT=766.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	<div>8.439</div> <div>1452</div> <div>6.1E-07</div>



S		Date of Analysis		H <sub>2</sub> S		COS		CH <sub>3</sub> SH_MTM		C <sub>2</sub> H <sub>5</sub> SH_ETM		CH <sub>3</sub> SCH <sub>3</sub> _DMS		CS <sub>2</sub>		(CH <sub>3</sub> ) <sub>2</sub> CHSH_IPM		(CH <sub>3</sub> ) <sub>2</sub> CSH_TBM		n-C <sub>3</sub> H <sub>7</sub> SH		n-C <sub>4</sub> H <sub>9</sub> SH		(CH <sub>2</sub> ) <sub>4</sub> SH_THT															
		1/14/2014		1E-09		1E-09		0.000000001		1.55E-09		1.52E-09		1.99E-09		1.15E-09		9.15E-10		1.40E-09		1.273E-09		1.27E-09															
File Names Injection		H2 VOLUME (mL)	Volume of Standard Injected (uL)	Injected Standard Conc (ppbv)	H2S RT	H2S Area	H <sub>2</sub> S RF, Conc. (PPBV) or % Spike Recovery	COS RT	COS Area	COS RF, Conc. (PPBV) or % Spike Recovery	CH3SH_MTM RT	CH3SH_MTM Area	CH <sub>3</sub> SH RF, Conc. (PPBV) or % Spike Recovery	C2H5SH_ETM RT	C2H5SH_ETM Area	C <sub>2</sub> H <sub>5</sub> SH RF, Conc. (PPBV) or % Spike Recovery	CH3SCH3_DMS S RT	CH3SCH3_DMS Area	CH <sub>3</sub> SCH <sub>3</sub> RF, Conc. (PPBV) or % Spike Recovery	CS2 RT	CS2 Area	CS <sub>2</sub> RF, Conc. (PPBV) or % Spike Recovery	(CH3)2CHSH_IPM PM RT	(CH3)2CHSH_IPM PM Area	(CH <sub>3</sub> ) <sub>2</sub> CHSH_IPM RF, Conc. (PPBV) or % Spike Recovery	(CH3)2CSH_TB BM RT	(CH3)2CSH_TB M Area	TBM RF, Conc. (PPBV) or % Spike Recovery	n-C3H7SH RT	n-C3H7SH Area	n-C <sub>3</sub> H <sub>7</sub> SH RF, Conc. (PPBV) or % Spike Recovery	n-C4H9SH RT	n-C4H9SH Area	THT RF, Conc. (PPBV) or % Spike Recovery	CH24SH_THT RT	CH24SH_THT Area	THT RF, Conc. (PPBV) or % Spike Recovery		
20uL G1035,1PPM/H2S,COS,CH3SH,C2S2,DB @H2O.LN, 1.4NPM0.027BM1.2IPM1.3THY1.5DMS1.5 EMI,INEM		500	20	1000	1.21	312	6.42E-08	1.33	415	4.82E-08	1.93	246	8.13E-08	2.95E+00	752	4.12E-08	3.253	819	3.72E-08	3.716	2042	1.95E-08	3.963	673	3.42E-08	4.735	469	3.90E-08	5.011	674	4.15E-08	6.817	4.20E+02	6.06E-08	8.199	435	6.85E-08		
14111411.D																																							
14111412.D																																							
14111413.D		500	10	1000	1.17	151	6.61E-08	1.28	204	4.90E-08	1.82	122	8.23E-08	2.81E+00	297	5.21E-08	3.138	440	3.46E-08	3.584	975	2.04E-08	3.843	235	4.90E-08	4.590	201	4.54E-08	4.856	227	6.14E-08	6.684	1.58E+02	8.03E-08	8.047	341	3.74E-08		
500mL 14CS1007.0181,CS2 79MPLA,DB@H2O.LN,SR141112		500			1.19	42	0.0060	1.30	87	0.0085	1.85	0	0	2.83E+00	0	0	3.138	0	0	3.610	123	0.0053	3.879	0	0	4.647	0	0	4.866	0	0	6.708	0.00E+00	0	8.066	0	0		
14111414.D		500	10	1000	1.17	115	% Recovery of 0.0201 ppbv is 53%	1.27	166	% Recovery of 0.0201 ppbv is 39%	1.83	108	% Recovery of 0.0201 ppbv is 107%	2.84E+00	203	% Recovery of 0.0201 ppbv is 62%	3.113	213	% Recovery of 0.0401 ppbv is 48%	3.566	563	% Recovery of 0.0401 ppbv is 48%	3.838	130	% Recovery of 0.023 ppbv is 52%	4.657	151	% Recovery of 0.018 ppbv is 71%	4.871	166	% Recovery of 0.025 ppbv is 65%	6.664	1.30E+02	% Recovery of 0.025 ppbv is 78%	8.036	211	% Recovery of 0.025 ppbv is 72%		
14111415.D		500	10	1000	1.17	116	8.50E-08	1.28	200	5.00E-08	1.85	74	1.34E-07	2.83E+00	315	4.92E-08	3.138	271	5.62E-08	3.575	806	2.47E-08	3.879	205	5.61E-08	4.647	207	4.42E-08	4.866	232	6.02E-08	6.708	1.42E+02	8.95E-08	8.066	362	3.52E-08		



# 11. HCOOH

Date of Analysis 11/15/2014

FILE NAME	Injection	Volume of Hydrogen (mL)	Volume Injected (uL) of HCOOH Standard @ 5.89%	Volume of HCOOH (uL) Injected in Standard & Spike Analysis	RET TIME OF HCOOH	HEIGHT OF HCOOH	Response Factor or Sample Conc in ppmv, Spike Recovery	HCOOH Spiking Concentration (ppmv)
001F0301.D	500ML 14CSU007-01#1, CSU 70MPA H2, SR141112. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.OT=100C. INJT=250C. 30M*0.53MM1.5UM DB-5 (SCOCC001). LIQ. N2.	500			0.43	44453	0.0056	
001F0401.D	0.04UL HEADSPACE (HS) OF P0132, 44.8MMHG HCOOH VAPOR/759.5MMHG AP=0.059+500ML14CSU007-01#1, CSU 70MPA H2, SR141112. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.OT=100C. INJT=250C. 30M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2.	500	0.04	0.0024	0.408	53116	5.8E-08	0.005
001F0501.D	500ML 14CSU007-01#1, CSU 70MPA H2, SR141112. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.OT=100C. INJT=250C. 30M*0.53MM1.5UM DB-5 (SCOCC001). LIQ. N2.	500			0.367	12562	0.0016	
001F0601.D	0.04UL HEADSPACE (HS) OF P0132, 44.8MMHG HCOOH VAPOR/759.5MMHG AP=0.059+500ML14CSU007-01#1, CSU 70MPA H2, SR141112. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.OT=100C. INJT=250C. 30M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2.	500	0.04	0.0024	0.393	38533	9.1E-08	0.005
001F0701.D	0.08UL HEADSPACE (HS) OF P0132, 44.8MMHG HCOOH VAPOR/759.5MMHG AP=0.059+500ML14CSU007-01#1, CSU 70MPA H2, SR141112. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.OT=100C. INJT=250C. 30M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2.	500	0.08	0.0047	0.377	128245	4.1E-08	0.009



12. **NH<sub>3</sub>**

Date of Analysis 11/15/2014

FILE NAME	Injection	H2 VOLUME (ML)	Volume Injected (uL) of NH3 Standard @ 5457 PPMV	Injected Standard Volume (uL)	RET TIME OF NH3	HEIGHT OF NH3	Response Factor or <i>Sample Conc in ppmv, Spike Recovery</i>	NH3 Spiking Concentration (ppmv)
001F0201.D	500ML 14CSU007-01#1,CSU 70MPA H2 STATION. SOLVENT=N-PROPANOL, SP=1.5ML/MN, CF=33ML/MN,CF+MUF=117ML/MN. PUMP=MIDDLE.FILTER=S.INJT=250C. OT=100C. SCOCC001N (30M*0.53MM ID 1.5UM DB-5). DESORBED BY OVEN.	500			0.38	40158	0.000870	
001F0301.D	0.1UL G0929 (5457 PPMV NH3 IN H2)+500ML 14CSU007-01#1,CSU 70MPA H2 STATION.SOLVENT=N-PROPANOL, SP=1.5ML/MN, CF=33ML/MN,CF+MUF=117ML/MN. PUMP=MIDDLE.FILTER=S.INJT=250C. OT=100C. SCOCC001N (30M*0.53MM ID 1.5UM DB-5). DESORBED BY OVEN.	500	0.1	0.0005457	0.393	81700	1.3E-08	0.001
001F0501.D	500ML 14CSU007-01#1,CSU 70MPA H2 STATION. SOLVENT=N-PROPANOL, SP=1.5ML/MN, CF=33ML/MN,CF+MUF=117ML/MN. PUMP=MIDDLE.FILTER=S.INJT=250C. OT=100C. SCOCC001N (30M*0.53MM ID 1.5UM DB-5). DESORBED BY OVEN.	500			0.391	40585	0.000880	
001F0601.D	0.1UL G0929 (5457 PPMV NH3 IN H2)+500ML 14CSU007-01#1,CSU 70MPA H2 STATION.SOLVENT=N-PROPANOL, SP=1.5ML/MN, CF=33ML/MN,CF+MUF=117ML/MN. PUMP=MIDDLE.FILTER=S.INJT=250C. OT=100C. SCOCC001N (30M*0.53MM ID 1.5UM DB-5). DESORBED BY OVEN.	500	0.1	0.0005457	0.46	104497	8.5E-09	0.001
001F0901.D	500ML 14CSU007-01#1,CSU 70MPA H2 STATION. SOLVENT=N-PROPANOL, SP=1.5ML/MN, CF=33ML/MN,CF+MUF=117ML/MN. PUMP=MIDDLE.FILTER=S.INJT=250C. OT=100C. SCOCC001N (30M*0.53MM ID 1.5UM DB-5). DESORBED BY OVEN.	500			0.373	41169	0.000892	



13.1 Cl<sub>2</sub>

Date of Analysis 11/15/2014

FILE NAME	Injection	Volume of Hydrogen (mL)	Volume Injected (uL) of Cl <sub>2</sub> Standard @ 5000.0 PPMV	Volume of Cl <sub>2</sub> (uL) Injected in Standard & Spike Analysis	RET TIME OF Cl <sub>2</sub>	HEIGHT OF Cl <sub>2</sub>	Response Factor or <i>Sample Conc in ppmv, Spike Recovery</i>	Cl <sub>2</sub> Spiking Concentration (ppmv)
001F0101.D	500ML 14CSU007-01#1,CSU 70MPA H2,SR141112. SOLVENT=N- PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.COL=30M SCOCC001.INJT=250C.OT=100C.	500			0.844	1.33E+04	4.5E-05	
001F0201.D	0.1UL G1022 (5000PPMV CL2 IN N2)+500ML 14CSU007-01#1,CSU 70MPA H2,SR141112.SOLVENT=N- PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.COL=30MSCOCC001.I NJT=250C.OT=100C.	500	0.1	0.0005	0.775	7.98E+04	7.5E-09	0.001
001F0301.D	500ML 14CSU007-01#1,CSU 70MPA H2,SR141112. SOLVENT=N- PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.COL=30M SCOCC001.INJT=250C.OT=100C.	500			0.801	2.88E+04	9.7E-05	
001F0401.D	0.05UL G1022 (5000PPMV CL2 IN N2)+500ML 14CSU007-01#1,CSU 70MPA H2,SR141112.SOLVENT=N- PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.COL=30MSCOCC001.I NJT=250C.OT=100C.	500	0.05	0.00025	0.465	1.77E+05	1.7E-09	0.0005



13.2 HCl

Date of Analysis 11/15/2014

FILE NAME	Injection	Volume of Hydrogen (mL)	Volume Injected (uL) of HCl Standard @ 0 PPMV	Volume of HCl (uL) Injected in Standard & Spike Analysis	RET TIME OF HCl	HEIGHT OF HCl	Response Factor or Sample Conc in ppmv, Spike Recovery	HCl Spiking Concentration (ppmv)
001F0401.D	0.1UL G1025 (5.7% HCL IN H2)+500ML 14CSU007-01#1,CSU 70MPA H2,SR141112. SOLVENT=N-PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.COL=30M SCOCC001.INJT=250C.OT=100C.	500	0.1	0.0057	0.42	4.63E+05	1.4E-08	0.011
001F0501.D	500ML 14CSU007-01#1,CSU 70MPA H2,SR141112. SOLVENT=N-PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.COL=30M SCOCC001.INJT=250C.OT=100C.	500			0.425	4.52E+04	1.2E-03	
001F0601.D	500ML 14CSU007-01#1,CSU 70MPA H2,SR141112. SOLVENT=N-PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.COL=30M SCOCC001.INJT=250C.OT=100C.	500			0.4	2.95E+04	3.5E-05	
001F0701.D	0.06UL G1025 (5.7% HCL IN H2)+500ML 14CSU007-01#1,CSU 70MPA H2,SR141112. SOLVENT=N-PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. PUMP=MIDDLE.FILTER=S.COL=30M SCOCC001.INJT=250C.OT=100C.	500	0.06	0.00342	0.375	5.85E+06	5.9E-10	0.007



13.3 HBr

Date of Analysis 11/15/2014

FILE NAME	Injection	Volume of Hydrogen (mL)	Volume Injected (uL) of HBr Standard	Volume of HBr (uL) Injected in Standard & Spike Analysis	RET TIME OF HBr	HEIGHT OF HBr	Response Factor or Sample Conc in ppmv, Spike Recovery	HBr Spiking Concentration (ppmv)
001F0101.D	500ML 14CSU007-01#1,CSU H70 H2, SR140917. SOLVENT=N- PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. SEPTEN PURGE=1.5ML/MN. PUMP=MIDDLE.FILTER=S. OT=150C. INJT=250C.30MSCOCC001 (0.53MM OD, 1.5UM DB-5). LIQ. N2.	500			0.461	1.22E+05	1.8E-03	
001F0201.D	500ML 14CSU007-01#1,CSU H70 H2, SR140917. SOLVENT=N- PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. SEPTEN PURGE=1.5ML/MN. PUMP=MIDDLE.FILTER=S. OT=150C. INJT=250C.30MSCOCC001 (0.53MM OD, 1.5UM DB-5). LIQ. N2.	500			0.457	1.96E+05	2.9E-03	
001F0301.D	500ML 14CSU007-01#1,CSU H70 H2, SR140917. SOLVENT=N- PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. SEPTEN PURGE=1.5ML/MN. PUMP=MIDDLE.FILTER=S. OT=150C. INJT=250C.30MSCOCC001 (0.53MM OD, 1.5UM DB-5). LIQ. N2.	500			0.409	7.35E+04	1.1E-03	
001F0401.D	1UL G1031 (5000PPMV HBR IN N2)+500ML 14CSU007-01#1,CSU H70 H2, SR140917. SOLVENT=N- PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. SEPTEN PURGE=1.5ML/MN. PUMP=MIDDLE.FILTER=S. OT=150C. INJT=250C.30M SCOCC001 (0.53MM OD, 1.5UM DB-5). LIQ. N2.	500	1	0.005	0.482	7.48E+05	7.4E-09	0.0100
001F0501.D	500ML 14CSU007-01#1,CSU H70 H2, SR140917. SOLVENT=N- PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. SEPTEN PURGE=1.5ML/MN. PUMP=MIDDLE.FILTER=S. OT=150C. INJT=250C.30MSCOCC001 (0.53MM OD, 1.5UM DB-5). LIQ. N2.	500			0.42	1.13E+05	3.8E-03	
001F0801.D	1UL G1031 (5000PPMV HBR IN N2)+500ML 14CSU007-01#1,CSU H70 H2, SR140917. SOLVENT=N- PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. SEPTEN PURGE=1.5ML/MN. PUMP=MIDDLE.FILTER=S. OT=150C. INJT=250C.30M SCOCC001 (0.53MM OD, 1.5UM DB-5). LIQ. N2.	500	1	0.005	0.406	4.15E+05	1.7E-08	0.0100
001F0901.D	500ML 14CSU007-01#1,CSU H70 H2, SR140917. SOLVENT=N- PROPANOL,CF=33ML/MN,CF+MUF=115ML/MN. SEPTEN PURGE=1.5ML/MN. PUMP=MIDDLE.FILTER=S. OT=150C. INJT=250C.30MSCOCC001 (0.53MM OD, 1.5UM DB-5). LIQ. N2.	500			0.377	7.17E+04	2.4E-03	