

Report on Quality of Hydrogen from H70 Nozzle of CSU LA H₂ Station on April 11, 2014



Table of Contents

Report

Report Summary

Particulate

Table I - Sizes and Images of Particulates

Table II - Filter and Particulate Concentration

Sampling

Table III - Particulate and Gaseous Sampling Parameters

Particulate Sampling Procedure - ASTM D7650

Gaseous Sampling Procedure - ASTM D7606

Analysis of Gaseous Sample

Analytical data for Non-Hydrogen Gaseous Constituents

Report Summary

Cal State University, Los Angeles

Quality of Hydrogen Fuel from 700 bar Nozzle of CSA Hydrogen Station

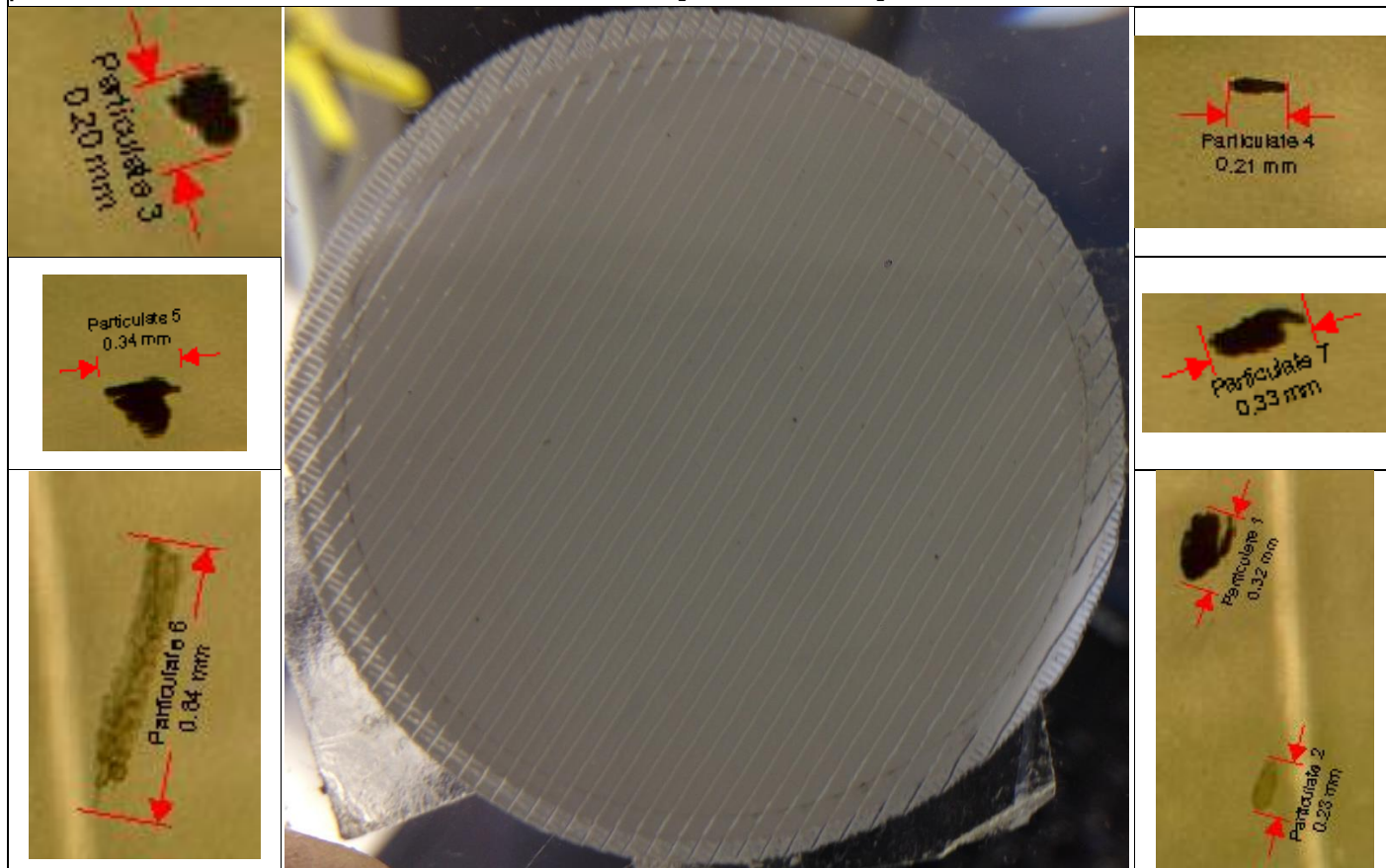
Sampling Date: 4/11/2014

Smart Chemistry No: 14CSU006

Constituent	SAE Limits ($\mu\text{mol/mol}$)	Smart Chemistry Detection Limits ($\mu\text{mol/mol}$)	Concentration ($\mu\text{mol/mol}$)	Concentration (mg/Liter)	Analytical Method
Water	5	1	< 1		ASTM D7649-10
Total Hydrocarbons (C ₁ Basis)	2	1			
Methane		0.001	0.024	0.000016	ASTM WK34574
Cyclohexane		0.001	0.041	0.000024	ASTM WK34574
Isopropyl Alcohol			0.0063	0.000005	ASTM WK34574
Oxygen	5	2	< 2		ASTM D7649-10
Helium	300	10	< 10		ASTM D1946
Nitrogen, Argon	100				
Nitrogen		5	14	0.016	ASTM D7649-10
Argon		0.5	0.58	0.00095	ASTM D7649-10
Carbon Dioxide	2	0.5	< 0.5		ASTM D7649-10
Carbon Monoxide	0.2	0.0008	0.00099	0.0000011	ASTM WK34574
Total Sulfur	0.004	0.00001	0.000076		ASTM D7652-11
Hydrogen Sulfide		0.00001	0.000057	0.00000008	ASTM D7652-11
Carbonyl Sulfide		0.00001	0.000011	0.000000028	ASTM D7652-11
Methyl Mercaptan (MTM)		0.00001	< 0.00001		ASTM D7652-11
Ethyl Mercaptan (ETM)		0.00001	< 0.00001		ASTM D7652-11
Dimethyl Sulfide (DMS)		0.00001	< 0.00001		ASTM D7652-11
Carbon Disulfide		0.000005	0.0000074	0.000000023	ASTM D7652-11
Isopropyl Mercaptan (IPM)		0.00001	< 0.00001		ASTM D7652-11
Tert-Butyl Mercaptan (TBM)		0.00001	< 0.00001		ASTM D7652-11
n-Propyl Mercaptan		0.00001	< 0.00001		ASTM D7652-11
Tetrahydrothiophene (THT)		0.00001	< 0.00001		ASTM D7652-11
Formaldehyde	0.01	0.001	< 0.001		ASTM WK34574
Formic Acid	0.2	0.001	< 0.005		ASTM WK34574
Ammonia	0.1	0.001	< 0.001		ASTM WK34574
Total halogenates	0.05				
Chlorine		0.001	< 0.001		ASTM WK34574
Hydrogen Chloride		0.003	< 0.003		ASTM WK34574
Hydrogen Bromide		0.01	< 0.01		ASTM WK34574
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		0.075 mg/kg		ASTM D7651-10
Particulates Found & Size (ASTM D7634-10) - Images of particulates found is in Table 1			Particulate #1: 0.32mm Particulate #2: 0.25mm Particulate #3: 0.20mm Particulate #4: 0.21mm Particulate #5: 0.34mm Particulate #6: 0.84mm Particulate #7: 0.33mm		
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)				
	99.9985%				

Table I - Particulates Filter, Sizes and Images

These is the **0.2 μ m Teflon particulate filters** after ASTM D7650-10 particulate sampling at H70 nozzle of CSU LA hydrogen fueling nozzle without any flow regulation. The **Particulate concentration**, measured by ASTM D7651-10, is **0.075mg/kg** by sampling **2.0 kilogram hydrogen** with average sampling flow rate 5.4g per second. The Teflon filter shows no pinhole damage after particulate sampling. There are only seven particulates, shown below, found on the **0.2 μ m Teflon particulate filter**



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)	#144 Filter Weight (g) - Before Sampling	#144 Filter Weight (g) - After Sampling
2014-04-06time 13.19.02	0.09605		0.09738 0.09738 0.09741 0.09741 0.09741 0.0974 0.09738 0.0974 0.09746 0.09743	
2014-04-06time 17.21.52		0.09261		
2014-04-16time 18.20.16	0.0961			0.09751 0.09752 0.09756 0.09754 0.09757 0.09754 0.09755 0.09758 0.0976 0.09759
2014-04-16time 22.22.35		0.09258		
Number of Measurement	2	2	10	10
Average Filter Weight	0.09608	0.09260	0.09741	0.09756
Average Standard Deviation of Weight (g)	3.54E-05	2.12E-05	2.50E-05	2.95E-05
Relative Standard Deviation of Weight (g)	0.0368%	0.0229%	0.0257%	0.0303%
Average Weight of Particulates (g) on Filter				0.000150

Sampling from a Tank with capacity of				
20 kg at 6500 psi	Initial Tank Pressure (psi)	2000	Final Tank Pressure (psi)	1350
Sampling Duration				
Event	(second)	Inlet Pressure (bar)	Sampling Flow Rate (g/sec)	Hydrogen Sampled (kg)
Particulate Sampling	370	206	5.4	2.0
H ₂ Sampled for Particulate (m ³)				24.4

Particulate Concentration

Average Particulate Concentration (mg/kg)	0.075 mg/kg
Average Particulate Concentration (µg/L)	0.0061 µg/Liter

Sampling Summary

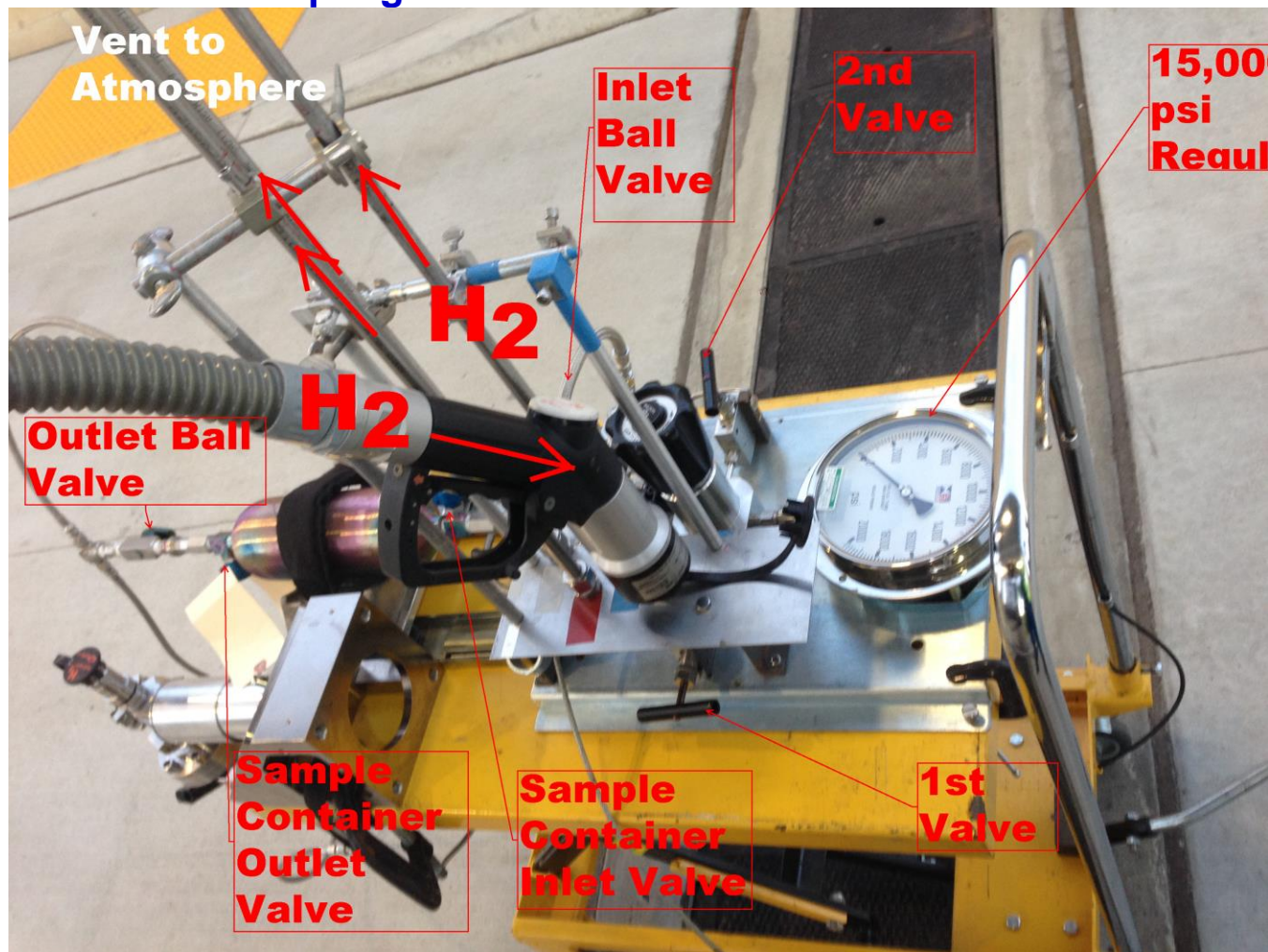
The hydrogen sampling is performed on April 11, 2014 at H70 fueling nozzles of CSU LA Hydrogen Fueling Stations.

The gaseous sampling by ASTM D7606 is to regulate the hydrogen fuel from the H70 fueling nozzle to 1000 psi before flowing 1 kg hydrogen fuel through a 1-Liter 1800 psi pressure proof sample container to obtain representative sample. At the end of sampling, the outlet valve of the gaseous sample container is closed first, as shown in the section - Gaseous Sampling Procedure – ASTM D7606. Three 1-Liter sample containers containing the gaseous hydrogen sample are collected in this manner. The 70 MPa hydrogen quality sampling assembly (HQSA) is employed to perform the gaseous sampling.

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 to perform particulate sampling. A total of 2.0 kg of hydrogen at average flow rate of 5.4 gram per second from the 70 MPa nozzle passes through a 0.2µm Teflon filter without either regulator or orifice in between. The particulate concentrations and size measurements follow ASTM D7651-10 and D7634-10, respectively.

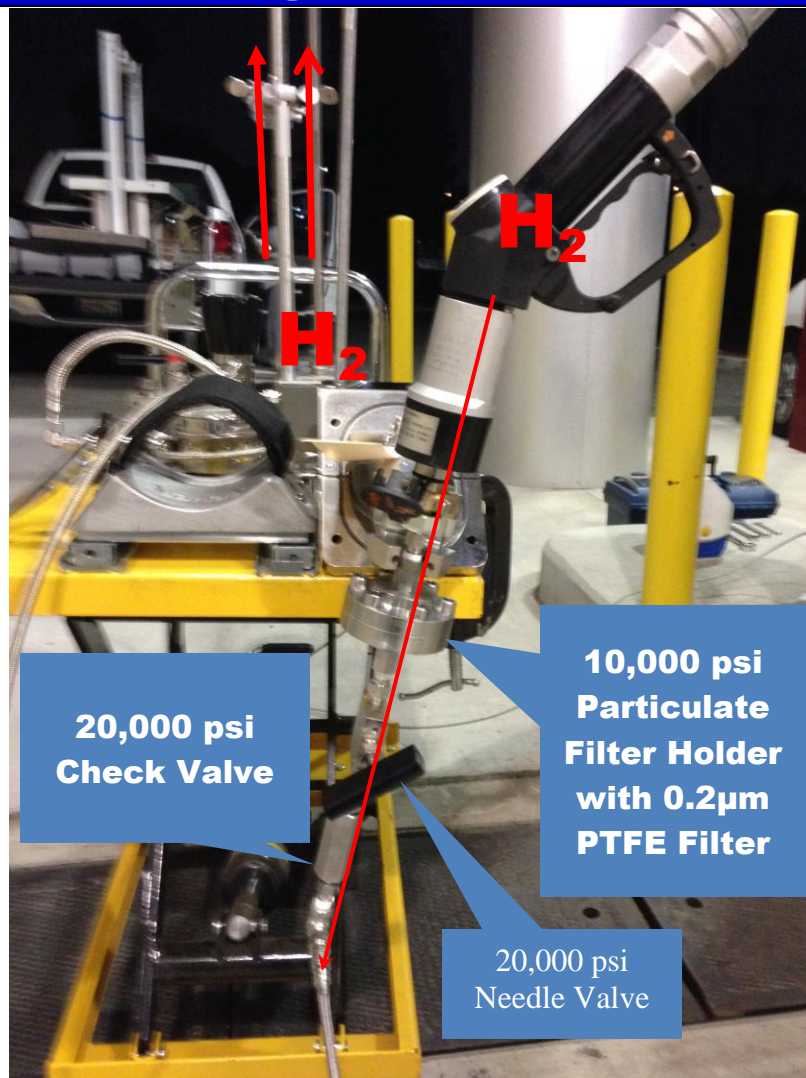
Table II Particulate and Gaseous Sampling Parameters						
Event	Sampling Time	Duration (second)	Total H ₂ Sampled (kg)	Hydrogen Tank Pressure (psi)	Flow Rate (g/second)	Hydrogen Inlet Pressure
1st Gaseous Sampling at Nozzle	4/11/2014, 19:37	123	1.02	3000→2668	8.3	12,500 psi
2nd Gaseous Sampling at Nozzle	4/11/2014, 19:45	155	0.98	2668→2350	6.3	12,500 psi
3rd Gaseous Sampling at Nozzle	4/11/2014, 19:50	190	1.12	2350→1987	5.9	12,500 psi
Particulate Sampling	4/11/2014, 20:15	370	2.0	2000→1350	5.4	206 bar

Gaseous Sampling Procedure at 70 MPa Nozzle – ASTM D7606



1. Assemble the gaseous sampling as above.
2. Attach the station suspensor nozzle to the receptacle. With the 1st valve closed and station leak 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 1st valve. If no leak and 2nd valve closed, open the 1st 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 1st valve to the 2nd valve. If no leak is found, open all the valves downwards from 2nd valve, except the outlet ball valve after sample container outlet valve. Open the 2nd valve to pressurize the sample container with 1000 psi hydrogen fuel sample. Check for leak from 2nd valve to the outlet ball valve, especially sample container.
4. Let approximate 1 kg hydrogen fuel 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 2nd valve, while the hydrogen fueling is ongoing. The hydrogen weight (g) sampled is calculated from the difference of the initial and final station storage tank pressures. 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.

Particulate Sampling Procedure – ASTM D7650-10



- 1. DURING PARTICULATE SAMPLING, SAMPLING PERSONNEL SHALL WEAR GOGGLES, EAR PROTECTION DEVICE, SAFETY SHOES AND A FLAME RESISTANT NOMEX LAB COAT.**
- 2. ALWAYS GROUND THE SAMPLING SETUP FIRST.**
- 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.
- Before particulate sampling, the particulate sampling assembly (PSA) is secured physically as shown above; the fueling nozzle is then attached to the PSA. Make sure the hydrogen pressure for particulate sampling is less than 5000 psi.
- Make sure the hydrogen to be sampled passes through the cooling unit.
- With the ball valve closed, perform station nozzle leak checking procedure. The portable hydrogen leak detector is used to check any hydrogen leak around the nozzle and filter holder.
- Open the needle valve to allow more than 1kg 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).

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.

Non-Hydrogen Gaseous Constituents	
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 ₂ S , COS, CH ₃ SH & CS ₂
9.2	Total Sulfurs – The sum of the concentrations of H ₂ S, COS, CH ₃ SH, CH ₃ CH ₂ SH, CS ₂ , (CH ₃) ₃ CSH 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 ₂ 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)	
40415B.D - PRAXAIR UHP H2 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 274.8	0.00	0	0 0 0	2799011 1410960 461953	0 0 0	6.7E-10 6.6E-10 8.1E-10	0.00	
14041501.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 333.5	0.00	0	0 0 0	2846933 1462744 618143	0 0 0	6.6E-10 6.4E-10 6.0E-10	0.00	
14041502.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 10,5,10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 324	0.00	0	0 0 0	2936409 1507061 491150	0 0 0	6.4E-10 6.2E-10 7.6E-10	0.00	
14041503.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 315.1	0.00	0	0 0 0	2900182 1450833 464305	0 0 0	6.4E-10 6.4E-10 8.0E-10	0.00	
14041504.D - PRAXAIR UHP H2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 277.9	0.00	0	0 0 0	3005327 1412232 489713	0 0 0	6.2E-10 6.6E-10 7.6E-10	0.00	
14041505.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 418.6	0.00	0	0 0 0	2973929 1484854 515352	0 0 0	6.3E-10 6.3E-10 7.2E-10	0.00	
14041506.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 391.9	0.00	0	0 0 0	3011750 1442279 461421	0 0 0	6.2E-10 6.5E-10 8.1E-10	0.00	
14041507.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 377.3	0.00	0	0 0 0	2756487 1329113 478301	0 0 0	6.8E-10 7.0E-10 7.8E-10	0.00	

Date: 04/15/2014 File Name	Analytical Data Injection	<div>2.1 CH₄</div> <div> Standard Conc. (PPMV) Volume of CH₄ in Standard (μL) Ret. Time (MIN) of CH₄ Area of CH₄ CH₄ Response Factor or Conc in ppmv </div>				
001F0101.D	G0991,6.0PPMV CO & 4.8PPMV CH4 (SYSTEM:101MTORR) [1L:39TORR] [R20] [FCTV=39.9,TT@20=138SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	4.8	0.245540	5.537	717107	3.4E-07
001F0201.D	G0900,0.24PPMV CO & 0.20PPMV CH4 (SYSTEM:56MTORR) [1L:26TORR] [R20] [FCTV=24,TT@20=151SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	0.20	0.006821	5.541	40138	0.403
001F0301.D	G0986,0.018PPMV CO & 0.014PPMV CH4 (SYSTEM:47MTORR) [1L:37TORR] [R20] [FCTV=37.4,TT@20=114SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	0.014	0.000679	5.546	91435	0.645
001F0401.D	P0210 H2 USED FOR G0986 (SYSTEM:61MTORR) [1L:48TORR] [R20] [FCTV=46.6,TT@20=144SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)			5.55	105365	0.573
001F0501.D	14CSU006#5,S140411,19:45 (SYSTEM:45MTORR) [1L:136TORR] [R20] [FCTV=137.7,TT@20=439SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)			5.545	12371	0.024
001F0701.D	G0986,0.018PPMV CO & 0.014PPMV CH4 (SYSTEM:31MTORR) [1L:38TORR] [R20] [FCTV=39.9,TT@20=136SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	0.014	0.000698	5.56	100019	0.687

Smart Chemistry Corporation

3402 La Grande Blvd, Sacramento, CA 95823, (916)391-3300, (916)391-3440 (fax), www.smartchemistry.com, jphsu@smartchemistry.com

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

Client:
Hydrogen Station at:
Sample Type: Hydrogen Fuel
Date Sampled: 04102014,19:45
Date Received: 04112014
Date Analyzed: 04162014
Time Analyzed: 2:52 pm

Field ID #: 400ML 14CSU006#5,S19:45,140411
Lab Sample ID: 14CSU00601
Concentration Units: PPBV
Date File Location
Data Filename: 14041603.D
Dilution Factor: 1.0

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	6.9	=	0.003	0.024	6	0.0414
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	50-0-0	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	2.1	=	0.002	0.0052	3	0.0063
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	108-38-3 & 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), %recovery	128	74-97-5		84	=				
4-BFB(surrogate), %recovery	174	460-00-4		110	=				

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 (PPBV) 0.009

Total Hydrocarbon (C1 Basis, PPMV)

0.000477

Analytical Data		3. O_2 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)
40415B.D - PRAXAIR UHP H2 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 274.8	0.00	0	96631 97712 89647	1907057 987714 352562	9.3E-09 9.2E-09 1.0E-08	2.1E-08 2.0E-08 2.2E-08	0.0
14041501.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 333.5	0.75	48068	89120 85733 84267	1903101 999835 337507	1.0E-08 1.1E-08 1.1E-08	2.1E-08 2.0E-08 2.3E-08	3.7
14041502.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 10,5,10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 324	0.76	39660	82600 85353 75662	1845826 985836 341332	1.1E-08 1.1E-08 1.2E-08	2.1E-08 2.0E-08 2.3E-08	3.1
14041503.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 315.1	0.75	41963	75698 73649 66955	1830413 964339 334138	1.2E-08 1.2E-08 1.3E-08	2.1E-08 2.0E-08 2.3E-08	3.2
14041504.D - PRAXAIR UHP H2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 277.9	0.00	0	67324 64654 65039	1847772 924278 331297	1.3E-08 1.4E-08 1.4E-08	2.1E-08 2.1E-08 2.4E-08	0.0
14041505.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 418.6	0.75	13796	60060 63610 66824	1828598 915633 330061	1.5E-08 1.4E-08 1.4E-08	2.1E-08 2.1E-08 2.4E-08	1.06
14041506.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 391.9	0.76	44070.94	69779 62180 71492	1839084 926936 335989	1.3E-08 1.5E-08 1.3E-08	2.1E-08 2.1E-08 2.3E-08	3.39
14041507.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 377.3	0.74	9357.445	78313 76170 66936	1788937 910108 347408	1.2E-08 1.2E-08 1.3E-08	2.2E-08 2.2E-08 2.3E-08	0.72

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Analytical Data

4. He

Date of
Analysis

04/15/2014

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.	3.813	164.2	14.42	11.4	
001F0201.D	G0973 (72.3 PPMV HE IN HYDROGEN). OT=40C.	3.784	72.3	7.63	9.5	
001F0301.D	G0814 (9.1 PPMV HE IN HYDROGEN). OT=40C.	3.789	9.1	0.81	11.2	
001F0501.D	14CSU006#5			0		0
001F0601.D	G0812 (164.2 PPMV HE IN HYDROGEN). OT=40C.	3.798	164.2	13.86	11.8	

Analytical Data		5. N ₂ 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)
40415B.D - PRAXAIR UHP H2 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 274.8	0.00	0	559555 556399 510787	11191137 6305392 2438557	1.6E-09 1.6E-09 1.8E-09	1.3E-08 1.2E-08 1.2E-08	0.0
14041501.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 333.5	0.75	167410	520570 483466 479174	11703695 6587112 2442633	1.7E-09 1.9E-09 1.9E-09	1.2E-08 1.1E-08 1.2E-08	3.7
14041502.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 3 10UL G793;10,5&2UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 324	0.75	128465	450753 466625 440150	11542460 6615915 2534257	2.0E-09 1.9E-09 2.1E-09	1.3E-08 1.1E-08 1.1E-08	2.8
14041503.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 315.1	0.75	185454	432557 433270 434296	11660794 6616234 2477314	2.1E-09 2.1E-09 2.1E-09	1.2E-08 1.1E-08 1.2E-08	4.1
14041504.D - PRAXAIR UHP H2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 277.9	0.00	0	392103 361290 378712	11863855 6485038 2536994	2.3E-09 2.5E-09 2.4E-09	1.2E-08 1.1E-08 1.1E-08	0.0
14041505.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 418.6	0.76	665988	400244 377943 401747	11936292 6519082 2539198	2.3E-09 2.4E-09 2.2E-09	1.2E-08 1.1E-08 1.1E-08	14.72
14041506.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 391.9	0.77	698502.582	370364 367235 402077	12049123 6597373 2584907	2.4E-09 2.5E-09 2.2E-09	1.2E-08 1.1E-08 1.1E-08	15.44
14041507.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 377.3	0.77	530875.226	477999 449944 421760	11818015 6538717 2601179	1.9E-09 2.0E-09 2.1E-09	1.2E-08 1.1E-08 1.1E-08	11.73

Analytical Data		6. Ar ASTM 7649-10 Date of Analysis 04/15/2014						
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)
40415B.D - PRAXAIR UHP H2 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 274.8	0.00	0	87823.30 95334.25 93328.25	216949 117674 41773	8.2E-09 7.5E-09 7.7E-09	8.0E-09 7.4E-09 8.3E-09	0.0	
14041501.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 333.5	0.78	33940	95789.95 98399.58 99754.96	227255 120417 44904	7.5E-09 7.3E-09 7.2E-09	7.7E-09 7.2E-09 7.8E-09	2.8	88
14041502.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 10,5,10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 324	0.78	34874	94408.41 96604.69 97788.90	218110 122170 44019	7.6E-09 7.4E-09 7.3E-09	8.0E-09 7.1E-09 7.9E-09	2.8	90
14041503.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 315.1	0.78	37767	96142.01 92505.96 97641.42	223670 118887 41112	7.5E-09 7.8E-09 7.4E-09	7.8E-09 7.3E-09 8.5E-09	3.1	98
14041504.D - PRAXAIR UHP H2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 277.9	0.00	0	94586.45 97335.30 99416.75	222965 116917 42799	7.6E-09 7.4E-09 7.2E-09	7.8E-09 7.4E-09 8.1E-09	0.0	
14041505.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 418.6	0.74	6110	93735 96777 93504	225152 116558 44272	7.7E-09 7.4E-09 7.7E-09	7.7E-09 7.5E-09 7.9E-09	0.50	
14041506.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 391.9	0.76	9593.381	94348 97920 100235	234048 121383 49464	7.6E-09 7.3E-09 7.2E-09	7.4E-09 7.2E-09 7.0E-09	0.78	
14041507.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 377.3	0.76	5686.309	100249 98427 94194	223119 120907 43244	7.2E-09 7.3E-09 7.6E-09	7.8E-09 7.2E-09 8.1E-09	0.46	

Analytical Data		7. CO ₂ ASTM 7649-10 Date of Analysis 04/15/2014						
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)
40415B.D - PRAXAIR UHP H2 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 274.8	0.00	0	378528 379429 406061	108146 55132 17491	2.4E-09 2.4E-09 2.2E-09	23 24 19	0.0	
14041501.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 333.5	0.78	164469	399431 424942 421099	294217 98975 16177	2.3E-09 2.1E-09 2.1E-09	64 43 18	3.8	96
14041502.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 10,5,10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 324	0.77	159818	402527 414018 418911	134672 65603 37074	2.2E-09 2.2E-09 2.2E-09	29 28 40	3.7	93
14041503.D - G0934,6PPM CO2,4.8PPM AR,6PPM N2 & O2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 315.1	0.77	159524	426673 400876 425807	110040 50758 15219	2.1E-09 2.3E-09 2.1E-09	24 22 16	3.7	93
14041504.D - PRAXAIR UHP H2;ES0.01 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 277.9	0.00	0	420075 422455 429930	152013 36947 21503	2.2E-09 2.1E-09 2.1E-09	33 16 23	0.0	
14041505.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 418.6	0.00	0	414659 421680 424063	111084 67602 19107	2.2E-09 2.1E-09 2.1E-09	24 29 21	0.00	
14041506.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 391.9	0.00	0	439153 429953 437327	126578 32089 19977	2.1E-09 2.1E-09 2.1E-09	27 14 22	0.00	
14041507.D - 14CSU006#5,S140411,19:45 3 10UL G793;10,5&2UL AIR;ES1:100;CF1.5MM 377.3	0.00	0	437994 415289 426022	149081 72304 11971	2.1E-09 2.2E-09 2.1E-09	32 31 13	0.00	

Date: 04/15/2014 - 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:101MTORR) [1L:39TORR] [R20] [FCTV=39.9,TT@20=138SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	<div>7.71</div> <div>547684</div> <div>5.6E-07</div>
001F0201.D	G0900,0.24PPMV CO & 0.20PPMV CH4 (SYSTEM:56MTORR) [1L:26TORR] [R20] [FCTV=24,TT@20=151SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	<div>7.737</div> <div>31878</div> <div>2.6E-07</div>
001F0301.D	G0986,0.018PPMV CO & 0.014PPMV CH4 (SYSTEM:47MTORR) [1L:37TORR] [R20] [FCTV=37.4,TT@20=114SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	<div>7.769</div> <div>2484</div> <div>3.5E-07</div>
001F0401.D	P0210 H2 USED FOR G0986 (SYSTEM:61MTORR) [1L:48TORR] [R20] [FCTV=46.6,TT@20=144SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	<div>7.8</div> <div>501</div> <div>0.0025</div>
001F0501.D	14CSU006#5,S140411,19:45 (SYSTEM:45MTORR) [1L:136TORR] [R20] [FCTV=137.7,TT@20=439SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	<div>7.795</div> <div>562</div> <div>0.0010</div>
001F0701.D	G0986,0.018PPMV CO & 0.014PPMV CH4 (SYSTEM:31MTORR) [1L:38TORR] [R20] [FCTV=39.9,TT@20=136SC]] (AT=762.4)(OT=80C)(5TH 2M GS TRAP IN LIQ. N2)(CF=7.0,RP=38PSI)	<div>7.789</div> <div>2725</div> <div>3.3E-07</div>

9. S	Date of Analysis 04/14/2014			H ₂ S 1E-09	COS 1E-09	CH ₃ SH_MTM 1E-09	C ₂ H ₅ SH_ETM 1.55E-09	CH ₃ SCH ₃ _DMS 1.52E-09	CS ₂ 1.99E-09	(CH ₃) ₂ CHSH_IPM 1.15E-09	(CH ₃) ₂ CSH_TBM 9.15E-10	n-C ₃ H ₇ SH 1.40E-09	(CH ₂) ₄ SH_THT 1.27E-09
File Names Injection	H2 VOLUME (mL)	Volume of Standard Injected (uL)	Injected Standard Conc (ppbv)	H2S RT H2S Area H ₂ 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 ₃ SH RF, Conc (PPBV) or % Spike Recovery	C2H5SH_ETM RT C2H5SH_ETM Area C ₂ H ₅ SH RF, Conc (PPBV) or % Spike Recovery	CH3SCH3_DMS RT CH3SCH3_DMS Area CH ₃ SCH ₃ RF, Conc (PPBV) or % Spike Recovery	CS2 RT CS2 Area CS ₂ RF, Conc (PPBV) or % Spike Recovery	(CH3)2CHSH_IPM M RT (CH3)2CHSH_IPM M Area (PM RF, Conc (PPBV) or % Spike Recovery	(CH3)2CSH_TBM M RT (CH3)2CSH_TBM M Area TBM RF, Conc (PPBV) or % Spike Recovery	n-C3H7SH RT n-C3H7SH Area n-C ₃ H ₇ SH RF, Conc (PPBV) or % Spike Recovery	(CH2)4SH_THT RT (CH2)4SH_THT Area THT RF, Conc (PPBV) or % Spike Recovery
14041401.D 50uL C0988,1PPM/V H2S,COS,CH3SH,C2CS2,DB@H2O,LN, 1.4NPM,0.927BM,1.2IPM,1.3THT,1.5DMS,1.5EM	50	1000	1000	1.28 1513 3.30E-08	1.39 3288 1.53E-08	2.00 1302 3.84E-08	3.06E+00 5111 1.51E-08	3.367 4764 1.60E-08	3.820 8696 1.14E-08	4.079 4548 1.27E-08	4.842 3437 1.33E-08	5.101 2882 2.42E-08	8.283 1315 4.84E-08
14041402.D 20uL C0988,1PPM/V H2S,COS,CH3SH,C2CS2,DB@H2O,LN, 1.4NPM,0.927BM,1.2IPM,1.3THT,1.5DMS,1.5EM				1.29 527 3.80E-08	1.40 1231 1.83E-08	2.02 520 3.84E-08	3.07E+00 1917 1.62E-08	3.387 1756 1.74E-08	3.838 3150 1.26E-08	4.118 1327 1.74E-08	4.844 1550 1.18E-08	5.107 1209 2.31E-08	8.269 536 4.75E-08
14041403.D 10uL C0988,1PPM/V H2S,COS,CH3SH,C2CS2,DB@H2O,LN, 1.4NPM,0.927BM,1.2IPM,1.3THT,1.5DMS,1.5EM				1.30 270 3.70E-08	1.42 608 1.64E-08	2.03 813 1.23E-08	3.09E+00 868 1.78E-08	3.403 989 1.54E-08	3.849 2145 9.28E-09	4.123 991 1.16E-08	4.866 1108 8.26E-09	5.107 1028 1.36E-08	8.247 654 1.95E-08
14041404.D 5uL C0988,1PPM/V H2S,COS,CH3SH,C2CS2,DB@H2O,LN, 1.4NPM,0.927BM,1.2IPM,1.3THT,1.5DMS,1.5EM	500ML 14CSU0598,R140411,19.50,DB@H2O,LN,	5	1000	1.28 135 3.70E-08	1.38 372 1.34E-08	1.98 206 2.43E-08	3.02E+00 386 2.01E-08	3.333 451 1.69E-08	3.798 1048 9.50E-09	4.075 425 1.36E-08	4.838 376 1.22E-08	5.092 358 1.95E-08	8.252 259 2.46E-08
14041422.D				1.31 739 0.055	1.42 984 0.030	2.00 0 0.00	3.05E+00 0 0	3.353 0 0	3.820 820 0.018	4.079 0 0.000	4.822 0 0.000	5.074 0 0.000	8.232 0 0.00
14041423.D 20uL C0988+500ML 14CSU0598,DB@H2O,LN,	500	20	1000	H2S Recovery @ 0.00 ppbv is 76%	COS Recovery @ 0.00 ppbv is 72%	CH3SH_MTM Recovery @ 0.00 ppbv is 62%	C2H5SH_ETM Recovery @ 0.00 ppbv is 81%	CH3SCH3_DMS Recovery @ 0.00 ppbv is 70%	CS2 Recovery @ 0.00 ppbv is 72%	(CH3)2CHSH_IPM Recovery @ 0.00 ppbv is 64%	(CH3)2CSH,T BM Recovery @ 0.00 ppbv is 59%	n-C3H7SH Recovery @ 0.00 ppbv is 56%	(CH2)4SH,THT Recovery @ 0.00 ppbv is 36%
14041424.D 20uL C0988,1PPM/V H2S,COS,CH3SH,C2CS2,DB@H2O,N, 1.4NPM,0.927BM,1.2IPM,1.3THT,1.5DMS,1.5EM				1.29 1182	1.40 1297	2.01 402	3.07E+00 1470	3.367 1281	3.815 2935	4.081 1073	4.837 915	5.085 749	8.222 257
	200	1000	1000	1.29 4900 4.08E-08	1.40 12514 1.60E-08	2.00 4815 4.15E-08	3.05E+00 19050 1.63E-08	3.353 17784 1.71E-08	3.807 31556 1.26E-08	4.079 17496 1.32E-08	4.822 13805 1.33E-08	5.074 11866 2.35E-08	8.232 6328 4.02E-08

11.

HCOOH

Date of Analysis 04/17/2014

FILE NAME	Injection	Volume of Hydrogen (mL)	Volume Injected (uL) of HCOOH Standard @ 5.90%	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
001F0201.D	0.04UL HEADSPACE (HS) OF P0132, 44.8MMHG HCOOH VAPOR/759.5MMHG AP=0.059. NON-FTSYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2..		0.04	0.0024	0.091	42981	5.5E-08
001F0301.D	0.1UL H2. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2..				0.103	7881	
001F0401.D	0.04UL HEADSPACE (HS) OF P0132, 44.8MMHG HCOOH VAPOR/759.5MMHG AP=0.059. NON-FTSYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2..		0.04	0.0024	0.096	34694	8.8E-08
001F0601.D	0.1UL H2. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2..				0.096	6277	
001F0701.D	0.04UL HEADSPACE (HS) OF P0132, 44.8MMHG HCOOH VAPOR/759.5MMHG AP=0.059. NON-FTSYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2..		0.04	0.0024	0.112	20097	1.7E-07
001F0801.D	0.1UL H2. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2..				0.093	3824	
001F0901.D	0.04UL HEADSPACE (HS) OF P0132, 44.8MMHG HCOOH VAPOR/759.5MMHG AP=0.059. NON-FTSYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2..		0.04	0.0024	0.095	34146	7.8E-08
001F1001.D	0.5UL H2. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2..				0.087	10629	
001F1101.D	500ML 14CSU006#5, S140411,19:45. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2..	500			0.161	3324	0.00075
001F1501.D	0.04UL HEADSPACE (HS) OF P0132, 44.8MMHG HCOOH VAPOR/759.5MMHG AP=0.059+500ML14CSU006#5, S140411,19:45. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ.	500	0.04	0.002359447	0.185	38557	Percent Spike Recovery of HCOOH @0.005 PPMV is 111%
001F1601.D	0.1UL H2. NON-FT SYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2..				0.093	6034	
001F1701.D	0.04UL HEADSPACE (HS) OF P0132, 44.8MMHG HCOOH VAPOR/759.5MMHG AP=0.059. NON-FTSYRINGE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=50C. 1.9M*0.53MM 1.5UM DB-5 (SCOCC001). LIQ. N2..		0.04	0.0024	0.088	41094	6.7E-08

12.

NH₃

Date of Analysis 04/17/2014

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>
001F0101.D	0.1UL G0929 (5457 PPMV NH3 IN H2). SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.		0.1	0.0005457	0.086	36465	1.5E-08
001F0201.D	0.1UL H2. SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.				0.096	7028	
001F0301.D	0.1UL G0929 (5457 PPMV NH3 IN H2). SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.		0.1	0.0005457	0.065	57216	1.1E-08
001F0401.D	0.1UL H2. SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.				0.097	7044	
001F0501.D	0.1UL G0929 (5457 PPMV NH3 IN H2). SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.		0.1	0.0005457	0.062	76606	7.8E-09
001F0601.D	0.1UL H2. SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.				0.093	6089	
001F0701.D	0.1UL G0929 (5457 PPMV NH3 IN H2). SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.		0.1	0.0005457	0.062	61600	9.8E-09
001F0801.D	0.1UL H2. SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.				0.102	7372	
001F0901.D	500ML 14CSU006#5,S140411, 19:45. SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.	500			0.125	6626	0.00013
001F1001.D	500ML 14CSU006#5,S140411, 19:45. SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.	500			0.154	5301	0.00011
001F1101.D	0.1UL G0929 (5457 PPMV NH3 IN H2)+500ML 14CSU006#5,S140411, 19:45. SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.	500	0.1	0.000546	0.056	50017	<i>Percent Spike Recovery of NH3 @0.000 PPMV is 83%</i>
001F1201.D	0.1UL H2. SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.				0.093	7707	
001F1301.D	0.1UL G0929 (5457 PPMV NH3 IN H2). SOLVENT=N-PROPANOL, SP=1.26ML/MN, CF=17ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.		0.1	0.0005457	0.075	77851	7.0E-09

13.1

Cl₂

Date of Analysis 04/17/2014

FILE NAME	Injection	Volume of Hydrogen (mL)	Volume Injected (uL) of Cl2 Standard @ 5000.0 PPMV	Volume of Cl2 (uL) Injected in Standard & Spike Analysis	RET TIME OF Cl2	HEIGHT OF Cl2	Response Factor or <i>Sample Conc in ppmv, Spike Recovery</i>
001F0101.D	0.1UL G0993 (5000PPMV CL2 IN N2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.		0.1	0.0005	0.091	1.33E+05	3.8E-09
001F0301.D	0.2UL H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.				0.081	4.08E+04	
001F0401.D	NONE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.				0.074	1.50E+04	
001F0501.D	0.1UL G0993 (5000PPMV CL2 IN N2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.		0.1	0.0005	0.065	1.32E+05	3.8E-09
001F0601.D	0.1UL G0993 (5000PPMV CL2 IN N2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.		0.1	0.0005	0.079	2.20E+05	2.3E-09
001F0701.D	0.1UL G0993 (5000PPMV CL2 IN N2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.		0.1	0.0005	0.08	2.19E+05	2.3E-09
001F0801.D	0.1UL G0993 (5000PPMV CL2 IN N2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.		0.1	0.0005	0.077	1.60E+05	3.1E-09
001F0901.D	0.1UL G0993 (5000PPMV CL2 IN N2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.		0.1	0.0005	0.069	2.55E+05	2.0E-09
001F1001.D	0.1UL G0993 (5000PPMV CL2 IN N2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.		0.1	0.0005	0.075	5.67E+05	8.8E-10
001F1101.D	0.1UL G0993 (5000PPMV CL2 IN N2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.		0.1	0.0005	0.09	1.88E+06	2.7E-10
001F1201.D	NONE. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.	500			0.08	6.76E+04	
001F1301.D	500ML 14CSU006#5, S140411, 19:45. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.				0.16	5.63E+03	2.3E-05
001F1501.D	0.1UL G0993 (5000PPMV CL2 IN N2)+500ML 14CSU006#5, S140411, 19:45. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.		0.1	0.0005	0.246	1.11E+06	Percent Spike Recovery of Cl2 @0.001 PPMV is 49%
001F1601.D	0.1UL G0993 (5000PPMV CL2 IN N2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MIDDLE.FILTER=S.INJT=100C.COL=1.9M SCOC001.		0.1	0.0005	0.087	2.79E+06	1.8E-10

13.2 HCl

Date of Analysis 04/17/2014

FILE NAME	Injection	Volume of Hydrogen (mL)	Volume Injected (uL) of HCl Standard	Volume of HCl (uL) Injected in Standard & Spike Analysis	RET TIME OF HCl	HEIGHT OF HCl	Response Factor of Sample Conc in ppmv, Spike Recovery
001F1001.D	0.1UL H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).				0.08	6.61E+04	
001F1101.D	0.06UL G0979(2.1% HCL IN H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S. INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).		0.06	0.00126	0.089	6.68E+05	2.1E-09
001F1201.D	0.1UL H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).				0.082	1.28E+05	
001F1301.D	0.06UL G0979(2.1% HCL IN H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S. INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).		0.06	0.00126	0.082	4.31E+05	4.2E-09
001F1401.D	0.1UL H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).				0.077	1.24E+05	
001F1501.D	0.06UL G0979(2.1% HCL IN H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S. INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).				0.086	1.77E+05	
001F1601.D	0.06UL G0979(2.1% HCL IN H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S. INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).		0.06	0.00126	0.083	1.13E+06	1.3E-09
001F1701.D	0.1UL H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).				0.09	1.10E+05	
001F1801.D	500ML 14CSU006#5,S140411,19:45. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S. INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).	500			0.31	5.63E+04	0.000316
001F2001.D	0.06UL G0979(2.1% HCL IN H2)+500ML 14CSU006#5,S140411,19:45. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S. INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).	500	0.06	0.00126	0.173	8.84E+04	Percent Spike Recovery of HCl @0.003 PPMV is 20%
001F2101.D	0.1UL H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).				0.085	6.87E+04	
001F2201.D	0.06UL G0979(2.1% HCL IN H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S. INJT=100C.COL=190CM SCOC001 (0.53MM ID 1.5UM DB-5).		0.06	0.00126	0.076	4.13E+05	3.7E-09

13.3 HBr

Date of Analysis 04/17/2014

FILE NAME	Injection	Volume of Hydrogen (mL)	Volume Injected (uL) of HBr Standard @ 0 PPMV	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
001F0401.D	0.5UL H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).				0.082	1.75E+04	
001F0501.D	0.5UL G0992 (0.89% HBR IN H2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MI DDLE.FILTER=S. INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).		0.5	0.00445	0.077	5.05E+04	1.4E-07
001F0601.D	0.5UL H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).				0.079	2.17E+04	
001F0701.D	0.5UL G0992 (0.89% HBR IN H2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MI DDLE.FILTER=S. INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).		0.5	0.00445	0.08	1.29E+05	4.1E-08
001F0801.D	0.5UL H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).				0.08	2.89E+04	
001F0901.D	0.5UL G0992 (0.89% HBR IN H2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MI DDLE.FILTER=S. INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).		0.5	0.00445	0.085	6.48E+04	1.2E-07
001F1001.D	0.5UL H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).				0.076	1.40E+04	
001F1101.D	500ML 14CSU006#5,S140411,19:45. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MI DDLE.FILTER=S. INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).	500			0.387	1.47E+04	3.0E-03
001F1301.D	0.5UL G0992 (0.89% HBR IN H2)+500ML 14CSU006#5,S140411,19:45. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S. INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).	500	0.5	0.00445	0.186	2.32E+04	Percent Spike Recovery of HBr @0.009 PPMV is 41%
001F1401.D	500ML 14CSU006#5,S140411,19:45. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MI DDLE.FILTER=S. INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).	500			0.143	5.10E+03	1.0E-03
001F1501.D	0.5UL H2. SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN. PUMP=MIDDLE.FILTER=S.INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).				0.083	7.75E+03	
001F1601.D	0.5UL G0992 (0.89% HBR IN H2). SOLVENT=N-PROPANOL,CF=20ML/MN,CF+MUF=100ML/MN.PUMP=MI DDLE.FILTER=S. INJT=100C.190CM SCOCC001 (0.53MM OD, 1.5UM DB-5).		0.5	0.00445	0.085	5.05E+04	1.0E-07