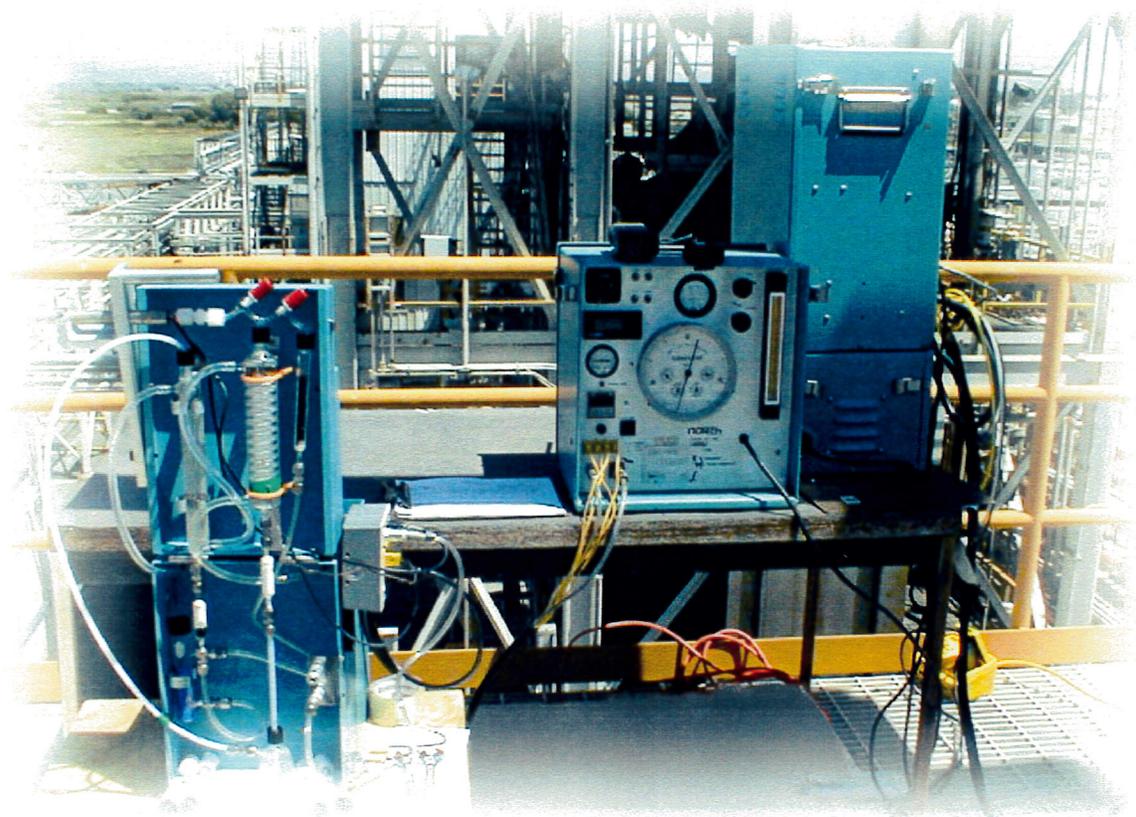


Trial Burn Report
for
THE DOW CHEMICAL COMPANY
Symtet Halogen Acid Furnace
VOLUME 1 OF 4: TEXT



Prepared for:
The Dow Chemical Company
Pittsburg Facility
End of Loveridge Road
Pittsburg, CA 94565

July 2000



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**TRIAL BURN REPORT
FOR
THE DOW CHEMICAL COMPANY
SYMTET HALOGEN ACID FURNACE**

Prepared for:

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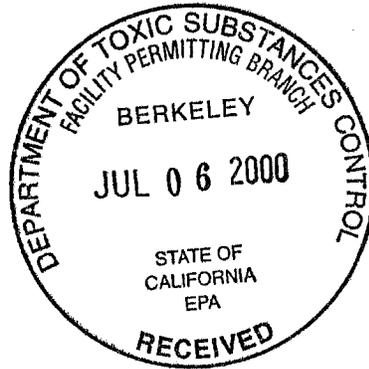


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ACRONYMS LIST

General Project Acronyms

acfm	Actual cubic feet per minute
As ₂ O ₃	Arsenic trioxide
ASTM	American Society for Testing Materials
BAAQMD	Bay Area Air Quality Management District
BIF	Boiler and Industrial Furnace
Btu/lb	British thermal units per pound
°C	Degrees Celsius
CARB	California Air Resources Board
CdS	Cadmium sulfide
CEM	Continuous emission monitor
CFR	Code of Federal Regulations
Cl	Chloride
Cl ₂	Chlorine
CO	Carbon Monoxide
CO ₂	Carbon Dioxide
Cr ⁺⁶	Hexavalent chromium
DI	Deionized
DMI	Dames and Moore, Inc.
DNPH	Dinitrophenylhydrazine
DRE	Destruction and removal efficiency
dscf	Dry standard cubic feet
dscfm	Dry standard cubic feet per minute
DTSC	Department of Toxic Substances Control
°F	Degrees Fahrenheit
Fe ₂ O ₃	Ferric oxide
FID	Flame ionization detection (detector)
g	Gram
g/hr	Gram per hour
GC	Gas chromatography
GC/MS	Gas chromatography/mas spectroscopy

ACRONYMS LIST (Continued)

General Project Acronyms

gr	Grain
gr/dscf	Grains per dry standard cubic feet
H ₂ O ₂	Hydrogen peroxide
H ₂ SO ₄	Sulfuric acid
HAF	Halogen Acid Furnace
HCl	Hydrogen chloride
HCl acid	Hydrochloric acid
HHV	Higher heating value
HNO ₃	Nitric acid
HpCDD	Heptachlorodibenzodioxin
HpCDF	Heptachlorodibenzofuran
HPLC	High performance liquid chromatography
HRA	Hourly rolling average
HRGC	High resolution gas chromatograph
HRMS	High resolution mass spectroscopy
HxCDD	Hexachlorodibenzodioxin
HxCDF	Hexachlorodibenzofuran
IC	Ion chromatography
ICAP (ICP)	Inductively coupled argon plasma
ID	Identification
kg	Kilogram
KOH	Potassium hydroxide
L	Liter
lb/hr	Pound per hour
LCS	Laboratory control sample
LCS/LCSD	Laboratory control sample/laboratory control sample duplicate
L/G	Liquid-to-gas
µg	Microgram
M	Molar
MEI	Maximum exposed individual

ACRONYMS LIST (Continued)

General Project Acronyms

MEK	Methyl ethyl ketone
mg	Milligram
mL	Milliliter
MQO	Measurement quality objective
MS	Manufacturing Services
MS/MSD	Matrix spike/matrix spike duplicate
N	Normal (normality)
NA	Not applicable
NaOH	Sodium hydroxide
Na ₂ SO ₃	Sodium thiosulfate
ND	Not detected
NDIR	Nondispersive infrared
ng	Nanogram
NiO	Nickel oxide
NO _x	Nitrogen oxide
NR	No result reported or able to be calculated
NS	Not specified or not sampled
NSCR	Non-selective catalytic reduction
O ₂	Oxygen
OCDD	Octachlorodibenzodioxin
OCDF	Octachlorodibenzofuran
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo-p-dioxin
PCDF	Polychlorinated dibenzofuran
PeCDD	Pentachlorodibenzodioxin
PeCDF	Pentachlorodibenzofuran
PIC	Product of incomplete combustion
POHC	Principle Organic Hazardous Constituent
ppm	Part per million

ACRONYMS LIST (Continued)

General Project Acronyms

ppmv	Part per million by volume
ppmw	Part per million by weight
psig	Pound per square inch gauge
QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
RAC	Reference air concentration
RCRA	Resource Conservation and Recovery Act
RPD	Relative percent difference
RSD	Relative standard deviation
SIM	Selective ion monitoring
SrCrO ₄	Strontium chromate
ST	Symtet
SVOC	Semivolatile organic compound
SW-846	Test Methods for Evaluating Solid Waste, U.S. EPA (3 rd Edition including current updates)
TCDD	Tetrachlorodibenzodioxin
TCDF	Tetrachloridibenzofuran
Total Cl	Total chlorine/chloride
THC	Total hydrocarbon
TICs	Tentatively identified compounds
U.S. EPA	United States Environmental Protection Agency
VOC	Volatile organic compound
VOST	Volatile Organic Sampling Train
wt %	Percent by weight

1.0 Introduction

The Dow Chemical Company (Dow) operates two Halogen Acid Furnaces (HAFs) at its Pittsburg, California, facility. These HAFs are classified as industrial furnaces and, therefore, must comply with the Resource Conservation and Recovery Act (RCRA) Boiler and Industrial Furnace (BIF) Rule. The Symtet (ST) HAF, presently operating under interim status, must demonstrate compliance with all applicable BIF Rule emission standards (40 Code of Federal Regulations [CFR] 266.104 through 266.107). The ST HAF operations have been regulated by a Bay Area Air Quality Management District (BAAQMD) permit since June 1980 and by the United States Environmental Protection Agency (U.S. EPA) since the BIF Rule became law. To demonstrate compliance with the applicable BIF Rule regulations, Dow submitted Certification of Compliance Test Reports on 21 August 1992, 17 August 1995, and 14 August 1998. The ST HAF is currently operating under the limitations identified in the 1998 Certification of Compliance Test Report.

In order to establish operating conditions for the ST HAF that meet the applicable BIF Rule regulations and to obtain a RCRA Part B operating permit, a Trial Burn Plan and Quality Assurance Project Plan (QAPP) were prepared and submitted to the Department of Toxic Substances Control (DTSC). These documents were approved by the regulatory agency in March 1999.

A trial burn, following the procedures described in these documents, was conducted in February and April 2000 to demonstrate that the ST HAF met the emission standards under the proposed trial burn operating conditions. The ST HAF was operated under three different conditions and samples were collected over three runs for each condition. This report presents the results of the ST HAF trial burn.

1.1 Process Description

The Dow Pittsburg site is located at the north end of Loveridge Road in Contra Costa County, California. Operations at this location include research, development, and the manufacture of products for agricultural operations, pest control services, paper manufacturers, carpet mills, and biocides.

The ST HAF has been in operation for nearly 20 years. During the manufacture of chemical products at the Pittsburg facility, specific liquid hazardous wastes are produced that are thermally oxidized in the HAF units; there are two HAFs on-site. In addition, the HAFs are used to abate tank and process vent emissions from manufacturing processes on the Pittsburg site. Aqueous hydrochloric acid (HCl acid) is produced as a result of oxidizing the chlorinated liquids and gas streams. The HCl acid is sold as a product to various industrial customers and is used for pH control at the Brine/Condensate Plant.

As indicated above, liquids and process vent gases from chemical production facilities on site are processed by the ST HAF. The liquid feed is introduced to the reactor through a single, atomizing spray nozzle into a natural gas flame at the top of the reactor. The feed stream is typically 85 percent (%) by weight chlorinated pyridine tars and 15% by weight ferric chloride. This feed stream may solidify at ambient temperatures, and is, therefore, maintained at a temperature between 140-195 degrees Celsius ($^{\circ}\text{C}$) to keep it in a liquid state. The reactor can be set up to oxidize an alternative feed stream of liquid chlorinated hydrocarbons. However, chlorinated pyridines are the only feeds expected to be treated at the ST HAF.

Combustion air is supplied to the reactor by a forced draft fan. Steam is supplied to increase the availability of hydrogen for the conversion of chlorine/chloride to HCl. The hot gas stream is then removed from the gas by an acid absorber to make product aqueous hydrochloric acid. The flue gas then enters a caustic scrubber. Dilute aqueous sodium hydroxide (NaOH) solution is circulated through the caustic scrubber to remove chlorine (Cl_2) and HCl remaining in the flue

gas. Removal of fine particulate matter is accomplished using a particulate scrubber. Finally, the flue gas is either discharged directly through the process stack or, alternatively, through a carbon adsorber and a nitrogen oxide (NO_x) reduction reactor before exhausting through the main stack to the atmosphere. The NO_x reactor uses non-selective catalytic reduction (NSCR) technology for NO_x removal. To control fugitive emissions, the combustion system is operated below atmospheric pressure.

1.2 General Information

Table 1-1 presents general facility information, including facility name, U.S. EPA identification number, contact person, telephone number, and address.

Table 1-1. General Facility Information

U.S. EPA Facility ID Number:	CAD 076528678
Facility Name:	The Dow Chemical Company, Pittsburg, CA
Contact Person, Title, and Telephone Number:	Marvin Louie, BIF Project Manager, (925) 432-5525
Facility Address:	The Dow Chemical Company End of Loveridge Road Pittsburg, CA 94565
Type of Boiler/Industrial Furnace:	Symtet Halogen Acid Furnace

1.3 Report Organization

This report summarizes the sampling and analytical procedures along with the results of the trial burn testing program. Results are reported for each run of the three operating conditions; average values over the condition are also included. The data presented are actual values and have not been blank corrected. The remainder of this report is organized as follows:

- ▶ Section 2.0 – Design of the Trial Burn,
- ▶ Section 3.0 – Sampling and Analytical Procedures;
- ▶ Section 4.0 – Results; and
- ▶ Section 5.0 – Quality Assurance/Quality Control.

In addition to this text volume, three separate volumes containing trial burn data and supporting documentation have been prepared as appendices to this report (i.e., the entire report consists of four volumes).

2.0 Design of the Trial Burn

The performance of the Symtet (ST) Halogen Acid Furnace (HAF) was demonstrated under three operating conditions as described in this section. Operating Condition 1 was designed to show compliance with the emission standards contained in 40 Code of Federal Regulations (CFR) 266.104 through 266.107 for emissions of particulate matter, hydrogen chloride (HCl), chlorine (Cl₂), and metals at the demonstrated operating limits. Conditions 1 and 2 were designed to show compliance with the organics emission standard contained in 40 CFR 266.104(a), which defines the required destruction and removal efficiency (DRE) for the selected Principal Organic Hazardous Constituent (POHC), and with the emission standard for carbon monoxide (CO) noted in 40 CFR 266.104(b). Condition 3 characterized the HAF emissions under normal operating parameters and demonstrated compliance with the CO standard.

In addition to demonstrating compliance with the emission standards noted above, the trial burn generated information for the health risk assessment on products of incomplete combustion (PICs). Under all operating conditions, PICs were identified and quantified in the stack gas emissions. PICs for this program included volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), dioxins and furans, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), and aldehydes.

2.1 Objectives

During the trial burn, the performance of the ST HAF was tested under three conditions that varied in a number of unit operating parameters (e.g., feed rate, combustion chamber temperature, etc.). Three test runs were conducted under each operating condition and quality control samples were collected. The objective of the trial burn was to demonstrate compliance with the applicable performance standards while operating the ST HAF under different conditions.

The trial burn was conducted to demonstrate that the ST HAF was capable of meeting the following emission standards under the proposed operating conditions:

- ▶ Particulate matter emissions will not exceed 0.08 grains per dry standard cubic foot (gr/dscf) corrected to 7% oxygen in the stack gas;
- ▶ CO concentration in the stack gas, corrected to 7% oxygen on a dry basis, will not exceed 100 parts per million by volume (ppmv) on an hourly rolling average (HRA);
- ▶ A 99.99% DRE will be met for the POHC;
- ▶ Emission limits for metals will be based on modeled impacts to a hypothetical maximum exposed individual (MEI) and calculated public health impacts at that location; and
- ▶ HCl and Cl₂ emission limits will be based on modeled impacts to the hypothetical MEI and Boiler and Industrial Furnace (BIF) Rule Reference Air Concentrations (RACs).

In addition to demonstrating compliance with these emission standards, the trial burn also identified and quantified the PICs in the stack gas and provided information on the potential operational limits for a number of parameters (e.g., maximum feed rate of metals, minimum combustion chamber temperature, etc.). The trial burn defined the worst-case operating conditions for the ST HAF and demonstrated that the unit met these emission standards for a range of operating conditions. Several operating parameters recorded during the different operating conditions will be established as permit conditions in the RCRA operating permit for the ST HAF.

2.2 Trial Burn Operating Conditions

The following subsections describe objectives and considerations used to define the three operating conditions.

2.2.1 Condition 1 — Maximum Combustion Chamber Temperature

Under Condition 1, the feed, chlorine/chloride, Tier III metals, and ash inputs were maximized, while the sodium hydroxide (NaOH) scrubber pH, NaOH and particulate scrubber

liquid-to-gas (L/G) ratios, and scrubber blowdown rates were minimized. Stack gas samples were collected and analyzed for particulate matter, HCl/Cl₂, metals, hexavalent chromium, POHC (1,2-dichlorobenzene), PICs (including VOCs, SVOCs, dioxins/furans, PCBs, PAHs, and aldehydes), total hydrocarbons (THC), CO, oxygen (O₂), and carbon dioxide (CO₂).

The objectives of this test condition were to:

- ▶ Maximize combustion chamber temperature, pumpable feed, ash, and total Cl feed rates while minimizing scrubber pH, L/G ratios, and blowdowns;
- ▶ Confirm the proposed limits for the Tier III metal feed rates;
- ▶ Demonstrate compliance with the requirement for 99.99% DRE for the POHC (1,2-dichlorobenzene);
- ▶ Demonstrate compliance with the emission limits for particulate matter, HCl/Cl₂, and CO;
- ▶ Set limits for maximum operating temperature, pumpable feed, ash, and total Cl feed rates, along with NaOH scrubber minimum pH, NaOH and particulate scrubber L/G ratios, and scrubber blowdowns; and
- ▶ Identify and quantify PIC emissions.

The proposed and actual process values for Condition 1 of the trial burn are presented in Table 2-1.

2.2.2 Condition 2 — Minimum Combustion Chamber Temperature

Condition 2 was designed to demonstrate compliance with the DRE and CO performance standards while operating the ST HAF at the minimum combustion chamber temperature. To achieve this condition, the feed rate was reduced in order to lower the heat input to the system to reach the desired minimum combustion chamber temperature while the quench steam and combustion air were maximized. In addition, to generate information for the health risk assessment evaluation, typical feed was treated under operating conditions that were intended to minimize combustion efficiency (e.g., run at minimum combustion chamber temperature). Stack gas samples were collected and analyzed for the POHC (1,2-dichlorobenzene), PICs (including VOCs, SVOCs, dioxins/furans, PCBs, PAHs, and aldehydes), THC, CO, O₂, and CO₂ during Condition 2.

Table 2-1. Condition 1 Process Parameters

Process Parameters	Proposed Values ^a		Trial Burn Values-Run 1	Trial Burn Values-Run 2	Trial Burn Values-Run 3	Average	Working Units	Notes
Process Unit Inputs								
Waste/Spike Feed Total Mass	650	lb/hr	586	587	572	582	lb/hr	a,b
Waste/Spike Feed Total Heat Content	2.6	MMBtu/hr	2.2	1.9	1.9	2.0	calculated	a
Natural Gas Total	0.38	MMBtu/hr	0.33	0.35	0.34	0.34	scfh	c
Steam Flow Rate	150	lb/hr	60	51	60	57	lb/hr	c
Combustion Air Flow Rate	425	scfm	478	464	456	465	scfm	c
Stack Gas Flow Rate	—	scfm	490	476	457	474	scfm	c
Combustion Temperature	1,400	°C	1,356	1,363	1,360	1,360	°C	a
Cl Feed Total	900	lb/hr	1,032	1,015	1,023	1,023	calculated	a,d
Dichlorobenzene (POHC)	29.2	lb/hr	29.5	29.6	29.9	29.7	calculated	c,e
Arsenic	0.0027	lb/hr	0.0016	0.0016	0.0015	0.0016	calculated	c,e
Cadmium	0.019	lb/hr	0.016	0.018	0.015	0.015	calculated	c,e
Hexavalent Chromium	0.22	lb/hr	0.17	0.17	0.16	0.17	calculated	c,e
Nickel	0.88	lb/hr	0.55	0.56	0.52	0.54	calculated	c,e
Ash Total	65	lb/hr	63	62	62	62	calculated	c
Air Pollution Control Parameters								
Anhydrous HCl Production	900	lb/hr	1,032	1,015	1,023	1,023	calculated	a
NaOH Scrubber pH	7.4	pH	7.4	7.2	7.4	7.3	pH	a
NaOH Scrubber L/G	55	gal/1,000 scf	79	67	72	73	calculated	a
NaOH Scrubber Blowdown	100	lb/hr	762	235	93	363	lb/hr	a
Maximum Flue Gas Temperature Entering X-505	140	°F	113	113	118	115	°F	a
X-505 PM Scrubber L/G	20	gal/1,000 scf	26	25	27	26	calculated	a
X-505 PM Scrubber Blowdown	200	lb/hr	195	195	197	196	lb/hr	a
Stack CO (HRA @ 7% O ₂)	<100	ppmv	66	94	55	72	ppmv	a

^a Hourly rolling average (HRA). Values listed as "average" are the averages of the three highest (feed, HCl, metals, ash, combustion temperature, scrubber temperature, and CO) or lowest (other scrubber parameters) HRA values from each of the runs of this condition.

^b Feed for Condition 1 was 90% Symtet tar spiked with 2% ash/metals spike (ash and metals dispersed in ethylene glycol), 3% ash dispersion (ash dispersed in ethylene glycol), and 5% POHC (1,2-dichlorobenzene).

^c Average value over the run. For spiked materials, the average and the HRA are the same value.

^d Total Cl feed limit to be increased to 1,000 lb/hr from the current level of 700 lb/hr. The production rate of HCl acid is assumed to be equal to the raw material (Cl) feed rate.

^e Feed rate for these materials were computed from laboratory analysis of the spiking materials and feed and averaged monitored mass flow over the duration of the test.

The objectives of Condition 2 were to:

- ▶ Minimize the combustion chamber temperature to the lowest values required to maintain adequate DRE;
- ▶ Create a worst-case combustion scenario intended to maximize the generation of PICs using typical waste feed constituents;
- ▶ Identify and quantify PIC emissions;
- ▶ Demonstrate compliance with the requirement for 99.99% DRE for the POHC (1,2-dichlorobenzene) at the proposed minimum temperature condition; and
- ▶ Demonstrate compliance with the CO emission limit.

The proposed and actual process values for Condition 2 are shown in Table 2-2.

2.2.3 Condition 3 — Normal Operating Parameters

Condition 3 was designed to simulate normal ST HAF operating conditions and generate information for the health risk assessment evaluation on emissions during typical unit operations. Feed rates, operating temperature, and scrubber parameters were set at typical or normal operating values. Stack gas samples were collected and analyzed for particulate matter, HCl/Cl₂, metals, hexavalent chromium, PICs (including VOCs, SVOCs, dioxins/furans, PCBs, PAHs, and aldehydes), THC, CO, O₂, and CO₂ during Condition 3.

Because the total Cl feed is not required to be maintained at a specified level during Condition 3, the vent streams treated in the ST HAF during Condition 3 were the vent streams fed during typical unit operation.

The objectives of this condition were to:

- ▶ Simulate typical operating conditions including typical waste and vent feed compositions and feed rates, operating temperature, and scrubber parameters;
- ▶ Determine emissions under typical or normal operating conditions;

Table 2-2. Condition 2 Process Parameters

Process Parameters	Proposed Values ^a		Trial Burn Values-Run 1	Trial Burn Values-Run 2	Trial Burn Values-Run 3	Average	Working Units	Notes
Process Unit Inputs								
Waste/Spike Feed Total Mass	115	lb/hr	142	146	156	148	lb/hr	a
Waste/Spike Feed Total Heat Content	0.5	MMBtu/hr	0.57	0.57	0.60	0.58	calculated	a
Natural Gas Total	0.5	MMBtu/hr	0.33	0.33	0.35	0.34	scfm	a
Steam Flow Rate	250	lb/hr	160	160	160	160	lb/hr	a
Combustion Air Flow Rate	250	scfm	327	324	328	326	scfm	a
Stack Gas Flow Rate	—	scfm	308	359	367	345	scfm	a
Combustion Temperature	1,000	°C	1,015	1,026	1,016	1,019	°C	a
Cl Feed Total	210	lb/hr	308	359	367	345	calculated	a
Dichlorobenzene (POHC)	20	lb/hr	20.2	15.0	15.0	16.7	calculated	a,d
Ash Total	—	lb/hr	13.0	13.8	14.6	13.8	lb/hr	a,b
Air Pollution Control Parameters								
Anhydrous HCl Production	210	lb/hr	308	359	367	345	calculated	a
NaOH Scrubber pH	8.1	pH	7.9	8.0	7.9	7.9	pH	a
NaOH Scrubber L/G	80	gal/1,000 scf	118	112	124	118	calculated	a
NaOH Scrubber Blowdown	600	lb/hr	935	763	653	784	lb/hr	a
Maximum Flue Gas Temperature Entering X-505	105	°F	81	79	81	80	°F	a
X-505 PM Scrubber L/G	35	gal/1,000 scf	36	34	74	48	calculated	a
X-505 PM Scrubber Blowdown	1,400	lb/hr	1,507	1,718	1,590	1,605	lb/hr	a
Stack CO (HRA @ 7% O ₂)	<100	ppmv	9	11	11	10	ppmv	c

^a Average value over the run. The average and the HRA are the same value for the POHC.

^b No metals or ash were spiked during this condition.

^c Hourly rolling average (HRA). Values listed are the highest HRA values from the higher of the two CO monitors.

^d Feed rate for the POHC was computed from laboratory analysis of the feed and spike, and the averaged monitored mass flows over the duration of the test.

- ▶ Identify and quantify PIC emissions; and
- ▶ Demonstrate compliance with the CO emission limit.

The proposed and actual process values for Condition 3 are presented in Table 2-3.

Table 2-3. Condition 3 Process Parameters

Process Parameters	Proposed Values ^a		Trial Burn Values-Run 1	Trial Burn Values-Run 2	Trial Burn Values-Run 3	Average	Working Units	Notes
Process Unit Inputs								
Waste/Spike Feed Total Mass	330	lb/hr	321	319	330	323	lb/hr	a
Waste/Spike Feed Total Heat Content	1.1	MMBtu/hr	1.1	1.1	1.1	1.1	calculated	a
Natural Gas Total	0.4	MMBtu/hr	0.29	0.29	0.32	0.30	scfh	a
Steam Flow Rate	200	lb/hr	238	240	240	239	lb/hr	a
Combustion Air Flow Rate	330	scfm	311	304	307	307	scfm	a
Stack Gas Flow Rate	—	scfm	395	347	325	342	scfm	a
Combustion Temperature	1,200	°C	1,291	1,292	1,243	1,275	°C	a
Cl Feed Total	400	lb/hr	479	449	472	467	calculated	a
Ash Feed Total	35	lb/hr	37	35	37	36	calculated	a,b
Dichlorobenzene (POHC)	0.00	lb/hr	-	-	-	-	calculated	a,b
Arsenic	0.00	lb/hr	0.00024	0.00019	0.00000	0.00014	calculated	a,b
Cadmium	0.00	lb/hr	-	-	-	-	calculated	a,b
Hexavalent Chromium	0.00	lb/hr	0.011	0.011	0.012	0.011	calculated	a,b
Nickel	0.00	lb/hr	0.018	0.019	0.020	0.019	calculated	a,b
Ash Total	—	lb/hr	36.8	35.1	37.3	36.4	lb/hr	a,b
Air Pollution Control Parameters								
Anhydrous HCl Production	400	lb/hr	477	449	474	467	calculated	a
NaOH Scrubber pH	8.1	pH	8.1	8.3	8.1	8.2	pH	a
NaOH Scrubber L/G	80	gal/1,000 scf	130	142	138	137	calculated	a
NaOH Scrubber Blowdown	600	lb/hr	533	497	630	553	lb/hr	a
Maximum Flue Gas Temperature Entering X-505	105	°F	92	91	80	88	°F	a
X-505 PM Scrubber L/G	35	gal/1,000 scf	63	69	68	67	calculated	a
X-505 PM Scrubber Blowdown	1,400	lb/hr	1,775	1,709	1,543	1,676	lb/hr	a
Stack CO (HRA @ 7% O ₂)	<100	ppmv	19	18	17	18	ppmv	c

^a The values shown in this table are average values over the duration of the run. These values were defined for this condition based on typical operating conditions for this unit. The purpose of this condition is to examine products of combustion under typical conditions. No operating limits will be established based on Condition 3 results.

^b No metals or ash were spiked during this condition. Feed rates for these materials were computed from laboratory analysis of the feed and averaged monitored mass flow over the duration of the test.

^c Hourly rolling average (HRA). Values listed are the highest HRA values from the higher of the two CO monitors.

3.0 Sampling and Analytical Procedures

During the trial burn, Dow personnel were responsible for operating the Symtet (ST) Halogen Acid Furnace (HAF) under the three defined operating conditions over the testing period. These operating conditions were briefly described in Section 2.0 of this report. Process and stack gas samples were collected at the ST HAF once steady state operations were achieved. The sampling and analytical matrices, which indicate the parameters measured during the three operating conditions, are presented in Tables 3-1, 3-2, and 3-3. Three runs were performed for each condition during the trial burn in order to provide data for demonstrating compliance with the emission standards and to determine operational limits for the unit.

The schematic diagram of the ST HAF presented in Figure 3-1 identifies the sampling locations used during the trial burn. Samples were collected to determine the concentration of target analytes in the various process streams and to characterize the emissions from the ST HAF. In addition to the collection and analysis of samples, plant instrumentation was used to continuously monitor and record several stack gas and process parameters. Recorded process values and analytical results for the trial burn samples and instrumentation are presented in Sections 2.0 and 4.0, respectively. The following sections describe the sampling and analytical procedures for the process and stack gas samples.

3.1 Process Samples

Process liquid samples (spiking mixtures, feed, scrubber effluent, and hydrochloric acid [HCl acid] product) were collected during each of the trial burn runs (as indicated in Tables 3-1 through 3-3) by Dow technicians and composited over the sampling period for analysis. The composite containers were large enough to accommodate all grab samples collected for each type of liquid over the entire test run. Samples for most parameters were collected in duplicate (i.e., there were numerous backup samples of each process stream available for analysis in case of breakage, etc.). Quality control (QC) samples (e.g., field duplicate samples, were also

Table 3-1. Sampling and Analytical Matrix for Condition 1

Stream	Parameter	Sampling Method	Collection Frequency (per run)	Analytical Method	Laboratory
POHC Spiking Mixture	1,2-Dichlorobenzene	Tap (Method 004)	Three grab samples per run; composite sample for analysis.	Certificate of Analysis or Method 8270C	Radian ^a
Metals and Ash Spiking Mixtures	Arsenic, Cadmium, Chromium, Nickel, Ash	Tap (Method 004)	Three grab samples per run; composite sample for analysis.	Certificate of Analysis or Method 6010B ^b ASTM D482	Radian Timpview
Feed ^c	Total Cl ^d Metals ^e SVOCs ^f Ultimate Analysis ^g Higher Heating Value	Tap (Method 004)	Grab sample every 30 minutes; composite sample for analysis.	Methods 5050/9252 Method 6010B Method 8270C ASTM D3176/D482/D5373 ASTM D1989	Timpview Radian Radian Timpview/Dow Timpview
Vent Stream	Total Cl ^d	Stainless Steel Container	One grab sample per run.	Volumetric	Dow
Scrubber Effluent	Total Cl ^d Metals ^e SVOCs ^f	Tap (Method 004)	Grab sample every 30 minutes; composite sample for analysis.	Method 300.0 Method 6010B Method 8270C	Radian Radian Radian
HCl Acid Product	Chloride Metals ^e SVOCs ^f	Tap (Method 004)	Grab sample every 30 minutes; composite sample for analysis.	Method 300.0 Method 6010B Method 8270C	Radian Radian Radian
Stack Gas	Particulate Matter HCl/Cl ₂ Metals Hexavalent Chromium VOCs ^f + top 25 TICs SVOCs + top 25 TICs	Method 5 Method 0050 Method 0060 Method 0061 Method 0030 (VOST) Method 0010	2-hour integrated composite. 2-hour integrated composite. 1 hour integrated composite. 1 hour integrated composite. 20 minutes per pair; 6 pairs per run. 3-hour integrated composite.	Gravimetric Method 9057 Method 6010B Method 7199 Methods 5041A/8260B Method 8270C	Radian Radian Radian Radian Air Toxics Alta/Radian

Table 3-1 (Continued)

Stream	Parameter	Sampling Method	Collection Frequency (per run)	Analytical Method	Laboratory
Stack gas (cont.)	Dioxins/Furans	Method 23	3-hour integrated composite.	Method 8290	Alta
	PCBs	Method 0010	3-hour integrated composite.	Modified Method 680	Alta
	PAHs	Method 0010	3-hour integrated composite.	CARB 429	Alta
	Aldehydes	Method 0011	2-hour integrated composite.	Method 0011	Air Toxics
	THC	Method 25A	Continuous.	Flame ionization detection (FID)	DMI
	CO	Method 10	Continuous.	Nondispersive infrared detection (NDIR)	Dow
	O ₂	Method 3A	Continuous.	Paramagnetic	Dow
	CO ₂	Method 3	Integrated composite.	Absorption	Field measurement

^a Samples were analyzed by Radian's Analytical Reference Material Laboratory. Except for the POHC spiking mixture samples, all other samples were analyzed by the Radian laboratory that was bought by Severn Trent Laboratories in November 1999.

^b Method was adapted for high level (i.e., percent level) concentrations.

^c The feed consisted of chlorinated pyridine streams.

^d Total Cl is total chlorine/chloride.

^e Metals included arsenic, cadmium, chromium, and nickel.

^f Included analysis for the POHC (1,2-dichlorobenzene).

^g Ultimate analysis included carbon, hydrogen, oxygen, nitrogen, sulfur, and ash on a percent by weight basis. Oxygen was determined by difference.

ASTM = American Society for Testing Materials

CARB = California Air Resources Board

CO = Carbon monoxide

CO₂ = Carbon dioxide

DMI = Dames and Moore, Inc.

FID = Flame ionization detection

HCl/Cl₂ = Hydrogen chloride/chlorine

NDIR = Nondispersive infrared

O₂ = Oxygen

PAHs = Polycyclic aromatic hydrocarbons

PCBs = Polychlorinated biphenyls

POHC = Principal Organic Hazardous Constituent

SVOCs = Semivolatile organic compounds

THC = Total hydrocarbon

TICs = Tentatively identified compounds

VOCs = Volatile organic compounds

VOST = Volatile Organic Sampling Train

Table 3-2. Sampling and Analytical Matrix for Condition 2

Stream	Parameter	Sampling Method	Collection Frequency (per run)	Analytical Method	Laboratory
POHC Spiking Mixture	1,2-Dichlorobenzene	Tap (Method 004)	Two grab samples per run; composite sample for analysis.	Certificate of Analysis or Method 8270C	Radian ^a
Feed ^b	Total Cl ^c SVOCs Ultimate Analysis ^d Higher Heating Value	Tap (Method 004)	Grab sample every 30 minutes; composite sample for analysis.	Methods 5050/9252 Method 8260B ASTM D3176/D482/D5373 ASTM D1989	Timpview Timpview Timpview/Dow Timpview
Vent Stream	Total Cl ^c	Stainless Steel Container	One grab sample per run.	Volumetric	Dow
Scrubber Effluent	Total Cl ^c SVOCs ^e	Tap (Method S004)	Grab sample every 30 minutes; composite sample for analysis.	Method 300.0 Method 8270C	Radian Radian
HCl Acid Product	Chloride SVOCs ^e	Tap (Method S004)	Grab sample every 30 minutes; composite sample for analysis.	Method 300.0 Method 8270C	Radian Radian
Stack Gas	VOCs + top 25 TICs SVOCs + top 25 TICs Dioxins/Furans PCBs PAHs Aldehydes	Method 0030 (VOST) Method 0010 Method 23 Method 0010 Method 0010 Method 0011	20 minutes per pair; up to 6 pairs per run. 3-hour integrated composite. 3-hour integrated composite. 3-hour integrated composite. 3-hour integrated composite. 2-hour integrated composite.	Methods 5041A/8260B Method 8270C Method 8290 Modified Method 680 CARB 429 Method 0011	Air Toxics Alta/Radian Alta Alta Alta Air Toxics

Table 3-2 (Continued)

Stream	Parameter	Sampling Method	Collection Frequency (per run)	Analytical Method	Laboratory
Stack Gas (cont.)	THC	Method 25A	Continuous.	FID	DMI
	CO	Method 10	Continuous.	NDIR	Dow
	O ₂	Method 3A	Continuous.	Paramagnetic	Dow
	CO ₂	Method 3	Integrated composite.	Absorption	Field measurement

^a Samples were analyzed by Radian's Analytical Reference Material Laboratory. Except for the POHC spiking mixture samples, all other samples were analyzed by the Radian laboratory that was bought by Severn Trent Laboratories in November 1999.

^b The feed consisted of chlorinated pyridine streams.

^c Total Cl is total chlorine/chloride.

^d Ultimate analysis included carbon, hydrogen, oxygen, nitrogen, sulfur, and ash on a percent by weight basis. Oxygen was determined by difference.

^e Sample was analyzed for the POHC (1,2-dichlorobenzene).

ASTM = American Society for Testing Materials

CARB = California Air Resources Board

CO = Carbon monoxide

CO₂ = Carbon dioxide

DMI = Dames and Moore, Inc.

FID = Flame ionization detection

HCl/Cl₂ = Hydrogen chloride/chlorine

NDIR = Nondispersive infrared

O₂ = Oxygen

PAHs = Polycyclic aromatic hydrocarbons

PCBs = Polychlorinated biphenyls

POHC = Principal Organic Hazardous Constituent

SVOCs = Semivolatile organic compounds

THC = Total hydrocarbon

TICs = Tentatively identified compounds

VOCs = Volatile organic compounds

VOST = Volatile Organic Sampling Train

Table 3-3. Sampling and Analytical Matrix for Condition 3

Stream	Parameter	Sampling Method	Collection Frequency (per run)	Analytical Method	Laboratory
Feed ^a	Total Cl ^b	Tap (Method 004)	Grab sample every 30 minutes; composite sample for analysis.	Methods 5050/9252	Timpview
	Metals ^c			Method 6010B	Radian ^d
	SVOCs			Method 8270C	Radian
	Ultimate Analysis ^e			ASTM D3176/D482/D5373	Timpview/Dow
	Higher Heating Value			ASTM D1989	Timpview
Scrubber Effluent	Total Cl ^b	Tap (Method 004)	Grab sample every 30 minutes; composite sample for analysis.	Method 300.0	Radian
	Metals ^c			Methods 6010B	Radian
	SVOCs			Method 8270C	Radian
HCl Acid Product	Chloride	Tap (Method 004)	Grab sample every 30 minutes; composite sample for analysis.	Method 300.0	Radian
	Metals ^c			Methods 6010B	Radian
	SVOCs			Method 8270C	Radian
Stack Gas	Particulate Matter	Method 5	2-hour integrated composite.	Gravimetric	Radian
	HCl/Cl ₂	Method 0050	2-hour integrated composite.	Method 9057	Radian
	Metals ^c	Method 0060	1-hour integrated composite.	Methods 6010B	Radian
	Hexavalent Chromium	Method 0061	1-hour integrated composite.	Method 7199	Radian
	VOCs + top 25 TICs	Method 0030 (VOST)	20 minutes per pair; up to six pairs per run.	Methods 5041A/8260B	Air Toxics
	SVOCs + top 25 TICs	Method 0010	2-hour integrated composite.	Method 8270C	Alta/Radian
	Dioxins/Furans	Method 23	3-hour integrated composite.	Method 8290	Alta
	PCBs	Method 0010	3-hour integrated composite.	Modified Method 680	Alta
	PAHs	Method 0010	3-hour integrated composite.	CARB 429	Alta
Aldehydes	Method 0011	2-hour integrated composite.	Method 0011	Air Toxics	

Table 3-3 (Continued)

Stream	Parameter	Sampling Method	Collection Frequency (per run)	Analytical Method	Laboratory
Stack Gas (cont.)	THC	Method 25A	Continuous.	FID	DMI
	CO	Method 10	Continuous.	NDIR	Dow
	O ₂	Method 3A	Continuous.	Paramagnetic	Dow
	CO ₂	Method 3	Integrated composite.	Absorption	Field measurement

^a The feed consisted of chlorinated pyridine streams.

^b Total Cl is total chlorine/chloride.

^c Metals included arsenic, cadmium, chromium, and nickel.

^d Samples were analyzed by the Radian laboratory that was bought by Severn Trent Laboratories in November 1999

^e Ultimate analysis included carbon, hydrogen, oxygen, nitrogen, sulfur, and ash on a percent by weight basis. Oxygen was determined by difference.

ASTM = American Society for Testing Materials

CARB = California Air Resources Board

CO = Carbon monoxide

CO₂ = Carbon dioxide

DMI = Dames and Moore, Inc.

FID = Flame ionization detection

HCl/Cl₂ = Hydrogen chloride/chlorine

NDIR = Nondispersive infrared

O₂ = Oxygen

PAHs = Polycyclic aromatic hydrocarbons

PCBs = Polychlorinated biphenyls

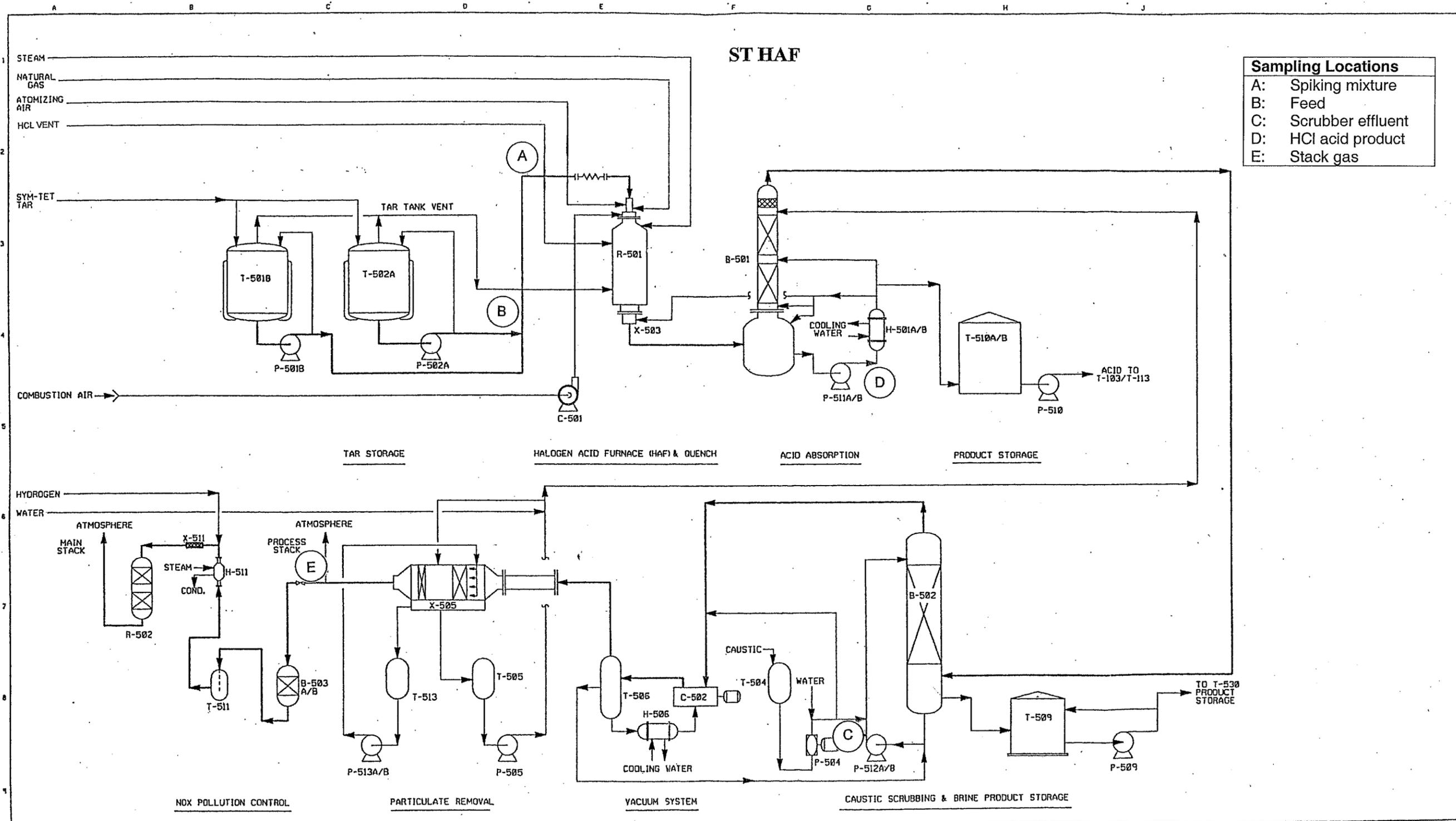
POHC = Principal Organic Hazardous Constituent

SVOC = Semivolatile organic compound

THC = Total hydrocarbon

TICs = Tentatively identified compounds

VOCs = Volatile organic compounds



Sampling Locations	
A:	Spiking mixture
B:	Feed
C:	Scrubber effluent
D:	HCl acid product
E:	Stack gas

Figure 3-1. Process Sampling Locations

REVISION		REVISION		DRAWING ISSUE RECORD				DESIGNED		CHECKED		APPROVED		PROJECT		PLANT NO.		THE DOW CHEMICAL COMPANY			
NO.	DATE	BY	CHK	APP	DATE	NO.	DATE	BY	CHK	APP	DATE	NO.	DATE	NO.	DATE	NO.	DATE	NO.	DATE	NO.	DATE
A		RA	CJ	CJ	9/94																

collected during the trial burn for each stream. Results of the QC sample analyses and the impact to the trial burn data are presented in Section 5.0.

3.1.1 Principal Organic Hazardous Constituent Spiking Mixture

The feed to the ST HAF was spiked with the Principal Organic Hazardous Constituent (POHC) during Conditions 1 and 2 of the trial burn. The POHC for this trial burn was 1,2-dichlorobenzene. The POHC solution was introduced to the feed stream between the feed pumps and the thermal reactor (see Figure 3-1) at a rate of approximately 5% by weight of total liquid feed; the POHC was fed during the startup period to establish a steady state flow at the required feed rate. The feed line that delivered feed from tanks T-501B and T-502A to the ST HAF was equipped with a valve where the POHC was introduced. A steam-traced feed line was used to preheat the POHC before it was blended with the feed. A positive displacement metering pump was used to inject the spiking mixture into the feed stream at a constant flow rate.

Grab samples of the POHC liquid were collected at the beginning, middle, and end of each test run. The three grab samples collected during each run were composited in the field prior to analysis. The concentration of the POHC in the spiking mixture was determined by gas chromatography (GC)/mass spectrometry (MS). Analyses were performed in triplicate and density measurements were made on each sample to correlate mass to volume. Results of the spiking material analyses are discussed in Section 4.0.

3.1.2 Ash and Metals Spiking Mixtures

The ash and metals inputs to the ST HAF during Condition 1 (maximum combustion chamber temperature) of the trial burn were supplemented by spiking the feed with dispersions of finely ground metal compounds in an ethylene glycol mixture. The spiking mixtures were injected into the top of the HAF through an air-assisted feed lance which was positioned

along-side the feed gun. Two separate spiking mixtures were used so that the ash and metals spiking rates could be refined based on the ash and metals content of the feed on the day of testing.

The Tier III metals spiking mixture (arsenic, cadmium, chromium, and nickel) fed to the ST HAF during the trial burn was formulated with metal compounds suspended in an ethylene glycol matrix to yield the following theoretical composition:

- ▶ ~54,000 parts per million by weight (ppmw) strontium chromate (SrCrO_4) for a total hexavalent chromium (Cr^{+6}) feed rate of 90 grams per hour (g/hr);
- ▶ ~1,400 ppmw cadmium sulfide (CdS) for a total cadmium feed rate of 7.3 g/hr;
- ▶ ~240 ppmw arsenic trioxide (As_2O_3) for a total arsenic feed rate of 1.2 g/hr;
- ▶ ~66,000 ppmw of nickel oxide (NiO) for a total nickel feed rate of 340 g/hr; and
- ▶ ~200,000 ppmw of ferric oxide (Fe_2O_3) for a total ash feed rate of 1,250 g/hr.

In addition to the ash added as part of the metals spiking mixture, a separate ash spiking mixture was used. The ash spiking mixture was formulated with 320,000 ppm Fe_2O_3 spiked at a rate such that total ash feed to the system was approximately 65 pounds per hour (lb/hr). Positive displacement pumps were used to inject the spiking mixtures into the HAF at a constant flow rate. The spiking mixtures were fed during the startup period to establish a steady state flow at the required feed rate.

Grab samples of the ash and metals spiking mixtures were collected at the beginning, middle, and end of each run. The three grab samples collected during each run were composited for analysis prior to submittal to the laboratory. The composite sample was analyzed for arsenic, cadmium, chromium, and nickel by inductively coupled argon plasma (ICAP) spectroscopy (Method 6010B); the metals and ash spiking mixtures were analyzed for ash by

American Society for Testing Materials (ASTM) Method D482. The concentrations of arsenic, cadmium, chromium, nickel, and ash used in calculations were based on the analysis of actual spiking mixture samples collected during the trial burn. These results are presented in Section 4.0.

3.1.3 Feed

The ST HAF treats chlorinated pyridine waste streams that are by-products from the production of intermediate commercial chloropyridine compounds. For Condition 1, the maximum combustion chamber temperature condition, the feed was 90% by weight chlorinated pyridine waste and 5% 1,2-dichlorobenzene (the POHC). The feed was spiked with the POHC to demonstrate compliance with the DRE performance standard under maximum feed conditions. The ash and metals spiking mixtures, along with the anhydrous HCl vent stream, were also fed to the unit during Condition 1. Results of the actual feed composition are provided in Section 4.0.

For Condition 2, the minimum combustion chamber temperature condition, the chlorinated pyridine feed was spiked with approximately 15% by weight 1,2-dichlorobenzene. A lower feed rate combined with higher combustion air and steam injection rates were used to suppress the temperature in the combustion chamber. The anhydrous HCl vent stream was also fed to the unit during Condition 2.

For Condition 3, the typical operating parameter condition, the feed consisted of only the chlorinated pyridine waste streams. There were no POHCs, metals, or ash spiked during this condition and normal process vent streams were treated in the unit.

During all runs, the chlorinated pyridine stream was sampled from the feed line on the discharge side of the feed tank pumps. This sampling location is designated as point B on Figure 3-1. The sample was collected by a Dow technician from a tap. The feed was maintained at a temperature around 195°C to remain molten in the line. Every 30 minutes, a grab sample was

collected from the tap and transferred to a composite container placed in a heated sand bath. Once the sample was obtained, the sample tap was closed and sample information was recorded on a data sheet. At the conclusion of each test run, subsamples were taken from the composite sample and sent to the lab to be analyzed for total chlorine/chloride (total Cl), metals (Conditions 1 and 3), semivolatile organic compounds (SVOCs), ash, ultimate analysis, and higher heating value.

Feed samples collected during Conditions 1 and 3 were analyzed for metals according to Method 6010B (ICAP). These samples were digested with nitric acid (HNO₃), nebulized, and the resulting aerosol transported to the plasma torch. Element-specific emission spectra were produced by a radio frequency inductively coupled plasma. The spectra were dispersed by a grating spectrometer, and the intensities of the emission lines were monitored by photosensitive devices.

Concentrations of SVOCs, including dichlorobenzene, were determined according to Method 8270C (GC/MS). Identification of target analytes was accomplished by comparing the mass spectra of the samples to that of the standards.

Samples of the feed were analyzed for ultimate analysis and higher heating value according to standard ASTM Methods D3176/D482/D5373 and D1989, respectively. Ultimate analysis included the determination of carbon, hydrogen, nitrogen, sulfur, and ash on an as-received weight basis. Oxygen was determined by differential measurement (i.e., not by direct measurement).

3.1.4 Vent Stream

The total Cl feed to the ST HAF during the trial burn was supplemented by a vent stream of anhydrous HCl during Conditions 1 and 2. No other vent streams were fed to the unit during testing under Conditions 1 or 2. For Condition 1, the flow of the vent stream was adjusted to bring the total Cl feed up to the proposed limit of approximately 900 lb/hr. The anhydrous HCl

vent stream flow during Condition 2 was consistent with typical vent stream flows. The anhydrous HCl vent stream was fed to the ST HAF combustion chamber (see Figure 3-1) using the same connections and feed mechanism as used for normal vent gas processing. The flow rate of HCl to the combustion chamber was monitored by an orifice flowmeter. Normal process vents were treated in the ST HAF during Condition 3; the anhydrous HCl vent stream was not used during Condition 3.

Sampling of the anhydrous HCl vent stream was done once during each test run to determine the Cl content of the gas. Samples were collected by a Dow technician in stainless steel containers that were flushed with nitrogen and evacuated. Samples were collected from the sample port in the HCl vent header (header pressure is approximately 60 pounds per square inch gauge [psig]). The sample container was taken to a fume hood in the Dow lab where the HCl was transferred to a 3-liter Tedlar[®] bag. A 400 milliliter (mL) sample was drawn and the Cl content of the sample was determined volumetrically.

3.1.5 Scrubber Effluent

The scrubber effluent samples were collected from the sampling box at the discharge of pump P-512, scrubber column B-502 recycle pump (point C in Figure 3-1) by a Dow technician. A grab sample of the scrubber effluent was collected from a sample tap mounted on the scrubber recycle line every 30 minutes during testing and placed into a composite container. At the completion of each run, subsamples were collected from the composite sample and sent to the lab for analysis of total Cl, SVOCs, and metals (arsenic, cadmium, chromium, and nickel for Conditions 1 and 3).

Samples of the scrubber effluent were analyzed for total Cl by an ion chromatograph according to Method 300.0 procedures. Scrubber effluent samples collected during Conditions 1 and 3 were also analyzed for metals by ICAP spectroscopy according to Method 6010B. Samples were digested into an HNO₃/HCl mixture and nebulized before the resulting aerosol was transported to the plasma torch. Element-specific emission spectra were

produced by a radio frequency inductively coupled plasma. The spectra were dispersed by a grating spectrometer and the intensities of the emission lines were monitored by photosensitive devices.

SVOCs in the scrubber effluent were extracted following Method 3520C, a continuous liquid-liquid extraction procedure. The SVOCs were then introduced into a gas chromatograph (GC) column as specified in Method 8270C. The gas chromatograph column was temperature-programmed to separate the analytes, which were then detected with a mass spectrometer. Identification of compounds was accomplished by comparing the mass spectra of the samples to that of the standards.

3.1.6 HCl Acid Product

The HCl acid product samples were collected from the ST HAF acid absorption train (sample point D in Figure 3-1) by a Dow technician. A grab sample of the HCl acid product was collected every 30 minutes during testing from the tap and placed into a composite container. At the completion of each run, subsamples were collected from the composite sample and sent to the laboratory for analysis of chloride, SVOCs, and metals (Conditions 1 and 3).

HCl acid product samples were analyzed for chloride by an ion chromatograph according to Method 300.0 procedures. Samples of the HCl acid product were also collected during Conditions 1 and 3 and analyzed for metals (arsenic, cadmium, chromium, and nickel) by ICAP spectroscopy according to Method 6010B. Samples were digested into an HNO₃/HCl mixture and nebulized before the resulting aerosol was transported to the plasma torch. Element-specific emission spectra were produced by a radio frequency inductively coupled plasma. The spectra were dispersed by a grating spectrometer and the intensities of the emission lines were monitored by photosensitive devices.

Semivolatile organic compounds in the HCl acid product were determined using Method 8270C. Samples were extracted by Method 3520C which is a continuous liquid-liquid extraction procedure. The SVOCs were then introduced into the GC column, which was

temperature-programmed to separate the analytes, prior to detection by the mass spectrometer. Identification of compounds was accomplished by comparing the mass spectra of the samples to that of the standards.

3.2 Stack Gas Samples

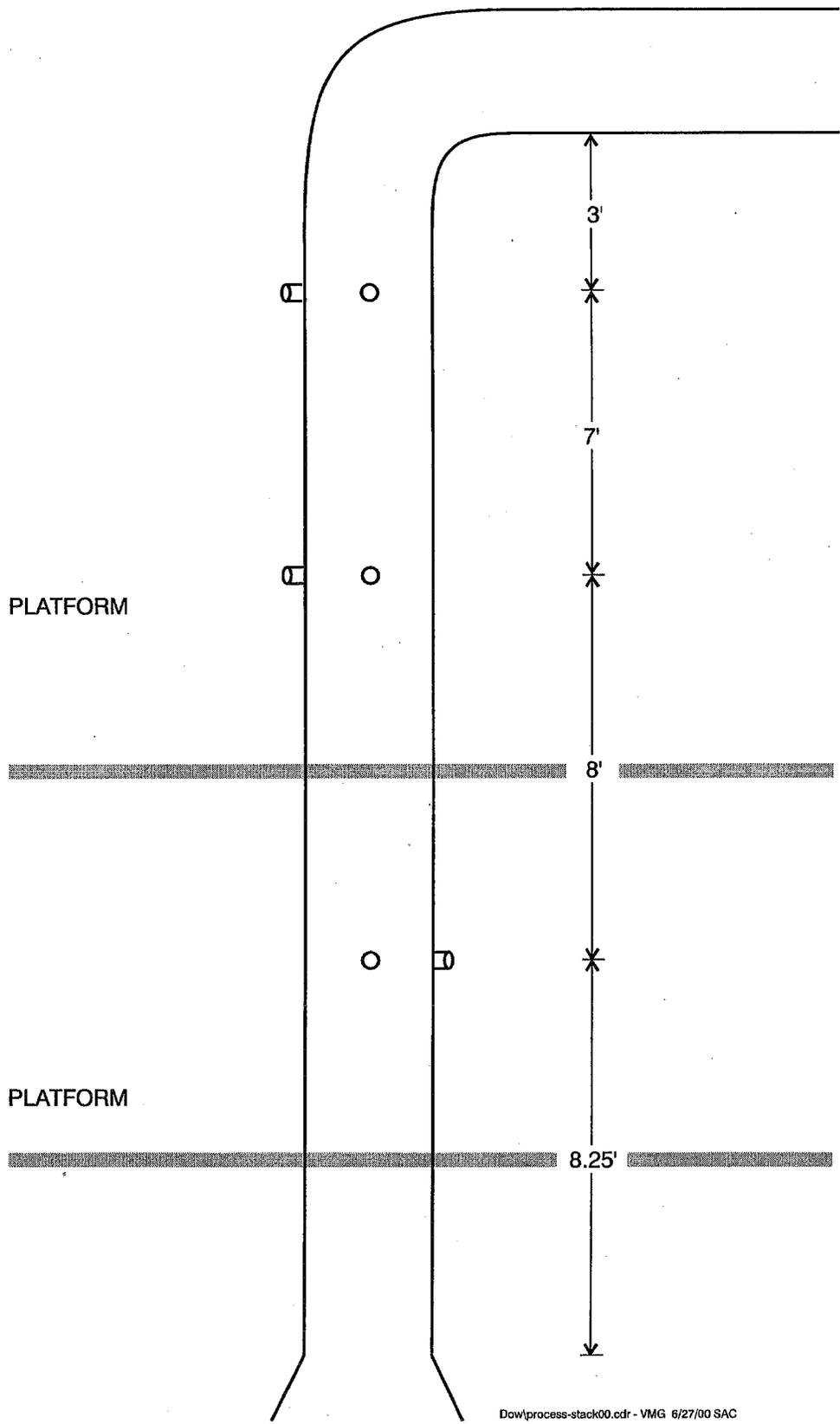
Gas samples were collected from the ST HAF process stack (sample point E in Figure 3-1) during the trial burn. The stack, shown in Figure 3-2, is made of 8-inch outside-diameter (7.5 inch inside diameter) fiberglass pipe and contains six 3-inch ports that were easily accessible. These ports were used during trial burn sampling.

Stack samples were collected for particulate matter, HCl/Cl₂, metals (arsenic, cadmium, chromium, nickel, and hexavalent chromium), VOCs, SVOCs, dioxins/furans, polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons (PAHs), aldehydes, total hydrocarbons (THC), carbon monoxide (CO), oxygen (O₂), and carbon dioxide (CO₂). Specific sampling and analysis methods used during each condition of the trial burn are briefly described in the following subsections.

The preparation and retrieval of all stack gas samples were performed in a controlled environment (i.e., Radian's mobile laboratory) to reduce the possibility of sample contamination. Prior to assembly, each component of the sampling train was rinsed thoroughly with the appropriate solvent or solution. All connections to the train were installed dry (i.e., no grease) or with Teflon[®] to reduce potential contamination.

3.2.1 U.S. EPA Methods 1 through 4

The number and location of sampling traverse points necessary for isokinetic sampling and velocity measurements at the exhaust stack were determined by the United States Environmental Protection Agency (U.S. EPA) Method 1 protocol. Traverse points were determined by the duct distance that separates the sampling ports from the closest downstream and upstream flow disturbances.



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Figure 3-2. Process Stack

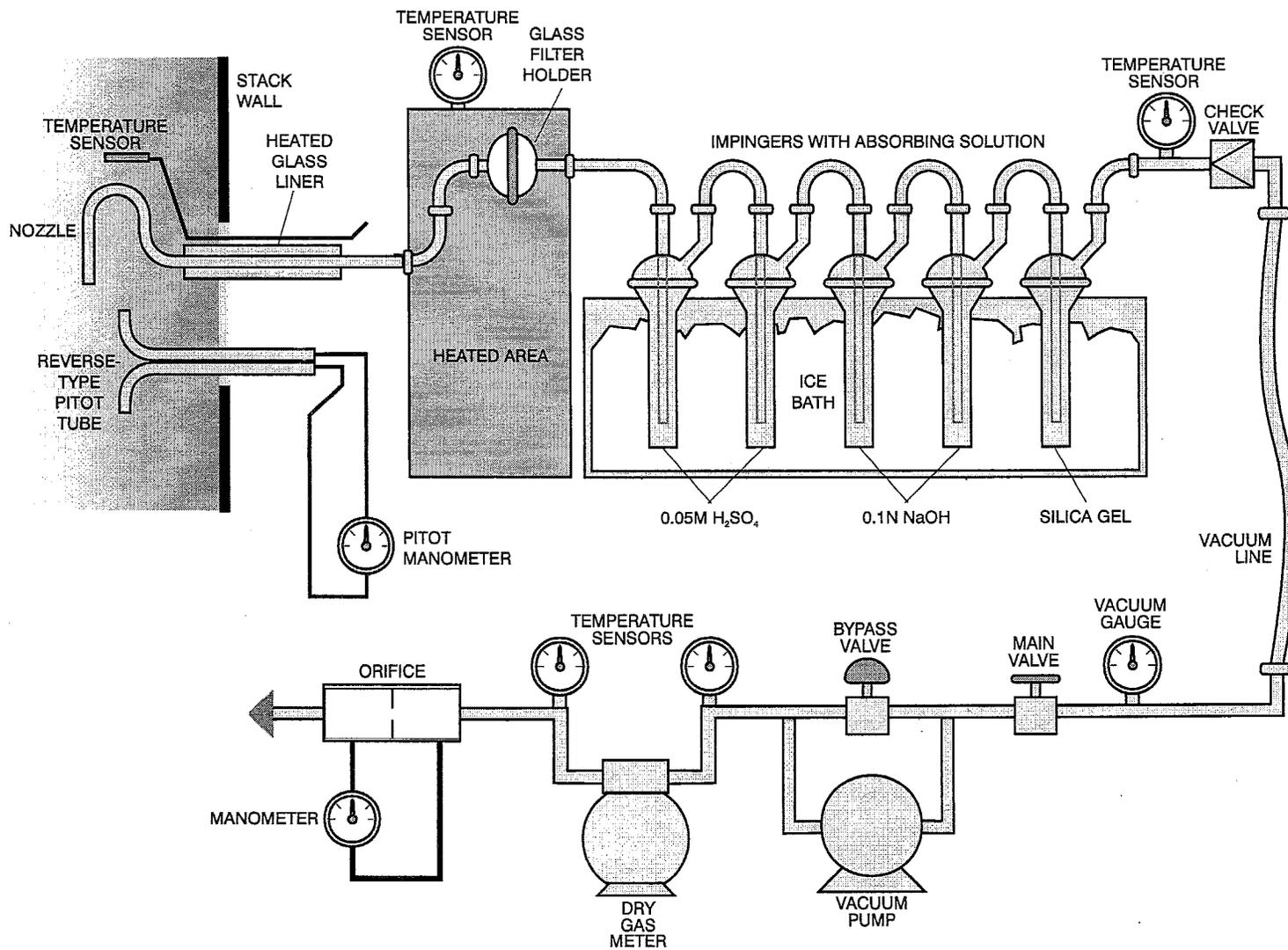
Volumetric flow rates were measured according to U.S. EPA Method 2. A mercury-in-glass thermometer and pitot tube were used to measure stack gas temperature and velocity, respectively. All of the isokinetic methods used in this testing program incorporated U.S. EPA Method 2 into the sampling procedures. The parameters that were measured at each traverse point included the pressure drop across the pitot tube, stack temperature, and stack static pressure. To minimize blockage effects, the velocity traverses were performed immediately prior to the sampling intervals. Post-test velocity measurements indicated that vent gas velocities did not change significantly during the test periods.

Stack gas concentrations of O₂ and CO₂ were determined according to U.S. EPA Method 3 using a Fyrite analyzer. Results were recorded on field data sheets and used to calculate the molecular weight of the gas stream.

The average stack gas moisture content was determined according to U.S. EPA Method 4. Before sampling, the initial weights of the impingers were recorded on a data sheet. When sampling was completed, the final weights of the impingers were recorded and the weight gain was calculated. The weight gain and the volume of gas sampled were used to calculate the average moisture content (percent) of the stack gas. Method 4 is incorporated in the reference methods used for gas sampling (except for the volatile organics train).

3.2.2 Particulate Matter (U.S. EPA Method 5)

Particulate matter emissions from the exhaust stack were measured using U.S. EPA Method 5, combined with SW-846 Method 0050 for HCl/Cl₂. Sample gas was withdrawn isokinetically from the stack through a temperature-controlled, glass-lined probe and collected on a tared, quartz-fiber filter. A diagram of the sampling train is presented in Figure 3-3. Sampling was performed isokinetically at a total of eight traverse points (i.e., four points per diameter) positioned in the stack according to U.S. EPA Method 1 specifications. The sampling time per run was 120 minutes. Particulate quantities collected were determined gravimetrically.



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Figure 3-3. Particulate Matter and HCl/Cl, Sampling System

3.2.3 Hydrogen Chloride and Chlorine (SW-846 Methods 0050 and 9057)

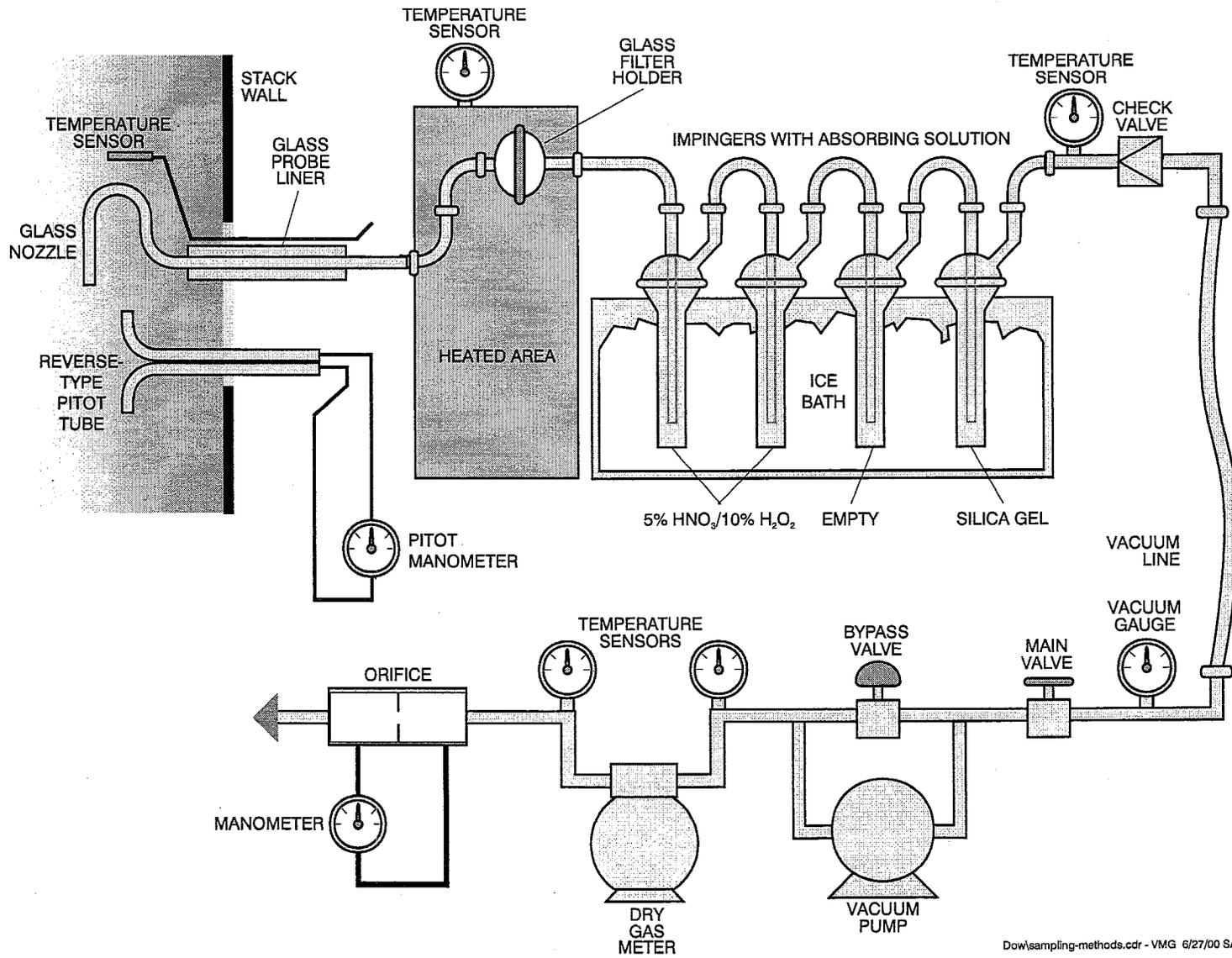
HCl and Cl₂ emissions were determined using SW-846 Method 0050, combined with U.S. EPA Method 5 for particulate matter (see Section 3.2.2). After passing through a filter to remove the particulate matter, the sample gas stream passed through a series of five chilled impingers. As shown in Figure 3-3, the impinger train consisted of two impingers containing 0.05 molar (M) sulfuric acid (H₂SO₄), for HCl collection, and two impingers containing 0.1 normal (N) sodium hydroxide (NaOH), for Cl₂ collection. A final impinger contained silica gel to dry the gas before entering the metering system.

Following sample collection, the two H₂SO₄ impinger solutions were transferred to a clean sample bottle and sent to the laboratory for analysis. Similarly, the two NaOH impinger solutions were composited and placed into a clean sample bottle for shipment to the laboratory. The impinger solutions were preserved with sodium thiosulfate (e.g., 0.5M Na₂SO₃) at approximately 1 mL per 100 mL of caustic.

In the laboratory, the total liquid volumes of the solutions were measured and reported. Aliquots of each sample were analyzed for chloride (Cl) by ion chromatography (IC) following SW-846 Method 9057 procedures. The samples were analyzed in duplicate as required by the method.

3.2.4 Metals (SW-846 Methods 0060 and 6010B)

SW-846 Method 0060 for multiple metals was used to determine stack gas emissions of arsenic, cadmium, chromium, and nickel. Sample gas was withdrawn isokinetically from the stack and passed through a quartz filter and a series of four impingers. As shown in Figure 3-4, the first and second impingers contained approximately 100 mL of 5% HNO₃/10% hydrogen peroxide (H₂O₂) solution, the third impinger was empty, and the fourth impinger contained silica gel. The sampling time per run was 60 minutes.



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Figure 3-4. Metals Sampling System

Following sample collection, the impinger solutions and filter were recovered from the sampling system. The sampling train components, from the nozzle through the third impinger, were rinsed with 0.1 N nitric acid; the rinse was collected with the filter and impinger solutions and submitted to the laboratory for analysis. The probe and nozzle rinses were combined with the filter and digested following the procedures outlined in Method 0060. The resulting digestate was analyzed for arsenic, cadmium, total chromium, and nickel by Method 6010B. The entire contents of both HNO₃/H₂O₂ impingers were composited, concentrated (to improve detection levels), and digested with HNO₃. The resulting digestate was concentrated and analyzed by Method 6010B, using an axial-torch ICP-AES. The front-half (i.e., probe rinse and filter) and back-half (impinger solution) fractions were analyzed separately.

3.2.5 Hexavalent Chromium (SW-846 Methods 0061 and 7199)

SW-846 Method 0061 was used to determine hexavalent chromium (Cr⁺⁶) emissions from the ST HAF. Samples were collected isokinetically with a recirculating sample probe, through which the impinger solution (0.1 N potassium hydroxide [KOH]) was continuously recirculated to the nozzle. The recirculating probe minimizes the reduction of hexavalent chromium (i.e., conversion of hexavalent chromium to trivalent chromium) between the nozzle and impingers. Sample gas was bubbled through three impingers containing a total of 300 milliliters of the KOH solution. The final impinger contained indicating-type silica gel. The entire sample collection train (including the impingers) was Teflon[®], with the exception of the nozzle (glass); the method protocol does not include a filter in the sampling train. The configuration of the sampling train is depicted in Figure 3-5. Sample collection time was 60 minutes per run.

Following sampling, deionized (DI) water was introduced to the recirculation pump to rinse the probe and tubing connections. Recovery procedures included a post-sampling nitrogen purge of the impinger solution in the field. Following the purge, the KOH impinger solutions were composited for analysis. The pH of the solution was determined with pH paper.

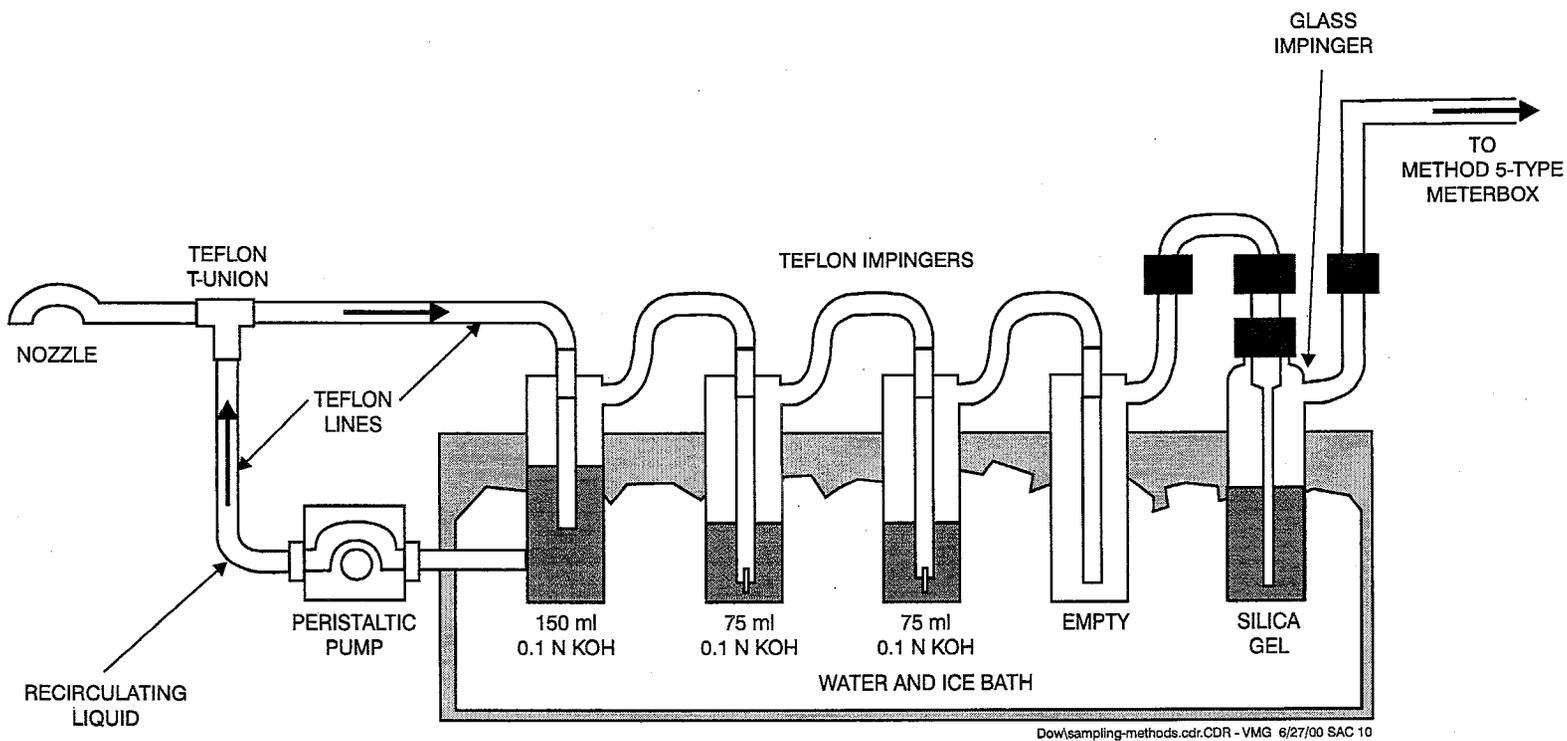


Figure 3-5. Hexavalent Chromium Sampling System

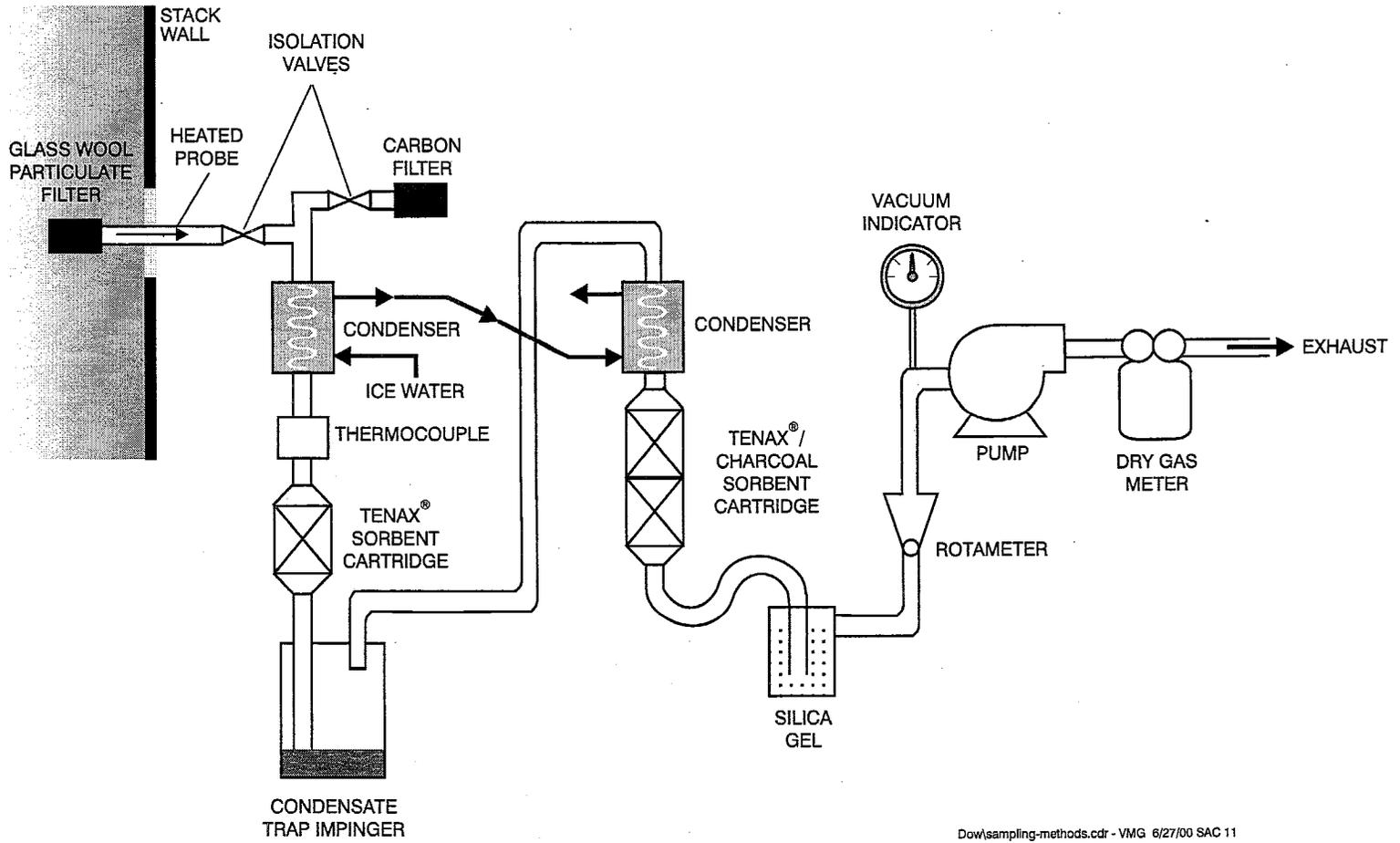
The solution was then pressure-filtered through a glass fiber filter to separate any collected particulate material. The filtered solution was then transferred to a sample bottle and sent to the laboratory for analysis. The impinger solution weights (i.e., pre-test and post-test) were not determined with the hexavalent chromium train (i.e., for stack gas moisture measurements) because of the complexity of the sample recovery procedure. Stack gas moisture values associated with the hexavalent chromium results were based on data collected during concurrent sampling runs (e.g., from the aldehyde train).

In the laboratory, the impinger solution volume was measured and recorded. An aliquot of the solution was then injected into an ion chromatograph equipped with a concentration column and a post-column reactor. Hexavalent chromium quantities in the solution were measured with a spectrophotometric detector according to Method 7199.

3.2.6 Volatile Organic Compounds (U.S. EPA Method 0030 and Method 0541A)

Emissions of VOCs were measured at the stack using the Volatile Organic Sampling Train (VOST), U.S. EPA SW-846 Method 0030. The VOST sampling system consisted of a heated probe, VOC collection system, and a gas metering system (see Figure 3-6). The VOC collection system included condensers to cool the gas to less than 20°C, followed by a pair of sorbent resin traps containing Tenax[®] and Tenax[®]/charcoal. Samples (i.e., a pair of traps) were collected at a single point in the stack for 20 minutes at a flow rate of 1.0 liter per minute. During each run of each operating condition, six consecutive samples were collected. A separate analysis of the Tenax[®] and Tenax[®]/charcoal tube was performed for three pairs to assess potential breakthrough of the target analytes. Because of the low stack gas moisture content, no condensate samples were collected.

Following sample collection, each trap was placed in its own transport tube, labeled, sealed, and kept on ice before and during shipment to the laboratory. Samples were thermally desorbed into a GC/MS following SW-846 Method 5041A.



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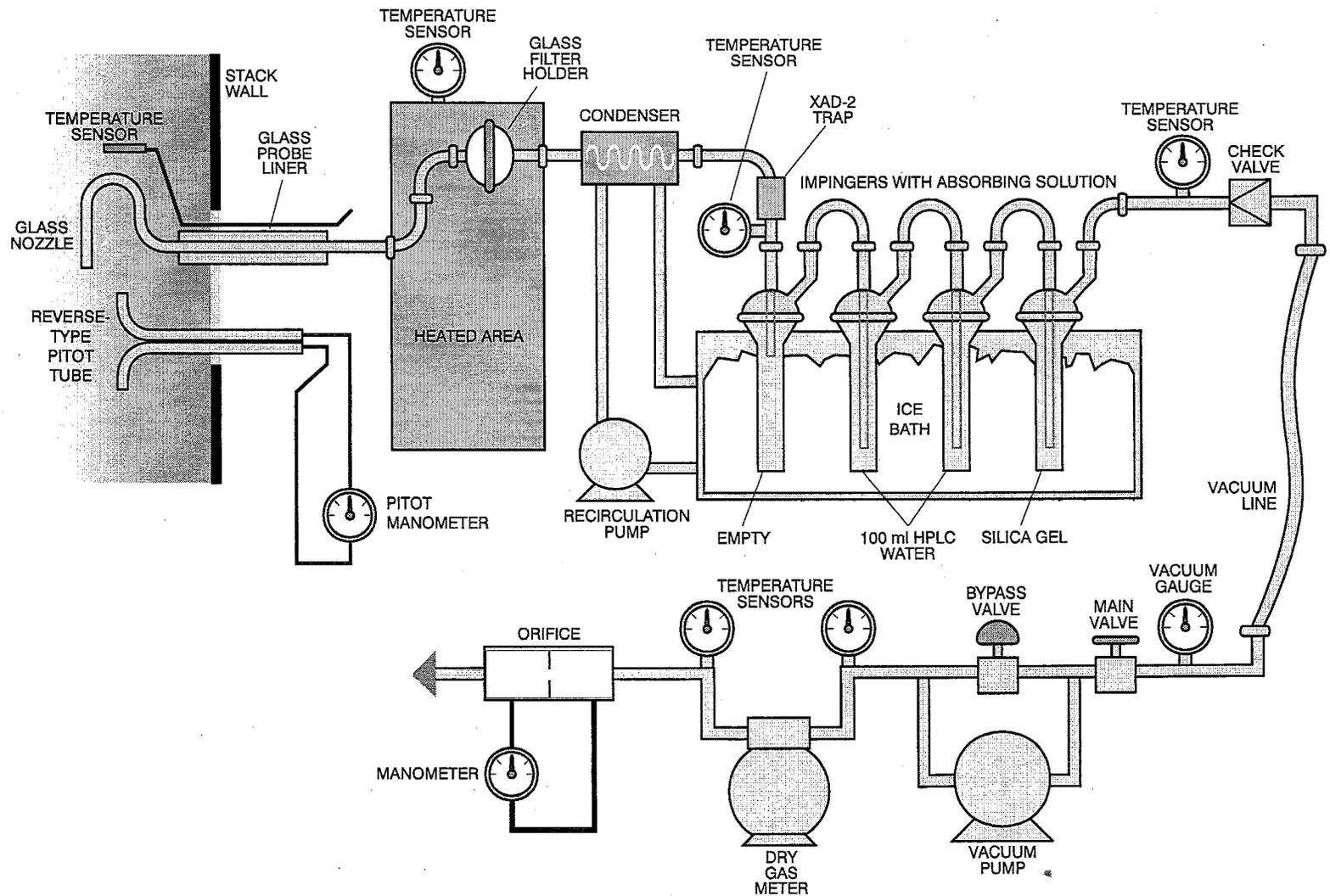
Figure 3-6. VOST Sampling System

3.2.7 Semivolatile Organics, Polychlorinated Biphenyls, and Polycyclic Aromatic Hydrocarbons (SW-846 Method 0010, Method 8270C, Modified Method 680, and CARB Method 429)

Emissions of SVOCs, PCBs, and PAHs were determined using SW-846 Method 0010; these compounds are considered to be products of incomplete combustion (PICs). The sampling system (the Modified Method 5 train) consisted of a glass nozzle, heated glass-lined probe, heated glass-fiber filter, XAD-2 sorbent module, and pump/meter console. Sample gas was isokinetically withdrawn from the stack, filtered at 250°F, passed through a water-cooled condenser, followed by an adsorbent cartridge filled with XAD-2 resin. The sample gas then passed through the impinger train that consisted of a knock-out impinger (for collecting the condensate), two impingers containing 100 mL of DI water (each), and an impinger containing approximately 300 grams (g) of silica gel to dry the sample gas before it entered the metering system. A pump and dry gas meter were used to control and monitor the sample gas flow rate. A schematic of the sampling system is shown in Figure 3-7.

Sampling was performed at eight traverse points; traverse points were positioned according to U.S. EPA Method 1 specifications. The sampling time was 180 minutes per run. Following the run, the samples were recovered from the sampling train as six fractions, consisting of the filter, the XAD-2 sorbent trap, solvent rinse (a 1:1 mixture of methanol and methylene chloride) of the front-half glassware, solvent rinse of the back-half glassware, the knock-out impinger solution, and the Impinger 2 and 3 solutions (combined). The samples were stored on ice prior to submittal to the laboratory for analysis.

In the laboratory, the samples were prepared for analysis according to California Air Resources Board (CARB) Method 429 and U.S. EPA Method 680 procedures. Sample preparation steps included matrix-specific extractions of the sampling media (e.g., filters, XAD-2) and preliminary fractionation/cleanup of the extracts. The sample media were spiked with isotopically labeled PAH and PCB standards for quantitation purposes. The front-half and



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Figure 3-7. Semivolatile Organics and Dioxins/Furans Sampling System

back-half fractions were combined, yielding one sample (i.e., extract) per sampling train. Prior to analysis, the sample extract was split for multiple compound analysis. One portion of the extract was analyzed for PAHs and PCBs while the remainder of the sample was sent to another laboratory for analysis of SVOCs.

Analysis for PCB compounds was performed using gas chromatography/high resolution mass spectrometry/selective ion monitoring (GC/HRMS/SIM), according to U.S. EPA Method 680. The PCBs of specific interest included coplanar PCBs, mono-ortho substituted PCB congeners, and PCB homologues. PCB quantities were determined as follows:

- ▶ For PCB congeners with labeled analogs, the GC/MS system was calibrated, and the concentration of each compound was determined using the isotope dilution technique; or
- ▶ For PCB congeners without labeled isotopes, and for PCB homologues, the GC/MS system was calibrated and the concentration of each compound was determined using the internal standard technique.

PAH compounds were determined according to CARB Method 429. This analytical method included isotope dilution mass spectrometry combined with high-resolution gas chromatography. SVOCs were identified and quantified using GC/MS according to SW-846 Method 8270C.

3.2.8 Dioxins/Furans (Methods 23 and 8290)

Polychlorinated dibenzo-p-dioxin (PCDD) and polychlorinated dibenzofuran (PCDF) samples were collected at the exhaust stack using Method 23. The sampling system, identical to the Method 0010 sampling train for SVOCs, consisted of a glass nozzle, heated probe (glass), heated filter, sorbent module, and pump/meter unit. The XAD-2 resin trap was prespiked with isotopically labeled PCDD/PCDF compounds prior to sampling. The sampling time was 180 minutes per run. The sampling system and sample collection techniques were identical to the SVOC/PCB/PAH sampling described in Section 3.2.7. The PCDD/PCDF sampling train is shown in Figure 3-7.

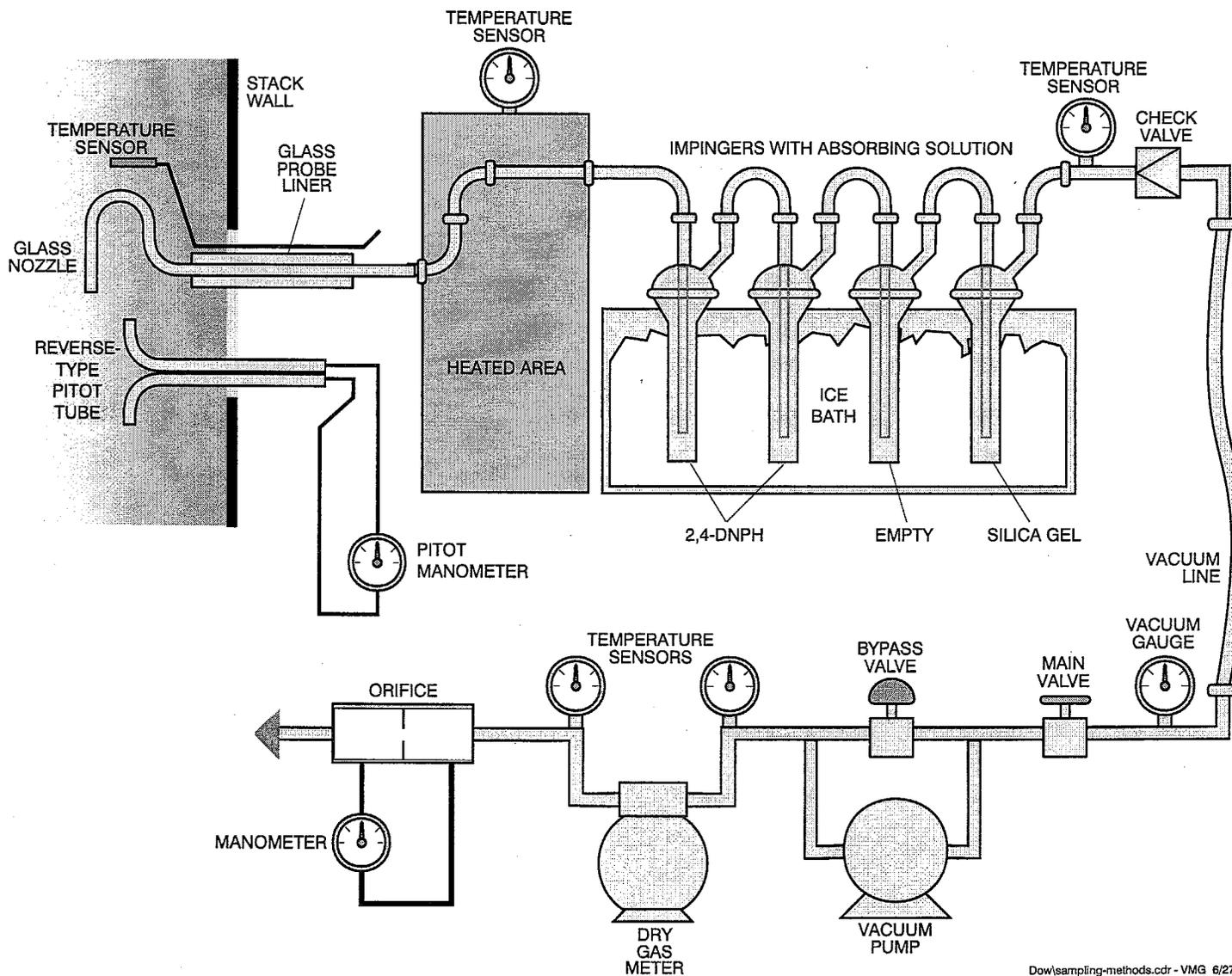
The PCDD/PCDF samples were recovered from the sampling train in four fractions, consisting of the filter, the XAD-2 sorbent trap, solvent rinses (sequential rinsing with acetone, methylene chloride, and toluene) of the front-half and back-half glassware, and the condensate and impinger solutions (combined). The samples were stored on ice prior to submittal to the laboratory for analysis. In the laboratory, the samples were analyzed for dioxins/furans by high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS) following Method 8290 and Method 23 procedures. The front-half and back-half fractions were combined during the sample extraction and cleanup procedures, yielding one sample per sampling train for analysis. Calibration of the GC/MS was accomplished using internal standards.

Results in Section 4.0 are presented as specific isomers and as congener classes. The laboratory analysis included quantification of all dioxins and furans containing four or more chlorine atoms. Toxicity equivalents were calculated according to the formula presented in the BIF regulations and method manual (40 Code of Federal Regulations [CFR] 266, Appendix IX, Section 4.0).

3.2.9 Aldehydes (Method 0011)

Aldehyde emissions were determined according to U.S. EPA Method 0011. Sample gas was withdrawn isokinetically through a heated, glass-lined probe followed by four impingers immersed in an ice bath. As shown in Figure 3-8, the impinger train consisted of two impingers containing approximately 100 mL each of 2,4-dinitrophenylhydrazine (DNPH) solution; the third impinger was empty, and the final impinger contained a pre-weighed quantity of indicating-type silica gel. After exiting the final impinger, the sample gas passed through a dry gas meter/vacuum pump assembly. The sampling time was 120 minutes per run.

Following sample collection, the impinger solution was quantitatively recovered. The sampling train (i.e., from the nozzle to the fourth impinger) was rinsed with methylene chloride and the impingers were rinsed with DI water. The impinger solution and rinses were placed into a clean sample bottle.



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Figure 3-8. Aldehyde Sampling System

In the laboratory, the samples were extracted with methylene chloride and concentrated. The samples were analyzed for the target analytes using high performance liquid chromatography (HPLC) coupled with an ultraviolet detector.

To minimize background contamination and ensure sample integrity, special precautions were taken as noted below:

- ▶ The 2,4-DNPH reagent was used within five days of preparation.
- ▶ Background levels of the 2,4-DNPH were determined prior to use to ensure that the solution contained acceptably low background quantities. Trip spike and trip blank samples were prepared. These samples accompanied the 2,4-DNPH reagent to the test site and were analyzed with the test samples.

The DNPH reagent was stored to minimize reagent degradation and contamination. The reagent was sealed in an amber glass bottle that was placed in another sealed container (e.g., friction-top can) with activated charcoal and kept cold (i.e., stored on ice or refrigerated).

3.2.10 Continuous Emissions Monitoring

Concentrations of O₂ and CO in the exhaust gas were monitored using Dow's continuous emission monitors (CEMs). A sample was acquired by drawing exhaust gas through a filter mounted at the end of a stainless steel probe that extended into the central part of the stack. The sample passed through a heated Teflon[®] sample line and into a sample conditioner for removal of particulate and moisture. From the conditioner, the sample was introduced to a distribution manifold (at atmospheric pressure) from which sample gas was distributed to the monitors. The data from the instruments (O₂ and CO) were recorded on data loggers and hourly rolling averages were calculated for CO.

Annual performance specification tests were performed and the instruments were calibrated according to method specifications prior to the trial burn testing. The continuous

emission monitors were leak-checked, zeroed, and calibrated with a certified gas. To check the accuracy of the instrument, they were zeroed and spanned prior to and after each test run by a Dow technician.

Exhaust gas concentrations of THC's were also continuously monitored during the trial burn according to U.S. EPA Method 25A. The gas stream was drawn from the stack through a heated Teflon[®] sample line. The THC monitor output was recorded by a data logger. The sampling system is shown in Figure 3-9. Multi-point calibrations of the THC monitor were performed periodically using a zero and a mid-range calibration gas (propane). Low- and high-level calibration gases were also used to demonstrate the linearity of the monitor in the measurement range. THC results were reported on a propane-equivalent basis.

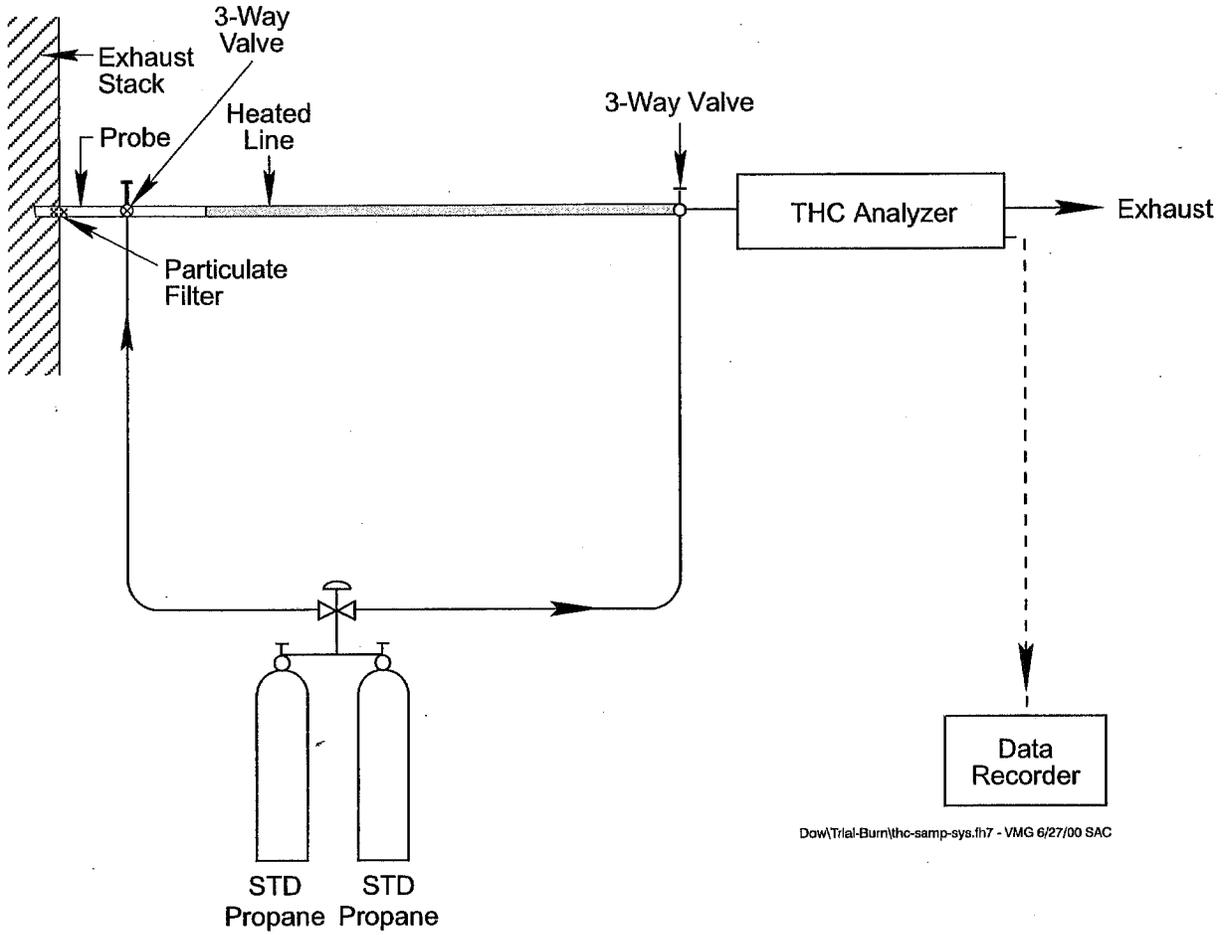


Figure 3-9. THC Sampling System

4.0 Results

This section presents the results of the trial burn performed at the Symtet Halogen Acid Furnace (ST HAF) from February 8 through 18 and April 2 through 6, 2000. While the trial burn testing was scheduled to be completed in February 2000, process interruptions extended the testing until April, at which time the ST HAF was operated under the proposed operating conditions. Three runs consisting of process and stack gas sample collection were conducted under each operating condition.

The sampling and analytical procedures used during the trial burn for each stream are described in Section 3.0. Quality control (QC) samples including field blanks, sample duplicates, and matrix spike/matrix spike duplicates (MS/MSDs) were also collected and analyzed. Data presented in this section are actual values and have not been blank corrected. In addition, the detection limit was used to calculate emissions of target analytes that were reported below the detection limit (i.e., the data reported in this section are conservative values). The results of the QC sample analyses, along with an assessment of the data quality, are presented in Section 5.0.

The field sampling data sheets, continuous emission monitoring data, and laboratory reports used to calculate the results are presented in Appendices A, B, and C, respectively. Data spreadsheets are included in Appendix D and sampling equipment calibration data are attached in Appendix E. A summary of the process operating data collected during the trial burn is presented in Appendix F, and information on the spiking materials is contained in Appendix G.

4.1 Process Operating Data

Various ST HAF operating parameters were monitored by Dow personnel during the trial burn. Average values for key parameters were presented in Section 2.0, along with a description of the different operating conditions under which the performance of the unit was

being demonstrated. Additional process data are included in Appendix F. The ST HAF was operated under maximum and minimum combustion chamber temperatures during Conditions 1 and 2, respectively. During Condition 3, the unit was operated under normal conditions.

4.2 Spiking Mixtures and Process Samples

Samples of the spiking mixtures and process liquids (e.g., feed, scrubber effluent, and hydrochloric acid [HCl acid] product) were collected during each trial burn run and composited over the sampling period for analysis. Results of the sample analyses for each trial burn operating condition are presented in the following subsections. Additional information on the spiking process is included in Appendix G.

4.2.1 Principal Organic Hazardous Constituent Spiking Mixture

During Conditions 1 and 2 of the trial burn, the feed to the ST HAF was spiked with the Principal Organic Hazardous Constituent (POHC). The POHC for this trial burn was 1,2-dichlorobenzene. Dichlorobenzene was introduced into the chlorinated pyridine feed just upstream of the burner at a rate of approximately 10% by weight of the total feed.

The theoretical input concentration of the POHC was based on the certificate of analysis provided by the spiking material vendor (Blue Ridge Chemicals). Samples of the spiking mixture were collected during the trial burn to verify the POHC composition of the spiking mixture. These results, presented in Table 4-1, were used to determine the concentration of dichlorobenzene spiked into the ST HAF. Input rates were then used to calculate the destruction and removal efficiency (DRE) of the POHC (see Tables 4-28).

4.2.2 Ash and Metals Spiking Mixture

The ash and metals input to the ST HAF was supplemented by spiking the feed with metals dispersions during Condition 1 of the trial burn. The proposed input rates and the actual rates achieved during the trial burn are presented in Section 2.0. The ash and metals

Table 4-1. POHC Spiking Mixture Results

Compound	Condition 1				Condition 2			
	Run 1	Run 2	Run 3	Average	Run 1	Run 2	Run 3	Average
1,2-Dichlorobenzene (%)	98.5	98.8	98.6 ^a	98.6	101.3	99.9	100.0 ^a	100.4

^a Average of sample and field duplicate sample.

POHC = Principal Organic Hazardous Constituent

spiking mixtures were injected into the burner. The metals spiking mixture contained ferric oxide (Fe_2O_3), arsenic, cadmium, chromium, and nickel in ethylene glycol and the ash spiking mixture contained Fe_2O_3 in ethylene glycol.

The proposed input concentrations of ash and metals to the ST HAF were based on the certificate of analysis provided by the spiking material vendor. Samples of the ash and metals spiking mixtures were collected during the trial burn to verify the composition of the spiking dispersion. Results of the spiking mixture analyses are presented in Table 4-2. These results were used to determine the metals and ash input rates.

4.2.3 Feed

The ST HAF treats chlorinated pyridine waste streams. During all three operating conditions, chlorinated pyridine feed was the only liquid stream treated in the ST HAF. Samples of the feed were collected during all trial burn runs and analyzed for a variety of parameters. Results of these analyses are presented in Tables 4-3 through 4-5.

As shown in the tables, the average total chlorine (total Cl) concentration ranged from 56.3% (Condition 3) to 58.9% (Condition 1). Metals, including arsenic, barium, beryllium, chromium, copper, lead, manganese, mercury, nickel, and zinc, were detected in at least one feed sample. Manganese, with an average concentration of 200 milligrams per kilogram (mg/kg) and 251 mg/kg for Conditions 1 and 3, respectively, was the metal detected at the highest level in the feed samples.

Results of the ultimate analysis indicated the feed was approximately 65% oxygen, 24% carbon, and 3 to 4% nitrogen (with hydrogen and sulfur making up just less than 1%). The average ash content of the feed ranged from 10.1% (Condition 1) to 11.2% (Condition 3), and the average higher heating value ranged from 3,565 British thermal units per pound (Btu/lb) (Condition 3) to 4,049 Btu/lb (Condition 2). No semivolatile organic compounds (SVOCs) except the chloropyridines were reported above the detection limits in the feed samples.

Table 4-2. Ash and Metals Spiking Mixtures Results

Compound	Condition 1			
	Run 1	Run 2	Run 3	Average
Ash (%) ^a	31.1	30.5	30.5 ^b	30.7
Arsenic (mg/kg)	106.8 ^b	114.7 ^b	102.1 ^c	107.9
Cadmium (mg/kg)	1,319 ^b	1,527 ^b	1,274 ^c	1,373
Chromium (mg/kg)	12,550 ^b	13,200 ^b	11,800 ^c	12,517
Nickel (mg/kg)	43,800 ^b	44,700 ^b	41,417 ^c	43,306
Ash (%) ^d	30.1	29.6	29.2 ^b	29.6

^a Percent by weight (at 775°C) in the ash spiking mixture.

^b Average of two samples.

^c Average of four samples and field duplicate sample.

^d Percent by weight (at 775°C) in the metals spiking mixture.

mg/kg = Milligram per kilogram

Table 4-3. Feed Results-Condition 1

Parameter	Units	Run 1	Run 2	Run 3	Average
Total Cl	%	61.4	55.1	60.1 ^a	58.9
Metals	mg/kg				
Arsenic		ND (<0.526)	ND (<0.44)	ND (<0.527) ^a	ND (<0.498)
Barium		0.0913	0.165	0.114 ^a	0.123
Beryllium		ND (<0.0348)	ND (<0.0291)	ND (<0.035) ^a	ND (<0.0330)
Cadmium		ND(<0.0913)	ND(<0.0764)	ND (<0.091) ^a	ND(<0.0862)
Chromium		28.6	29.2	29.5 ^a	29.1
Copper		21.9	22.3	21.4 ^a	21.9
Lead		2.29	1.32	1.88 ^a	1.83
Manganese		201	203	197 ^a	200
Nickel		44.3	44.5	44.1 ^a	44.3
Selenium		ND (<1.03)	ND (<0.865)	ND (<1.04) ^a	ND (<0.978)
Thallium		ND (<0.65)	ND (<0.544)	ND (<0.650) ^a	ND (<0.615)
Zinc		2.84	2.85	2.91 ^a	2.87
Mercury		ND (<0.013)	ND (<0.0109)	ND (<0.0132) ^a	ND (<0.0124)
Ultimate Analysis	%				
Carbon		23.4	23.4	23.6 ^a	23.5
Hydrogen		0.66	0.60	0.56 ^a	0.61
Oxygen		65.1	64.8	64.3 ^a	64.7
Nitrogen		3.69	3.89	3.77 ^a	3.78
Sulfur		0.10	0.11	0.14 ^a	0.12
Ash	%	10.2	10.0	10.2 ^a	10.1
Higher Heating Value	Btu/lb	3,093	4,361	3,877 ^a	3,777
SVOCs	ug/g				
1,2,4-Trichlorobenzene		ND (<181)	ND (<170)	ND (<261) ^a	ND (<204)
1,2-Dichlorobenzene ^b		ND (<192)	ND (<181)	ND (<278) ^a	ND (<217)
1,3-Dichlorobenzene		ND (<205)	ND (<193)	ND (<296) ^a	ND (<231)
1,4-Dichlorobenzene		ND (<199)	ND (<188)	ND (<288) ^a	ND (<225)
2-Chlorophenol		ND (<190)	ND (<179)	ND (<275) ^a	ND (<215)
Hexachloro-1,3-butadiene		ND (<181)	ND (<170)	ND (<261) ^a	ND (<204)

Table 4-3 (Continued)

Parameter	Units	Run 1	Run 2	Run 3	Average
Hexachlorobenzene		ND (<170)	ND (<160)	ND (<246) ^a	ND (<192)
Hexachloroethane		ND (<199)	ND (<188)	ND (<288) ^a	ND (<225)
Pentachloroethane		ND (<211)	ND (<199)	ND (<306) ^a	ND (<239)
Pentachlorophenol		ND (<164)	ND (<155)	ND (<238) ^a	ND (<186)
Phenol		ND (<224)	ND (<211)	ND (<323) ^a	ND (<253)
1,2,3-Trichlorobenzene ^c		ND (<200)	ND (<200)	ND (<300) ^a	ND (<233)
1,3,5-Trichlorobenzene ^c		ND (<200)	ND (<200)	ND (<300) ^a	ND (<233)
1,3-Cyclopentadiene ^c		ND (<200)	ND (<200)	ND (<300) ^a	ND (<233)
2-Fluoropyridine ^c		ND (<200)	ND (<200)	ND (<300) ^a	ND (<233)
3-Fluoropyridine ^c		ND (<200)	ND (<200)	ND (<300) ^a	ND (<233)
1-Chloropyridine ^c		62,700	60,400	65,600 ^a	62,900
2-Chloropyridine ^c		188,000	196,000	215,000 ^a	199,667
3-Chloropyridine ^c		29,500	30,600	33,650 ^a	31,250
Cyclopenta(c,d)pyrene ^c		ND (<200)	ND (<200)	ND (<300) ^a	ND (<233)
Other Fluoropyridines ^c		ND (<200)	ND (<200)	ND (<300) ^a	ND (<233)

^a Average of two samples.

^b Designated POHC.

^c Tentatively identified compound.

Btu/lb = British thermal units per pound

mg/kg = Milligram per kilogram

ug/g = Microgram per gram

ND = Not detected (detection limit)

% = Percent by weight

Table 4-4. Feed Results-Condition 2

Parameter	Units	Run 1	Run 2	Run 3	Average
Total Cl	%	52.5	60.0	60.8	57.8
Ultimate Analysis	%				
Carbon		23.7	23.6	23.6	23.6
Hydrogen		0.61	0.62	0.59	0.61
Oxygen		65.8	66.8	66.1	66.2
Nitrogen		3.40	3.23	3.36	3.33
Sulfur		0.14	0.17	0.22	0.18
Ash	%	10.7	10.5	10.4	10.5
Higher Heating Value	Btu/lb	4,458	4,162	3,527	4,049
SVOCs	ug/g				
1,2,4-Trichlorobenzene		ND (<143)	ND (<134)	ND (<142)	ND (<140)
1,2-Dichlorobenzene ^a		ND (<202)	ND (<189)	ND (<200)	ND (<197)
1,3-Dichlorobenzene		ND (<260)	ND (<243)	ND (<257)	ND (<253)
1,4-Dichlorobenzene		ND (<257)	ND (<240)	ND (<254)	ND (<250)
2-Chlorophenol		ND (<224)	ND (<209)	ND (<221)	ND (<218)
Hexachloro-1,3-butadiene		ND (<262)	ND (<245)	ND (<259)	ND (<255)
Hexachlorobenzene		ND (<229)	ND (<214)	ND (<226)	ND (<223)
Hexachloroethane		ND (<270)	ND (<252)	ND (<267)	ND (<263)
Pentachloroethane		ND (<391)	ND (<365)	ND (<387)	ND (<381)
Pentachlorophenol		ND (<183)	ND (<171)	ND (<181)	ND (<178)
Phenol		ND (<493)	ND (<461)	ND (<488)	ND (<481)
1,2,3-Trichlorobenzene ^b		ND (<400)	ND (<400)	ND (<400)	ND (<400)
1,3,5-Trichlorobenzene ^b		ND (<400)	ND (<400)	ND (<400)	ND (<400)
1,3-Cyclopentadiene ^b		ND (<400)	ND (<400)	ND (<400)	ND (<400)
2-Fluoropyridine ^b		ND (<400)	ND (<400)	ND (<400)	ND (<400)
3-Fluoropyridine ^b		ND (<400)	ND (<400)	ND (<400)	ND (<400)
1-Chloropyridine ^b		23,000	46,200	26,700	31,967
2-Chloropyridine ^b		87,200	43,700	125,000	85,300
3-Chloropyridine ^b		18,100	34,300	25,000	25,800
Cyclopenta(c,d)pyrene ^b		ND (<400)	ND (<400)	ND (<400)	ND (<400)
Other Fluoropyridines ^b		ND (<400)	ND (<400)	ND (<400)	ND (<400)

^a Designated POHC.

^b Tentatively identified compound.

Btu/lb = British thermal units per pound

ug/g = Microgram per gram

ND = Not detected (detection limit)

% = Percent by weight

Table 4-5. Feed Results-Condition 3

Parameter	Units	Run 1	Run 2	Run 3	Average
Total Cl	%	59.9	54.7	54.2 ^a	56.3
Metals	mg/kg				
Arsenic		0.757	0.591 ^a	ND (<0.417)	<0.588
Barium		0.187	0.211 ^a	0.205	0.201
Beryllium		0.0352	ND (<0.031) ^a	ND (<0.0276)	<0.0313
Cadmium		ND (<0.0778)	ND (<0.081) ^a	ND (<0.0724)	ND(<0.0771)
Chromium		33.5	35.0 ^a	35.4	34.6
Copper		31.8	32.7 ^a	33.1	32.5
Lead		1.74	1.82 ^a	1.55	1.70
Manganese		243	256 ^a	253	251
Nickel		55.3	58.9 ^a	59.5	57.9
Selenium		ND (<0.881)	<1.05 ^a	1.28	<1.07
Thallium		ND (<0.554)	ND (<0.574) ^a	ND (<0.516)	ND (<0.548)
Zinc		3.17	3.2 ^a	3.27	3.21
Mercury		0.0286	0.026 ^a	ND (<0.0103)	<0.022
Ultimate Analysis	%				
Carbon		23.7	24.5	23.5 ^a	23.9
Hydrogen		0.69	0.68	0.55 ^a	0.64
Oxygen		65.9	64.1	66.5 ^a	65.5
Nitrogen		3.59	3.44	3.17 ^a	3.40
Sulfur		0.06	0.07	0.12 ^a	0.08
Ash	%	11.3	11.0	11.3	11.2
Higher Heating Value	Btu/lb	3,732	3,612	3,351 ^a	3,565
SVOCs	ug/g				
1,2,4-Trichlorobenzene		ND (<142)	ND (<142) ^a	ND (<141)	ND (<142)
1,2-Dichlorobenzene ^b		ND (<200)	ND (<200) ^a	ND (<199)	ND (<200)
1,3-Dichlorobenzene		ND (<257)	ND (<258) ^a	ND (<256)	ND (<257)
1,4-Dichlorobenzene		ND (<254)	ND (<255) ^a	ND (<253)	ND (<254)
2-Chlorophenol		ND (<221)	ND (<222) ^a	ND (<221)	ND (<221)
Hexachloro-1,3-butadiene		ND (<259)	ND (<260) ^a	ND (<258)	ND (<259)
Hexachlorobenzene		ND (<226)	ND (<227) ^a	ND (<225)	ND (<226)
Hexachloroethane		ND (<267)	ND (<268) ^a	ND (<266)	ND (<267)
Pentachloroethane		ND (<387)	ND (<388) ^a	ND (<385)	ND (<387)
Pentachlorophenol		ND (<181)	ND (<181) ^a	ND (<180)	ND (<181)
Phenol		ND (<488)	ND (<490) ^a	ND (<486)	ND (<488)

Table 4-5 (Continued)

Parameter	Units	Run 1	Run 2	Run 3	Average
1,2,3-Trichlorobenzene ^c		ND (<400)	ND (<400) ^a	ND (<400)	ND (<400)
1,3,5-Trichlorobenzene ^c		ND (<400)	ND (<400) ^a	ND (<400)	ND (<400)
1,3-Cyclopentadiene ^c		ND (<400)	ND (<400) ^a	ND (<400)	ND (<400)
2-Fluoropyridine ^c		ND (<400)	ND (<400) ^a	ND (<400)	ND (<400)
3-Fluoropyridine ^c		ND (<400)	ND (<400) ^a	ND (<400)	ND (<400)
1-Chloropyridine ^c		32,400	8,720 ^a	35,200	25,440
2-Chloropyridine ^c		157,000	34,750 ^a	167,000	119,583
3-Chloropyridine ^c		22,000	5,645 ^a	25,000	17,548
Cyclopenta(c,d)pyrene ^c		ND (<400)	ND (<400) ^a	ND (<400)	ND (<400)
Other Fluoropyridines ^c		ND (<400)	ND (<400) ^a	ND (<400)	ND (<400)

^a Average of sample and field duplicate sample.

^b Designated POHC.

^c Tentatively identified compound.

Btu/lb = British thermal units per pound
 mg/kg = Milligram per kilogram
 ug/g = Microgram per gram
 ND = Not detected (detection limit)
 % = Percent by weight

4.2.4 Scrubber Effluent

Grab samples of the scrubber effluent liquid stream were collected every 30 minutes during each trial burn run and composited for analysis. Results of the scrubber effluent analyses for the three conditions are presented in Table 4-6 through 4-8.

The total Cl results for these samples ranged from 3,417 milligrams per liter (mg/L) (Condition 3) to 7,853 mg/L (Condition 2). The concentration of target metal analytes was low in all scrubber effluent samples. Metals results for cadmium, chromium, and nickel were higher in the Condition 1 samples due to the increased metals loading to the unit (i.e., additional metals input due to spiking). Nickel, at an average concentration of 11.7 mg/L in the Condition 1 samples, was the highest metal result reported. No SVOCs, except for pentachloroethane in the Conditions 1 and 2 samples, were reported above the detection limits in any scrubber effluent sample.

4.2.5 HCl Acid Product

HCl acid product samples were collected every 30 minutes during each run of the trial burn and composited for analysis. Results of these analyses are shown in Tables 4-9 through 4-11.

As expected, the average chloride concentration in these samples was very high, ranging from 173,667 mg/L (Condition 2) to 248,500 mg/L (Condition 1). Results of the Dow sample analyses indicated that the average percent HCl ranged from 16.8% (Condition 2) to 22.1% (Condition 1). Metals concentrations in the HCl acid product samples were higher in the Condition 1 samples than the Condition 3 samples. Both chromium and nickel results were an order of magnitude higher in the Condition 1 samples. No SVOCs were reported above the detection limit in any HCl acid product samples.

Table 4-6. Scrubber Effluent Results-Condition 1

Parameter	Units	Run 1	Run 2	Run 3	Average
Total Cl	mg/L	6,110	3,930 ^a	3,255 ^b	4,432
Metals	mg/L				
Arsenic		0.013	0.00871 ^a	0.0139 ^b	0.0119
Cadmium		0.148	0.138 ^a	0.163 ^b	0.15
Chromium		0.629	0.582 ^a	0.716 ^b	0.642
Nickel		16.1	10.4 ^a	8.52 ^b	11.7
SVOCs	µg/L				
1,2,4-Trichlorobenzene		ND (<1.4)	ND (<1.4)	ND (<1.34) ^b	ND (<1.38)
1,2-Dichlorobenzene ^c		ND (<1.54)	ND (<1.54)	ND (<1.67) ^b	ND (<1.58)
1,3-Dichlorobenzene		ND (<1.75)	ND (<1.75)	ND (<1.92) ^b	ND (<1.81)
1,4-Dichlorobenzene		ND (<1.53)	ND (<1.53)	ND (<1.78) ^b	ND (<1.61)
2-Chlorophenol		ND (<0.54)	ND (<0.54)	ND (<0.89) ^b	ND (<0.66)
Hexachloro-1,3-butadiene		ND (<2.02)	ND (<2.02)	ND (<2.02) ^b	ND (<2.02)
Hexachlorobenzene		ND (<0.454)	ND (<0.454)	ND (<0.867) ^b	ND (<0.592)
Hexachloroethane		ND (<5.1)	ND (<5.1)	ND (<3.75) ^b	ND (<4.65)
Pentachloroethane		37.6	95.8	<35.6 ^b	<56.3
Pentachlorophenol		ND (<2.78)	ND (<2.78)	ND (<2.21) ^b	ND (<2.59)
Phenol		ND (<1.64)	ND (<1.64)	ND (<1.68) ^b	ND (<1.65)
1,2,3-Trichlorobenzene ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1,3,5-Trichlorobenzene ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1,3-Cyclopentadiene ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
2-Fluoropyridine ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
3-Fluoropyridine ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1-Chloropyridine ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
2-Chloropyridine ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
3-Chloropyridine ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
Cyclopenta(c,d)pyrene ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
Other Fluoropyridines ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)

^a Average of sample and field duplicate sample.

^b Average of two samples.

^c Designated POHC.

^d Tentatively identified compound.

µg/L = Microgram per liter
 mg/L = Milligram per liter
 ND = Not detected (detection limit)
 % = Percent

Table 4-7. Scrubber Effluent Results-Condition 2

Parameter	Units	Run 1	Run 2	Run 3	Average
Total Cl	mg/L	6,050	8,720	8,790	7,853
SVOCs	µg/L				
1,2,4-Trichlorobenzene		ND (<14)	ND (<14) ^a	ND (<14)	ND (<14)
1,2-Dichlorobenzene ^b		ND (<15.4)	ND (<15.4) ^a	ND (<15.4)	ND (<15.4)
1,3-Dichlorobenzene		ND (<17.5)	ND (<17.5) ^a	ND (<17.5)	ND (<17.5)
1,4-Dichlorobenzene		ND (<15.3)	ND (<15.3) ^a	ND (<15.3)	ND (<15.3)
2-Chlorophenol		ND (<5.4)	ND (<5.4) ^a	ND (<5.4)	ND (<5.4)
Hexachloro-1,3-butadiene		ND (<20.2)	ND (<20.2) ^a	ND (<20.2)	ND (<20.2)
Hexachlorobenzene		ND (<4.54)	ND (<4.54) ^a	ND (<4.54)	ND (<4.54)
Hexachloroethane		ND (<51)	ND (<51) ^a	ND (<51)	ND (<51)
Pentachloroethane		88.9	81 ^a	74.4	81.4
Pentachlorophenol		ND (<27.8)	ND (<27.8) ^a	ND (<27.8)	ND (<27.8)
Phenol		ND (<16.4)	ND (<16.4) ^a	ND (<16.4)	ND (<16.4)
1,2,3-Trichlorobenzene ^c		ND (<40)	ND (<40) ^a	ND (<40)	ND (<40)
1,3,5-Trichlorobenzene ^c		ND (<40)	ND (<40) ^a	ND (<40)	ND (<40)
1,3-Cyclopentadiene ^c		ND (<40)	ND (<40) ^a	ND (<40)	ND (<40)
2-Fluoropyridine ^c		ND (<40)	ND (<40) ^a	ND (<40)	ND (<40)
3-Fluoropyridine ^c		ND (<40)	ND (<40) ^a	ND (<40)	ND (<40)
1-Chloropyridine ^c		ND (<40)	ND (<40) ^a	ND (<40)	ND (<40)
2-Chloropyridine ^c		ND (<40)	ND (<40) ^a	ND (<40)	ND (<40)
3-Chloropyridine ^c		ND (<40)	ND (<40) ^a	ND (<40)	ND (<40)
Cyclopenta(c,d)pyrene ^c		ND (<40)	ND (<40) ^a	ND (<40)	ND (<40)
Other Fluoropyridines ^c		ND (<40)	ND (<40) ^a	ND (<40)	ND (<40)

^a Average of sample and field duplicate sample.

^b Designated POHC.

^c Tentatively identified compound.

µg/L = Microgram per liter
 mg/L = Milligram per liter
 ND = Not detected (detection limit)
 % = Percent

Table 4-8. Scrubber Effluent Results-Condition 3

Parameter	Units	Run 1	Run 2	Run 3	Average
Total Cl	mg/L	3,630	3,020	3,600	3,417
Metals	mg/L				
Arsenic		0.02	ND (<0.00635)	0.0147	<0.0137
Cadmium		ND (<0.00235)	ND (<0.00235)	ND (<0.00235)	ND (<0.00235)
Chromium		0.464	0.131	0.088	0.228
Nickel		1.73	1.34	1.53	1.53
SVOCs	µg/L				
1,2,4-Trichlorobenzene		ND (<1.4)	ND (<1.4)	ND (<1.4)	ND (<1.4)
1,2-Dichlorobenzene ^a		ND (<1.54)	ND (<1.54)	ND (<1.54)	ND (<1.54)
1,3-Dichlorobenzene		ND (<1.75)	ND (<1.75)	ND (<1.75)	ND (<1.75)
1,4-Dichlorobenzene		ND (<1.53)	ND (<1.53)	ND (<1.53)	ND (<1.53)
2-Chlorophenol		ND (<0.54)	ND (<0.54)	ND (<0.54)	ND (<0.54)
Hexachloro-1,3-butadiene		ND (<2.02)	ND (<2.02)	ND (<2.02)	ND (<2.02)
Hexachlorobenzene		ND (<0.454)	ND (<0.454)	ND (<0.454)	ND (<0.454)
Hexachloroethane		ND (<5.1)	ND (<5.1)	ND (<5.1)	ND (<5.1)
Pentachloroethane		ND (<1.54)	ND (<1.54)	ND (<1.54)	ND (<1.54)
Pentachlorophenol		ND (<2.78)	ND (<2.78)	ND (<2.78)	ND (<2.78)
Phenol		ND (<1.64)	ND (<1.64)	ND (<1.64)	ND (<1.64)
1,2,3-Trichlorobenzene ^b		ND (<4.0)	ND (<4.0)	ND (<4.0)	ND (<4.0)
1,3,5-Trichlorobenzene ^b		ND (<4.0)	ND (<4.0)	ND (<4.0)	ND (<4.0)
1,3-Cyclopentadiene ^b		ND (<4.0)	ND (<4.0)	ND (<4.0)	ND (<4.0)
2-Fluoropyridine ^b		ND (<4.0)	ND (<4.0)	ND (<4.0)	ND (<4.0)
3-Fluoropyridine ^b		ND (<4.0)	ND (<4.0)	ND (<4.0)	ND (<4.0)
1-Chloropyridine ^b		ND (<4.0)	ND (<4.0)	ND (<4.0)	ND (<4.0)
2-Chloropyridine ^b		ND (<4.0)	ND (<4.0)	ND (<4.0)	ND (<4.0)
3-Chloropyridine ^b		ND (<4.0)	ND (<4.0)	ND (<4.0)	ND (<4.0)
Cyclopenta(c,d)pyrene ^b		ND (<4.0)	ND (<4.0)	ND (<4.0)	ND (<4.0)
Other Fluoropyridines ^b		ND (<4.0)	ND (<4.0)	ND (<4.0)	ND (<4.0)

^a Designated POHC.

^b Tentatively identified compound.

µg/L = Microgram per liter
 mg/L = Milligram per liter
 ND = Not detected (detection limit)
 % = Percent

Table 4-9. HCl Acid Product Results-Condition 1

Parameter	Units	Run 1	Run 2	Run 3	Average
Chloride	mg/L	237,000	252,000 ^a	256,500 ^b	248,500
% HCl	%	21.0	22.7	22.7 ^b	22.1
Metals	mg/L				
Arsenic		0.643	0.535 ^a	0.577 ^b	0.585
Cadmium		7.54	6.55 ^a	6.74 ^b	6.94
Chromium		31.8	36.5 ^a	38.5 ^b	35.6
Nickel		147	151 ^a	155 ^b	151
SVOCs	µg/L				
1,2,4-Trichlorobenzene		ND (<2.57)	ND (<2.57)	ND (<2.57) ^b	ND (<2.57)
1,2-Dichlorobenzene ^c		ND (<3.58)	ND (<3.58)	ND (<3.58) ^b	ND (<3.58)
1,3-Dichlorobenzene		ND (<4.17)	ND (<4.17)	ND (<4.17) ^b	ND (<4.17)
1,4-Dichlorobenzene		ND (<4.04)	ND (<4.04)	ND (<4.04) ^b	ND (<4.04)
2-Chlorophenol		ND (<2.47)	ND (<2.47)	ND (<2.47) ^b	ND (<2.47)
Hexachloro-1,3-butadiene		ND (<4.04)	ND (<4.04)	ND (<4.04) ^b	ND (<4.04)
Hexachlorobenzene		ND (<2.55)	ND (<2.55)	ND (<2.55) ^b	ND (<2.55)
Hexachloroethane		ND (<4.78)	ND (<4.78)	ND (<4.78) ^b	ND (<4.78)
Pentachloroethane		ND (<3.54)	ND (<3.54)	ND (<3.54) ^b	ND (<3.54)
Pentachlorophenol		ND (<3.27)	ND (<3.27)	ND (<3.27) ^b	ND (<3.27)
Phenol		ND (<3.43)	ND (<3.43)	ND (<3.43) ^b	ND (<3.43)
1,2,3-Trichlorobenzene ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1,3,5-Trichlorobenzene ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1,3-Cyclopentadiene ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
2-Fluoropyridine ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
3-Fluoropyridine ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1-Chloropyridine ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
2-Chloropyridine ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
3-Chloropyridine ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
Cyclopenta(c,d)pyrene ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
Other Fluoropyridine ^d		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)

^a Average of sample and field duplicate sample.

^b Average of two samples.

^c Designated POHC.

^d Tentatively identified compound.

µg/L = Microgram per liter
 mg/L = Milligram per liter
 ND = Not detected (detection limit)
 % = Percent

Table 4-10. HCl Acid Product Results-Condition 2

Parameter	Units	Run 1	Run 2	Run 3	Average
Chloride	mg/L	181,000	169,000	171,000	173,667
% HCl	%	17.3	16.5	16.6	16.8
SVOCs	µg/L				
1,2,4-Trichlorobenzene		ND (<2.81)	ND (<2.81)	ND (<2.81)	ND (<2.81)
1,2-Dichlorobenzene ^a		ND (<3.08)	ND (<3.08)	19.6	<8.59
1,3-Dichlorobenzene		ND (<3.5)	ND (<3.5)	ND (<3.5)	ND (<3.5)
1,4-Dichlorobenzene		ND (<3.06)	ND (<3.06)	ND (<3.06)	ND (<3.06)
2-Chlorophenol		ND (<1.08)	ND (<1.08)	ND (<1.08)	ND (<1.08)
Hexachloro-1,3-butadiene		ND (<4.03)	ND (<4.03)	ND (<4.03)	ND (<4.03)
Hexachlorobenzene		ND (<0.907)	ND (<0.907)	ND (<0.907)	ND (<0.907)
Hexachloroethane		ND (<10.2)	ND (<10.2)	ND (<10.2)	ND (<10.2)
Pentachloroethane		ND (<3.08)	ND (<3.08)	ND (<3.08)	ND (<3.08)
Pentachlorophenol		ND (<5.57)	ND (<5.57)	ND (<5.57)	ND (<5.57)
Phenol		ND (<3.27)	ND (<3.27)	ND (<3.27)	ND (<3.27)
1,2,3-Trichlorobenzene ^b		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1,3,5-Trichlorobenzene ^b		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1,3-Cyclopentadiene ^b		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
2-Fluoropyridine ^b		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
3-Fluoropyridine ^b		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1-Chloropyridine ^b		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
2-Chloropyridine ^b		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
3-Chloropyridine ^b		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
Cyclopenta(c,d)pyrene ^b		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
Other Fluoropyridines ^b		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)

^a Designated POHC.

^b Tentatively identified compound.

µg/L = Microgram per liter
 mg/L = Milligram per liter
 ND = Not detected (detection limit)
 % = Percent

Table 4-11. HCl Acid Product Results-Condition 3

Parameter	Units	Run 1	Run 2	Run 3	Average
Chloride	mg/L	259,000	224,000	210,000	231,000
% HCl	%	21.9	18.5	18.7	19.7
Metals	mg/L				
Arsenic		0.102	0.0569	0.0925	0.0838
Cadmium		ND (<0.0047)	ND (<0.0047)	ND (<0.0047)	ND (<0.0047)
Chromium		6.1	5.14	4.25	5.16
Nickel		13	10.4	8.8	10.7
SVOCs	µg/L				
1,2,4-Trichlorobenzene		ND (<2.81)	ND (<2.81)	ND (<2.81) ^a	ND (<2.81)
1,2-Dichlorobenzene ^b		ND (<3.08)	ND (<3.08)	ND (<3.08) ^a	ND (<3.08)
1,3-Dichlorobenzene		ND (<3.5)	ND (<3.5)	ND (<3.5) ^a	ND (<3.5)
1,4-Dichlorobenzene		ND (<3.06)	ND (<3.06)	ND (<3.06) ^a	ND (<3.06)
2-Chlorophenol		ND (<1.08)	ND (<1.08)	ND (<1.08) ^a	ND (<1.08)
Hexachloro-1,3-butadiene		ND (<4.03)	ND (<4.03)	ND (<4.03) ^a	ND (<4.03)
Hexachlorobenzene		ND (<0.907)	ND (<0.907)	ND (<0.907) ^a	ND (<0.907)
Hexachloroethane		ND (<10.2)	ND (<10.2)	ND (<10.2) ^a	ND (<10.2)
Pentachloroethane		ND (<3.08)	ND (<3.08)	ND (<3.08) ^a	ND (<3.08)
Pentachlorophenol		ND (<5.57)	ND (<5.57)	ND (<5.57) ^a	ND (<5.57)
Phenol		ND (<3.27)	ND (<3.27)	ND (<3.27) ^a	ND (<3.27)
1,2,3-Trichlorobenzene ^c		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1,3,5-Trichlorobenzene ^c		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1,3-Cyclopentadiene ^c		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
2-Fluoropyridine ^c		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
3-Fluoropyridine ^c		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
1-Chloropyridine ^c		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
2-Chloropyridine ^c		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
3-Chloropyridine ^c		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
Cyclopenta(c,d)pyrene ^c		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)
Other Fluoropyridines ^c		ND (<4.0)	ND (<4.0)	ND (<4.0) ^b	ND (<4.0)

^a Average of sample and field duplicate sample.

^b Designated POHC.

^c Tentatively identified compound.

µg/L = Microgram per liter

mg/L = Milligram per liter

ND = Not detected (detection limit)

% = Percent

4.2.6 Vent Stream

The total Cl input to the ST HAF during the trial burn was supplemented by a vent stream of anhydrous HCl during Conditions 1 and 2. No other vent streams were fed to the ST HAF during these conditions. The anhydrous HCl vent stream was fed to the ST HAF combustion chamber using the same connections and feed mechanism as is used for normal vent gas processing. The flow rate of HCl to the combustion chamber was monitored by an orifice flow meter.

Samples of the anhydrous HCl vent stream were collected by a Dow technician during each test run to determine the Cl content of the gas. As shown in Table 4-12, results indicated an average total chlorine content of 98.3% and 97.0% for the Condition 1 and Condition 2 samples, respectively. These values were used to determine the total chlorine loading to the ST HAF as presented in Section 2.0.

4.3 Stack Gas Samples

Gas samples were collected for a variety of parameters from the ST HAF process stack during the three trial burn conditions. Results presented in the following subsections have not been blank corrected and are, therefore, conservative values. Emission rates that are reported as less than (<) values have been calculated using the detection limit (i.e., the detection limit has been used to determine emission rates when analytical results were reported below the detection limit).

4.3.1 Particulate Matter, Hydrogen Chloride, and Chlorine

Stack gas samples were collected during Conditions 1 and 3 for particulate matter, hydrogen chloride (HCl), and chlorine (Cl₂). Results of the emission testing are presented in Tables 4-13 and 4-14. Also included in the table are various stack gas parameters (e.g., flow rate, temperature, moisture) that were measured during the sampling run. The stack gas volumetric flow rate, temperature, and moisture content during Condition 1 were higher than those reported for Condition 3.

Table 4-12. Anhydrous HCl Vent Results

	HCl % ^a			
	Run 1	Run 2	Run 3	Average
Condition 1	98.7	98.0 ^b	98.2 ^c	98.3
Condition 2	97.7 ^d	97.4 ^d	96.0 ^d	97.0

^a Percent by volume.

^b Average of sample and field duplicate sample.

^c Average of two samples.

^d Average of duplicate analyses.

Table 4-13. Particulate Matter, HCl, and Cl₂ Emission Data - Condition 1

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	2 April 2000	4 April 2000	5 April 2000	NA
Run Time	NA	1409-1622	0837-1049	0836-1236	NA
Sample Volume	dscf	84.5	96.5	90.2	90.4
Stack Gas Volumetric Flow Rate	acfm	698	691	664	684
Stack Gas Volumetric Flow Rate	dscfm	604	645	604	618
Stack Gas Temperature	°F	108	89	97	98
Stack Gas Moisture	% volume	8.0	4.5	5.9	6.1
Percent Isokinetic	%	94.8	101.4	101.3	99.2
Particulate Collected	mg	62.1	55.3	123.6	80.3
Particulate Emission Rate	lb/hr x 10 ⁻²	5.9	4.9	10.9	7.2
Particulate Concentration	gr/dscf x 10 ⁻³	9.5	7.5	17.4	11.5
HCl Collected	mg	17.8	17.5	4.1	13.1
HCl Concentration	ppmv	4.9	4.2	1.1	3.4
HCl Emission Rate	lb/hr x 10 ⁻²	1.7	1.5	0.36	1.2
Chlorine Collected	mg	0.51	0.33	0.68	0.51
Chlorine Concentration	ppmv	0.073	0.041	0.091	0.068
Chlorine Emission Rate	lb/hr x 10 ⁻⁴	4.8	2.9	6.0	4.6

acfm = Actual cubic feet per minute
 dscf = Dry standard cubic feet
 dscfm = Dry standard cubic feet per minute
 °F = Degrees Fahrenheit
 gr/dscf = Grains per dry standard cubic feet, corrected to 7% oxygen
 lb/hr = Pound per hour
 mg = Milligram
 NA = Not applicable
 ppmv = Part per million by volume
 % = Percent

Table 4-14. Particulate Matter, HCl, and Cl₂ Emission Data - Condition 3

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	8 February 2000	9 February 2000	10 February 2000	NA
Run Time	NA	1256-1619	1217-1428	1205-1425	NA
Sample Volume	dscf	95.9	100.2	99.4	98.5
Stack Gas Volumetric Flow Rate	acfm	498	513	512	508
Stack Gas Volumetric Flow Rate	dscfm	475	485	493	484
Stack Gas Temperature	°F	79	80	73	77
Stack Gas Moisture	% volume	3.3	3.5	2.6	3.1
Percent Isokinetic	%	99.5	101.8	99.3	100.2
Particulate Collected	mg	10.5	10.6	9.8	10.3
Particulate Emission Rate	lb/hr x 10 ⁻³	6.9	6.8	6.4	6.7
Particulate Concentration	gr/dscf x 10 ⁻³	1.4	1.3	1.2	1.3
HCl Collected	mg	1.6	1.9	1.5	1.7
HCl Concentration	ppmv	0.39	0.45	0.34	0.39
HCl Emission Rate	lb/hr x 10 ⁻³	1.1	1.2	1.0	1.1
Chlorine Collected	ug	< 0.007	< 0.008	< 0.008	< 0.008
Chlorine Concentration	ppbv	< 0.93	< 0.97	< 0.98	< 0.96
Chlorine Emission Rate	lb/hr x 10 ⁻⁶	< 4.9	< 5.2	< 5.3	< 5.1

acfm = Actual cubic feet per minute
 dscf = Dry standard cubic feet
 dscfm = Dry standard cubic feet per minute
 °F = Degrees Fahrenheit
 gr/dscf = Grains per dry standard cubic feet, corrected to 7% oxygen
 lb/hr = Pound per hour
 mg = Milligram
 ug = Microgram
 NA = Not applicable
 ppmv = Part per million by volume
 ppbv = Part per billion by volume
 % = Percent

As shown in Tables 4-13 and 4-14, the average weight of the particulate matter collected in the sampling train for Condition 1 (80.3 mg) was greater than that for Condition 3 (10.3 mg). This was expected since ash and metals were spiked into the ST HAF during Condition 1, increasing the particulate loading to the system. As a result, the particulate emissions during Condition 1 were higher than the Condition 3 emissions. However, particulate matter emissions (corrected to 7% oxygen) were low for both conditions, ranging from 1.3×10^{-3} grains per dry standard cubic feet (gr/dscf) for Condition 3 to 11.5×10^{-3} gr/dscf for Condition 1. These results are significantly below the 8.0×10^{-2} gr/dscf performance standard for particulate matter.

In conjunction with the particulate matter, HCl and Cl₂ emissions were measured during Conditions 1 and 3. As shown in Tables 4-13 and 4-14, the average HCl and Cl₂ emission rates were higher for Condition 1 than Condition 3 (1.2×10^{-2} lb/hr and 4.6×10^{-4} lb/hr for HCl and Cl₂ versus 1.1×10^{-3} lb/hr and $<5.1 \times 10^{-6}$ lb/hr, respectively).

4.3.2 Metals

Samples of the stack gas were collected and analyzed for arsenic, cadmium, total chromium, and nickel during Conditions 1 and 3. As shown in Tables 4-15 and 4-16, the stack gas parameters (stack gas volumetric flow rate, temperature, and moisture content) measured during the two operating conditions were higher for Condition 1. Results indicated that nickel was the metal emitted at the highest rate during each condition, followed by total chromium. Emission rates for nickel ranged from 7.6×10^{-6} lb/hr to 7.9×10^{-4} lb/hr, while total chromium rates ranged from 3.7×10^{-6} lb/hr to 1.5×10^{-4} lb/hr for Conditions 3 and 1, respectively. Metals emission rates for arsenic, cadmium, chromium, and nickel were higher during Condition 1 than Condition 3. This was expected due to the increased metals loading to the ST HAF during Condition 1.

4.3.3 Hexavalent Chromium

Hexavalent chromium samples were collected during Conditions 1 and 3 of the trial burn. Results, including stack gas parameters, are presented in Tables 4-17 and 4-18. The

Table 4-15. Metals Emission Data - Condition 1

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	2 April 2000	4 April 2000	6 April 2000	NA
Run Time	NA	1501-1607	1745-1851	1343-1449	NA
Sample Volume	dscf	40.7	45.7	44.4	43.6
Stack Gas Volumetric Flow Rate	acfm	675	673	687	679
Stack Gas Volumetric Flow Rate	dscfm	586	600	597	594
Stack Gas Temperature	°F	107	102	108	106
Stack Gas Moisture	% volume	7.9	6.8	8.1	7.6
Percent Isokinetic	%	94.3	103.3	100.9	99.5
Arsenic Collected	µg	0.82	< 0.45 ^a	0.74	< 0.67
Arsenic Emission Rate	lb/hr x 10 ⁻⁶	1.6	< 0.8	1.3	< 1.2
Cadmium Collected	µg	10.0	24.7	24.7	19.8
Cadmium Emission Rate	lb/hr x 10 ⁻⁵	1.9	4.3	4.4	3.5
Total Chromium Collected	µg	38.7	105	106	83.2
Total Chromium Emission Rate	lb/hr x 10 ⁻⁴	0.74	1.8	1.9	1.5
Nickel Collected	µg	191	579	567	445
Nickel Emission Rate	lb/hr x 10 ⁻⁴	3.6	10.1	10.1	7.9

^a Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

acfm = Actual cubic feet per minute
dscf = Dry standard cubic feet
dscfm = Dry standard cubic feet per minute
°F = Degrees Fahrenheit
lb/hr = Pound per hour
µg = Microgram
NA = Not applicable
% = Percent

Table 4-16. Metals Emission Data - Condition 3

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	8 February 2000	9 February 2000	10 February 2000	NA
Run Time	NA	1508-1621	1350-1456	1330-1438	NA
Sample Volume	dscf	46.7	46.2	45.0	46.0
Stack Gas Volumetric Flow Rate	acfm	504	493	473	490
Stack Gas Volumetric Flow Rate	dscfm	477	466	458	467
Stack Gas Temperature	°F	81	80	70	77
Stack Gas Moisture	% volume	3.6	3.5	2.5	3.2
Percent Isokinetic	%	96.3	97.6	96.8	96.9
Arsenic Collected	µg	< 0.57 ^a	< 0.57	< 0.57	< 0.57
Arsenic Emission Rate	lb/hr x 10 ⁻⁷	< 7.7	< 7.6	< 7.7	< 7.7
Cadmium Collected	µg	1.1	1.4	1.1	1.2
Cadmium Emission Rate	lb/hr x 10 ⁻⁶	1.5	1.9	1.5	1.6
Total Chromium Collected	µg	3.8	2.3	2.1	2.7
Total Chromium Emission Rate	lb/hr x 10 ⁻⁶	5.1	3.0	2.8	3.7
Nickel Collected	µg	6.9	4.8	5.2	5.6
Nickel Emission Rate	lb/hr x 10 ⁻⁶	9.3	6.4	7.0	7.6

^a Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

acfm = Actual cubic feet per minute
dscf = Dry standard cubic feet
dscfm = Dry standard cubic feet per minute
°F = Degrees Fahrenheit
lb/hr = Pound per hour
µg = Microgram
NA = Not applicable
% = Percent

Table 4-17. Hexavalent Chromium Emission Data - Condition 1

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	2 April 2000	4 April 2000	6 April 2000	NA
Run Time	NA	1323-1430	1404-1708	1203-1309	NA
Sample Volume	dscf	41.9	45.2	44.4	43.8
Stack Gas Volumetric Flow Rate	acfm	688	669	667	675
Stack Gas Volumetric Flow Rate	dscfm	598	602	596	599
Stack Gas Temperature	°F	107	100	101	103
Stack Gas Moisture	% volume	7.8	6.4	6.6	6.9
Percent Isokinetic	%	95.0	101.9	101.1	99.3
Cr ⁺⁶ Collected	µg	5.6	6.9	2.8	5.1
Cr ⁺⁶ Emission Rate	lb/hr x 10 ⁻⁶	10.5	12.1	4.9	9.2

acfm = Actual cubic feet per minute
 Cr⁺⁶ = Hexavalent chromium
 dscf = Dry standard cubic feet
 dscfm = Dry standard cubic feet per minute
 °F = Degrees Fahrenheit
 lb/hr = Pound per hour
 µg = Microgram
 NA = Not applicable
 % = Percent

Table 4-18. Hexavalent Chromium Emission Data - Condition 3

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	8 February 2000	9 February 2000	10 February 2000	NA
Run Time	NA	1152-1259	1103-1211	1111-1218	NA
Sample Volume	dscf	47.0	47.7	44.0	46.2
Stack Gas Volumetric Flow Rate	acfm	496	510	456	488
Stack Gas Volumetric Flow Rate	dscfm	474	481	442	465
Stack Gas Temperature	°F	79	81	70	77
Stack Gas Moisture	% volume	3.3	3.6	2.5	3.1
Percent Isokinetic	%	97.6	97.8	98.2	97.9
Cr ⁺⁶ Collected	µg	3.3	2.0	2.6	2.6
Cr ⁺⁶ Emission Rate	lb/hr x 10 ⁻⁶	4.4	2.7	3.4	3.5

acfm = Actual cubic feet per minute
 Cr⁺⁶ = Hexavalent chromium
 dscf = Dry standard cubic feet
 dscfm = Dry standard cubic feet per minute
 °F = Degrees Fahrenheit
 lb/hr = Pound per hour
 µg = Microgram
 NA = Not applicable
 % = Percent

stack gas flow rate, temperature, and moisture content were slightly higher during Condition 1 than Condition 3. The hexavalent chromium emission rate (9.2×10^{-6} lb/hr) during Condition 1, was higher than the Condition 3 emission rate (3.5×10^{-6} lb/hr). Overall, hexavalent chromium emissions from the ST HAF process stack were low.

4.3.4 Volatile Organic Compounds

Stack gas samples were collected and analyzed for VOCs using the Volatile Organic Sampling Train (VOST) during all three operating conditions. Results presented in Tables 4-19 through 4-21 are the average values of three pairs of VOST traps since multiple samples were collected and analyzed for each condition. The VOST traps were analyzed separately to assess potential breakthrough of the organics onto the back trap. Results reported in the tables are conservative since the detection limit was used for all values reported below the detection limit for each trap to calculate the emission rate of the target compound.

Four chlorinated compounds (carbon tetrachloride, chloroform, chloromethane, and methylene chloride) were detected in most of the VOST samples. The VOC emitted at the highest average rate was chloroform at 75.8×10^{-5} lb/hr during Condition 1, followed by carbon tetrachloride at 39.9×10^{-5} lb/hr (Condition 1), and methylene chloride at 6.2×10^{-5} lb/hr (Condition 3). The top 25 tentatively identified compounds (TICs) were also reported for all samples; emission rates for these compounds are listed in Tables 4-19 through 4-21 as "other compounds".

4.3.5 Dioxins and Furans

During all trial burn operating conditions, stack gas samples were collected and analyzed for dioxins and furans. Information on the stack gas parameters measured during the different operating conditions are presented in Tables 4-22 through 4-24. Stack gas volumetric flow rate, temperature, and moisture content were highest during Condition 1 and lowest during Condition 2.

**Table 4-19. Volatile Organic Compound
Emission Data (VOST Samples) - Condition 1**

Compound	Run 1 Average Emission Rate^a (lb/hr x 10⁻⁵)	Run 2 Average Emission Rate^a (lb/hr x 10⁻⁵)	Run 3 Average Emission Rate^a (lb/hr x 10⁻⁵)	Average Emission Rate^a (lb/hr x 10⁻⁵)
Benzene	<1.41 ^b	<0.57	<1.1	<1.0
1,3-Butadiene ^c	<0.23	<0.23	<1.1	<0.52
Carbon tetrachloride	75.7	21.1	22.8	39.9
Chloroethane	<0.41	<0.33	<1.1	<0.61
Chloroform	104	58.9	64.4	75.8
Chloromethane	6.7	2.7	3.0	4.1
1-Chloropropane ^c	<0.19	<0.19	<0.98	<0.45
2-Chloropropane ^c	<0.23	<0.49	<1.0	<0.57
1,1-Dichloroethane	<0.61	<0.41	<1.1	<0.71
1,2-Dichloroethane	<5.4	<4.7	<0.72	<3.6
trans-1,2-Dichloroethene	<0.52	<0.24	<1.1	<0.62
1,2-Dichloropropane	<1.0	<1.0	<0.52	<0.84
cis-1,3-Dichloropropene	<0.23	<0.23	<1.1	<0.52
trans-1,3-Dichloropropene	<0.24	<0.23	<1.1	<0.52
Methylene chloride	43.5	12.3	<3.2	<19.7
Monochlorobenzene	<0.33	<0.25	<0.80	<0.46
Tetrachloroethylene	<1.6	<0.56	<2.6	<1.6
Toluene	<0.26	<0.23	2.8	<1.1
1,1,1-Trichloroethane	<0.23	<0.23	<1.1	<0.52
Trichloroethene	<0.86	<0.28	<1.1	<0.75
Styrene	<0.23	<0.23	<1.1	<0.52
Other Compounds				
1,2-Dichlorobenzene	<0.38	<0.23	<1.0	<0.54
1-Bromo-2-chloroethane	<0.42	<0.61	<1.0	<0.68
1-Chloro-2-nitropropane	<0.23	<0.48	<1.0	<0.57
1-Propene	<0.23	<0.23	<1.0	<0.49
2-Methyl-1-propene	<0.94	<0.50	<1.0	<0.81
2-Propanol	<0.50	0.79	<1.0	<0.76
2-Propanone	<1.4	<0.23	<1.0	<0.88
Bromodichloromethane	8.0	<0.23	<1.0	<3.1
Dibromochloromethane	2.1	<0.23	<1.0	<1.1
Tribromomethane	<0.76	<0.23	<1.0	<0.66

Table 4-19 (Continued)

Compound	Run 1 Average Emission Rate ^a (lb/hr x 10 ⁻⁵)	Run 2 Average Emission Rate ^a (lb/hr x 10 ⁻⁵)	Run 3 Average Emission Rate ^a (lb/hr x 10 ⁻⁵)	Average Emission Rate ^a (lb/hr x 10 ⁻⁵)
Other Compounds (Continued)				
Unknown	0.59	NR	NR	NR
Unknown	17.2	NR	NR	NR
Unknown	6.8	NR	NR	NR
Unknown	12.9	NR	NR	NR
Unknown	3.6	NR	NR	NR
Unknown	11.2	NR	NR	NR
Unknown	1.0	NR	NR	NR
Unknown	0.83	NR	NR	NR
Unknown	10.6	NR	NR	NR
Unknown	NR	7.0	NR	NR
Unknown	NR	13.6	NR	NR
Unknown	NR	4.4	NR	NR
Unknown	NR	16.3	NR	NR
Unknown	NR	6.6	NR	NR
Unknown	NR	9.8	NR	NR
Unknown	NR	NR	5.2	NR
Unknown	NR	NR	10.4	NR

^a Results presented in the table are the average values for three pairs of VOST tubes collected during each run.

^b Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

^c Tentatively identified compound.

lb/hr = Pound per hour

NR = No result reported or able to be calculated

**Table 4-20. Volatile Organic Compound
Emission Data (VOST Samples) - Condition 2**

Compound	Run 1 Average Emission Rate^a (lb/hr x 10⁻⁵)	Run 2 Average Emission Rate^a (lb/hr x 10⁻⁵)	Run 3 Average Emission Rate^a (lb/hr x 10⁻⁵)	Average Emission Rate^a (lb/hr x 10⁻⁵)
Benzene	<0.22 ^b	<0.17	<0.23	<0.21
1,3-Butadiene ^c	<0.18	<0.16	<0.16	<0.17
Carbon tetrachloride	1.4	1.6	1.7	1.6
Chloroethane	<0.18	<0.15	<0.16	<0.16
Chloroform	64.5	60.5	62.8	62.6
Chloromethane	1.6	1.5	1.5	1.5
1-Chloropropane ^c	<0.18	<0.16	<0.16	<0.17
2-Chloropropane ^c	<0.18	<0.16	<0.16	<0.17
1,1-Dichloroethane	<0.18	<0.16	<0.16	<0.17
1,2-Dichloroethane	<0.18	<0.16	<0.16	<0.17
trans-1,2-Dichloroethene	<0.18	<0.16	<0.16	<0.17
1,2-Dichloropropane	<0.18	<0.16	<0.16	<0.17
cis-1,3-Dichloropropene	<0.18	<0.16	<0.16	<0.17
trans-1,3-Dichloropropene	<0.18	<0.16	<0.16	<0.17
Methylene chloride	<5.5	0.62	0.80	<2.3
Monochlorobenzene	<0.18	<0.16	<0.16	<0.17
Tetrachloroethylene	<0.18	<0.16	<0.16	<0.17
Toluene	<0.18	<0.16	<0.16	<0.17
1,1,1-Trichloroethane	<0.18	<0.16	<0.16	<0.17
Trichloroethene	<0.18	<0.16	<0.16	<0.17
Styrene	<0.18	<0.16	<0.16	<0.17
Other Compounds				
1,2-Heptadiene	<0.29	<0.16	<0.16	<0.20
1-Propenyl-cyclopropane	<0.18	<0.16	<0.51	<0.28
2-Methyl-1,4-pentadiene	<0.36	<0.25	<0.43	<0.35
2-Methyl-1-propene	1.3	0.53	1.9	1.2
2-Propanol	<1.3	<0.29	<0.41	<0.67
Bromodichloromethane	17.8	7.3	10.2	11.8
Dibromochloromethane	8.4	4.2	8.0	6.9
Ethenylcyclobutane	<0.47	<0.16	<0.16	<0.26
Tribromomethane	3.2	1.6	2.4	2.4
Trichloronitromethane	<0.30	<0.16	<0.59	<0.35

Table 4-20 (Continued)

Compound	Run 1 Average Emission Rate ^a (lb/hr x 10 ⁻⁵)	Run 2 Average Emission Rate ^a (lb/hr x 10 ⁻⁵)	Run 3 Average Emission Rate ^a (lb/hr x 10 ⁻⁵)	Average Emission Rate ^a (lb/hr x 10 ⁻⁵)
Other Compounds (Continued)				
Unknown	1.9	NR	NR	NR
Unknown	0.97	NR	NR	NR
Unknown	1.9	NR	NR	NR
Unknown	1.6	NR	NR	NR
Unknown	1.5	NR	NR	NR
Unknown	5.2	NR	NR	NR
Unknown	3.4	NR	NR	NR
Unknown	NR	0.93	NR	NR
Unknown	NR	0.40	NR	NR
Unknown	NR	0.92	NR	NR
Unknown	NR	NR	1.0	NR
Unknown	NR	NR	2.0	NR
Unknown	NR	NR	2.3	NR
Unknown	NR	NR	1.0	NR
Unknown	NR	NR	0.87	NR
Unknown	NR	NR	4.8	NR
Unknown	NR	NR	4.1	NR
Unknown	NR	NR	0.72	NR

^a Results presented in the table are the average values for three pairs of VOST tubes collected during each run.

^b Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

^c Tentatively identified compound.

lb/hr = Pound per hour

NR = No result reported or able to be calculated

**Table 4-21. Volatile Organic Compound
Emission Data (VOST Samples) - Condition 3**

Compound	Run 1 Average Emission Rate^a (lb/hr x 10⁻⁵)	Run 2 Average Emission Rate^a (lb/hr x 10⁻⁵)	Run 3 Average Emission Rate^a (lb/hr x 10⁻⁵)	Average Emission Rate^a (lb/hr x 10⁻⁵)
Benzene	<0.29	<0.31	<0.29	<0.30
1,3-Butadiene ^c	<0.17	<0.18	<0.17	<0.17
Carbon tetrachloride	3.3	5.4	5.6	4.8
Chloroethane	<0.21	<0.18	<0.17	<0.19
Chloroform	<2.9	<2.0	<1.6	<2.2
Chloromethane	5.7	2.7	1.3	3.2
1-Chloropropane ^c	<0.17	<0.18	<0.17	<0.17
2-Chloropropane ^c	<0.17	<0.18	<0.17	<0.17
1,1-Dichloroethane	<0.17	<0.18	<0.17	<0.17
1,2-Dichloroethane	<0.17	<0.18	<0.17	<0.17
trans-1,2-Dichloroethene	<0.17	<0.18	<0.17	<0.17
1,2-Dichloropropane	<0.19	<0.18	<0.17	<0.18
cis-1,3-Dichloropropene	<0.17	<0.18	<0.17	<0.17
trans-1,3-Dichloropropene	<0.17	<0.18	<0.17	<0.17
Methylene chloride	7.5	5.7	5.3	6.2
Monochlorobenzene	<0.21	<0.18	<0.17	<0.19
Tetrachloroethylene	<0.21	<0.83	<0.59	<0.54
Toluene	<0.23	<0.19	<0.35	<0.26
1,1,1-Trichloroethane	<0.17	<0.18	<0.17	<0.17
Trichloroethene	<0.20	<0.18	<0.17	<0.18
Styrene	<0.17	<0.18	<0.17	<0.17
Other Compounds				
1,1'-Bicyclopropyl	<0.49	<0.18	<0.17	<0.28
1,2,4-Trichlorobenzene	<0.27	<0.18	<0.17	<0.21
2-Methyl-1,4-pentadiene	<0.92	0.86	<0.77	<0.85
2-Methyl-1-propene	3.6	4.2	2.5	3.4
2-Propanol	0.85	<0.82	<0.34	<0.67
3-Chloro-1-propene	<0.30	<0.18	<0.17	<0.22
Cyanogen bromide	<0.17	<0.18	<0.25	<0.20
Dibromochloromethane	<0.17	<0.18	<0.27	<0.21
Dihydro-3-methyl-2,3-furandione	<0.84	<0.18	<0.17	<0.40
Tribromomethane	<0.17	<0.18	3.1	<1.2
Unknown	9.5	NR	NR	NR
Unknown	1.0	NR	NR	NR
Unknown	2.2	NR	NR	NR
Unknown	1.4	NR	NR	NR
Unknown	0.53	NR	NR	NR
Unknown	14.6	NR	NR	NR
Unknown	0.58	NR	NR	NR
Unknown	4.0	NR	NR	NR
Unknown	1.3	NR	NR	NR

Table 4-21 (Continued)

Compound	Run 1 Average Emission Rate ^a (lb/hr x 10 ⁻⁵)	Run 2 Average Emission Rate ^a (lb/hr x 10 ⁻⁵)	Run 3 Average Emission Rate ^a (lb/hr x 10 ⁻⁵)	Average Emission Rate ^a (lb/hr x 10 ⁻⁵)
Other Compounds (Continued)				
Unknown	0.46	NR	NR	NR
Unknown	7.3	NR	NR	NR
Unknown	0.58	NR	NR	NR
Unknown	NR	1.1	NR	NR
Unknown	NR	8.4	NR	NR
Unknown	NR	0.56	NR	NR
Unknown	NR	2.0	NR	NR
Unknown	NR	9.7	NR	NR
Unknown	NR	0.77	NR	NR
Unknown	NR	1.1	NR	NR
Unknown	NR	0.84	NR	NR
Unknown	NR	7.1	NR	NR
Unknown	NR	1.1	NR	NR
Unknown	NR	NR	2.1	NR
Unknown	NR	NR	9.1	NR
Unknown	NR	NR	0.59	NR
Unknown	NR	NR	1.1	NR
Unknown	NR	NR	0.43	NR
Unknown	NR	NR	5.6	NR
Unknown	NR	NR	2.7	NR
Unknown	NR	NR	0.56	NR
Unknown	NR	NR	10.1	NR
Unknown	NR	NR	0.76	NR
Unknown	NR	NR	1.0	NR

^a Results presented in the table are the average values for three pairs of VOST tubes collected during each run.

^b Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

^c Tentatively Identified Compound.

lb/hr = Pound per hour

NR = No result reported or able to be calculated

Table 4-22. Dioxin and Furan Emission Data - Condition 1

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	2 April 2000	4 April 2000	6 April 2000	NA
Run Time	NA	1015-1328	1355-1909	1200-1508	NA
Sample Volume	dscf	131.2	137.7	133.7	134.2
Stack Gas Volumetric Flow Rate	acfm	691	677	678	682
Stack Gas Volumetric Flow Rate	dscfm	605	608	598	604
Stack Gas Temperature	°F	104	100	105	103
Stack Gas Moisture	% volume	7.3	6.4	7.3	7.0
Percent Isokinetic	%	98.0	102.3	101.1	100.4
PCDD Emission Rates	lb/hr x 10 ⁻¹¹				
2,3,7,8-TCDD		1.1	0.82	< 0.58 ^a	< 0.70
Total TCDD		31.6	28.1	30.2	29.1
1,2,3,7,8-PeCDD		< 1.1	< 0.64	< 0.59	< 0.62
Total PeCDD		1.5	< 1.5	< 2.1	< 1.80
1,2,3,4,7,8-HxCDD		< 0.70	< 0.76	< 0.71	< 0.74
1,2,3,6,7,8-HxCDD		< 0.70	< 0.76	< 0.71	< 0.74
1,2,3,7,8,9-HxCDD		< 0.64	< 0.70	< 0.65	< 0.68
Total HxCDD		< 0.70	< 0.76	< 0.71	< 0.74
1,2,3,4,6,7,8-HpCDD		< 0.55	< 0.51	< 0.47	< 0.49
Total HpCDD		< 0.55	< 0.51	< 0.47	< 0.49
OCDD		2.0	< 1.0	< 1.4	< 1.2
<i>Total PCDD Equivalent</i>	lb/hr x 10 ⁻¹¹	1.8	1.4	1.1	1.4
PCDF Emission Rates	lb/hr x 10 ⁻¹¹				
2,3,7,8-TCDF		17.5	15.2	20.1	17.6
Total TCDF		1,344	1,052	1,243	1,213
1,2,3,7,8-PeCDF		17.5	11.7	14.2	14.5
2,3,4,7,8-PeCDF		4.6	3.0	4.4	4.0
Total PeCDF		310	210	249	256
1,2,3,4,7,8-HxCDF		17.5	7.6	9.5	11.5
1,2,3,6,7,8-HxCDF		7.0	3.2	4.3	4.8
2,3,4,6,7,8-HxCDF		1.3	< 0.26	< 0.53	< 0.69
1,2,3,7,8,9-HxCDF		< 0.47	< 0.38	< 0.49	< 0.44
Total HxCDF		58.4	26.3	32.6	39.1
1,2,3,4,6,7,8-HpCDF		16.9	4.8	6.5	9.4
1,2,3,4,7,8,9-HpCDF		2.3	< 0.42	0.71	< 1.2
Total HpCDF		25.1	4.8	8.9	12.9
OCDF		38.6	8.8	8.3	18.5
<i>Total PCDF Equivalent</i>	lb/hr x 10 ⁻¹¹	7.8	4.8	6.5	6.4

^a Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

acfm = Actual cubic feet per minute
dscf = Dry standard cubic feet
dscfm = Dry standard cubic feet per minute
°F = Degrees Fahrenheit

lb/hr = Pound per hour
NA = Not applicable
% = Percent

Table 4-23. Dioxin and Furan Emission Data - Condition 2

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	17 February 2000	17 February 2000	18 February 2000	NA
Run Time	NA	1002-1313	1648-1957	1030-1348	NA
Sample Volume	dscf	143.4	129.4	133.9	135.6
Stack Gas Volumetric Flow Rate	acfm	492	449	455	466
Stack Gas Volumetric Flow Rate	dscfm	476	436	442	451
Stack Gas Temperature	°F	73	73	73	73
Stack Gas Moisture	% volume	2.7	2.3	2.5	2.5
Percent Isokinetic	%	98.9	97.4	99.4	98.6
PCDD Emission Rates	lb/hr x 10 ⁻¹¹				
2,3,7,8-TCDD		< 0.10 ^a	0.53	0.36	< 0.33
Total TCDD		2.3	3.4	3.0	2.9
1,2,3,7,8-PeCDD		< 0.31	< 0.24	< 0.30	< 0.28
Total PeCDD		< 0.31	< 0.67	< 0.30	< 0.43
1,2,3,4,7,8-HxCDD		< 0.26	< 0.37	< 0.24	< 0.29
1,2,3,6,7,8-HxCDD		< 0.21	< 0.30	< 0.20	< 0.23
1,2,3,7,8,9-HxCDD		< 0.20	< 0.29	< 0.19	< 0.22
Total HxCDD		< 0.26	< 0.37	< 0.24	< 0.29
1,2,3,4,6,7,8-HpCDD		< 0.18	< 0.28	< 0.18	< 0.22
Total HpCDD		< 0.18	< 0.28	< 0.18	< 0.22
OCDD		< 0.68	< 0.71	< 0.87	< 0.76
<i>Total PCDD Equivalent</i>	lb/hr x 10 ⁻¹¹	0.32	0.75	0.57	0.55
PCDF Emission Rates	lb/hr x 10 ⁻¹¹				
2,3,7,8-TCDF		0.79	9.4	6.1	5.4
Total TCDF		87.8	138	105	110
1,2,3,7,8-PeCDF		< 0.61	1.8	1.4	< 1.3
2,3,4,7,8-PeCDF		< 0.18	0.89	0.70	< 0.59
Total PeCDF		8.8	20.1	14.0	14.3
1,2,3,4,7,8-HxCDF		< 0.24	< 0.33	< 0.24	< 0.27
1,2,3,6,7,8-HxCDF		< 0.17	< 0.23	< 0.17	< 0.19
2,3,4,6,7,8-HxCDF		< 0.16	< 0.22	< 0.16	< 0.18
1,2,3,7,8,9-HxCDF		< 0.11	< 0.38	< 0.12	< 0.20
Total HxCDF		< 0.53	< 0.38	< 0.17	< 0.36
1,2,3,4,6,7,8-HpCDF		< 0.15	< 0.18	< 0.09	< 0.14
1,2,3,4,7,8,9-HpCDF		< 0.20	< 0.25	< 0.13	< 0.19
Total HpCDF		< 0.20	< 0.25	< 0.13	< 0.19
OCDF		< 0.57	< 0.49	0.92	< 0.66
<i>Total PCDF Equivalent</i>	lb/hr x 10 ⁻¹¹	0.27	1.6	1.1	0.99

^a Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

acfm = Actual cubic feet per minute
dscf = Dry standard cubic feet
dscfm = Dry standard cubic feet per minute
°F = Degrees Fahrenheit

lb/hr = Pound per hour
NA = Not applicable
% = Percent

Table 4-24. Dioxin and Furan Emission Data - Condition 3

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	8 February 2000	9 February 2000	10 February 2000	NA
Run Time	NA	0845-1158	0815-1128	0800-1115	NA
Sample Volume	dscf	144.0	145.5	138.1	142.5
Stack Gas Volumetric Flow Rate	acfm	510	511	478	500
Stack Gas Volumetric Flow Rate	dscfm	488	492	463	481
Stack Gas Temperature	°F	78	74	70	74
Stack Gas Moisture	% volume	3.2	2.8	2.4	2.8
Percent Isokinetic	%	96.8	97.1	97.9	97.3
PCDD Emission Rates	lb/hr x 10 ⁻¹¹				
2,3,7,8-TCDD		< 0.25 ^a	< 0.09	< 0.06	< 0.13
Total TCDD		4.1	3.6	1.3	3.0
1,2,3,7,8-PeCDD		< 0.36	< 0.30	< 0.23	< 0.30
Total PeCDD		< 0.36	< 0.30	< 0.23	< 0.30
1,2,3,4,7,8-HxCDD		< 0.25	< 0.17	< 0.15	< 0.19
1,2,3,6,7,8-HxCDD		< 0.20	< 0.13	< 0.12	< 0.15
1,2,3,7,8,9-HxCDD		< 0.19	< 0.13	< 0.12	< 0.14
Total HxCDD		< 0.25	< 0.17	< 0.15	< 0.19
1,2,3,4,6,7,8-HpCDD		< 0.23	< 0.13	< 0.13	< 0.16
Total HpCDD		< 0.23	< 0.13	< 0.13	< 0.16
OCDD		< 0.45	< 0.35	< 0.35	< 0.38
Total PCDD Equivalent	lb/hr x 10 ⁻¹¹	0.50	0.29	0.22	0.33
PCDF Emission Rates	lb/hr x 10 ⁻¹¹				
2,3,7,8-TCDF		1.5	1.2	0.62	1.1
Total TCDF		157	121	62.1	113
1,2,3,7,8-PeCDF		0.85	0.63	< 0.26	< 0.58
2,3,4,7,8-PeCDF		< 0.18	< 0.16	< 0.11	< 0.15
Total PeCDF		21.1	15.7	6.7	14.5
1,2,3,4,7,8-HxCDF		< 0.36	< 0.22	< 0.17	< 0.25
1,2,3,6,7,8-HxCDF		< 0.25	< 0.15	< 0.12	< 0.17
2,3,4,6,7,8-HxCDF		< 0.11	< 0.08	< 0.12	< 0.10
1,2,3,7,8,9-HxCDF		< 0.18	< 0.13	< 0.19	< 0.17
Total HxCDF		< 0.22	< 0.22	< 0.19	< 0.21
1,2,3,4,6,7,8-HpCDF		< 0.22	< 0.12	< 0.10	< 0.15
1,2,3,4,7,8,9-HpCDF		< 0.30	< 0.17	< 0.14	< 0.20
Total HpCDF		< 0.30	< 0.17	< 0.14	< 0.20
OCDF		< 0.63	< 0.32	< 0.62	< 0.52
Total PCDF Equivalent	lb/hr x 10 ⁻¹¹	0.38	0.29	0.19	0.29

^a Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

acfm = Actual cubic feet per minute
dscf = Dry standard cubic feet
dscfm = Dry standard cubic feet per minute
°F = Degrees Fahrenheit

lb/hr = Pound per hour
NA = Not applicable
% = Percent

As shown in the tables, some of the target dioxin and furan congeners were detected in the stack gas samples for each run of the three operating conditions. Emission rates were calculated using the detection limit for those compounds that were reported by the analytical laboratory as non-detected values. The emission rates calculated using the detection limit are reported as less than values. The measured dioxin and furan emission rates were converted to toxic equivalents based on the cancer risk factor for these compounds. The toxic equivalents for dioxins and furans were the highest for Condition 1; values were 1.4×10^{-11} lb/hr and 6.4×10^{-11} lb/hr, respectively. The lowest total dioxin and furan emission rates were reported during Condition 3.

4.3.6 Semivolatile Organic Compounds, Polychlorinated Biphenyls, and Polycyclic Aromatic Hydrocarbons

A single sample train was used to collect stack gas samples for semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and polycyclic aromatic hydrocarbons (PAHs). As shown in Tables 4-25 through 4-27, the stack gas parameters (volumetric flow rate, temperature, and moisture content) were highest during Condition 1.

The SVOC target analyte list was rather extensive. As presented in the tables, most of the SVOCs in the stack gas samples were reported below the detection limit. Emission rates for non-detected compounds were calculated using the detection limit and are presented as less than values in the table. Chloropyridines and hexachlorobenzene were detected in all samples and 1,2-dichlorobenzene and phenol were detected in most samples. The average chloropyridine emission rate ranged from 2.0×10^{-6} to 79.7×10^{-6} lb/hr, while the hexachlorobenzene emission rate ranged from 3.7×10^{-6} to 16.3×10^{-6} lb/hr. Dichlorobenzene and phenol emission rates were highest during Condition 1 (6.1×10^{-6} and 9.7×10^{-6} , respectively).

Dichlorobenzene, the POHC, was reported below the detection limit for only two of the nine stack gas samples. The destruction and removal efficiency (DRE), as shown in Table 4-28, was greater than the performance standard of 99.99% for all samples collected.

Table 4-25. SVOC, PCB, and PAH Emission Data - Condition 1

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	2 April 2000	4 April 2000	6 April 2000	NA
Run Time	NA	1017-1330	1357-1911	1202-1510	NA
Sample Volume	dscf	133.5	135.0	131.8	133.4
Stack Gas Volumetric Flow Rate	acfm	721	674	679	691
Stack Gas Volumetric Flow Rate	dscfm	632	605	598	612
Stack Gas Temperature	°F	104	101	105	103
Stack Gas Moisture	% volume	7.3	6.5	7.3	7.0
Percent Isokinetic	%	95.5	100.8	99.7	98.7
SVOC Emission Rates	lb/hr x 10 ⁻⁶				
1,3-Cyclopentadiene ^a		< 2.5 ^b	<2.4	<2.4	<2.4
1,2,3-Trichlorobenzene ^a		< 2.5	<2.4	<2.4	<2.4
1,2,4-Trichlorobenzene		< 0.20	<0.19	<0.19	<0.19
1,3,5-Trichlorobenzene ^a		< 2.5	< 2.4	< 2.4	< 2.4
Chlorophenol		< 0.22	< 0.21	< 0.21	< 0.22
Chloropyridine-1 ^c		19.1	19.6	9.5	16.1
Chloropyridine-2 ^c		46.6	36.0	17.0	33.2
Chloropyridine-3 ^c		9.4	7.3	4.0	6.9
Cyclopenta (cd) pyrene ^a		< 2.5	< 2.4	< 2.4	< 2.4
1,2-Dichlorobenzene		10.0	4.6	3.9	6.1
1,3-Dichlorobenzene		< 0.21	< 0.20	< 0.21	< 0.21
1,4-Dichlorobenzene		< 0.15	< 0.14	< 0.15	< 0.15
2-Fluoropyridine		< 2.5	< 2.4	< 2.4	< 2.4
3-Fluoropyridine		< 2.5	< 2.4	< 2.4	< 2.4
Hexachlorobenzene		20.5	15.4	13.1	16.3
Hexachlorobutadiene		< 0.24	< 0.23	< 0.23	< 0.24
Hexachloroethane		< 0.31	< 0.30	< 0.30	< 0.30
Pentachloroethane		< 1.3	< 1.2	< 1.2	< 1.2
Pentachlorophenol		< 1.4	< 1.3	< 1.4	< 1.4
Phenol		11.0	8.7	9.4	9.7
PCB Emissions Rates	lb/hr x 10 ⁻⁹				
Decachlorobiphenyl		14.4	3.4	4.9	7.6
Dichlorobiphenyl		751	522	600	624
Heptachlorobiphenyl		18.8	8.3	7.8	11.6
Hexachlorobiphenyl		157	107	150	138
Monochlorobiphenyl		81.4	56.4	78.0	71.9
Nonachlorobiphenyl		8.8	< 1.2	< 1.2	< 3.7
Octachlorobiphenyl		< 1.3	< 1.2	< 1.2	< 1.2
Pentachlorobiphenyl		939	712	780	810
Tetrachlorobiphenyl		1,941	1,365	1,680	1,662

Table 4-25 (Continued)

Parameter	Units	Run 1	Run 2	Run 3	Average
Trichlorobiphenyl	lb/hr x 10 ⁻⁹	1,690	1,365	1,500	1,518
3,3',4,4'-Tetrachlorobiphenyl (PCB-77)		15.7	11.9	18.0	15.2
2,3,3',4,4'-Pentachlorobiphenyl (PCB-105)		8.1	5.9	7.2	7.1
3,3',4,4',5-Pentachlorobiphenyl (PCB-126)		1.5	< 1.2	< 1.2	< 1.3
2,3,3',4,4',5-Hexachlorobiphenyl (PCB-156)		4.4	1.4	5.9	3.9
2,3,3',4,4',5-Hexachlorobiphenyl (PCB-157)		< 1.3	< 1.2	< 1.2	< 1.2
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB-167)		1.4	< 1.2	< 1.2	< 1.3
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB-169)		< 1.3	< 1.2	< 1.2	< 1.2
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB-170)		< 1.3	< 1.2	< 1.2	< 1.2
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB-180)		1.6	< 1.2	< 1.2	< 1.3
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB-189)		< 1.3	< 1.2	< 1.2	< 1.2
2,3,4,4',5-Pentachlorobiphenyl (PCB-114)		2.0	2.0	2.6	2.2
2,3',4,4',5-Pentachlorobiphenyl (PCB-118)		24.4	17.8	24.6	22.3
2',3,4,4',5-Pentachlorobiphenyl (PCB-123)		8.8	5.9	9.0	7.9
PAH Emission Rates	lb/hr x 10 ⁻⁹				
Naphthalene		876	350	1,020	749
2-Methylnaphthalene		23.2	16.6	20.4	20.1
Acenaphthylene		7.5	< 3.0	< 3.0	< 4.5
Acenaphthene		< 3.1	< 3.0	< 3.0	< 3.0
Fluorene		15.7	10.7	12.6	13.0
Phenanthrene		313	214	162	230
Anthracene		13.1	12.5	9.6	11.7
Fluoranthene		50.7	35.6	36.6	41.0

Table 4-25 (Continued)

Parameter	Units	Run 1	Run 2	Run 3	Average
Pyrene	lb/hr x 10 ⁻⁹	5.9	6.5	5.3	5.9
Chrysene		< 3.1	< 3.0	< 3.0	< 3.0
Benzo(a)anthracene		< 3.1	< 3.0	< 3.0	< 3.0
Benzo(b)fluoranthene		< 3.1	< 3.0	< 3.0	< 3.0
Benzo(k)fluoranthene		< 3.1	< 3.0	< 3.0	< 3.0
Benzo(a)pyrene		< 3.1	< 3.0	< 3.0	< 3.0
Benzo(e)pyrene		< 3.1	< 3.0	< 3.0	< 3.0
Perylene		< 3.1	< 3.0	< 3.0	< 3.0
Indeno(1,2,3-c,d)pyrene		< 3.1	< 3.0	< 3.0	< 3.0
Dibenz(a,h)anthracene		< 3.1	< 3.0	< 3.0	< 3.0
Benzo(g,h,i)perylene		< 3.1	< 3.0	< 3.0	< 3.0

^a Tentatively identified compound.

^b Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below detection limit.

^c Chloropyridine included (2-chloro-6-(trichloromethyl)-pyridine, 2,5-Dichloro-6-(trichloromethyl)-pyridine, and 2,3-Dichloro-6-(trichloromethyl)-pyridine)

acfm = Actual cubic feet per minute
dscf = Dry standard cubic feet
dscfm = Dry standard cubic feet per minute
°F = Degrees Fahrenheit
lb/hr = Pound per hour
NA = Not applicable
PAH = Polycyclic aromatic hydrocarbon
PCB = Polychlorinated biphenyl
SVOC = Semivolatile organic compound
% = Percent

Table 4-26. SVOC, PCB, and PAH Emission Data - Condition 2

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	17 February 2000	17 February 2000	18 February 2000	NA
Run Time	NA	1004-1315	1650-1959	1032-1350	NA
Sample Volume	dscf	145.7	128.5	136.7	135.6
Stack Gas Volumetric Flow Rate	acfm	503	447	469	473
Stack Gas Volumetric Flow Rate	dscfm	489	434	455	459
Stack Gas Temperature	°F	73	73	73	73
Stack Gas Moisture	% volume	2.3	2.4	2.6	2.4
Percent Isokinetic	%	97.9	97.2	98.6	97.9
SVOC Emission Rates	lb/hr x 10 ⁻⁶				
1,3-Cyclopentadiene ^a		< 1.8 ^b	< 1.8	< 1.8	< 1.8
1,2,3-Trichlorobenzene ^a		< 1.8	< 1.8	< 1.8	< 1.8
1,2,4-Trichlorobenzene		< 0.14	< 0.14	< 0.14	< 0.14
1,3,5-Trichlorobenzene ^a		< 1.8	< 1.8	< 1.8	< 1.8
Chlorophenol		< 0.16	< 0.16	< 0.16	< 0.16
Chloropyridine-1 ^c		31.6	11.8	9.2	17.5
Chloropyridine-2 ^c		137	46.9	55.5	79.7
Chloropyridine-3 ^c		21.5	9.2	10.2	13.6
Cyclopenta (cd) pyrene ^a		< 1.8	< 1.8	< 1.8	< 1.8
1,2-Dichlorobenzene		4.2	1.4	< 0.18	< 1.9
1,3-Dichlorobenzene		< 0.15	< 0.15	< 0.15	< 0.15
1,4-Dichlorobenzene		< 0.11	< 0.11	< 0.11	< 0.11
2-Fluoropyridine		< 1.8	< 1.8	< 1.8	< 1.8
3-Fluoropyridine		< 1.8	< 1.8	< 1.8	< 1.8
Hexachlorobenzene		4.1	3.2	3.7	3.7
Hexachlorobutadiene		< 0.17	< 0.17	< 0.17	< 0.17
Hexachloroethane		< 0.22	< 0.22	< 0.22	< 0.22
Pentachloroethane		< 0.89	< 0.89	< 0.88	< 0.89
Pentachlorophenol		< 1.0	< 1.0	< 1.0	< 1.0
Phenol		3.4	< 0.20	< 0.19	< 1.3
PCB Emissions Rates	lb/hr x 10 ⁻⁹				
Decachlorobiphenyl		< 0.89	< 0.89	< 0.88	< 0.89
Dichlorobiphenyl		1,775	1,518	1,982	1,759
Heptachlorobiphenyl		< 0.89	< 0.89	< 0.88	< 0.89
Hexachlorobiphenyl		15.1	13.4	12.8	13.8
Monochlorobiphenyl		186	134	185	168
Nonachlorobiphenyl		< 0.89	< 0.89	< 0.88	< 0.89
Octachlorobiphenyl		< 0.89	< 0.89	< 0.88	< 0.89
Pentachlorobiphenyl		275	250	216	247
Tetrachlorobiphenyl		932	804	1,101	946

Table 4-26 (Continued)

Parameter	Units	Run 1	Run 2	Run 3	Average
Trichlorobiphenyl	lb/hr x 10 ⁻⁹	2,352	1,742	1,630	1,908
3,3',4,4'-Tetrachlorobiphenyl (PCB-77)		1.1	2.6	2.2	2.0
2,3,3',4,4'-Pentachlorobiphenyl (PCB-105)		< 0.89	< 0.89	< 0.88	< 0.89
3,3',4,4',5-Pentachlorobiphenyl (PCB-126)		< 0.89	< 0.89	< 0.88	< 0.89
2,3,3',4,4',5-Hexachlorobiphenyl (PCB-156)		< 0.89	< 0.89	< 0.88	< 0.89
2,3,3',4,4',5-Hexachlorobiphenyl (PCB-157)		< 0.89	< 0.89	< 0.88	< 0.89
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB-167)		< 0.89	< 0.89	< 0.88	< 0.89
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB-169)		< 0.89	< 0.89	< 0.88	< 0.89
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB-170)		< 0.89	< 0.89	< 0.88	< 0.89
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB-180)		< 0.89	< 0.89	< 0.88	< 0.89
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB-189)		< 0.89	< 0.89	< 0.88	< 0.89
2,3,4,4',5-Pentachlorobiphenyl (PCB-114)		< 0.89	< 0.89	< 0.88	< 0.89
2,3',4,4',5-Pentachlorobiphenyl (PCB-118)		1.8	2.3	2.5	2.2
2',3,4,4',5-Pentachlorobiphenyl (PCB-123)		< 0.89	< 0.89	< 0.88	< 0.89
PAH Emission Rates	lb/hr x 10 ⁻⁹				
Naphthalene		240	152	176	189
2-Methylnaphthalene		20.0	18.3	15.0	17.8
Acenaphthylene		< 2.2	< 2.2	< 2.2	< 2.2
Acenaphthene		< 2.2	< 2.2	< 2.2	< 2.2
Fluorene		19.5	11.6	11.5	14.2
Phenanthrene		271	67.0	123	154
Anthracene		3.4	2.7	2.8	3.0
Fluoranthene		3.1	2.5	2.5	2.7

Table 4-26 (Continued)

Parameter	Units	Run 1	Run 2	Run 3	Average
Pyrene	lb/hr x 10 ⁻⁹	3.5	3.2	3.5	3.4
Chrysene		< 2.2	< 2.2	< 2.2	< 2.2
Benzo(a)anthracene		< 2.2	< 2.2	< 2.2	< 2.2
Benzo(b)fluoranthene		< 2.2	< 2.2	< 2.2	< 2.2
Benzo(k)fluoranthene		< 2.2	< 2.2	< 2.2	< 2.2
Benzo(a)pyrene		< 2.2	< 2.2	< 2.2	< 2.2
Benzo(e)pyrene		< 2.2	< 2.2	< 2.2	< 2.2
Perylene		< 2.2	< 2.2	< 2.2	< 2.2
Indeno(1,2,3-c,d)pyrene		< 2.2	< 2.2	< 2.2	< 2.2
Dibenz(a,h)anthracene		< 2.2	< 2.2	< 2.2	< 2.2
Benzo(g,h,i)perylene		< 2.2	< 2.2	< 2.2	< 2.2

^a Quantified as a tentatively identified compound.

^b Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below detection limit.

^c Chloropyridine included (2-chloro-6-(trichloromethyl)-pyridine, 2,5-Dichloro-6-(trichloromethyl)-pyridine, and 2,3-Dichloro-6-(trichloromethyl)-pyridine)

- acfm = Actual cubic feet per minute
- dscf = Dry standard cubic feet
- dscfm = Dry standard cubic feet per minute
- °F = Degrees Fahrenheit
- lb/hr = Pound per hour
- NA = Not applicable
- PAH = Polycyclic aromatic hydrocarbon
- PCB = Polychlorinated biphenyl
- SVOC = Semivolatile organic compound
- % = Percent

Table 4-27. SVOC, PCB, and PAH Emission Data - Condition 3

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	8 February 2000	9 February 2000	10 February 2000	NA
Run Time	NA	0847-1200	0817-1130	0802-1117	NA
Sample Volume	dscf	140.4	145.4	135.9	140.6
Stack Gas Volumetric Flow Rate	acfm	498	513	475	495
Stack Gas Volumetric Flow Rate	dscfm	476	493	460	476
Stack Gas Temperature	°F	78	74	70	74
Stack Gas Moisture	% volume	3.2	2.9	2.4	2.8
Percent Isokinetic	%	96.8	96.9	97.0	96.9
SVOC Emission Rates	lb/hr x 10 ⁻⁶				
1,3-Cyclopentadiene ^a		< 1.8 ^b	< 1.8	< 1.8	< 1.8
1,2,3-Trichlorobenzene ^a		2.9	1.7	< 1.8	< 2.1
1,2,4-Trichlorobenzene		8.4	5.7	1.5	5.2
1,3,5-Trichlorobenzene ^a		1.6	< 1.8	< 1.8	< 1.7
Chlorophenol		< 0.16	< 0.16	< 0.16	< 0.16
Chloropyridine-1 ^c		1.8	1.9	2.1	2.0
Chloropyridine-2 ^c		17.8	18.0	13.0	16.3
Chloropyridine-3 ^c		5.2	5.1	3.3	4.5
Cyclopenta(cd)pyrene ^a		< 1.8	< 1.8	< 1.8	< 1.8
1,2-Dichlorobenzene		1.8	1.8	< 0.18	< 1.3
1,3-Dichlorobenzene		1.8	1.2	< 0.15	< 1.1
1,4-Dichlorobenzene		2.2	0.76	< 0.11	< 1.0
2-Fluoropyridine		< 1.8	< 1.8	< 1.8	< 1.8
3-Fluoropyridine		< 1.8	< 1.8	< 1.8	< 1.8
Hexachlorobenzene		13.6	21.2	9.7	14.8
Hexachlorobutadiene		< 0.17	< 0.17	< 0.17	< 0.17
Hexachloroethane		< 0.22	< 0.22	< 0.22	< 0.22
Pentachloroethane		< 0.90	< 0.90	< 0.90	< 0.90
Pentachlorophenol		< 1.0	< 1.0	< 1.0	< 1.0
Phenol		3.6	4.0	4.7	4.1
PCB Emissions Rates	lb/hr x 10 ⁻⁹				
Decachlorobiphenyl		< 0.90	< 0.90	< 0.90	< 0.90
Dichlorobiphenyl		16,603	9,861	4,924	10,462
Heptachlorobiphenyl		6.3	1.0	< 0.90	< 2.7
Hexachlorobiphenyl		103	62.8	17.0	61.0
Monochlorobiphenyl		5,833	3,093	1,029	3,319
Nonachlorobiphenyl		< 0.90	< 0.90	< 0.90	< 0.90
Octachlorobiphenyl		< 0.90	< 0.90	< 0.90	< 0.90
Pentachlorobiphenyl		1,077	762	331	723
Tetrachlorobiphenyl		3,859	2,644	1,343	2,615

Table 4-27 (Continued)

Parameter	Units	Run 1	Run 2	Run 3	Average
Trichlorobiphenyl	lb/hr x 10 ⁹	9,423	7,171	4,118	6,904
3,3',4,4'-Tetrachlorobiphenyl (PCB-77)		2.2	1.4	1.4	1.7
2,3,3',4,4'-Pentachlorobiphenyl (PCB-105)		1.1	< 0.90	< 0.90	< 0.97
3,3',4,4',5-Pentachlorobiphenyl (PCB-126)		< 0.90	< 0.90	< 0.90	< 0.90
2,3,3',4,4',5-Hexachlorobiphenyl (PCB-156)		< 0.90	< 0.90	< 0.90	< 0.90
2,3,3',4,4',5-Hexachlorobiphenyl (PCB-157)		< 0.90	< 0.90	< 0.90	< 0.90
2,3',4,4',5,5'-Hexachlorobiphenyl (PCB-167)		< 0.90	< 0.90	< 0.90	< 0.90
3,3',4,4',5,5'-Hexachlorobiphenyl (PCB-169)		< 0.90	< 0.90	< 0.90	< 0.90
2,2',3,3',4,4',5-Heptachlorobiphenyl (PCB-170)		< 0.90	< 0.90	< 0.90	< 0.90
2,2',3,4,4',5,5'-Heptachlorobiphenyl (PCB-180)		< 0.90	< 0.90	< 0.90	< 0.90
2,3,3',4,4',5,5'-Heptachlorobiphenyl (PCB-189)		< 0.90	< 0.90	< 0.90	< 0.90
2,3,4,4',5-Pentachlorobiphenyl (PCB-114)		< 0.90	< 0.90	< 0.90	< 0.90
2,3',4,4',5-Pentachlorobiphenyl (PCB-118)		3.9	2.4	2.4	2.9
2',3,4,4',5-Pentachlorobiphenyl (PCB-123)		1.2	< 0.90	< 0.90	< 1.0
PAH Emission Rates	lb/hr x 10 ⁹				
Naphthalene		3,949	2,151	537	2,212
2-Methylnaphthalene		162	85.2	32.7	93.1
Acenaphthylene		220	80.7	22.4	108
Acenaphthene		16.2	7.6	2.4	8.7
Fluorene		359	220	94.0	224
Phenanthrene		2,872	2,286	1,209	2,122
Anthracene		44.9	20.6	11.6	25.7
Fluoranthene		21.1	17.5	12.1	16.9
Pyrene		4.5	3.1	4.1	3.9

Table 4-27 (Continued)

Parameter	Units	Run 1	Run 2	Run 3	Average
Chrysene	lb/hr x 10 ⁻⁹	< 2.2	< 2.2	< 2.2	< 2.2
Benzo(a)anthracene		< 2.2	< 2.2	< 2.2	< 2.2
Benzo(b)fluoranthene		< 2.2	< 2.2	< 2.2	< 2.2
Benzo(k)fluoranthene		< 2.2	< 2.2	< 2.2	< 2.2
Benzo(a)pyrene		< 2.2	< 2.2	< 2.2	< 2.2
Benzo(e)pyrene		< 2.2	< 2.2	< 2.2	< 2.2
Perylene		< 2.2	< 2.2	< 2.2	< 2.2
Indeno(1,2,3-c,d)pyrene		< 2.2	< 2.2	< 2.2	< 2.2
Dibenz(a,h)anthracene		< 2.2	< 2.2	< 2.2	< 2.2
Benzo(g,h,i)perylene		< 2.2	< 2.2	< 2.2	< 2.2

^a Quantified as a tentatively identified compound.

^b Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below detection limit.

^c Chloropyridine-1: 2-chloro-6-(trichloromethyl)-pyridine

Chloropyridine-2: 2,5-Dichloro-6-(trichloromethyl)-pyridine

Chloropyridine-3: 2,3-Dichloro-6-(trichloromethyl)-pyridine)

acfm = Actual cubic feet per minute
dscf = Dry standard cubic feet
dscfm = Dry standard cubic feet per minute
°F = Degrees Fahrenheit
lb/hr = Pound per hour
NA = Not applicable
PAH = Polycyclic aromatic hydrocarbon
PCB = Polychlorinated biphenyl
SVOC = Semivolatile organic compound
% = Percent

**Table 4-28. Destruction and Removal Efficiency of the POHC -
Conditions 1 and 2**

Condition No.	Run No.	1,2-Dichlorobenzene Input Rate (lb/hr)	1,2-Dichlorobenzene Emission Rate (lb/hr x 10 ⁻⁶)	1,2-Dichlorobenzene DRE (%)
1	1	29.5	10.0	99.999
1	2	29.6	4.6	99.999
1	3	29.9	3.9	99.999
1	Average	29.7	6.1	99.999
2	1	20.2	4.2	99.999
2	2	15.0	1.4	99.999
2	3	15.0	<0.18	>99.999
2	Average	16.7	4.2	>99.999

DRE = Destruction and removal efficiency
 lb/hr = Pound per hour
 POHC = Principal Organic Hazardous Constituent
 % = Percent

For PCBs, monochlorobiphenyl through hexachlorobiphenyl classes of PCB compounds were detected in all of the samples. The PCB emission rates for Condition 3 were generally higher than the other two operating conditions. All the specific PCB congeners (versus compound classes) on the target analyte list were reported as non-detected values.

As shown in Tables 4-25 through 4-27, seven PAHs (naphthalene, 2-methylnaphthalene, fluorene, phenanthrene, anthracene, fluoranthene, and pyrene) were detected in all stack gas samples. Naphthalene was emitted at the highest rate (emission rates ranged from 7.5×10^{-7} lb/hr to 2.2×10^{-6} lb/hr) for all conditions; this compound, however, is a typical contaminant of the resin (XAD-2) used to collect semivolatile compounds and may have contributed to the naphthalene levels. Emissions of PAHs were generally higher for the Condition 3 samples.

4.3.7 Aldehydes

During all three operating conditions, stack gas samples were collected and analyzed for aldehydes. The stack gas parameters, shown in Tables 4-29 through 4-31, were higher during Condition 1 than the other operating conditions. Acetaldehyde, acetone, and formaldehyde were detected in all samples. Results indicated that acetone was present at the highest level in the Condition 2 and 3 samples, whereas acetaldehyde emission rates were slightly higher than acetone for Condition 1. The reagent used to collect aldehyde samples (dinitrophenyl-hydrazine) is especially susceptible to acetone contamination and may have contributed to the acetone levels. Pentanal was the only other compound detected at low levels in two of the Condition 1 samples. Emission rates for non-detected values are presented as less than values in the tables.

4.3.8 Total Hydrocarbons, Oxygen, and Carbon Monoxide

Continuous emission monitors (CEMs) were used to measure the concentration of oxygen (O₂), carbon monoxide (CO), and total hydrocarbons (THCs) in the stack gas during all trial burn operating conditions. The O₂ and CO concentrations were monitored using Dow's permanent process instruments; THC levels were monitored using a contractor's instrument.

Table 4-29. Aldehyde Emission Data - Condition 1

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	2 April 2000	4 April 2000	5 April 2000	NA
Run Time	NA	1407-1620	0835-1047	0834-1234	NA
Sample Volume	dscf	61.7	66.6	66.5	64.9
Stack Gas Volumetric Flow Rate	acfm	694	659	672	675
Stack Gas Volumetric Flow Rate	dscfm	600	616	613	610
Stack Gas Temperature	°F	108	89	97	98
Stack Gas Moisture	% volume	8.1	4.5	5.6	6.1
Percent Isokinetic	%	96.7	101.7	102.1	100.1
Aldehyde Emission Rates	lb/hr x 10 ⁻⁶				
Acetaldehyde		38.0	135	8.8	60.5
Acetone		54.7	96.7	17.1	56.2
Acrolein		< 5.8 ^a	< 4.3	< 4.3	< 4.8
Benzaldehyde		< 5.8	< 4.3	36.6	< 15.6
Crotonaldehyde		< 5.8	< 4.3	< 4.3	< 4.8
Formaldehyde		36.0	68.5	15.8	40.1
Hexanal		< 5.8	< 4.3	6.5	< 5.5
Isopentanal		< 5.8	< 4.3	< 4.3	< 4.8
m,p-Tolualdehyde		< 5.8	< 4.3	< 4.3	< 4.8
o-Tolualdehyde		< 5.8	< 4.3	< 4.3	< 4.8
Pentanal		6.1	< 4.3	17.1	< 9.2
Propanal		< 5.8	< 4.3	< 4.3	< 4.8

^a Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

acfm = Actual cubic feet per minute
dscf = Dry standard cubic feet
dscfm = Dry standard cubic feet per minute
°F = Degrees Fahrenheit
lb/hr = Pound per hour
NA = Not applicable
% = Percent

Table 4-30. Aldehyde Emission Data - Condition 2

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	17 February 2000	17 February 2000	18 February 2000	NA
Run Time	NA	1318-1524	2010-2215	1407-1613	NA
Sample Volume	dscf	65.8	65.7	65.7	65.7
Stack Gas Volumetric Flow Rate	acfm	465	468	464	466
Stack Gas Volumetric Flow Rate	dscfm	451	457	448	452
Stack Gas Temperature	°F	72	71	75	73
Stack Gas Moisture	% volume	2.5	2.1	2.7	2.5
Percent Isokinetic	%	99.0	97.3	99.4	98.6
Aldehyde Emission Rates	lb/hr x 10⁻⁶				
Acetaldehyde		190	111	199	166
Acetone		363	359	217	313
Acrolein		< 6.5	< 2.9	< 5.6	< 5.0
Benzaldehyde		< 6.5	7.0	< 5.6	< 6.4
Crotonaldehyde		< 6.5	< 2.9	< 5.6	< 5.0
Formaldehyde		30.8	39.6	49.6	40.0
Hexanal		< 6.5	< 2.9	< 5.6	< 5.0
Isopentanal		< 6.5	< 2.9	< 5.6	< 5.0
m,p-Tolualdehyde		< 6.5	< 2.9	< 5.6	< 5.0
o-Tolualdehyde		< 6.5	< 2.9	< 5.6	< 5.0
Pentanal		< 6.5	< 2.9	< 5.6	< 5.0
Propanal		< 6.5	< 2.9	< 5.6	< 5.0

^a Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

acfm = Actual cubic feet per minute
dscf = Dry standard cubic feet
dscfm = Dry standard cubic feet per minute
°F = Degrees Fahrenheit
lb/hr = Pound per hour
NA = Not applicable
% = Percent

Table 4-31. Aldehyde Emission Data - Condition 3

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	8 February 2000	9 February 2000	10 February 2000	NA
Run Time	NA	1253-1617	1215-1426	1203-1423	NA
Sample Volume	dscf	98.7	72.6	70.7	80.7
Stack Gas Volumetric Flow Rate	acfm	517	524	494	NA
Stack Gas Volumetric Flow Rate	dscfm	493	496	475	488
Stack Gas Temperature	°F	79	80	73	77
Stack Gas Moisture	% volume	3.3	3.4	2.6	3.1
Percent Isokinetic	%	98.6	98.5	100.1	99.1
Aldehyde Emission Rates	lb/hr x 10⁻⁶				
Acetaldehyde		125	108	133	122
Acetone		195	131	160	162
Acrolein		< 4.3 ^a	< 3.1	< 4.0	< 3.8
Benzaldehyde		< 4.3	< 3.1	< 4.0	< 3.8
Crotonaldehyde		< 4.3	< 3.1	< 4.0	< 3.8
Formaldehyde		17.2	24.8	25.8	22.6
Hexanal		< 4.3	< 3.1	< 4.0	< 3.8
Isopentanal		< 4.3	< 3.1	< 4.0	< 3.8
m,p-Tolualdehyde		< 4.3	< 3.1	< 4.0	< 3.8
o-Tolualdehyde		< 4.3	< 3.1	< 4.0	< 3.8
Pentanal		< 4.3	< 3.1	< 4.0	< 3.8
Propanal		< 4.3	< 3.1	< 4.0	< 3.8

^a Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

- acfm = Actual cubic feet per minute
- dscf = Dry standard cubic feet
- dscfm = Dry standard cubic feet per minute
- °F = Degrees Fahrenheit
- lb/hr = Pound per hour
- NA = Not applicable
- % = Percent

Results of the continuous emission monitoring are presented in Tables 4-32 through 4-34. Average oxygen concentrations ranged from 3.4% (Condition 1) to 9.3% (Conditions 2 and 3). The average CO concentration (parts per million by volume [ppmv] corrected to 7% O₂) was greatest during Condition 1 (37.2 ppmv) and dropped to 3.3 ppmv during Condition 2. For all conditions, THC concentrations were less than 1.0 ppmv as propane corrected to 7% O₂.

Table 4-32. Continuous Emissions Monitor Data-Condition 1

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	2 April 2000	4 April 2000	5-6 April 2000	NA
Run Time	NA	1015-1629	0831-1912	0830-1249 1200-1513	NA
Stack Gas Volumetric Flow Rate	dscfm	610	619	604	611
O ₂ Concentration	%	3.8	3.3	3.2	3.4
THC Concentration	ppmv as propane	0.70	0.50	0.36	0.52
THC Concentration, Corrected	ppmv corrected to 7% O ₂	0.57	0.40	0.28	0.42
THC Emission Rate	lb/hr x 10 ⁻³	2.9	2.1	1.5	2.2
CO Concentration	ppmv	51.8	56.1	50.3	52.7
CO Concentration	ppmv corrected to 7% O ₂	42.1	44.3	39.5	42.0
CO Emission Rate	lb/hr x 10 ⁻¹	1.4	1.5	1.3	1.4

CO = Carbon monoxide
 dscfm = Dry standard cubic feet per minute
 NA = Not applicable
 O₂ = Oxygen
 ppmv = Part per million by volume (dry basis)
 THC = Total hydrocarbon
 % = Percent

Table 4-33. Continuous Emissions Monitor Data - Condition 2

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	17 February 2000	17 February 2000	18 February 2000	NA
Run Time	NA	1000-1530	1647-2215	1030-1611	NA
Stack Gas Volumetric Flow Rate	dscfm	467	446	448	454
O ₂ Concentration	%	9.5	9.3	9.0	9.3
THC ^c Concentration	ppmv as propane	< 0.10 ^a	< 0.10	< 0.10	< 0.10
THC Concentration, Corrected	ppmv corrected to 7% O ₂	< 0.13	< 0.12	< 0.12	< 0.12
THC Emission Rate	lb/hr x 10 ⁻³	<0.30	<0.30	<0.30	<0.30
CO Concentration	ppmv	8.9	9.4	9.3	9.2
CO Concentration	ppmv corrected to 7% O ₂	10.9	11.3	10.9	11.0
CO Emission Rate	lb/hr x 10 ⁻²	1.8	1.8	1.8	1.8

^a Emission rates reported as "less than" values were calculated using the detection limit. Sample results were below the detection limit.

- CO = Carbon monoxide
- dscfm = Dry standard cubic feet per minute
- NA = Not applicable
- O₂ = Oxygen
- ppmv = Part per million by volume (dry basis)
- THC = Total hydrocarbon
- % = Percent

Table 4-34. Continuous Emissions Monitor Data - Condition 3

Parameter	Units	Run 1	Run 2	Run 3	Average
Date	NA	8 February 2000	9 February 2000	10 February 2000	NA
Run Time	NA	0845-1202 1517-1629	0815-1457	0800-1442	NA
Stack Gas Volumetric Flow Rate	dscfm	483	492	473	483
O ₂ Concentration	%	9.5	9.3	9.0	9.3
THC Concentration	ppmv as propane	0.52	0.47	0.47	0.49
THC Concentration, Corrected	ppmv corrected to 7% O ₂	0.42	0.38	0.37	0.39
THC Emission Rate	lb/hr x 10 ⁻³	1.7	1.6	1.5	1.6
CO Concentration	ppmv	18.0	17.8	11.7	15.8
CO Concentration	ppmv corrected to 7% O ₂	14.3	14.1	9.3	12.6
CO Emission Rate	lb/hr x 10 ⁻²	3.8	3.8	2.4	3.3

CO = Carbon monoxide
 dscfm = Dry standard cubic feet per minute
 NA = Not applicable
 O₂ = Oxygen
 ppmv = Part per million by volume (dry basis)
 THC = Total hydrocarbon
 % = Percent

5.0 Quality Assurance/Quality Control

A quality assurance project plan (QAPP), *Quality Assurance Project Plan for The Dow Chemical Company Symtet Halogen Acid Furnace*, September 1999, was prepared and implemented as part of the trial burn testing program. By following the procedures described in the QAPP during the Symtet (ST) Halogen Acid Furnace (HAF) trial burn, the quality of project measurement data was well documented and the data are reliable, defensible, and met project objectives for precision, accuracy, completeness, representativeness, and comparability.

The primary objectives of the quality assurance/quality control (QA/QC) procedures implemented in this program were to control, assess, and document data quality. To accomplish these objectives, the trial burn QA/QC approach consisted of the following key elements:

- ▶ Definition of measurement quality objectives that reflect the overall technical objectives of the project.
- ▶ Design of a sampling, analytical, QA/QC, and data analysis system to meet these objectives.
- ▶ Evaluation of the performance of the measurement systems.
- ▶ Initiation of corrective action when measurement system performance did not meet the specifications.

The sampling and analytical methods, calibration procedures, QC checks, data reduction and validation procedures, and sample tracking activities described in the QAPP were followed during all runs of the trial burn. Results of the QC analysis, including estimates of precision and accuracy for target analytes, are presented in this section. Supporting documentation, including field data sheets, laboratory reports, and equipment calibration records are included as appendices (three separate volumes) to this report.

5.1 Measurement Quality Objectives

The measurement quality objectives (MQOs) for precision, accuracy, completeness, representativeness, and comparability were presented in the QAPP. These values

are estimates of the degree of uncertainty that is considered acceptable for the data collected during the trial burn. The QA/QC program focused on controlling and quantifying measurement error within these limits and provided a basis for understanding the uncertainty associated with these data. During data validation, measurement data were compared with the MQOs specified in the QAPP to determine whether performance problems occurred.

Precision is defined as the degree of mutual agreement (or reproducibility) among independent measurements as the result of repeated application of the same process under similar conditions. Analytical precision is a measurement of the variability associated with duplicate (i.e., 2) or replicate (more than 2) analyses of the same sample in the laboratory. Total precision, which measures the variability associated with the entire sampling and analysis process, is determined by analysis of duplicate (or replicate) field samples; it incorporates the variability caused by the sample matrix, field sampling procedures, and analytical procedures.

To assess field and analytical precision, some trial burn samples were collected in duplicate. Results for these samples are presented in Table 5-1 as the relative percent difference (RPD) between field duplicates. Laboratory control sample and laboratory control sample duplicate (LCS/LCSD) results were used to demonstrate that the laboratory systems were in statistical control. Sample heterogeneity and matrix effects on precision were assessed using matrix spike and matrix spike duplicate (MS/MSD) and field duplicate results. A summary of the measured precision, along with the project MQOs, are presented in Table 5-2.

Accuracy is a statistical measurement of correctness and includes components of random error (variability due to imprecision) and systematic error (bias). A measurement is considered accurate when the value reported falls within the expected range of deviations from the true value or known concentration of a spike or standard. Analytical accuracy is typically measured by determining the percent recovery of known target analytes that are spiked into an analyte-free control matrix at known concentrations. Accuracy objectives apply to spiking levels at five times the method detection limits or higher. Matrix spike and surrogate compound results were used to evaluate accuracy due to potential influences from the sample matrix. Results are shown in Table 5-2.

Table 5-1. Duplicate Results^a

Analyte	Condition 1			Condition 2			Condition 3		
	Sample 1	Sample 2	RPD	Sample 1	Sample 2	RPD	Sample 1	Sample 2	RPD
Spiking Mixture Results									
<i>Ash (%)</i>									
Metals Mixture	29.6	29.5	0.34	NA	NA	NA	NA	NA	NA
Ash Mixture	30.4	30.5	0.33	NA	NA	NA	NA	NA	NA
<i>Metals (mg/kg)</i>									
Arsenic	69.6	75.6	8.3	NA	NA	NA	NA	NA	NA
Cadmium	1,100	1,200	8.7	NA	NA	NA	NA	NA	NA
Chromium	13,400	13,300	0.75	NA	NA	NA	NA	NA	NA
Nickel	43,800	41,900	4.4	NA	NA	NA	NA	NA	NA
<i>Semivolatile Organic Compound (%)</i>									
1,2-Dichlorobenzene	98.8	98.8	0	NA	NA	NA	NA	NA	NA
Feed Results									
<i>Inorganic and Physical Analyses</i>									
Ash (%)	NA	NA	NA	NA	NA	NA	5.92	6.49	9.2
Carbon (%)	NA	NA	NA	NA	NA	NA	23.5	23.5	0
Total Chlorine (%)	NA	NA	NA	NA	NA	NA	58.8	49.5	17
Heating Value (Btu/lb)	NA	NA	NA	NA	NA	NA	2,992	3,709	21
Hydrogen (%)	NA	NA	NA	NA	NA	NA	0.57	0.53	7.3
Nitrogen (%)	NA	NA	NA	NA	NA	NA	3.15	3.18	0.95
Oxygen (%)	NA	NA	NA	NA	NA	NA	66.7	66.2	7.5
Total Sulfur (%)	NA	NA	NA	NA	NA	NA	0.12	0.11	8.7
<i>Semivolatile Organic Compounds (µg/g)</i>									
1-Chloropyridine	NA	NA	NA	NA	NA	NA	7,730	9,710	21
2-Chloropyridine	NA	NA	NA	NA	NA	NA	27,800	41,700	40
3-Chloropyridine	NA	NA	NA	NA	NA	NA	4,560	6,730	38

Table 5-1 (Continued)

Analyte	Condition 1			Condition 2			Condition 3		
	Sample 1	Sample 2	RPD	Sample 1	Sample 2	RPD	Sample 1	Sample 2	RPD
Metals (mg/kg)									
Arsenic	NA	NA	NA	NA	NA	NA	0.675	0.507	28
Barium	NA	NA	NA	NA	NA	NA	0.175	0.247	34
Chromium	NA	NA	NA	NA	NA	NA	35.3	34.6	2.0
Copper	NA	NA	NA	NA	NA	NA	31.9	33.4	4.6
Lead	NA	NA	NA	NA	NA	NA	1.93	1.70	13
Manganese	NA	NA	NA	NA	NA	NA	259	252	2.7
Mercury	NA	NA	NA	NA	NA	NA	0.0354	0.0163	74
Nickel	NA	NA	NA	NA	NA	NA	59.4	58.4	1.7
Selenium	NA	NA	NA	NA	NA	NA	ND	1.10	NC
Zinc	NA	NA	NA	NA	NA	NA	3.20	3.19	0.31
HCl Acid Product Results									
Metals (mg/L)									
Arsenic	0.529	0.541	2.2	NA	NA	NA	NA	NA	NA
Cadmium	6.54	6.57	0.31	NA	NA	NA	NA	NA	NA
Chromium	36.4	36.5	0.27	NA	NA	NA	NA	NA	NA
Nickel	151	151	0	NA	NA	NA	NA	NA	NA
Chloride (mg/L)	250,000	254,000	1.6	NA	NA	NA	NA	NA	NA
Scrubber Effluent Results									
Metals (mg/L)									
Arsenic	0.00794	0.00944	17	NA	NA	NA	NA	NA	NA
Cadmium	0.130	0.137	5.2	NA	NA	NA	NA	NA	NA
Chromium	0.576	0.590	2.4	NA	NA	NA	NA	NA	NA
Nickel	10.4	11.1	6.5	NA	NA	NA	NA	NA	NA
Chloride (mg/L)	3,880	3,900	0.51	NA	NA	NA	NA	NA	NA
Semivolatile Organic Compound (mg/L)									
Pentachlorethane	NA	NA	NA	84.7	77.2	9.5	NA	NA	NA

Table 5-1 (Continued)

Analyte	Condition 1			Condition 2			Condition 3		
	Sample 1	Sample 2	RPD	Sample 1	Sample 2	RPD	Sample 1	Sample 2	RPD
Stack Gas Results^b									
<i>Aldehydes (µg)</i>									
Formaldehyde	26/21	30/22	14/4.7	NA	NA	NA	26/25	26/30	0/18
Acetaldehyde	26/220	33/220	24/0	NA	NA	NA	190/120	190/120	0/0
Acetone	43/2,000	42/2,000	2.4/0	NA	NA	NA	300/150	290/140	3.4/6.9
Benzaldehyde	4.0/2.7	3.8/1.9	5.1/35	NA	NA	NA	2.6/1.9	2.8/1.8	7.4/5.4
MEK/butgraldehyde	NC/18	NC/18	NC/0	NA	NA	NA	NC/3.2	NC/2.6	NC/21
Hexanal	1.9/NC	ND/NC	NC/NC	NA	NA	NA	NC/NC	NC/NC	NC/NC
Pentanal	4.3/NC	5.2/NC	19/NC	NA	NA	NA	NC/NC	NC/NC	NC/NC

Note: There are no measurement quality objectives listed in the Quality Assurance Project Plan (QAPP) for process samples. Italicized analytes are tentatively identified compounds (TICs) that were not calibrated for but were detected in the non-target analyte research.

^a The only analytes listed are those that were detected in at least one of the two duplicate samples. Unless otherwise noted, results are from field duplicate samples.

^b RPDs were calculated from analytical duplicate samples. Two samples were analyzed in duplicate for both Conditions 1 and 3.

Btu/lb = British thermal units per pound

µg/g = Microgram per gram

µg/L = Microgram per liter

mg/kg = Milligram per kilogram

mg/L = Milligram per liter

NA = Not applicable

NC = Value cannot be calculated

ND = Not detected

RPD = Relative percent difference

% = Percent by weight

Table 5-2. Summary of Precision and Accuracy Estimates

Parameters	Precision (RSD)		Accuracy (%)	
	Measured	Objective	Recovery Range	Objective
Semivolatile Organic Compounds (Feed Samples)				
2-Fluorobiphenyl				56-148
2-Fluorophenol				48-135
Nitrobenzene-d ₅				46-141
Phenol-d ₅				54-153
Terphenyl-d ₁₄				62-138
2,4,6-Tribromophenol				41-156
NOT REPORTED DUE TO HIGH SAMPLE DILUTIONS				
Semivolatile Organic Compounds (Scrubber Effluent Samples)				
2-Fluorobiphenyl	52	<50	45-234	56-148
2-Fluorophenol	184	<50	0-63	48-135
Nitrobenzene-d ₅	22	<50	75-144	46-141
Phenol-d ₅	231	<50	0-58	54-153
Terphenyl-d ₁₄	30	<50	69-182	62-138
2,4,6-Tribromophenol	156	<50	0-102	41-156
Semivolatile Organic Compounds (HCl Acid Product Samples)				
2-Fluorobiphenyl	3.0	<50	90-99	56-148
2-Fluorophenol	22	<50	49-90	48-135
Nitrobenzene-d ₅	3.2	<50	90-99	46-141
Phenol-d ₅	32	<50	38-97	54-153
Terphenyl-d ₁₄	4.3	<50	98-111	62-138
2,4,6-Tribromophenol	4.2	<50	87-99	41-156
Semivolatile Organic Compounds (Stack Gas)				
2-Fluorobiphenyl	3.8	<50	87-99	56-148
2-Fluorophenol	43	<50	16-77	48-135
Nitrobenzene-d ₅	6.4	<50	80-99	46-141
Phenol-d ₅	42	<50	15-91	54-153
Terphenyl-d ₁₄	3.8	<50	97-109	62-138
2,4,6-Tribromophenol	22	<50	40-96	41-156
Metals (Feed Samples)^a				
Arsenic	1.0	<25	91-93	75-125
Barium	1.5	<25	96-99	75-125
Beryllium	2.4	<25	96-100	75-125
Cadmium	5.6	<25	89-100	75-125
Chromium	34	<25	58-139	75-125
Copper	31	<25	64-140	75-125
Lead	2.1	<25	94-98	75-125
Manganese	20	<25	71-118	75-125
Mercury	2.1	<25	86-90	75-125
Nickel	45	<25	43-150	75-125
Selenium	3.2	<25	95-102	75-125
Thallium	2.0	<25	88-92	75-125
Zinc	4.6	<25	91-100	75-125

Table 5-2 (Continued)

Parameters	Precision (RSD)		Accuracy (%)	
	Measured	Objective	Recovery Range	Objective
Metals (Stack Gas and Process Streams)^b				
Hexavalent chromium	24	<25	36-57	80-120
Arsenic	6.1	<25	80-100	75-125
Cadmium	4.0	<25	88-99	75-125
Chromium	8.8	<25	81-110	75-125
Nickel	10	<25	82-118	75-125
POHC^c				
1,2-Dichlorobenzene	5.2	<50	90-114	50-150
Volatile Organic Compounds (Stack Gas VOST Samples)				
Dibromofluoromethane	5.2	<50	99-120	50-150
1,2-Dichloroethane-d ₄	7.9	<50	81-110	50-150
Toluene-d ₈	6.1	<50	89-13	50-150
4-Bromofluorobenzene	5.1	<50	91-115	50-150
PCDDs/PCDFs (Stack Gas)				
³⁷ C-2,3,7,8-TCDD	12	<50	84-112	40-135
¹³ C-2,3,4,7,8-PeCDF	17	<50	74-108	40-135
¹³ C-1,2,3,4,7,8-HxCDD	8.6	<50	88-115	40-135
¹³ C-1,2,3,4,7,8-HxCDF	6.5	<50	92-110	40-135
¹³ C-1,2,3,4,7,8,9-HpCDF	4.2	<50	108-121	40-135
¹³ C-1,2,3,7,8,9-HxCDF	16	<50	68-108	40-135
PCBs (Stack Gas)				
¹³ C-PCB-52	5.4	<50	86-98	50-150
¹³ C-PCB-178	4.4	<50	96-106	50-150
¹³ C-Tetrachlorobiphenyl	1.8	<50	85-88	50-150
¹³ C-Heptachlorobiphenyl	3.8	<50	97-104	50-150
PAHs (Stack Gas)				
d ₁₀ -Anthracene	24	<50	30-68	50-150
d ₁₂ -Benzo(e)pyrene	23	<50	52-147	50-150
Aldehydes^d (Stack Gas)				
Formaldehyde	2.0	<50	82-86	50-150
Acetaldehyde	2.3	<50	73-76	50-150
Acrolein	8.2	<50	65-78	50-150
Propanal	2.3	<50	87-92	50-150
Isobutyraldehyde/MEK	2.4	<50	95-100	50-150
Pentanal	3.5	<50	87-94	50-150
Hexanal	4.7	<50	81-90	50-150
HCl/Cl₂, Measured as Chloride^a (Stack Gas)				
Chloride	19	<15	67-126	85-115

Table 5-2 (Continued)

Parameters	Precision (RSD)		Accuracy (%)	
	Measured	Objective	Recovery Range	Objective
HCl/Cl₂, Measured as Total Chlorine^d (Feed)				
Total chlorine	8.5	<15	91-103	85-115

Note: Unless footnoted otherwise, accuracy and precision are based on data from surrogate recoveries from field samples. For analytical spike and matrix spike samples, results whose native concentrations exceeded the spike amounts by more than a factor of four were excluded from this table and were not used to assess accuracy or precision.

^a Based on matrix spike/matrix spike duplicate sample results.

^b Based on analytical spike results.

^c Accuracy and precision for the POHC are based on lab spike recoveries.

^d Based on LCS results.

- HCl/Cl₂ = Hydrogen chloride/chlorine
- H₇CDF = Heptachlorodibenzofuran
- H_xCDD = Hexachlorodibenzodioxin
- H_xCDF = Hexachlorodibenzofuran
- MEK = Methyl ethyl ketone
- PAHs = Polycyclic aromatic hydrocarbons
- PCBs = Polychlorinated biphenyls
- PCDDs/PCDFs = Polychlorinated dibenzodioxins/polychlorinated dibenzofurans
- PeCDF = Pentachlorodibenzofuran
- RSD = Relative standard deviation (standard deviation/mean of multiple measurements x 100)
- TCDD = Tetrachlorodibenzodioxin
- VOST = Volatile Organic Sampling Train

Completeness, also referred to as percent data capture, is defined as the percentage of valid data reported compared to the scheduled number of analyses. Valid data were determined during the data assessment process. Re-sampling is generally not feasible after the analytical results of a trial burn are evaluated, so the impact of any data loss is determined on a specific waste stream basis. The objective for completeness for all measurement parameters and all sample matrices was 90%. During the trial burn, all intended samples were collected and analyzed so the completeness objective was met.

Representative samples and measurement data were obtained during the trial burn by adhering to the procedures described in the QAPP. Samples were collected under well-defined process operating conditions using reference test methods and analyzed using standard procedures.

Comparability is the confidence with which one data set can be compared to other data. Comparability between the conditions was achieved by using the same standard methods for sampling and analyses, reporting data in standard units, using standard reporting formats, and tracing calibration accuracy to appropriate reference materials. The design of the test program, including selection of the Principal Organic Hazardous Constituent (POHC), operating conditions, and QA/QC approach, was based on existing industry standards and regulatory guidance documents.

For the trial burn, all the reported data are considered valid, technically defensible, and reliable for decision making. As detailed in this section, some results should be used with qualifications. These qualifications were either due to potential high biases based on blank results or spike recoveries, or potential low biases based on spike recoveries (refer to Table 5-2).

5.2 Process Data Quality Control

The primary activity used to ensure the quality of the trial burn process data was the use of appropriate, properly calibrated plant instrumentation. The instruments were calibrated

by qualified Dow technicians and information was documented on data sheets or in an electronic database that is maintained by the ST HAF technicians.

5.3 Sampling Quality Control

Sampling activities conducted during the trial burn are described in Section 3.0. Quality control activities associated with sampling were performed as described in the QAPP or reference methods. These activities included adherence to accepted reference method protocols, use of standardized data recording sheets, equipment calibration, and collection of reagent blanks. Reagent blanks were collected to determine background levels for critical target analytes. Field blanks for each type of stack gas sampling train were also collected during the trial burn. When appropriate, sampling media were certified to be free of target analytes prior to use in the field.

The Sampling Coordinator supervised field testing activities to ensure adherence to the project QAPP, including the use of method-specific sampling QC checks and appropriate documentation procedures. With respect to stack gas sampling activities, critical aspects are addressed below.

Pre-sampling preparations included:

- ▶ Calibration of dry gas meters, temperature sensors, nozzles, pitot tubes, and balances.
- ▶ Preparation of filters and sorbents, including handling, weighing, loading, and identification.
- ▶ Identification of appropriate stack gas sampling information including nozzle size, traverse points, sampling rate, etc.

Sampling operations included:

- ▶ Preliminary measurements for stack temperature, flow rate (including cyclonic flow rate), and moisture content.
- ▶ Sample train leak checks (including pitot tubes).
- ▶ Proper probe handling and plugging of ports during sampling (to prevent ambient air in-leakage).

- ▶ Temperature controls and documentation.
- ▶ Isokinetic determinations.
- ▶ Collection of sufficient sample volume or mass.
- ▶ Minimum sampling times and/or volumes.
- ▶ Completeness of data records.

Post-sampling operations included:

- ▶ Evaluation of sample volume or mass collected.
- ▶ Handling of train to minimize loss or contamination of sample.
- ▶ Verification of isokinetics.
- ▶ Identification of sample components and review of analytical data.
- ▶ Data reduction.
- ▶ Calibration of sampling equipment.

Review of the sample handling documentation indicated that there were no significant problems with sample custody or tracking. Regarding sample integrity, samples were received intact and cool, although a few semivolatile organic compound (SVOC) extracts arrived at the laboratory slightly warmer than the United States Environmental Protection Agency (U.S. EPA) recommended temperature of six degrees Celsius. Most samples were prepared and analyzed within the hold times specified in the QAPP. Total chlorine analyses for the Conditions 2 and 3 feed samples were performed outside the 28-day holding time. Polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs) were extracted from the Condition 3 stack gas samples outside the 14-day holding time. Semivolatile organic compounds (SVOCs) were extracted from stack gas samples from Condition 3 (and the field blank sample) outside the 14-day holding time.

5.4 Analytical Quality Control

Analytical methods used during the trial burn and the results of those analyses are presented in Sections 3.0 and 4.0 of this report, respectively. Additional information on the analytical procedures implemented, including the calibration and internal quality control procedures, can be found in the QAPP.

The sample-specific laboratory detection limits for all samples that could be analyzed undiluted met the QAPP reporting limits with three exceptions. The arsenic detection limits for the Condition 1 feed samples (ST-1104, ST-1304, and ST-1404) ranged from 0.515 to 0.538 mg/kg versus the QAPP limit of 0.5 mg/kg. The arsenic results for these samples were below the QAPP limit and the sample-specific detection limit, and ranged from 0.0913 to 0.116 mg/kg. These results were flagged with a 'J' by the laboratory to indicate that they should be considered estimates due to the low concentrations.

The following SVOC target analytes were calculated based on a 1-point calibration and are considered tentatively identified compounds (TICs): chloropyridines, 1,2,3-trichlorobenzene, 1,3,5-trichlorobenzene, and fluoropyridines. All other target analyte results were calculated using a 7-point calibration curve.

Results for the analyses of blanks, matrix spike samples, duplicate analysis, and surrogate spiked samples were reviewed. These samples control and assess measurement data quality and provide the basis for the precision and accuracy estimates. Results are presented in the following sections by stream type and by analytical parameter, providing a complete discussion of each stream and analysis combination.

These discussions are directed at project-specific or matrix-specific measurements. Routine laboratory activities such as calibration and calibration verification checks are not addressed in this section.

5.5 Spiking Mixtures

Samples of the metals and ash spiking mixtures were collected at the beginning, middle, and end of the Condition 1 sampling period. The composite sample was analyzed according to SW-846 Method 6010B for metals and according to American Society for Testing Materials (ASTM) Method D482 for ash. The QC data indicated the following:

- ▶ **Lab Blanks:** Metals results were below the detection limit in the blank, and spiking mixture sample results were well above the detection limit. No blank was included in the ash analysis.

- ▶ Spikes: Laboratory control sample (LCS) recoveries were within QAPP objectives for metals (75%-125% recovery). Matrix spike recoveries for cadmium, chromium, and nickel in the metals spiking mixture were unusable because of the high native concentrations. One of two arsenic matrix spike recoveries was within the accuracy objectives, as was the arsenic analytical spike recovery. No significant bias was indicated.
- ▶ Duplicates: LCS results were repeatable within project objectives. For analytes whose native concentrations were not significantly higher than the spike amounts in the matrix spikes, the arsenic recoveries were barely outside the QAPP objectives for precision. No significant bias was indicated.

Grab samples of the POHC spiking mixture were collected at the beginning, middle, and end of the Condition 1 and 2 sampling periods. Samples were certified for 1,2-dichlorobenzene by an analytical reference material laboratory using high performance liquid chromatography with ultraviolet detection. The spiking mixture sample was a composite sample.

- ▶ Spikes: The spike recoveries showed that accuracy was within QAPP objectives.
- ▶ Duplicates: the duplicate analysis and field duplicate sample results showed excellent agreement.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding times.

No quality problems were noted and data were considered usable without qualification.

5.6 Feed

Samples of the feed were collected from a tap using U.S. EPA Method S004. Determinations were made for total chlorine (total Cl), metals, SVOCs, ultimate analysis, and higher heating value. Results of the QA/QC activities are presented below for the feed samples.

Total Chlorine

Feed samples were analyzed for total Cl using U.S. EPA Methods 5050/9252. The QC data were summarized as follows:

- ▶ Lab Blanks: No target analyte was detected in the lab blanks.
- ▶ Spikes: The laboratory control sample recoveries were within QAPP objectives.
- ▶ Duplicates: Analytical duplicate results were repeatable within project objectives.

Total CI results for the feed samples were valid. The Conditions 2 and 3 results may be biased low because they were analyzed outside the U.S. EPA specified hold time.

Metals

Feed samples were analyzed for metals specified in the QAPP. Target metals were analyzed using SW-846 Method 6010B. The QC data are summarized as follows:

- ▶ Lab Blanks: Due to the low detection limits achieved, low-levels of several target analytes were reported in the lab blank at levels similar to low-level sample results. Therefore, sample results may be biased high for lead in all Condition 1 sample.
- ▶ Spikes: LCS recoveries were within QAPP objectives (75%-125% recovery). The feed analytical spike recovery for mercury was slightly below project objectives, but matrix spike recoveries were acceptable. Spike results for all other metals were within project objectives.
- ▶ Duplicates: LCS and MSD results were repeatable within project objectives.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding times.

Metals results were usable with one qualification. The lead results for the Condition 1 samples may have been biased high because the sample results were similar to the method blank results.

Semivolatile Organic Compounds (SW-846 Method 8270C)

Feed samples were analyzed for SVOCs using SW-846 Method 8270C. These samples had to be diluted significantly due to the percent level concentrations of chlorinated

pyridine compounds, resulting in elevated detection limits (i.e., compared to the detection limits for the other streams). The QC data are summarized as follows:

- ▶ Lab blanks: No target analytes were detected in the lab blanks.
- ▶ Spikes: The LCS recoveries met the accuracy objectives. Matrix spike recoveries for hexachlorobenzene (160% and 164%) and pentachlorophenol (1,900% and 1,800%) were high, but these analytes were not detected in any feed samples so a high bias is irrelevant. Recoveries for phenol (63% and 68%) were slightly low, but there were no detections. Significant levels of phenol would likely have been detected had they been present.
- ▶ Surrogates: Most surrogates were diluted out due to high target analyte concentrations.
- ▶ Internal standards: Three of the six internal standards for the Condition 1 samples had low recoveries. Potentially high biased results were flagged with an 'X' by the laboratory.
- ▶ Duplicates: LCSD and MSD results showed agreement within QAPP objectives.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding times.

The SVOC data for the feed were usable without qualification.

Physical Parameters

Feed samples were analyzed for physical parameters including higher heating value (HHV) by ASTM Method D1989, ash by ASTM Method D482 (modified), chlorine by U.S. EPA Methods 5050/9252, sulfur by ASTM Method D1552, carbon by ASTM Method D5373, hydrogen and nitrogen by ASTM Method 5373, and oxygen by ASTM Method D3176. The ASTM Method D482 modification involved using a programmed temperature ramp with hold cycles to better control sample loss during heating. Based on blank, spike, and duplicate results, Dow has found this modification to work well with the ST HAF feed. QC data are summarized as follows:

- ▶ Lab blank: Lab blanks were free of contaminants.
- ▶ Spikes: LCS recoveries showed that accuracy was within QAPP objectives.

- ▶ Duplicates: Duplicate results were repeatable and demonstrated precision within QAPP objectives.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding times.

Results reported for the trial burn samples were reliable and valid.

5.7 Scrubber Effluent Samples

Scrubber effluent samples were collected from a tap using U.S. EPA SW-846 Method S004 (*Sampling and Analysis Methods for Hazardous Waste Combustion*). Samples were collected and analyzed for total Cl, metals, and SVOCs. Results of the QA/QC review are provided below.

Total Cl

Scrubber effluent samples were analyzed for total Cl using U.S. EPA Method 300.0. The QC data are summarized as follows:

- ▶ Lab blanks: Chloride was not detected in the lab blanks.
- ▶ Spikes: LCS recoveries were within QAPP specifications, but matrix spike recoveries were slightly high (for Conditions 1 and 2).
- ▶ Duplicates: Spike duplicate results demonstrated that precision was within QAPP objectives.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding times.

All total Cl results are valid and reliable for the trial burn samples. Cl results may be biased slightly high due to matrix effects.

Metals

Scrubber effluent samples were analyzed for arsenic, cadmium, chromium, and nickel according to SW-846 Method 6010B. The QC data were summarized as follows:

- ▶ Lab blanks: A few results were reported below the lab detection limit. In each case, the sample results were all at least five times higher than the lab blank results.
- ▶ Spikes: LCS and analytical spike recoveries were within QAPP objectives. Arsenic and cadmium recoveries were acceptable in the matrix spikes. Chromium and nickel results in the scrubber effluent were over five times the spike amount, so matrix spike results for these two analytes were not used to evaluate precision or accuracy.
- ▶ Duplicates: LCS and MSD results (for analytes with native concentrations less than five times the spike amount) met project precision objectives.

Metals results for the scrubber effluent samples are usable without qualification.

Semivolatile Organic Compounds

Scrubber effluent samples were analyzed for SVOCs using SW-846 Method 8270C. Due to extract viscosity, these samples had to be analyzed at a 1:50 dilution. The QC data are summarized as follows:

- ▶ Lab blanks: No target analytes were detected in the lab blanks.
- ▶ Spikes: LCS recoveries demonstrated accuracy within QAPP objectives. In both matrix spike pairs analyzed, 2-chlorophenol, hexachloroethane, and phenol were recovered significantly low (1% to 43%).
- ▶ Surrogates: The acid-extractable surrogate recoveries were below laboratory accuracy limits in all scrubber effluent samples. In all but one sample, at least two of the three base/neutral extractable surrogate recoveries were acceptable. The sample from Condition 1 run 2 (ST-1207) had two base/neutral extractable surrogates that were high. Only one base/neutral target compound (pentachloroethane) was detected in this sample, and this result may be biased high.
- ▶ Internal standards: Perylene-d₁₂ was recovered low in the Condition 2 samples, but no target analytes that are quantitated using this internal standard were detected. Therefore, a potential high bias is irrelevant.
- ▶ Duplicates: LCSD results showed good agreement and met project objectives. MSD results were within project objectives except for 2-chlorophenol, hexachloroethane, and phenol.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding times.

Results of the scrubber effluent samples for SVOCs were reliable and valid with two qualifications. Results reported for the acid-extractable compounds and hexachloroethane may be biased significantly low such that low-level results could have gone undetected had they been present in the samples. In addition, the pentachloroethane result reported for the Condition 1 run 2 sample may be biased high.

5.8 HCl Acid Product

Samples of the HCl acid product were collected from a tap using U.S. EPA Method S004. The composite samples were analyzed for total Cl, metals, and VOCs.

Total Cl

HCl acid product samples were analyzed for total Cl using U.S. EPA Method 300.0. The QC data are summarized as follows:

- ▶ Lab blanks: Chloride was not detected in the lab blanks.
- ▶ Spikes: LCS recoveries and matrix spike recoveries were within QAPP specifications.
- ▶ Duplicates: Spike duplicate results demonstrated that precision was within QAPP objectives.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding time.

The total Cl results for HCl acid product samples are usable without qualification.

Metals

HCl acid product samples were analyzed for arsenic, cadmium, chromium, and nickel according to SW-846 Method 6010B. Condition 3 samples had to be diluted due to the high acid content. The QC data are summarized as follows:

- ▶ Lab blanks: All sample results were over five times greater than the method blank results, so no bias was indicated.

- ▶ Spikes: LCS and analytical spike recoveries (when the spike amount was near or greater than the unspiked concentration) were within QAPP objectives. Matrix spikes were not available because the samples did not require digestion.
- ▶ Duplicates: LCS and analytical spike sample duplicate results were repeatable within project objectives.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding time.

Metals results for the HCl acid product samples were usable without qualification.

Semivolatile Organic Compounds

HCl acid product samples were collected then analyzed for SVOCs using SW-846 Method 8270C. The QC data were summarized as follows:

- ▶ Lab blanks: No target analytes were detected in the lab blanks.
- ▶ Spikes: LCS and matrix spike recoveries demonstrated accuracy within QAPP objectives.
- ▶ Surrogates: All surrogate recoveries were within the laboratory accuracy objectives.
- ▶ Duplicates: LCSD and matrix spike duplicate results showed good agreement and met project objectives.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding times.

SVOC results for the HCl acid product were reliable and valid without qualification.

5.9 Vent Stream

Samples of the anhydrous hydrogen chloride (HCl) vent stream were collected in evacuated stainless steel containers by a Dow technician during each day of trial burn testing. Samples were analyzed for chloride volumetrically. No QC data were reported along with the sample results; however, a performance evaluation sample of 98% ($\pm 2\%$) HCl gas was analyzed three times. Recoveries averaged 97.1% and demonstrated excellent accuracy.

5.10 Stack Gas

The QC results, organized by parameter for specified stack gas measurements, are described in the following subsections.

Particulate Matter

Stack gas samples for particulate matter were collected on filters and in the probe, nozzle, and glassware rinses using Method 5; the samples were analyzed gravimetrically following evaporation of the solvent in the rinse samples. Mass determinations were made by weighing the filters and evaporated rinses to a constant weight. No QC data were reported for this method. Weights were determined by achieving constant weight in consecutive determinations (i.e., no more than 0.5 milligrams [mg] or 1% of the net weight, whichever was greater between measurements).

Hydrogen Chloride and Chlorine

Stack gas samples for hydrogen chloride and chlorine (HCl/Cl₂) were collected in the same sampling train as the particulate matter using Method 0050. Impinger samples for HCl and Cl₂, measured as chloride, were analyzed using SW-846 Method 9057. The QC data for this method are summarized as follows:

- ▶ Lab blanks: Chloride was not detected in the lab blanks.
- ▶ Field blank: Chloride was not detected in either of the two field blank samples.
- ▶ Spikes: All chloride recoveries met the QAPP accuracy and precision objectives for LCSs. For matrix spike samples, one of the two acid impinger samples (ST-3364) had slightly low recoveries (72% and 67%) but both caustic impinger samples had recoveries within project objectives.
- ▶ Duplicates: The analytical duplicate results for chloride were within the QAPP objectives for precision.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding times.

These data were usable with one qualification. The reported results for the Condition 3 run 3 sample (ST-3364) should be considered potential biased low because the matrix spike recoveries were below the project objectives.

Metals

Stack gas samples for metals were collected using U.S. EPA Method 0060 then analyzed for arsenic, cadmium, total chromium, and nickel according to SW-846 Method 6010B. The QC data for this method are summarized as follows:

- ▶ Lab blanks: Method blank results were all less than the lab detection limit.
- ▶ Field blank: All impinger sample results for cadmium, chromium, and nickel were within a factor of five of the impinger field blank. Also, the filter probe/nozzle rinse filter blank results for cadmium, chromium, and nickel were within a factor of five of all Condition 3 samples. For Condition 1 samples, the filter probe/nozzle rinse filter blank nickel result was within a factor of five of sample ST-1171/1172. These sample results may be biased high.
- ▶ Spikes: LCS recoveries were within the QAPP objectives. Analytical spike recoveries met project objectives as long as the native concentrations in the spike samples were no more than four times greater than the spiking concentration. Matrix spikes were not performed because the entire sample was digested.
- ▶ Duplicates: Laboratory control sample and analytical spike duplicate RPDs were within QAPP objectives.
- ▶ Holding times: All analysis hold times were met.

The microwave digestion procedure used for the filter/rinse composite samples uses boric acid. An inter-element correction is applied for arsenic due to inherent interferences this analyte has with boron. As a result, the arsenic results for the Condition 3 filter/rinse samples (ST-3171/3172, ST-3271/3272, and ST-3371/3372) should be considered estimates. This correction caused the method blank result for arsenic to be artificially high. The Condition 1 run 1 sample results should be considered biased high because they were within five times the field blank result. Nickel in the field blank was significantly higher than the Condition 3 filter/probe nickel results.

Hexavalent Chromium

Stack gas samples for hexavalent chromium were collected using U.S. EPA Method 0061 and analyzed using SW-846 Method 7199. The QC data for this method are summarized as follows:

- ▶ Lab blank: Hexavalent chromium was not reported above the detection limit and the blank results were well below the sample results.
- ▶ Field blank: Results for Condition 1 run 3 (ST-1381) and all Condition 3 results were within five times the field blank result.
- ▶ Spikes: LCS recoveries were within QAPP objectives. Due to poor peak shape for the field samples, matrix spike recoveries were low (ranging from 36% to 57%).
- ▶ Duplicates: LCS and MSD results were all within project objectives.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding time.

Sample results for Condition 1 run 3 and all three Condition 3 samples may be biased high because they were within five times the field blank result; however, the matrix spike results indicate a low bias for all sample results. Therefore, all hexavalent chromium results should be considered estimates.

Volatile Organic Compounds (VOST Samples)

Stack gas samples were collected using the Volatile Organic Sampling Train (VOST) as described in SW-846 Method 0030. Six pairs of traps were collected during each run and three pairs were submitted to the laboratory for analysis. Each tube was analyzed separately. In addition, field blanks were collected every day of sampling and trip blanks were included with each shipment of samples to the laboratory.

Sorbent resin tube samples were desorbed using SW-846 Method 5041A then analyzed using SW-846 Method 8260B. These analyses included the top 25 tentatively identified compounds (TICs) in addition to the target analyte list. As specified in the QAPP, three of the project target analytes (1,3-butadiene, 1-chloropropane, and 2-chloropropane) were analyzed as

TICs because they are not part of the routine suite of method analytes. Quantitation for TICs should be considered as estimated values. The QC data for this analytical method are summarized as follows:

- ▶ Lab blanks: No target compounds were detected in the lab blanks.
- ▶ Field blank: Methylene chloride was the only target analyte detected in one field blank. The reported value was much lower than the field sample results.
- ▶ Trip blank: Results for all analytes in the trip blanks were below the detection limit.
- ▶ Certification of clean media: The media from the lot used for sample collection was certified to be free of contamination.
- ▶ Surrogates: All surrogate recoveries were reported within the method limits. Benzene-d₆ was spiked into all samples that were diluted to ensure accurate sample transfer and dilution, and these recoveries were within lab objectives.
- ▶ Internal standards: Internal standards met project objectives or were associated with non-detects.
- ▶ Breakthrough: Breakthrough was indicated for the following compounds and Condition 1 samples: chloromethane in ST-1-101, ST-1-105, ST-1-201, ST-1-203, and ST-1-205; carbon tetrachloride in ST-1-203 and ST-1-205; and methylene chloride in ST-1-205.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding times.

Breakthrough was indicated for a few target analytes. Some results may be associated with increased analytical variability because they were quantitated above the instrument calibration range. Affected results included methylene chloride in ST-1-101A, ST-1-103A, ST-1-105A, ST-1-201A, chloroform in ST-1-101A, ST-1-103A, ST-1-105A, ST-1-201A, ST-1-203A, ST-1-205A and carbon tetrachloride results in ST-1-101A, ST-1-103A, ST-1-103B, ST-1-105A, ST-1-105B, ST-1-201A, ST-1-203A, ST-1-205A (all flagged with an 'E' by the laboratory). All of these samples were collected during Condition 1. No condensate samples were collected from the VOST system because of the low moisture content of the stack gas.

Semivolatile Organic Compounds

Samples for SVOCs were collected using the Modified Method 5 sampling train described in SW-846 Method 0010. This same train was used for the collection of PCBs and PAHs. Samples were extracted by a laboratory and analyzed for PCBs and PAHs. An aliquot of the extract was then sent to another laboratory for analysis of SVOCs by SW-846 Method 8270C. As specified in the QAPP, several of the project target analytes (1,3-cyclopentadiene, 1,2,3-trichlorobenzene, 1,3,5-trichlorobenzene, chloropyridines, cyclopenta(cd)pyrene, and fluoropyridines) were analyzed as TICs because they are not part of the routine suite of method analytes. Results for TICs should be considered as estimates (the estimated detection limit for these analytes is 4 µg/sample).

Six samples and the field blank arrived at the analytical laboratory at a temperature (13°C) outside the U.S. EPA-recommended range of 2 to 6°C. SVOC results for these samples may be biased slightly low, but the effect is probably nominal since they were refrigerated upon arrival at the laboratory and never reached ambient temperature.

Surrogate recoveries (six surrogates were added to each sample) were used to assess extraction efficiency (accuracy and precision) for the SVOC samples. The QC data for this method are summarized as follows:

- ▶ Lab blank: No target analytes were detected in the lab blanks.
- ▶ Field blank: No target analytes were detected in the field blank.
- ▶ Spikes: No matrix spike samples were extracted with the samples. However, LCSs were included and acceptable accuracy was demonstrated. TICs were not included in the LCSs or continuing calibration verification samples, so accuracy for those targets analyzed as TICs could not be assessed.
- ▶ Surrogates: Most of the surrogate recoveries were within the QAPP objectives and verified the accuracy of the sample preparation and analysis processes. Four samples (Condition 1 runs 1 and 2 and Condition 2 runs 1 and 3) had at least two of the three acid-extractable compounds recovered below project accuracy objectives. All other samples had at least two of the three surrogates from each extractable portion recovered within project objectives.

- ▶ Holding times: All samples met the QAPP-specified holding time for analysis; however, the Condition 3 samples and the field blank were extracted a few days outside the 14-day extraction holding time.

The SVOC results for the stack gas samples are usable with qualification. Based on surrogate recoveries, acid-extractable results reported for Condition 1 runs 1 and 2 samples and Condition 2 runs 1 and 3 samples may be biased low. The Condition 3 samples and the field blank were extracted from four to six days outside the 14-day extraction holding time specified in the QAPP. The associated sample results may be biased slightly low.

Polychlorinated Biphenyls

Samples for PCBs, along with SVOCs and PAHs, were collected using the MM5 sampling protocol outlined in SW-846 Method 0010. Samples were extracted and analyzed for PCBs using Method 680. The QC data for this method are summarized as follows:

- ▶ Lab blank: No analytes were reported above the detection limit and no contamination was indicated.
- ▶ Field blank: No target analytes were detected in the field blank.
- ▶ Spikes: LCS recoveries were within QAPP objectives for accuracy and precision.
- ▶ Internal standards: Recoveries were acceptable.
- ▶ Surrogates: The pre-spike recovery standard results were within QAPP objectives.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding time for analysis; however, the Condition 3 samples were extracted seven days outside the 14-day extraction holding time.

The PCB data were considered usable; however, the Condition 3 sample results may be biased low because the samples were extracted a week outside the holding time.

Polycyclic Aromatic Hydrocarbons

Samples for PAHs, along with SVOCs and PCBs, were collected using the MM5 sampling protocol outlined in SW-846 Method 0010. Samples were extracted and analyzed for

PAHs using California Air Resources Board (CARB) Method 429. The QC data for this method are summarized as follows:

- ▶ Lab blank: 2-Methylnaphthalene was detected in all Conditions 1 and 3 samples at levels within five times the blank results. Naphthalene was also detected in the method blanks, but the levels were less than five times the sample results so there was no impact on data quality.
- ▶ Field blank: Fluorene, 2-methylnaphthalene, and phenanthrene were detected just above the reporting limit in the field blank. Phenanthrene results in the trial burn samples were greater than five times the blank result and were not significantly affected; however, fluorene and 2-methylnaphthalene trial burn results for Conditions 1 and 2 may be biased high.
- ▶ Spikes: LCS recoveries were within QAPP objectives for accuracy and precision.
- ▶ Internal standards: Recoveries met the lab objectives except for acenaphthalene in the Condition 3 samples and naphthalene in the Condition 1 runs 2 and 3 samples.
- ▶ Surrogates: The pre-spike recovery standard results were within QAPP objectives, but alternate recovery standards in two Condition 2 samples (ST-2141 and ST-2341) were slightly low.
- ▶ Holding times: All samples were analyzed within the QAPP-specified holding time; however, the Condition 3 samples were extracted seven days outside the 14-day extraction holding time.

Results for fluorene and 2-methylnaphthalene in the trial burn samples for Conditions 1 and 2 may be biased high because they were within five times the field blank result. In addition, acenaphthalene results for the Condition 3 samples and naphthalene in the Condition 1 runs 2 and 3 samples may be biased high due to low internal standard recoveries. The Condition 3 sample results may be biased low because they were extracted a week outside the extraction holding time.

Dioxins/Furans

Samples for dioxins/furans were collected using the Method 23 sampling protocol described in SW-846 Method 0010. Samples were extracted and analyzed using U.S. EPA Method 8290. The QC data for this method are summarized as follows:

- ▶ Lab blank: No dioxins or furans were detected in the lab blank.

- ▶ Field blank: No dioxins or furans were detected in the field blank.
- ▶ Spikes: LCS and internal standard recoveries were within QAPP objectives.
- ▶ Surrogates: The pre-spike recovery standard recoveries were within QAPP objectives.
- ▶ Holding times: All samples were analyzed within the specified holding time for extraction and analysis.

The dioxin/furan results for the trial burn samples are valid and reliable.

Aldehydes

Stack gas samples for aldehydes were collected using SW-846 Method 0011 and analyzed using SW-846 Method 8315. The QC data are summarized as follows:

- ▶ Lab blanks: Acetone was reported below the detection limit in a lab blank, but all associated sample results were well over five times the blank result.
- ▶ Trip blank: Besides acetone (which was detected in the method blank), no target analytes were detected in the trip blanks.
- ▶ Reagent blanks: All detections for acetone and formaldehyde were much greater than five times the field blank results.
- ▶ Field blank: Formaldehyde, acetaldehyde, acetone, methyl ethyl ketone/butyraldehyde, and benzaldehyde were detected in the field blank at levels similar to those reported for the trial burn samples.
- ▶ Spikes: LCS, trip spike, and field spike recoveries were within project objectives. No matrix spike results were reported.
- ▶ Duplicates: Analytical duplicate results showed good agreement.
- ▶ Holding times: All samples were extracted and analyzed within the QAPP-specified holding times.

The laboratory flagged several results as having been biased due to apparent matrix interferences; however, the direction of the bias (high or low) was not indicated. The flagged results included methyl ethyl ketone/butyraldehyde in the Condition 3 run 2 sample (ST-3251) and benzaldehyde in Condition 1 run 2 (ST-1251) and Condition 3 run 3 (ST-3351) samples. Acetone was quantitated above the instrument calibration range in samples ST-1451, ST-2151, ST-2251, ST-3151, and ST-3251. Results for these analytes should be considered estimated values.

In addition, sample detections for the Condition 1 samples should be considered estimates because they exhibited no DNPH peak or yellow color. This suggests that the carbonyl present in the samples exceeded the derivatization capacity of the sampling reagent.

Formaldehyde, acetaldehyde, acetone, methyl ethyl ketone/butyraldehyde, and benzaldehyde results should be considered biased high or potentially false positives based on the field blank results.

5.11 Quality Control for Continuous Emission Monitoring

Continuous emission monitors (CEMs) were used and calibrated by a Dow technician in accordance with U.S. EPA procedures, Method 7C and Method 10 (40 Code of Federal Regulations [CFR] 60, Appendix A) for carbon monoxide (CO) and oxygen (O₂), respectively. Monitored CEM responses agreed with the calibration values within 1% for high and low ranges of CO and O₂ except for one CO value. The Condition 2 (17 February 2000) pre-test low-range calibration check was approximately 23% low. This value appears to be an anomaly (e.g., most likely a transcription error). Because the high range CO calibration check was within 1% of the calibration value, and because the post-test low-range CO value was accurate (within 1%), this anomaly has no significant impact on data quality. Total hydrocarbon (THC) monitoring was performed in accordance with Method 25A. The percent linearity and system calibration bias were below the 2% and 5% limits, respectively, during all trial burn conditions.