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Title:	Results of the May 1, 1990 Trace Metal Characterization Study on Units 1 and 2 at the Sherburne County Generating Station. Interpoll Laboratories, Inc., Circle Pines, Minnesota. July 18, 1990.

Ref 8

RESULTS OF THE MAY 1, 1990
TRACE METAL CHARACTERIZATION
STUDY ON UNITS 1 AND 2 AT
THE SHERBURNE COUNTY
GENERATING STATION

interpoll

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RESULTS OF THE MAY 1, 1990 TRACE METAL CHARACTERIZATION STUDY ON UNITS 1 AND 2 AT THE SHERBURNE COUNTY GENERATING STATION

Submitted to:

NORTHERN STATES POWER COMPANY
West of Highway 10
Becker, Minnesota 55308

Attention:

Bob Catron

ENGINEERING REPORT

Approved by:

Report Number 0-3033E
July 18, 1990
PL/prp

Perry Lonnes, Ph.D.
Director
Field Testing Division

TABLE OF CONTENTS

ABBREVIATIONS

ACFM	actual cubic feet per minute
cc (ml)	cubic centimeter (milliliter)
DSCFM	standard cubic foot of dry gas per minute
DSML	dry standard milliliter
DEG-F (^{0}F)	degrees Fahrenheit
DIA.	diameter
FP	finished product for plant
FT/SEC	feet per second
g	gram
GPM	gallons per minute
GR/ACF	grains per actual cubic foot
GR/DSCF	grains per dry standard cubic foot
g/dscm	grams per dry standard cubic meter
HP	horsepower
HRS	hours
IN.	inches
IN.HG.	inches of mercury
IN.WC.	inches of water
LB	pound
LB/DSCF	pounds per dry standard cubic foot
LB/HR	pounds per hour
LB/10^6BTU	pounds per million British Thermal Units heat input
LB/MMBTU	pounds per million British Thermal Units heat input
LTPD	long tons per day
MW	megawatt
mg/Nm^3	milligrams per dry standard cubic meter
ug/Nm^3	micrograms per dry standard cubic meter
microns (um)	micrometer
MIN.	minutes
ng	nanograms
ohm-cm	ohm-centimeter
PM	particulate matter
PPH	pounds per hour
PPM	parts per million
ppmC	parts per million carbon
ppm,d	parts per million, dry
ppm,w	parts per million, wet
ppt	parts per trillion
PSI	pounds per square inch
SQ.FT.	square feet
TPD	tons per day
ug	micrograms
v/v	percent by volume
w/w	percent by weight
<	$\leq$ (when following a number)

Standard conditions are defined as 68 ^{0}F (20 ^{0}C) and 29.92 IN. of mercury pressure.

Jeff Cole, RTI, says this is a dry bottom boiler, according to the UDI/EEI database. Jeff has been working with the NSP data for five years and, therefore, I am taking his word on this.

Jj

1 INTRODUCTION

On May 1, 1990, Interpoll Laboratories personnel conducted a trace metal characterization study on the Units 1 and 2 at the Northern States Power Company (NSP) Sherburne County Generating Station located in Becker, Minnesota. On-site testing was performed by R. Rosenthal, E. Trowbridge, C. Mosser and T. Hogan. Coordination between testing activities and plant operation was provided by Bob Catron of NSP.

Units 1 and 2 are identical Combustion Engineering 750 megawatt boilers which came on line in 1976. Particulate and sulfur dioxide emissions from each of the two units are controlled by a wet limestone scrubbing system which consists of twelve individual rod venturi scrubber spray towers. Cleaned flue gas from the two inlets is exhausted to the atmosphere by a common 600-foot radial steel-lined concrete stack.

The study consisted of simultaneous trace metal samplings at the Inlet to the wet limestone scrubbing system and the Common Stack. As stated above, the scrubber system consists of twelve individual modules on each of the two units. As a result of the inlet duct geometry, no common inlet test site exists, and thus each module must be individually tested.

The problem of inlet sampling is further complicated by the fact that the individual module inlet test sites are all less than 0.5 equivalent duct diameters from major flow disturbances in both the up-and downstream flow directions. Previous experience has shown that considerable large scale turbulence exists at these test sites and that relative particulate loadings and gas flow rates tend to vary from hour to hour and day to day.

Under these circumstances, the best approach to estimating inlet emissions is to sample all the inlet module test sites simultaneously which is cost prohibitive or to randomly sample several inlet test sites and assume that the average concentration from these sites is the best estimate of the overall inlet concentration. The latter method was selected by NSP in this work.

A Multi-Metal Modified Method 5 (4M5) sampling train was used to isokinetically collect solid and vapor phase trace metals. The samples were collected and analyzed as per the EPA Draft Method "Methodology for the Determination of Metals Emissions in Exhaust Gases from Stationary Source Combustion Processes". The aerosol or solid phase trace metal samples were collected on high purity Pallflex[R] filters. The vapor phase trace metals were collected in an all glass impinger train. The first and second impingers each contained 100 cc of a mixture of 5% HNO_3 and 10% H_2O_2. The third impinger contained 100 cc of a mixture of 4% $KMnO_4$ and 10% H_2SO_4. This impinger collects any elemental mercury which might penetrate the first two impingers and is used only when mercury is being sampled.

The recovered four-part trace metal samples were combined, dissolved in acid (including the glass fiber filter) and analyzed by Inductively Coupled Argon Plasma Emission Spectrometry (ICP). The samples were reanalyzed by graphite furnace atomic absorption spectrometry (GF/AA) for arsenic, beryllium, selenium, antimony and strontium to provide better detection limits. Mercury was analyzed by cold vapor atomic absorption. A field biased blank was collected and recovered at the test site and analyzed with the field samples.

An integrated flue gas sample was extracted simultaneously with each trace metal sample using a specially designed gas sampling system. Integrated flue gas samples were collected in 44-liter Tedlar bags housed in a protective aluminum housing. After sampling was complete, the bags were sealed and returned to the laboratory for Orsat analysis. Prior to sampling, the Tedlar bags are leak checked at 15 IN.HG. vacuum with an in-line rotameter. Bags with any detectable inleakage are discarded.

Testing at the individual scrubber module inlet test sites was performed using a horizontal row of six test ports on a vertical section of duct where the gas flow is downward into the module inlet. These ports are less than 0.5 equivalent duct diameters both up-and downstream to flow disturbances. A 24-point traverse was used to collect representative trace metal samples. Each traverse point was sampled 2.5 minutes to give a total sampling time of 60 minutes per scrubber module.

Testing on the Units 1 and 2 Common Stack was conducted from four test ports on the Stack oriented at 90 degrees. These test ports are located seven stack diameters downstream of the breeching inlet and eleven diameters upstream of the stack exit. A 16-point traverse was used to extract representative trace metals and Chromium VI samples. Each traverse point was sampled four minutes to give a total sampling time of 64 minutes per run.

The important results of the test are summarized in Section 2. Detailed results are presented in Section 3. Field data and all other supporting information are presented in the appendices.

2 SUMMARY AND DISCUSSION

The trace metal results have been broken into two sets; the eight which the State of Minnesota has identified as concerns, and sixteen additional metals for NSP In-House information. In addition, inlet trace-metal levels were determined for NSP In-House information. Concentrations and mass rates for the first set of eight metals are given in Table 1, and the removal efficiencies are summarized in Table 2. Concentrations and mass rates for the second set of sixteen metals are presented in Table 3. The removal efficiencies are summarized in Table 4. Chromium VI concentration and emission rates are given in Table 5.

No other difficulties were encountered in the field or in the laboratory evaluation of the samples. On the basis of this fact and a complete review of the entire data and results, it is our opinion, subject to the above qualifications, that the results reported herein are accurate and closely reflect the actual values which existed at the time the test was performed.

Table 1. Summary of the Results of the May 1, 1990 Trace Metals Removal Performance Test on the Combined Units 1 and 2 AQCS at the NSP Sherburne County Station (MPCA-selected elements).

	Concentration (ug/Nm^3)				
		Stack			
Element	Inlet	Run 1	Run 2	Run 3	Average
Arsenic	62.7	2.9	3.1	2.4	2.8
Beryllium	14.7	.3	.3	.3	.3
Cadmium	19.2	x	2.3	3.9	2.1
Chromium	269	10.8	8.1	7.3	8.7
Nickel	121	8.1?	5.7	4.1	3.3
Lead	458	10.3	9.5	8.0	9.3
Selenium	57.0	8.9	11.0	9.4	9.8
Mercury	8.1	7.5	6.3	5.0	6.3

	Mass Rate (LB/HR)				
		Stack			
Element	Inlet	Run 1	Run 2	Run 3	Average
Arsenic	.740	.035	.039	.030	.035
Beryllium	.173	.0037	.0042	.0038	.0039
Cadmium	.227	x	.029	.049	.039
Chromium	3.17	.133	.101	.092	.109
Nickel	1.43	.100?	.071	.052	.062
Lead	5.40	.127	.118	.100	.115
Selenium	.673	.109	.137	.118	.121
Mercury	.0956	.092	.078	.063	.078

x = Result invalidated due to field contamination

? = Result may be high due to field contamination; not used in calculating the average

Table 2 Summary of the May 1, 1990 Estimated Trace Metal Removal Efficiencies of the Units 1 and 2 AQCS at the NSP Sherburne County Station.

	Mass Rate (LB/HR)		AQCS Removal
Element	Inlet	Stack	Eff. (%w/w)
Arsenic	0.740	0.035	95.3
Beryllium	0.173	0.0039	97.7
Cadmium	0.227	0.039	82.8
Chromium	3.17	0.109	96.6
Nickel	1.43	0.062	95.7
Lead	5.40	0.115	97.9
Selenium	0.673	0.121	82.0
Mercury	0.0956	0.078	18.4

Table 3. Summary of the Results of the May 1, 1990 Trace Metals Removal Performance Test on the Combined Units 1 and 2 AQCS at the NSP Sherburne County Station (NSP-selected elements).

	Concentration (ug/Nm^3)				
		Stack			
Element	Inlet	Run 1	Run 2	Run 3	Average
Aluminum	305000	779	888	707	791
Boron	19000	7940	1455	3038	4154
Barium	14600	290	466	180	312
Calcium	392000	10200	11365	10260	10608
Copper	515	79.8?	16.1	18.1	11.4
Iron	113000	1180	1171	1031	1127
Potassium	22200	163	151	139	151
Magnesium	84000	436	614	471	507
Manganese	2640	22.9	32.2	21.8	25.6
Molybdenum	51.3	≤2.2	≤2.2	≤2.2	≤2.2
Sodium	81900	624	515	410	516
Antimony	45.2	1.3	0.9	0.7	0.97
Strontium	13200	265	307	247	273
Vanadium	632	24.4	23.4	22.5	23.4
Zinc	224	185?	56.3	35.5	30.6
Silver	≤2.4	≤2.4	≤2.4	≤2.4	≤2.4

	Mass Rate (LB/HR)				
		Stack			
Element	Inlet	Run 1	Run 2	Run 3	Average
Aluminum	3600	9.58	11.06	8.86	9.83
Boron	224	98.0	18.1	38.1	51.4
Barium	172	3.59	5.81	2.25	3.88
Calcium	4630	126	141	129	132
Copper	6.08	.981?	.200	.227	.214
Iron	1330	14.6	14.6	12.9	14.0
Potassium	262	2.00	1.88	1.74	1.87
Magnesium	991	5.36	7.65	5.91	6.31
Manganese	31.2	.281	.401	.273	.318
Molybdenum	.605	≤.027	≤.027	≤.027	≤.027
Sodium	966	7.67	6.42	5.13	6.41
Antimony	.533	.016	.011	.009	.012
Strontium	156	3.26	3.82	3.09	3.39
Vanadium	7.46	.300	.291	.282	.291
Zinc	2.64	1.94?	.70	.45	.38
Silver	≤.028	≤.009	.010	.030	≤.016

x = Result invalidated due to field contamination

? = Result may be high due to field contamination; not used in calculating the average

Table 4 Summary of the May 1, 1990 Estimated Trace Metal Removal Efficiencies of the Units 1 and 2 AQCS at the NSP Sherburne County Station.

	Mass Rate (LB/HR)		AQCS Removal
Element	Inlet	Stack	Eff. (%w/w)
Aluminum	3600	9.83	99.7
Boron	224	51.4	77.1
Barium	172	3.88	97.7
Calcium	4630	132	97.1
Copper	6.08	.214	96.5
Iron	1330	14.0	98.9
Potassium	262	1.87	99.3
Magnesium	991	6.31	99.4
Manganese	31.2	.318	99.0
Molybdenum	.605	≤.027	≥95.5
Sodium	966	6.41	99.3
Antimony	.533	.012	97.7
Strontium	156	3.39	97.8
Vanadium	7.46	.291	96.1
Zinc	2.64	.38	85.6
Silver	≤.028	≤.016	--

Table 5 Summary of the Results of the May 1, 1990 **Hexavalent Chromium (CrVI) Determinations** on the Units 1 and 2 Stack at the NSP Sherburne County Station.

Test/Run	Concentration (ug/Nm^3)	Emission Rate (LB/HR)
2/1	.47	.0060
2/2	.98	.0126
2/3	.62	.0080
Avg	.69	.0089

There is no discussion of how these emissions were measured, therefore, the data were not used.

Jack Johnson
5/16/95

3 RESULTS

The results of all field and laboratory evaluations are presented in this section. Gas composition (Orsat and moisture) are presented first followed by the computer printout of the trace metals and chromium VI sampling data. Preliminary measurements including test port locations are given in the appendices.

The results have been calculated on a personal computer using programs written in Extended BASIC specifically for source testing calculations. EPA-published equations have been used as the basis of the calculation techniques in these programs.

The emission rates have been calculated using the product of the concentration times flow method.

3.1 Results of Orsat and Moisture Analysis

Interpoll Report No. 0-3033
NSP - Sherco
Becker, Minnesota

Test No. 1
Scrubber Inlet

Results of Orsat & Moisture Analyses-----Methods 3 & 4(%v/v)

	Run 1	Run 2	Run 3
Date of run	05-01-90	05-01-90	05-01-90
Dry basis (orsat)			
carbon dioxide............	13.90	14.60	14.80
oxygen....................	6.00	5.30	5.10
carbon monoxide...........	0.00	0.00	0.00
nitrogen..................	80.10	80.10	80.10
Wet basis (orsat)			
carbon dioxide............	12.85	12.75	13.06
oxygen....................	5.55	4.63	4.50
carbon monoxide...........	0.00	0.00	0.00
nitrogen..................	74.04	69.94	70.69
water vapor...............	7.57	12.68	11.75
Dry molecular weight........	30.46	30.55	30.57
Wet molecular weight........	29.52	28.96	29.10
Specific gravity............	1.020	1.000	1.005
Water mass flow......(LB/HR)	0.00	0.00	0.00
FO	1.072	1.068	1.068

Test No. 1
Scrubber Inlet

Results of Orsat & Moisture Analyses-----Methods 3 & 4(%v/v)

	Run 4
Date of run	05-01-90
Dry basis (orsat)	
carbon dioxide............	13.30
oxygen....................	7.00
carbon monoxide...........	0.00
nitrogen..................	79.70
Wet basis (orsat)	
carbon dioxide............	11.88
oxygen....................	6.25
carbon monoxide...........	0.00
nitrogen..................	71.19
water vapor...............	10.68
Dry molecular weight........	30.41
Wet molecular weight........	29.08
Specific gravity...........	1.005
Water mass flow......(LB/HR)	0.00

FO 1.045

Test No. 1
Units 1 & 2 Stack

Results of Orsat & Moisture Analyses-----Methods 3 & 4(%v/v)

	Run 1	Run 2	Run 3
Date of run	05-01-90	05-01-90	05-01-90
Dry basis (orsat)			
carbon dioxide............	13.30	13.40	13.40
oxygen....................	6.60	6.60	6.70
carbon monoxide...........	0.00	0.00	0.00
nitrogen..................	80.10	80.00	79.90
Wet basis (orsat)			
carbon dioxide............	11.22	11.33	11.33
oxygen....................	5.57	5.58	5.66
carbon monoxide...........	0.00	0.00	0.00
nitrogen..................	67.58	67.66	67.55
water vapor...............	15.64	15.43	15.46
Dry molecular weight........	30.39	30.41	30.41
Wet molecular weight........	28.45	28.49	28.49
Specific gravity............	0.983	0.984	0.984
Water mass flow......(LB/HR)	0.00	0.00	0.00
FO	1.075	1.067	1.060

Test No. 3
Units 1 & 2 Stack

Results of Orsat & Moisture Analyses-----Methods 3 & 4(%v/v)

	Run 1	Run 2	Run 3
Date of run	05-01-90	05-01-90	05-01-90
Dry basis (orsat)			
carbon dioxide............	3.20	3.10	3.10
oxygen....................	6.60	6.70	6.80
carbon monoxide...........	0.00	0.00	0.00
nitrogen..................	90.20	90.20	90.10
Wet basis (orsat)			
carbon dioxide............	2.70	2.61	2.62
oxygen....................	5.57	5.65	5.74
carbon monoxide...........	0.00	0.00	0.00
nitrogen..................	76.14	76.05	76.05
water vapor...............	15.59	15.69	15.59
Dry molecular weight........	28.78	28.76	28.77
Wet molecular weight........	27.10	27.07	27.09
Specific gravity............	0.936	0.935	0.936
Water mass flow......(LB/HR)	0.00	0.00	0.00
FO	4.469	4.581	4.548

3.2 Results of the Multi Metal Modified Method 5 (4M5) Sampling

Test No. 1
Scrubber Inlet

Results of Multi-Metal Modified Method 5 (4M5) Sampling.....

	Run 1	Run 2	Run 3
Date of run	05-01-90	05-01-90	05-01-90
Time run start/end.....(HRS)	0810-0915	0940-1045	1110-1215
Static pressure......(IN.WC)	-20.60	-20.60	-20.60
Cross sectional area (SQ.FT)	76.50	76.50	76.50
Pitot tube coefficient......	0.840	0.840	0.840
Water in sample gas			
condenser.............(ML)	0.0	0.0	0.0
impingers..........(GRAMS)	35.0	106.0	103.0
desiccant..........(GRAMS)	10.0	28.0	13.0
total..............(GRAMS)	45.0	119.0	116.0
Gas meter coefficient.......	0.9949	0.9949	0.9949
Barometric pressure..(IN.HG)	28.80	28.80	28.80
Avg. orif.pres.drop..(IN.WC)	0.65	1.88	1.70
Avg. gas meter temp..(DEF-F)	84.2	88.1	91.0
Volume through gas meter....			
at meter conditions...(CF)	27.85	46.96	44.60
standard conditions.(DSCF)	25.91	43.51	41.09
standard conditions..(NM^3)	0.734	1.232	1.164
Total sampling time....(MIN)	60.00	60.00	60.00
Nozzle diameter.........(IN)	.180	.242	.242
Avg.stack gas temp ..(DEG-F)	314	287	289
Volumetric flow rate........			
actual..............(ACFM)	334640	293978	287291
dry standard.......(DSCFM)	192474	165477	162994
Isokinetic variation.....(%)	97.2	105.0	100.7

Test No. 1
Scrubber Inlet

Sampling Data for PCDD and PCDF Test-------SW846 Method 0010

	Run 4
Date of run	05-01-90
Time run start/end.....(HRS)	1238-1347
Static pressure......(IN.WC)	-20.60
Cross sectional area (SQ.FT)	76.50
Pitot tube coefficient......	0.840
Water in sample gas	
condenser.............(ML)	0.0
impingers..........(GRAMS)	86.0
desiccant..........(GRAMS)	15.0
total..............(GRAMS)	101.0
Gas meter coefficient.......	0.9949
Barometric pressure..(IN.HG)	28.80
Avg. orif.pres.drop..(IN.WC)	1.68
Avg. gas meter temp..(DEF-F)	89.3
Volume through gas meter....	
at meter conditions...(CF)	43.11
standard conditions.(DSCF)	39.84
standard conditions..(NM^3)	1.128
Total sampling time....(MIN)	60.00
Nozzle diameter.........(IN)	.242
Avg.stack gas temp ..(DEG-F)	310
Volumetric flow rate........	
actual..............(ACFM)	289049
dry standard.......(DSCFM)	161373
Isokinetic variation.....(%)	98.6

Test No. 1
Units 1 & 2 Stack

Results of Multi-Metal Modified Method 5 (4M5) Sampling.....

	Run 1	Run 2	Run 3
Date of run	05-01-90	05-01-90	05-01-90
Time run start/end.....(HRS)	0810-0929	1030-1146	1225-1340
Static pressure......(IN.WC)	-1.50	-1.50	-1.50
Cross sectional area (SQ.FT)	829.58	829.58	829.58
Pitot tube coefficient......	0.840	0.840	0.840
Water in sample gas			
condenser.............(ML)	0.0	0.0	0.0
impingers..........(GRAMS)	173.0	182.0	178.0
desiccant..........(GRAMS)	15.0	5.0	11.0
total..............(GRAMS)	188.0	193.0	189.0
Gas meter coefficient.......	1.0051	1.0051	1.0051
Barometric pressure..(IN.HG)	28.55	28.55	28.55
Avg. orif.pres.drop..(IN.WC)	1.82	1.90	1.94
Avg. gas meter temp..(DEF-F)	57.1	68.0	70.5
Volume through gas meter....			
at meter conditions...(CF)	48.63	50.17	50.81
standard conditions.(DSCF)	47.83	48.33	48.72
standard conditions..(NM³)	1.354	1.369	1.380
Total sampling time....(MIN)	64.00	64.00	64.00
Nozzle diameter.........(IN)	.188	.186	.185
Avg.stack gas temp ..(DEG-F)	184	184	184
Volumetric flow rate........			
actual..............(ACFM)	4991821	5046646	5078896
dry standard.......(DSCFM)	3284153	3326471	3347367
Isokinetic variation.....(%)	98.0	99.9	101.1

3.3 Results of the Hexavalent Chromium (Cr VI) Sampling

Test No. 3
Units 1 & 2 Stack

Results of Hexavalent Chromium (Cr VI) Sampling

	Run 1	Run 2	Run 3
Date of run	05-01-90	05-01-90	05-01-90
Time run start/end.....(HRS)	1600/1710	1735/1847	1910/2022
Static pressure......(IN.WC)	-1.50	-1.50	-1.50
Cross sectional area (SQ.FT)	829.58	829.58	829.58
Pitot tube coefficient......	.840	.840	.840
Water in sample gas			
condenser.............(ML)	0.0	0.0	0.0
impingers..........(GRAMS)	176.0	176.0	169.0
desiccant..........(GRAMS)	15.0	16.0	22.0
total..............(GRAMS)	191.0	192.0	191.0
Gas meter coefficient.......	1.0051	1.0051	1.0051
Barometric pressure..(IN.HG)	28.55	28.55	28.55
Avg. orif.pres.drop..(IN.WC)	1.93	1.94	1.95
Avg. gas meter temp..(DEF-F)	66.3	72.5	73.2
Volume through gas meter....			
at meter conditions...(CF)	50.45	50.91	51.09
standard conditions.(DSCF)	48.76	48.64	48.75
Total sampling time....(MIN)	64.00	64.00	64.00
Nozzle diameter.........(IN)	.186	.186	.186
Avg.stack gas temp ..(DEG-F)	184	184	178
Volumetric flow rate........			
actual..............(ACFM)	5220779	5207100	5185542
dry standard.......(DSCFM)	3434693	3421500	3443062
Isokinetic variation.....(%)	97.6	97.7	97.3

APPENDIX A

VOLUMETRIC FLOW RATE DETERMINATIONS

Test No. 1
Scrubber Inlet

Results of Volumetric Flow Rate Determination-------Method 2

Date of Determination............	05-01-90
Time of Determination.......(HRS)	1530
Barometric pressure.......(IN.HG)	28.86
Pitot tube coefficient...........	.84
Number of sampling ports.........	6
Total number of points...........	24
Shape of duct....................	Rectangular
Duct width...................(IN)	36
Duct length..................(IN)	306
Duct area.................(SQ.FT)	76.50
Direction of flow................	DOWN
Static pressure...........(IN.WC)	-20.6
Avg. gas temp.............(DEG-F)	314
Moisture content..........(% V/V)	7.57
Avg. linear velocity.....(FT/SEC)	77.1
Gas density..............(LB/ACF)	.04778
Molecular weight......(LB/LBMOLE)	30.46
Mass flow of gas..........(LB/HR)	1014112
Volumetric flow rate.............	
actual..................(ACFM)	353777
dry standard...........(DSCFM)	203786

APPENDIX B

LOCATION OF TEST PORTS

EPA Method 1 Specification

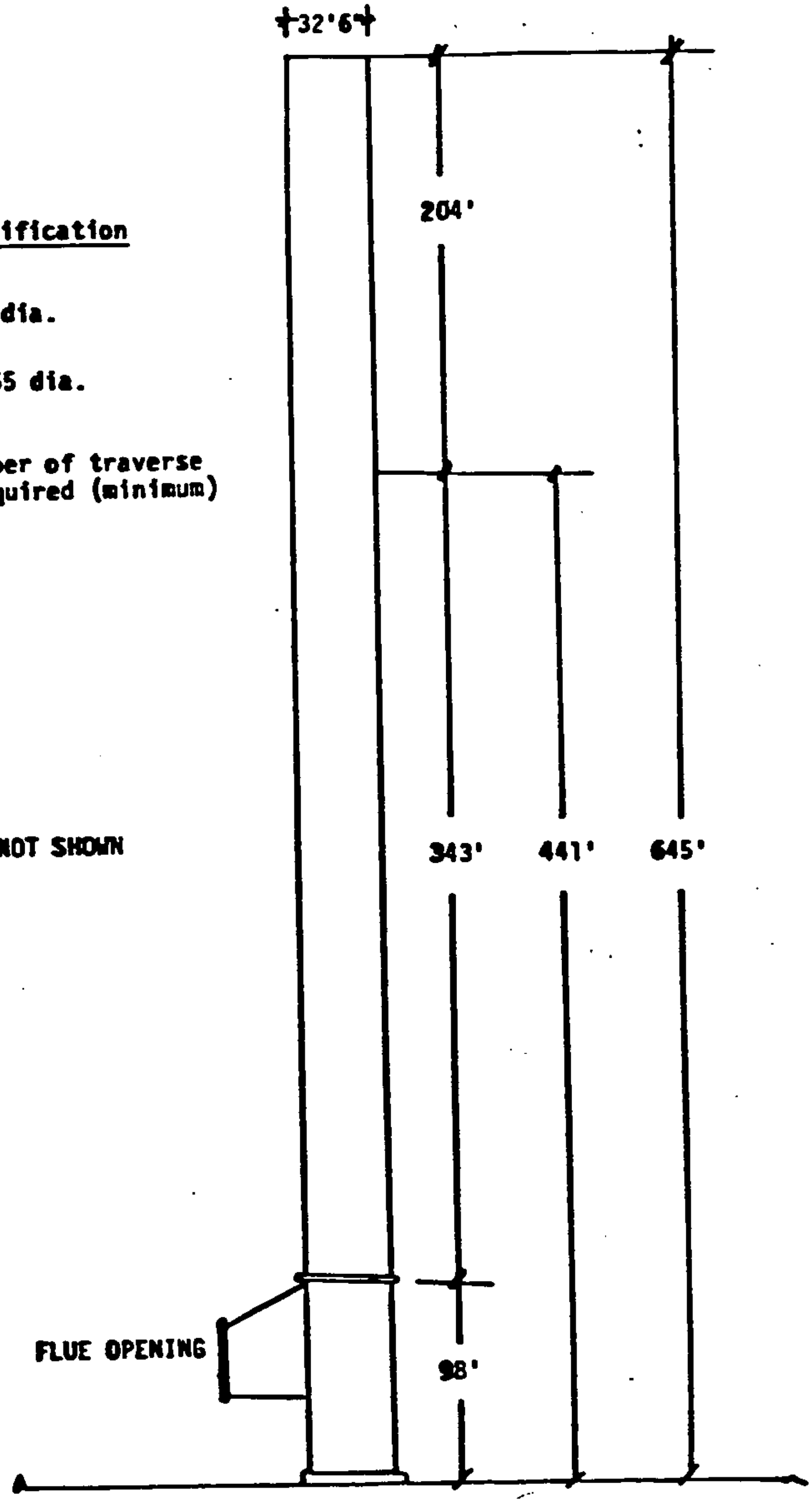
$A = \frac{204}{32.5} = 6.28$ dia.

$B = \frac{343}{32.5} = 10.55$ dia.

MN = Total number of traverse points required (minimum)

MN = 12

OUTER COLUMN NOT SHOWN



NSP SHERBURNE COUNTY GENERATING PLANT
UNITS 1&2 STACK

NOT TO SCALE

INTERPOLL INC.

APPENDIX C

FIELD DATA SHEETS

TABLE OF CONTENTS

INTERPOLL LABORATORIES EPA METHOD 2 FIELD DATA SHEET

Job NSP-SHERCO

Source BOILER NO 1 - INLET

Test 1 Run 1 Date 4-30-80

Stack dimen. 36 X 306 IN.

Dry bulb ______ °F Wet bulb ______ °F

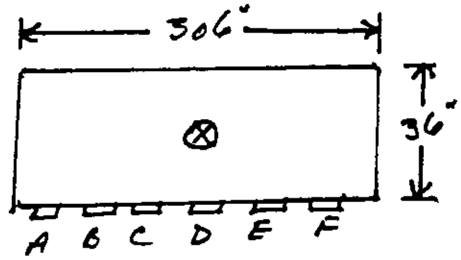
Manometer: ☒ Reg. ☐ Exp. ☐ Elec.

Barometric pressure 28.86 in Hg

Static pressure -20.6 in WC

Operators E. TROWBRIDGE - C. MOSSER

Pitot No. 21V-5 Cp .840



Schematic of Cross Section

Traverse Point No.		Fraction of Diameter	Distance from Stack Wall (in)	Distance from End of Port (in)	Velocity Pressure (in WC)	Temperature of gas (°F)
			Port length: 3 1/2 in.		Time start: 1530 hrs	
	A - 1		4.5	8.0	2.00	310
	2		13.5	17.8	1.80	
	3		22.5	26.0	1.40	
	4		33.5	35.0	1.20	
	B - 1				1.30	315
	2				1.35	
	3				1.35	
	4				1.20	
	C - 1				1.20	316
	2				1.15	
	3				1.10	
	4				1.10	
	D 1				.95	312
	2				1.00	
	3				1.20	
	4				1.20	
	E 1				1.00	318
	2				.95	
	3				1.20	
	4				1.35	
	F 1				.90	315
	2				1.10	
	3				1.00	
	4				1.20	
Temp. meas. tool & S/N: PDT-4					Time end: 1545 hrs	

R or nothing= reg. manometer; S= expanded; E = electronic S-392.1

INTERPOLL LABORATORIES EPA METHOD 5 FIELD DATA SHEET

Job NSP-SHELCO
Source Module 110-Scrubber Inlet
Date 5-1-90 Test 1 Run 1

Operators E.Trowbridge-C.Musser
Meter Box No. 9 ^H@ 1.85 IN WC
Gasmeter coeff. .9949

Pitot No. Z1V-5 Cp .840
Bar. Press. 28.80 inHg H2O x
Nozzle No. 9-3 Nozzle Dia .180 IN.

Traverse Point No.	Sampling Time (min)	Sample Volume (cf)	Velocity Head (inWC)	Orifice Meter (inWC)	Des. Vol. (cf)	VAC. inHg	Temperatures (°F) Stack	Probe	Oven	Impg.	Gas/In	Gas/Out	Oxygen (%v/v)
	0810	104.10											
F-4	2.5	110.23	1.05	.62	0.22	4.0	316	245	265	43	80	79	6.2
3	5	111.26	.80	.47	1.20	3.0	317				81	79	6.0
2	7.5	112.30	.90	.53	2.25	3.2	317	256	266	44	82	80	5.9
1	10	113.30	.85	.51	3.27	3.2	310				83	80	5.7
E-4	12.5	114.60	1.25	.74	4.50	4.1	319	259	260	44	85	81	6.6
3	15	115.70	1.00	.60	5.62	4.0	316				85	81	5.4
2	17.5	116.70	.85	.51	6.64	3.2	315	257	262	45	85	81	5.2
1	20	117.70	.80	.48	7.63		312				85	81	6.4
D 4	22.5	118.82	1.10	.66	8.80	4.0	316	255	260	45	86	82	5.4
3	25	119.99	1.10	.66	9.96	4.0	314				86	83	5.3
2	27.5	121.02	.85	.50	0.98	3.8	322	259	263	46	86	83	5.2
1	30	122.05	.80	.48	1.98	3.8	316				87	83	5.2
C 4	32.5	123.20	1.10	.66	3.14	4.3	320	258	260	46	87	83	6.2
3	35	124.37	1.10	.66	4.31	4.3	317				87	83	5.9
2	37.5	125.53	1.15	.69	5.50	4.3	315	262	258	46	88	83	5.9
1	40	126.63	.95	.57	6.59	4.1	318				88	83	5.6
B 4	42.5	127.84	1.20	.72	7.81	4.8	317	260	263	47	88	84	6.4
3	45	129.03	1.25	.75	9.05	4.9	316				88	84	6.6
2	47.5	130.26	1.15	.69	0.25	4.8	314	262	265	48	88	84	6.7
1	50	131.40	1.00	.60	1.37	4.2	312				88	84	6.6
A 4	52.5	132.51	1.06	.63	2.51	4.5	315	260	258	48	88	84	9.8
3	55	133.85	1.30	.80	3.79		300				88	84	9.6
2	57.5	135	1.65	1.01	5.24	6.1	302	262	260	48	88	84	6.8
1	60	136.95	1.80	1.11	6.75		295				88	84	6.7
	(0915)												
	θ = 60	Vm = 27.85		^H = .65							Avg. = 84.2		

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INTERPOLL LABORATORIES EPA METHOD 5 FIELD DATA SHEET

Job NSP-Sherco
Source Module 107 - Scrubber Inlet
Date 5-1-80 Test 1 Run x

Operators ET-CM
Meter Box No. 9 ΔH@ 1.85 IN WC
Gasometer coeff. .9949

Pitot No. 214-5 Cp .840
Bar. Press. 28.50 inHg H2O x
Nozzle No. 8-4 Nozzle Dia .272 IN.

Traverse Point No.	Sampling Time (min)	Sample Volume (cf)	Velocity Head (inWC)	Orifice Meter (inWC)	Gas. Vol. (cf)	VAC. inHg	Temperatures (°F) Stack	Probe	Oven	Impg.	Gas/In	Gas/Out	Oxygen (xv/v)
	0940	137.30											
F 4	2.5	139.25	.85	1.86	9.26	8.0	280	260	250	45	86	85	6.2
3	5	141.30	1.0	2.15	1.36	8.8	295				87	85	5.6
2	7.5	143.30	.88	1.89	3.33		295	262	248	46	88	86	5.7
1	10	145.40	.98	2.12	5.42	10.0	292				88	86	5.1
E 4	12.5	147.50	1.05	2.26	7.58	11.0	296	260	245	48	89	86	5.9
3	15	149.76	1.10	2.40	9.80	12.0	287				89	87	5.7
2	17.5	151.80	.91	1.98	1.82	12.0	291	260	248	49	89	87	5.4
1	20	153.95	1.05	2.28	3.98	12.2	290				89	87	5.6
D 4	22.5	156.15	1.10	2.38	6.20	13.0	294	262	250	50	89	87	5.4
3	25	157.94	.70	1.52	7.97	10.0	289				89	87	5.3
2	27.5	159.85	.75	1.63	9.81	10.0	290	257	252	50	89	87	5.4
1	30	161.53	.70	1.53	1.58	9.9	287				90	87	5.2
C 4	32.5	163.60	.95	2.07	3.65	11.8	288	260	250	51	90	87	5.0
3	35	165.55	.82	1.80	5.58	11.2	285				90	87	5.1
2	37.5	167.40	.80	1.75	7.48	11.1	285	263	255	50	90	87	5.1
1	40	169.30	.75	1.65	9.32	10.8	282				90	87	5.2
B 4	42.5	171.60	1.20	2.63	1.65	14.8	285	260	258	46	90	87	5.2
3	45	173.84	1.10	2.41	3.88	14.6	283				90	88	5.1
2	47.5	175.97	1.00	2.19	6.01		284	258	255	49	90	88	5.0
1	50	177.63	.54	1.24	7.61	10.0	280				90	88	5.1
A - 4	52.5	179.03	.40	.89	8.97	6.0	275	261	252	50	90	88	6.0
3	55	180.67	.58	1.28	0.60	10.0	277				90	88	5.7
2	57.5	182.00	.50	1.10		10.0	284	262	250	52	90	88	5.7
1	60	184.26	1.10	2.20	4.24	14.8	283				90	88	5.7
	(1045)												
	θ = 60	Vm = 46.96		ΔH = 1.88							Avg. = 88.1		

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CF-011

INTERPOLL LABORATORIES EPA METHOD 5 FIELD DATA SHEET

Job NSP-SHERCO
Source module 104 - scrubber inlet
Date 5-1-90 Test 1 Run 3

Operators ET-CM
Meter Box No. 9 ^H@ 1.85 IN WC
Gasmeter coeff. .9949

Pitot No. 21V-5 Cp .840
Bar. Press. 29.80 inHg H2O x
Nozzle No. 8-4 Nozzle Dia .242 IN.

Traverse Point No.		Sampling Time (min)	Sample Volume (cf)	Velocity Head (inWC)	Orifice Meter (inWC)	Dgs. Vol. (cf)	VAC. inHg	Temperatures (°F) Stack	Probe	Oven	Impg.	Cas/In	Cas/Out	Oxygen (%v/v)
		1110	184.60											
F	4	2.5	186.40	.76	1.56	6.39		292	247	251	46	90	89	6.1
	3	5	188.30	.84	1.72	8.27	8.0	294				90	89	5.7
	2	7.5	190.02	.70	1.44	0.00		292	250	255	48	91	89	5.4
	1	10	191.75	.66	1.37	1.69	7.0	285				91	89	5.5
E	4	12.5	193.52	.76	1.57	3.49	7.8	290	252	260	49	91	89	6.0
	3	15	195.30	.78	1.61	5.31	8.0	288				92	89	5.5
	2	17.5	196.90	.64	1.31	6.97	8.0	293	255	262	51	92	89	5.4
	1	20	198.20	.35	.72	8.19	4.8	290				92	89	5.5
D	4	22.5	200.15	.92	1.89	0.17	10.0	294	253	260	50	93	90	5.8
	3	25	202.10	.88	1.81	2.11	10.0	292				93	90	5.4
	2	27.5	203.75	.65	1.34	3.78	8.5	290	250	261	52	93	90	5.4
	1	30	205.51	.68	1.41	5.49	8.6	287				93	90	5.5
C	4	32.5	207.65	1.10	2.27	7.66	13.0	290	248	263	52	93	90	5.7
	3	35	209.62	.90	1.85	9.62	12.2	292				93	90	5.4
	2	37.5	211.38	.68	1.41	1.34	9.0	288	251	260	53	93	90	5.3
	1	40	213.14	.75	1.56	3.13	9.2	287				93	90	5.6
B	4	42.5	215.34	1.20	2.48	5.40	14.8	290	253	258	54	93	90	5.5
	3	45	217.50	1.05	2.16	7.52	14.5	292				93	90	5.3
	2	47.5	219.52	.97	2.00	9.55	14.3	290	256	260	54	93	90	5.2
	1	50	221.48	.85	1.76	1.46	13.0	290				93	90	5.3
A	4	52.5	222.68	.35	.73	2.70	6.0	285	252	259	55	93	90	5.7
	3	55	224.50	.70	1.46	4.44	9.0	281				93	90	5.7
	2	57.5	226.70	1.30	2.71	6.81	15.0	283	254	261	55	93	90	5.5
	1	60	229.20	1.30	2.71	9.18	15.0	281				93	90	5.5
		1215												
		θ = 60	Vm = 44.60		^H = 1.70							Avg. = 91.0		

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INTERPOLL LABORATORIES EPA METHOD 5 FIELD DATA SHEET

Job NSP-SHERCO
Source MODULE 101 SCRUBBER INLET
Date 5-1-90 Test 1 Run 4

Operators ET-CM
Meter Box No. 9 ^H@ 1.85 IN WC
Gasmeter coeff. .9940

Pitot No. 21V-5 Cp .840
Bar. Press. 28.30 inHg H2O 12 x
Nozzle No. P-4 Nozzle Dia .242 IN.

Traverse Point No.	Sampling Time (min)	Sample Volume (cf)	Velocity Head (inWC)	Orifice Meter (inWC)	Dgs. Vol. (cf)	VAC. inHg	Temperatures (°F) Stack	Probe	Oven	Impg.	Gas/In	Gas/Out	Oxygen (xv/v)
	1238	230.30											
F 4	2.5	232.08	.75	1.49	2.05		312	245	251	49	89	88	7.2
3	5	233.75	.65	1.28	3.68	4.2	314				90	88	6.9
2	7.5	235.38	.64	1.26	5.30	6.0	312	249	255	51	91	89	7.1
1	10	236.95	.66	1.31	6.94	4.1	310				91	89	6.7
E 4	12.5	238.80	.82	1.63	8.78	7.0	307	252	250	51	91	89	7.1
3	15	240.42	.68	1.35	0.45	6.8	309				92	89	6.8
2	17.5	242.25	.84	1.66	2.31	8.0	310	250	253	53	92	89	6.6
1	21	243.97	.66	1.30	3.95	6.2	315				92	89	6.5
D 4	22.5	245.90	.90	1.78	5.87	9.0	312	254	258	54	92	89	7.0
3	25	247.58	.70	1.38	7.56	8.0	315				92	89	6.6
2	27.5	249.38	.75	1.48	9.37	8.1	315	255	260	54	92	89	7.0
1	30	251.11	.80	1.58	1.12		312				92	89	7.0
C 4	32.5	253.10	.95	1.87	3.09	9.5	315	260	257	52	91	88	7.5
3	35	254.87	.78	1.53	4.87	9.0	315				91	88	7.9
2	37.5	256.70	.80	1.58	6.68	9.0	313	260	260	52	90	87	7.7
1	40	258.75	1.25	2.25	8.84	12.5	315				90	87	7.7
B 4	42.5	259.60	.15	.29	9.62	3.0	312	258	262	50	89	86	7.9
3	45	261.60	1.05	2.05	1.68	11.0	315				89	87	7.9
2	47.5	263.60	.98	1.92	3.67	10.9	313	255	264	52	90	87	8.0
1	50	265.55	1.30	2.56	5.97	15.0	310				90	87	7.9
A 4	52.5	268.00	1.05	2.07	8.03	12.2	312	257	260	52	90	87	7.9
3	55	269.88	.80	1.61	9.85	10.0	296				90	88	7.9
2	57.5	271.45	.57	1.15	1.40	8.0	295	255	260	54	90	88	9.3
1	60	273.41	1.05	2.11	3.49	12.8	295				90	88	8.0
	(1341)												
	θ = 60	Vm = 43.11		^H = 1.69							Avg. = 89.3		

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APPENDIX D

INTERPOLL LABS METALS RESULTS

TABLE OF CONTENTS

INTERPOLL LABORATORIES, INC.
(612)786-6020

NSP/Sherco
Laboratory Log No. 9449

Results of Trace Metal Analysis

Test: 1
Source: Scrubber Inlet
Sample Type: 4M5 Train Catch

		Total Mass of Trace Metal in Sample (ug)				
Trace Metal	EPA Method	Field Blank	Module 110 Run 1	Module 107 Run 2	Module 104 Run 3	Module 101 Run 4
(Log No.)		(9449-25)	(9449-26)	(9449-27)	(9449-28)	(9449-29)
Aluminum	SW-846, 6010	450	263000	450000	447000	130000
Arsenic	SW-846, 7060	< 0.5	35	70	130	39
Boron	SW-846, 6010	17	15900	8100	26000	28600
Barium	SW-846, 6010	12	12900	29300	11100	8550
Beryllium	SW-846, 6010	< 0.5	7	18	30	10
Calcium	SW-846, 6010	306	309000	536000	632000	191000
Cadmium	SW-846, 6010	1.5	10	23	40	13
Chromium	SW-846, 6010	5.4	128	334	550	200
Copper	SW-846, 6010	4.5	258	705	1150	185
Iron	SW-846, 6010	88	56100	157000	182000	103000
Potassium	SW-846, 6010	84	11300	27700	45300	13900
Magnesium	SW-846, 6010	46	58600	107000	144000	51600
Manganese	SW-846, 6010	2.8	1400	3250	5100	1840
Molybdenum	SW-846, 6010	32	55	97	136	72
Sodium	SW-846, 6010	620	51200	96500	160000	48000
Nickel	SW-846, 6010	2.7	80	144	220	91
Lead	SW-846, 6010	4.6	270	630	845	275
Selenium	SW-846, 7740	< 0.5	28	85	100	39
Antimony	SW-846, 6010	7.0	24	63	85	49
Strontium	3500-Sr. B[a]	< 5	4330	12500	17500	24400
Vanadium	SW-846, 6010	< 1	275	740	1280	510
Zinc	SW-846, 6010	12	142	270	400	200
Mercury	SW-846, 7470	0.26	2.55	4.38	11.8	2.79
Silver	SW-846, 6010	< 0.5	< 1.3	< 1.3	< 1.3	< 1.3

[a]Standard Methods, 17th Edition.

APPENDIX E

CALCULATION EQUATIONS

Calculation of Trace Metal Removal Rates

The trace metal mass rates at the inlet test sites cannot be accurately calculated using the volumetric flow rates measured at these test sites due to the large scale turbulence there. As discussed in the Introduction of this report, the best estimate of the particulate or trace metal concentration at the pollution control system inlet is the average of the concentrations measured in each scrubber (in this case: four). This estimate of the concentration at the pollution control system inlet can then be used with the volumetric flow rate measured at stack (which is an ideal location for flow measurement) to calculate the inlet mass rate. Naturally, the stack flow rate (dry, standard) must first be corrected to the same oxygen concentration as observed at the inlets during the test runs to correct for inleakage. Using this technique, only one estimate of the inlet trace metal concentrations and mass rates will be obtained. This value will be used then with the average of the outlet (stack) results to estimate the system removal rate over the entire test period.

The average dry standard volumetric flow rate at the stack test site was 3,320,000 DSCFM. The average oxygen concentration at the stack was 6.63% and at the inlet it was 5.85%. The average dry standard volumetric flow rate at the inlet test site can be calculated from the following expression:

$$Q_{INLET} = Q_{STACK}\left[\frac{20.9 - (O_2)_{STACK}}{20.9 - (O_2)_{INLET}}\right]$$

$$Q_{INLET} = 3150000\ DSCFM$$

The average mass rate at the inlet of each trace metal may be calculated now using the following expression:

$$\dot{m} = 3.746\times10^{-9}\ C{\cdot}Q$$

but Q = 3150000 and thus

$$\dot{m} = 1.18\times10^{-2}\ C$$