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 (°F)	degrees Fahrenheit
DIA.	diameter
FT/SEC	feet per second
GPM	gallons per minute
GR/ACF	grains per actual cubic foot
GR/DSCF	grains per dry standard cubic foot
g	gram
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
MW	megawatt
mg/DSCM	milligrams per dry standard cubic meter
microns (μm)	micrometer
MIN.	minutes
ohm-cm	ohm-centimeter
PPH	pounds per hour
PPM	parts per million
PSI	pounds per square inch
SQ. FT.	square feet
v/v	percent by volume
w/w	percent by weight

Standard conditions are defined as 68^oF (20^oC) and 29.92 in. of mercury pressure.

1 INTRODUCTION

On March 28, 1983, Interpoll Inc. personnel conducted a particulate and odor emission compliance test on the No. 8 incinerator at the Metropolitan Waste Control Commission Metro Plant located in St. Paul, Minnesota. On-site testing was performed by a two-man team under the direction of J. Stock. Coordination between testing activities and plant operation was provided by Peter T. Owre. The test was witnessed by Marty Osborn and Ray Bissonnette of the Minnesota Pollution Control Agency, Air Quality Division.

The No. 8 Sludge Incinerator System consists of an EBSP furnace designed to incinerate up to 23,000 LB/HR of sludge (or in the future to burn up to 3000 LB/HR coal). The furnace outlet temperature is maintained at 1200 ^{o}F or higher for odor control. Auxiliary fuel for sludge incineration may be either No. 2 fuel oil or natural gas. A quad cyclone system at the furnace outlet removes large particulate material which serves to protect the tubes in the waste heat recovery boiler which may produce up to 32,700 LB/HR of saturated steam (400 PSIG) which in turn is used to drive a steam turbine. When the waste heat boiler is off-line, the system employs an evaporative cooler to reduce flue gas temperatures to 500 ^{o}F, the design temperature for the precooler which combined with the downstream venturi scrubber (for fine particulate control) reduce the flue gas temperatures to approximately 172 ^{o}F. A subcooler further cools the flue gas to about 120 ^{o}F before the gas is reheated (reheater operated with 15 PSIG steam) to 220 ^{o}F for discharge through the ID fan and jacketed stack to the atmosphere.

Particulate determinations were performed in accordance with EPA Methods 1-5 and 9, CFR Title 40, Part 60, Appendix A (Revised July 1, 1982) and APC-28. A preliminary determination of the gas velocity profile was made before the first particulate run to allow selection of the appropriate nozzle diameter required for isokinetic sample

withdrawal. An Interpoll sampling train which meets or exceeds specifications in the above-cited reference was used to isokinetically extract particulate samples by means of a heated glass-lined probe.

Simultaneously with each particulate determination, an integrated flue gas sample was extracted using a specially designed gas sampling system. Flue gas samples were collected in 44-liter Tedlar or Teflon bags. In order to insure the integrity of each test bag, the oxygen concentration of the collected bag sample was measured on-site with a Teledyne Model 320P oxygen analyzer. After the samples were returned to Interpoll's laboratory for Orsat analysis, the oxygen concentration of the bag sample was measured again with a laboratory Teledyne oxygen analyzer.

Testing on the No. 8 Incinerator was conducted from two test ports on the stack oriented at 90 degrees and approximately eight diameters downstream of the breeching inlet and two diameters upstream of the stack outlet. A 16-point traverse was used to extract representative flyash samples. Each traverse point was sampled four minutes to give a total sampling time of 64 minutes per run.

Odor evaluations were also performed from the stack test site in accordance with ASTM 1391-57 as modified by Benforado et al and APC 9. Odor samples were collected from the stack using 7-liter Tedlar bags. The bag samples were returned to the laboratory and analyzed immediately by an experienced in-house seven-member odor panel.

The important results of the test are summarized in Section 2. Detailed results are presented in Section 3. Results of preliminary measurements, field data and all other supporting information are presented in the appendices.

2 SUMMARY AND DISCUSSION

The important results of the particulate emission test on the No. 8 Incinerator are summarized in Table 1. As will be noted, the particulate emission factor averaged 0.30 LB/TON dry sludge input. The odor concentration averaged 91 odor units/SCF.

No difficulties were encountered in the field or in the laboratory evaluation of the flue gas and particulate samples. On the basis of this fact and a complete review of the entire data and results, it is our opinion that the particulate and odor concentrations, emission rates and emission factors 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 March 28, 1983 Particulate Emission Compliance Test on the No. 8 Incinerator Stack at the MWCC Metro Plant Located in St. Paul, Minnesota

ITEM	RUN 1	RUN 2	RUN 3
Time of test (HRS)	0934/1040	1208/1313	1328/1444
Sludge input (TONS/HR,dry)	3.53	3.53	3.53
Volumetric flow			
ACTUAL (ACFM)	26400	25300	25700
STANDARD (DSCFM)	21300	20200	20600
Gas temperature (DEG-F)	162	167	167
Moisture content (% v/v)	3.57	3.21	3.09
Gas composition (% v/v dry)			
carbon dioxide	7.60	7.80	7.40
oxygen	12.40	12.20	12.40
nitrogen	80.00	80.00	80.20
Oxygen analyzer (% v/v, dry)	13.34	13.11	13.45
Isokinetic variation (%)	97.6	97.9	97.3
Particulate mass rate (LB/HR)	1.45	1.14	.63
Particulate concentration			
ACTUAL (GR/ACF)	.0064	.0053	.0029
STANDARD (GR/DSCF)	.0080	.0066	.0036
12% CO2 (GR/DSCF)	.0126	.0102	.0058
(LB/TON dry sludge input)	.41	.32	.18

3 RESULTS

The results of all field and laboratory evaulations are presented in this section. Gas composition results (Orsat and moisture) are presented first; followed by the computer printout of particulate and visible emission data and results of odor concentration determinations. Preliminary measurements including traverse point description are given in Appendices A and B.

The results have been calculated on a DEC PDP-11 Computer using standard Fortran programs. EPA-published equations have been used as the basis of the calculation techniques in these programs. It should be noted in interpreting these results that the particulate emission rates have been calculated by both the "concentration x flow" and the "ratio of areas" methods and the average reported. The average is the best estimate of the true value, since the bias introduced by anisokinetic sampling is approximately equal but of opposite sign in the two calculation techniques and thus cancels in the average.

Test No. 1
No. 8 Incinerator Stack

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

	Run 1	Run 2	Run 3
Date of run	03/28/83	03/28/83	03/28/83
Dry basis (orsat)			
carbon dioxide	7.60	7.80	7.40
oxygen	12.40	12.20	12.40
carbon monoxide	.00	.00	.00
nitrogen	80.00	80.00	80.20
Wet basis (orsat)			
carbon dioxide	7.33	7.55	7.17
oxygen	11.96	11.81	12.02
carbon monoxide	.00	.00	.00
nitrogen	77.15	77.43	77.72
Moisture content	3.57	3.21	3.09
Dry molecular weight	29.71	29.74	29.68
Wet molecular weight	29.29	29.36	29.32
Specific gravity (relative to air)	1.0119	1.0141	1.0127
Teledyne oxygen analyzer (velocity & time weighted avg.)	13.34	13.11	13.45
FO	1.12	1.12	1.15

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No. 8 Incinerator Stack

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nitrogen	80.00	80.00	80.20
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carbon dioxide	7.33	7.55	7.17
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nitrogen	77.15	77.43	77.72
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Specific gravity (relative to air)	1.0119	1.0141	1.0127
Teledyne oxygen analyzer (velocity & time weighted avg.)	13.34	13.11	13.45
FO	1.12	1.12	1.15

Test No. 1
No. 8 Incinerator Stack

3.2 Results of Particulate Loading Determinations -- Method 5(BE)

	Run 1	Run 2	Run 3
Date of run	03/28/83	03/28/83	03/28/83
Time run start/end (HRS)	0934/1040	1208/1313	1328/1444
Pitot tube coefficient	.853	.853	.853
Water in sample			
condensate (ml)	23.0	21.0	23.0
silica gel (grams)	19.0	15.0	12.0
Total particulate material collected (grams) *	.0276	.0218	.0119
Meter correction coefficient	1.0000	1.0000	1.0000
Volume through gas meter			
at meter conditions...(CF)	55.58	53.79	54.65
standard conditions..(SCF)	53.51	51.10	51.68
Total sampling time (MIN)	64.0	64.0	64.0
Nozzle diameter (IN)	.184	.184	.184
Average stack gas temperature during determination (DEG-F)	162	167	167
Volumetric flow			
actual.....(CFM)	26446	25302	25693
standard.....(DSCFM)	21273	20249	20590
Isokinetic variation (%)	97.6	97.9	97.3
Particle concentration			
actual.....(GR/ACF)	.0064	.0053	.0029
dry standard....(GR/DSCF)	.0080	.0066	.0036
Particle mass flow (LB/HR)	1.45	1.14	.63

* Dry Catch plus Organic Wet Catch

Test No. 1
No. 8 Incinerator Stack

3.3 Results of Opacity Observations - EPA Method 9

Percent Opacity	Optical Density	Relative Frequency (%)
0	.0000	.00
5	.0223	100.00
10	.0458	.00
15	.0706	.00
20	.0969	.00
25	.1249	.00
30	.1549	.00
35	.1871	.00
40	.2219	.00
45	.2596	.00
50	.3010	.00
55	.3468	.00
60	.3979	.00
65	.4559	.00
70	.5229	.00
75	.6021	.00
80	.6990	.00
85	.8239	.00
90	1.0000	.00
95	1.3010	.00
99	2.0000	.00
5.00	.02230	Time Average

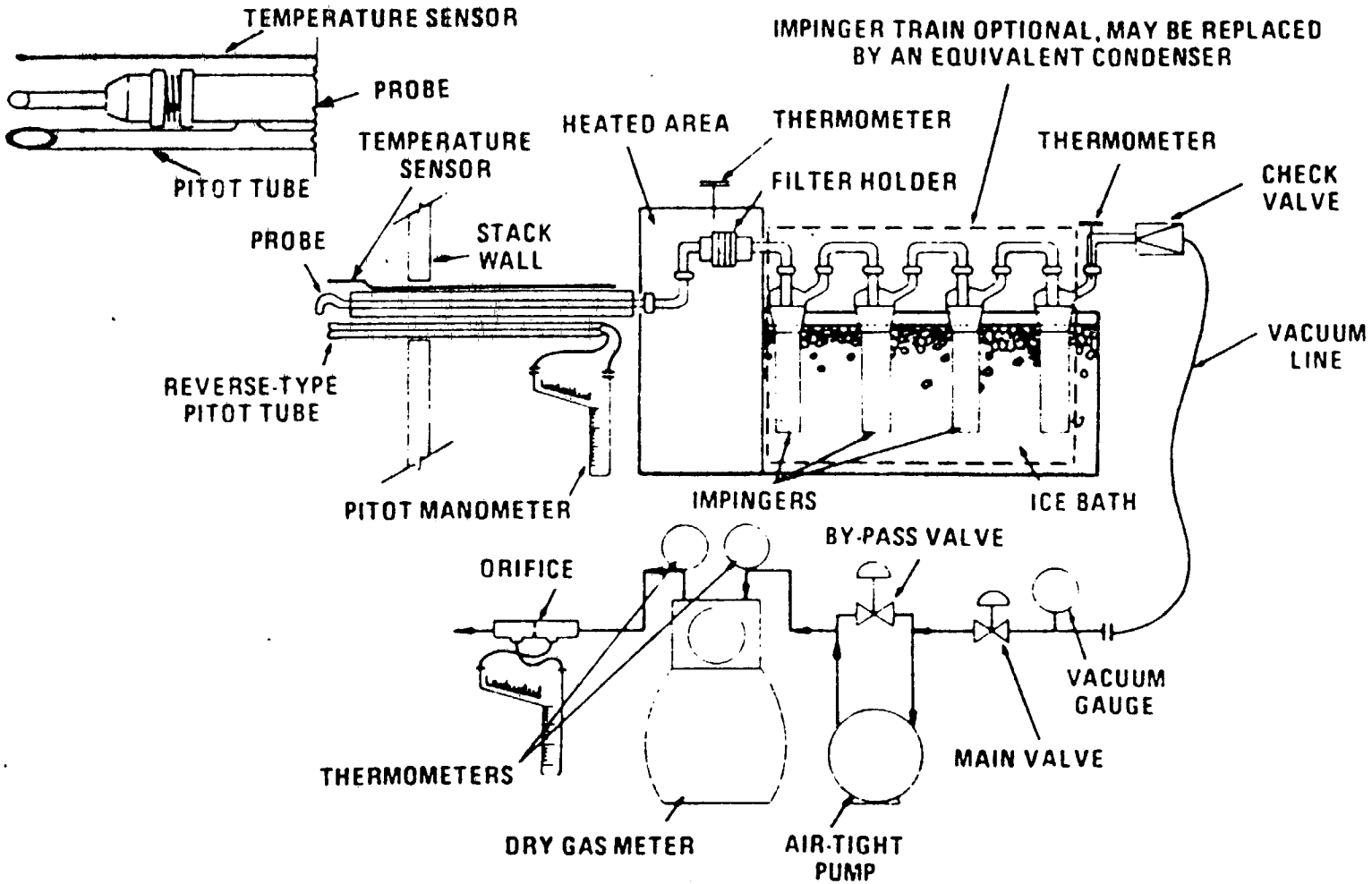
Observer: K. Goodman
Cert. Date: 06/10/82
Date of Observation: 03/28/83
Time of Observation: 1205

After sampling is complete, the filter is removed and placed in a clean container. The nozzle and inlet side of the filter holder are quantitatively washed with acetone and the washings are stored in a second container. A brush is often used in the cleaning step to help dislodge deposits. The samples are returned to the laboratory where they are logged in and analyzed. The volume of the acetone rinse ("probe wash") is noted and then the rinse is quantitatively transferred to a tared 120 cc porcelain evaporating dish and the acetone evaporated off at 97-105 ^{o}F. This temperature is used to prevent condensation of atmospheric moisture due to the cooling effect induced by the evaporation of acetone. The acetone-free sample is then transferred to an oven and dried at 105 ^{o}C for 30 minutes, cooled in a desiccator over Drierite, and then weighed to the nearest .01 mg. The filter sample is quantitatively transferred to a 6-inch watch glass and dried in an oven at 105 ^{o}C for two hours. The filter and watch glass are then cooled in a desiccator and the filter weighed to the nearest .01 mg. All weighings are performed in a balance room where the relative humidity is hydrostatted to less than 50% relative humidity. Microscopic examination of the samples is performed if any unusual characteristics are observed. The weight of the acetone rinse is corrected for the acetone blank. The Drierite column is weighed on-site and the water collected by Drierite is added to the condensate so that the total amount of absorbed water may be ascertained.

Integrated flue gas samples for Orsat analysis were collected simultaneously from the stack and from the breeching at the inlet to the wet scrubber. The samples were collected in 44-liter Tedlar or teflon gas sampling bags at a constant flow rate throughout each particulate run. The bags were then returned to the laboratory and analyzed by Orsat analysis. Standard commercially prepared solutions were used in the Orsat analyzer (sat. KOH for carbon dioxide and reduced methylene blue for oxygen). In addition to the above, the oxygen content of the flue gas was measured at each traverse during the particulate determinations using a Teledyne Model 320P-4 Portable Oxygen Analyzer to sample the effluent from the Method 5 train.

Wet Catch Analyses

The particulate catch concentrations and emission rates given in the body of the report have been calculated on the basis of the dry catch only, i.e. the material collected in the sampling train up to and including the filter catch. The impinger contents were, however, also analyzed to determine the "organic" wet catch. The organic catch was determined by the chloroform-diethyl ether extraction (FR 36(159:15715).



Particulate sampling train.

APPENDIX I

CALCULATION EQUATIONS

CALCULATION EQUATIONS

METHOD 2

$$\bar{V}_s = 85.48\, C_p\, (\sqrt{\Delta p})_{avg} \sqrt{\frac{T_{s(avg)}}{P_s M_s}}$$

$$Q_{s,d} = 60(1 - B_{ws})\, \bar{V}_s\, A \left[\frac{528}{T_{s(avg)}}\right] \left[\frac{P_s}{29.92}\right]$$

$$Q_a = 60\, \bar{V}_s\, A$$

$$\dot{m}_g = \frac{4.995\, Q_{s,d}\, G_d}{1 - B_{ws}}$$

$$RH^* = 100\, [vp_{twb} - 0.0003641\, P_s\, (T_{db} - T_{wb})]/vp_{tdb}$$

$$B^*_{ws} = RH(vp_{tdb})/P_s$$

$$\rho = \frac{4.585 \times 10^{-2}\, P_s M_s}{T_{s\,(avg)}}$$

*Alternate equations for calculating moisture content from wet bulb and dry bulb data.

MINNESOTA POLLUTION CONTROL AGENCY
Air Quality Division

PERFORMANCE TEST EVALUATION REPORT

I. DESCRIPTION

SOURCE: Metropolitan Waste Control FILE: 879

LOCATION: Pigs Eye, St. Paul

BY: M. Osborn (Tested by Intertek) DATE: March 28, 1983 of Test

II. COMPLIANCE DETERMINATION

Analysis of the performance test indicates the following has been demonstrated:

Parameter	Compliance	Non-Compliance	Not Determined
TSP	X		
SO_2			X
NO_x			X
V.E.	X		
Acid Alkalines			X
Odor		X	
Other			X

N.S.P. Standard = 1.3 lb/ton Part.
V.E. ≤ 20%
Odor - 150 @ 1,000,000

Explanation of Non-Compliance / DISCUSSION :-

Incinerator # 8 was tested on March 28th. The average sludge feed was 3.5 ton/hr dry (11.46 wet ton/hr) which is design spec. The test was for particulate odor & V.E. Particulate was found to be 0.30 lb/ton, V.E. was 5% and odor averaged 91 @ SCF which resulted in 1.88×10^6 OU/min (1.0×10^6 is allowable). Back half was ≈ 5% of total particulate catch. Particulate & V.E. are well below requirement. Isokinetic variation was good.

III. MAJOR DEFICIENCIES IN TEST REPORT

1) The V.E. observer did not have a current certification.
2) The third run was significantly below the other two.
3) No information on auxiliary fuel or sludge B.T.U.
4) Not the original report - No com data included.

IV. RECOMMENDATIONS

A. Source in Compliance

Recommendations for special conditions in the operating permit:

B. Source not in Compliance

Recommendations for action:

We should meet in house to discuss the odor emission rate violation

5/18/83