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RESULTS OF THE NOVEMBER 25, 1980 PARTICULATE EMISSION COMPLIANCE TEST ON THE NO. 4 SLUDGE INCINERATOR WET SCRUBBER STACK AT THE MWCC ST. PAUL WASTEWATER TREATMENT PLANT IN ST. PAUL, MINNESOTA

Submitted to:

THE METROPOLITAN WASTE CONTROL COMMISSION
2400 Childs Road
St. Paul, Minnesota 55106

Attention: Wilbur Blain
Plant Manager

Approved by:

Perry Lonnes, Ph.D.
Director of Environmental
Measurements Section

Report Number 0-805
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bjr

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SYMBOLS AND ABBREVIATIONS

ACFM	actual cubic feet per minute
DSCFM	standard cubic foot of dry gas per minute
DEG-F	degrees Fahrenheit
FT/SEC	feet per second
GR/ACF	grains per actual cubic foot
GR/DSCF	grains per dry standard cubic foot
G	gram
HRS	hours
IN.	inches
IN. H.G.	inches of mercury
IN. W.C.	inches of water
LB	pound
LB/HR	pounds per hour
LB/10^6BTU	million British Thermal Units heat input
microns (μm)	micrometer
MIN	minutes
SQ. FT.	square feet
v/v	percent by volume
mg/DSCM	milligrams per dry standard cubic meter
LB/DSCF	pounds per dry standard cubic foot
MWH	megawatt hours
ohm-cm	ohm-centimeter
HP	horsepower
PSI	pounds per square inch
w/w	percent by weight

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

1 INTRODUCTION

On November 25, 1980, Interpoll Inc. personnel conducted a particulate emission compliance test on the No. 4 Sludge Incinerator wet scrubber stack at the Metropolitan Waste Control Commission (MWCC) Wastewater Treatment Plant located in St. Paul, Minnesota. The objective of this test was to establish compliance status with respect to Minnesota Air Pollution Regulation APC-7 which restricts particulate emissions from incinerators of this type and size to 0.1 GR/DSCF (adjusted to 12% CO_2). On-site testing was performed by a three-man team under the direction of E. Trowbridge. Coordination between incinerator and wet scrubber operation and testing activities was provided by N. Shamat of the MWCC. The tests were not witnessed by a member of the Minnesota Pollution Control Agency (MPCA).

The No. 4 Sludge Incinerator is a Nicols Herreshoff eight hearth incinerator which was installed about 1938. This incinerator fires oil as a supplementary fuel. The original rated capacity of this incinerator was 2.1 DRY TONS/HR. This rating was based on combustion of sludge with a higher volatile content than is presently fired and thus the current capacity is substantially less. Particulate emissions from this incinerator are controlled by a Heil impingement wet scrubber which was installed in the Spring of 1979. Cleaned flue gas is exhausted to the atmosphere by a radial fiberglass stack which has an internal diameter of three feet.

Particulate evaluations were performed in accordance with EPA Methods 1-5 and 9, CFR Title 40, Part 60, Appendix A (Revised July 1, 1979) and APC-7. A preliminary determination of the gas linear velocity profile was made in the stack 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 extract particulate samples by means of a heated glass-lined probe.

Testing at the scrubber outlet (i.e. stack) was conducted from two test ports oriented at 90° on the stack. These ports are 19 feet downstream of the I.D. fan inlet and three feet upstream of the stack outlet. A 36-point traverse was used to extract representative particulate samples. Each traverse point was sampled two minutes to give a total sampling time of 72 minutes per run. Visible emissions were also read by a currently-certified observer during the particulate determinations. Integrated flue gas samples were also collected at the inlet to the scrubber (incinerator outlet) simultaneously to those collected at the stack test location during each of the particulate runs so that the particulate concentration could be adjusted to 12% CO_2 as prescribed in APC-7. Two volumetric flow rate determinations and one moisture content determination were also performed at the inlet to the scrubber during each particulate run to provide additional data required to correct particulate concentrations to 12% CO_2.

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 compliance test on the No. 4 Incinerator wet scrubber stack are summarized in Table 1. As will be noted, the particulate concentration adjusted to 12% CO_2 ranged from .048 to .059 GR/DSCF**. These concentrations were measured when the sludge burning rate was 2.0 DRY TONS/HR. The corresponding supplemental fuel burning rate (oil) ranged from 44.6 to 58.0 GPH.

No difficulties were encountered in the field or in the laboratory evalution 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 concentrations and emission rates reported herein are accurate and closely reflect the actual values which existed at the time the test was conducted.

** MPCA Method of Adjusting to 12% CO_2 (See Appendix I).

Table 1. Summary of the Results of the November 25, 1980 Particulate Emission Compliance Test on the No. 4 Sludge Incinerator Wet Scrubber Stack at the Metropolitan Waste Control Commission St. Paul Wastewater Treatment Plant.

ITEM	PRELIMINARY	RUN 1	RUN 2	RUN 3
Time of test (HRS)	0945	1000-1117	1230-1345	1420-1532
Sludge burning rate				
DRY (TONS/HR)		2.0	2.0	2.0
WET (TONS/HR)		7.2	7.2	7.1
Oil burning rate (GPH)		44.6	58.0	51.3
Volumetric flow				
ACTUAL (ACFM)	16300	16200	17500	18300
STANDARD (DSCFM)	15300	14800	16600	17300
Gas temperature (DEG-F)	80	87	77	78
Gas moisture content (% v/v)	3.54	4.40	2.98	3.24
Gas composition (% v/v, dry)				
INCINERATOR OUTLET				
carbon dioxide		9.51	8.20	7.91
oxygen		9.71	11.63	11.71
nitrogen		80.78	80.17	80.38
STACK				
carbon dioxide		6.90	5.71	5.51
oxygen		11.71	13.61	13.71
nitrogen		81.39	80.68	80.78
Isokinetic variation (%)		98.6	97.7	98.4
Particulate emission rate (LB/HR)		3.42	3.58	4.04
Particulate concentration				
ACTUAL (GR/ACF)		.025	.024	.026
STANDARD (GR/DSCF)		.027	.025	.028
(GR/DSCF @ 12% CO_2)*		.041	.047	.052
(GR/DSCF @ 12% CO_2)**		.048	.053	.059

*EPA-Alternate Method (Excess Air) of Adjusting to 12% CO_2 (See Appendix I)
**MPCA Method of Adjusting to 12% CO_2 (See Appendix I)

3 RESULTS

The results of all field and laboratory evaluations are presented in this section. Gas composition results are presented first, followed by the computer printout of particulate emission data and results of visible emission determinations. Preliminary measurements including traverse point description are given in Appendix 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 an isokinetic sampling is approximately equal but of opposite sign in the two calculation techniques and thus cancels in the average.

3.1 Results of Orsat and Moisture Analyses

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3.1.1 TEST NO. 1 NO. 4 INCINERATOR OUTLET

RESULTS OF ORSAT & MOISTURE ANALYSES -- METHOD 3 & 4 (% V/V)

	RUN 1	RUN 2	RUN 3
DATE OF RUN	11/25/80	11/25/80	11/25/80
DRY BASIS (ORSAT)			
CARBON DIOXIDE	9.51	8.20	7.91
OXYGEN	9.71	11.63	11.71
CARBON MONOXIDE	0.00	0.00	0.00
NITROGEN	80.78	80.17	80.38
WET BASIS (ORSAT)			
CARBON DIOXIDE	6.40	5.83	5.82
OXYGEN	6.54	8.27	8.61
CARBON MONOXIDE	0.00	0.00	0.00
NITROGEN	54.40	57.02	59.13
MOISTURE CONTENT	32.66	28.87	26.44
DRY MOLECULAR WEIGHT	29.91	29.78	29.73
WET MOLECULAR WEIGHT	26.02	26.38	26.63
SPECIFIC GRAVITY (RELATIVE TO AIR)	0.8988	0.9111	0.9199
FO	1.18	1.13	1.16

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3.1.2 TEST NO. 1 NO. 4 INCINERATOR SCRUBBER STACK

RESULTS OF ORSAT & MOISTURE ANALYSES -- METHOD 3 & 4 (% V/V)

	RUN 1	RUN 2	RUN 3
DATE OF RUN	11/25/80	11/25/80	11/25/80
DRY BASIS (ORSAT)			
CARBON DIOXIDE	6.90	5.71	5.51
OXYGEN	11.71	13.61	13.71
CARBON MONOXIDE	0.00	0.00	0.00
NITROGEN	81.39	80.68	80.78
WET BASIS (ORSAT)			
CARBON DIOXIDE	6.60	5.54	5.33
OXYGEN	11.19	13.20	13.27
CARBON MONOXIDE	0.00	0.00	0.00
NITROGEN	77.81	78.27	78.16
MOISTURE CONTENT	4.40	2.98	3.24
DRY MOLECULAR WEIGHT	29.57	29.46	29.43
WET MOLECULAR WEIGHT	29.06	29.12	29.06
SPECIFIC GRAVITY (RELATIVE TO AIR)	1.0039	1.0057	1.0038
VELOCITY WEIGHTED AND TIME-AVERAGED OXYGEN DURING METHOD 5 RUNS	11.29	12.86	12.86

** CONDENSED WATER VAPOR IN GAS STREAM; MOISTURE CONTENT CALCULATED FROM AVERAGE STACK GAS TEMPERATURE ASSUMING SATURATION.

FO	1.33	1.28	1.30

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TEST NO. 1 NO. 4 INCINERATOR SCRUBBER STACK

3.2 RESULTS OF PARTICULATE LOADING DETERMINATIONS -- METHOD 5(BE)

	RUN 1	RUN 2	RUN 3
DATE OF RUN	11/25/80	11/25/80	11/25/80
TIME RUN START/END(HRS)	1000/1117	1230/1345	1420/1532
PITOT TUBE COEFFICIENT	0.848	0.848	0.848
WATER IN SAMPLE			
CONDENSATE (ML)	28.0	22.0	24.0
SILICA GEL (GRAMS)	22.0	13.0	16.0
TOTAL PARTICULATE MATERIAL COLLECTED(GRAMS) *	0.0850	0.0886	0.1003
VOLUME THROUGH GAS METER			
AT METER CONDITIONS (CF)	47.41	54.72	58.49
STANDARD CONDITIONS (SCF)	48.35	53.63	56.29
TOTAL SAMPLING TIME (MIN)	72.0	72.0	72.0
NOZZLE DIAMETER (IN)	0.244	0.244	0.244
AVERAGE STACK GAS TEMPERATURE DURING DETERMINATION (DEG-F)	87.	77.	78.
VOLUMETRIC FLOW**			
ACTUAL ..... (ACFM)	16180.	17531.	18329.
DRY STANDARD ... (DSCFM)	14806.	16590.	17271.
ISOKINETIC VARIATION (%)	98.6	97.7	98.4
PARTICLE CONCENTRATION			
ACTUAL ..... (GR/ACF)	0.0249	0.0242	0.0260
DRY STANDARD ... (GR/DSCF)	0.0271	0.0255	0.0275
PARTICLE MASS FLOW (LB/HR)	3.42	3.58	4.04

* DRY CATCH ONLY

** CALCULATED ON THE BASIS OF VELOCITY PRESSURES MEASURED DURING THIS PARTICULATE DETERMINATION.

TEST NO. 1 SOURCE: No. 4 Incinerator Scrubber Stack

3.3 RESULTS OF OPACITY OBSERVATIONS - EPA METHOD 9

PERCENT OPACITY	OPTICAL DENSITY	RELATIVE FREQUENCY (%)
0	0	39.17
5	.0223	60.83
10	.0458	0
15	.0706	0
20	.0969	0
25	.1249	0
30	.1549	0
35	.1871	0
40	.2219	0
45	.2596	0
50	.3010	0
55	.3468	0
60	.3979	0
65	.4559	0
70	.5229	0
75	.6021	0
80	.6990	0
85	.8239	0
90	1.000	0
95	1.301	0
100		0
3.04	0.0136	TIME AVERAGE

OBSERVER: N. Christ

CERTIFICATION DATE: 9-9-80

DATE OF OBSERVATION: 11-25-80

TIME OF OBSERVATION: 1230-1330