AD-A063 622 OFFICE OF THE PROJECT MANAGER CHEM DEMILITARIZATION I--ETC F/G 13/2
DEMILITARIZATION PLAN OPERATION OF THE CHEMICAL AGENT MUNITIONS--ETC(U)
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LEVEL II

OPERATION OF THE CHEMICAL AGENT MUNITIONS DISPOSAL SYSTEM (CAMDS) AT TOOELE ARMY DEPOT, UTAH

MARCH 1977

INCLOSURE NO. 15

DUNNAGE INCINERATOR TESTING

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: DRCPM-DRD-TR-72023	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle): Final Demilitarization Plan; Operation of the CAMDS at Tooele Army Depot Inclosure 15 Dunnage Incinerator Testing	5. TYPE OF REPORT & PERIOD COVERED: Final - March 72
	6. PERFORMING ORG. REPORT NUMBER: 99-06-72
7. AUTHOR(s): Robert L. Hanson, PE, MAJ, MSC	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: AEHA, APG, Maryland 21010	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: OFFICE OF THE PROJECT MANAGER FOR CHEMICAL DEMILITARIZATION AND INSTALLATION RESTORATION ABERDEEN PROVING GROUND, MARYLAND 21010	12. REPORT DATE: March 1972
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Dunnage Incinerator
Particulate Emissions
Tooele Army Depot, Utah
Air Pollution Sampling
Ringlemann Scale
Transportable Disposal System

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

An air pollution engineering source sampling survey was conducted at Tooele Army Depot to evaluate particulate and visible emissions from the (TDS) dunnage incinerator with respect to standards of 0.2 gr/scf and No. 1 Ringlemann. The waste charging rate was 500 lb/hr. The measured particulate emissions for the two required test runs were 0.113 and 0.190 gr/scf. The observed visible emission was essentially zero on the Ringlemann Scale.

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(6)

DEMILITARIZATION PLAN

OPERATION

OF THE

CHEMICAL AGENT MUNITIONS DISPOSAL SYSTEM

(CAMDS)

AT

TOOELE ARMY DEPOT.

(9) Final rept.,

(10) Robert L. Hanson

(11) Mar 77

(12) 54 p.

(14) DRCPM-DRD-TR-77023

MARCH 1977

INCLOSURE ~~NO.~~ number 15.

DUNNAGE INCINERATOR TESTING.

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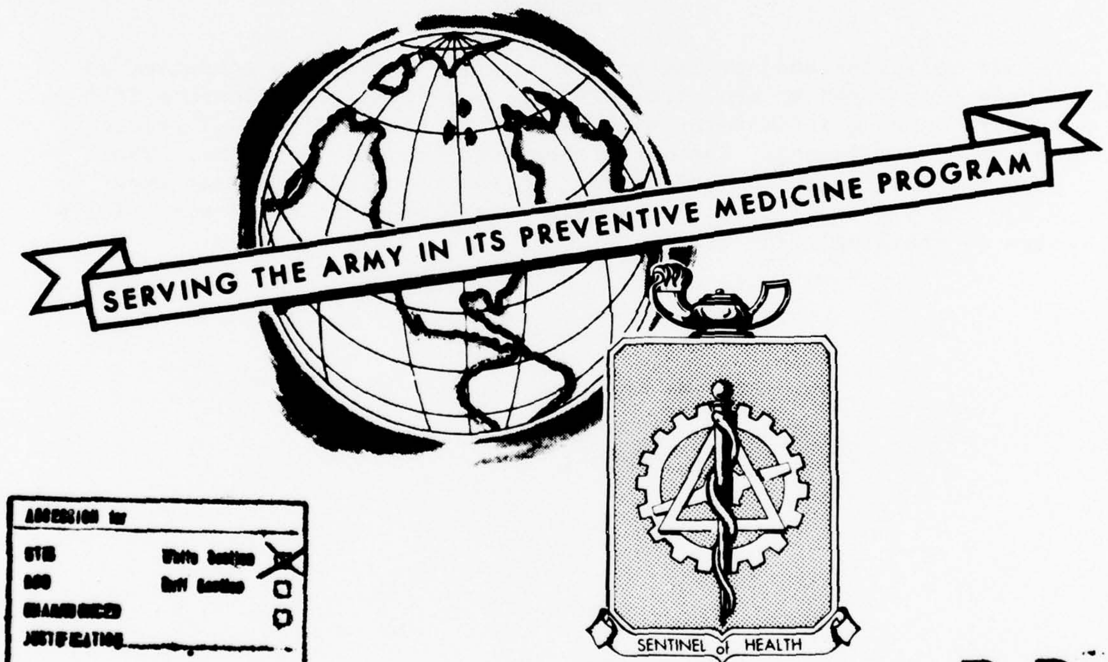
LEVEL II

(1)

AIR POLLUTION ENGINEERING SOURCE SAMPLING
SURVEY NO. 99-06-72
ACCEPTANCE TEST OF TDS DUNNAGE INCINERATOR
TOOELE ARMY DEPOT
TOOELE, UTAH
10 MARCH 1972



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USAEHA-EA 19 JUL 1972

AIR POLLUTION ENGINEERING SOURCE SAMPLING SURVEY NO. 99-6-72
ACCEPTANCE TEST OF TDS DUNNAGE INCINERATOR
TOOELE ARMY DEPOT
TOOELE, UTAH
10 MARCH 1972

ABSTRACT

An air pollution engineering source sampling survey was conducted at Tooele Army Depot to evaluate particulate and visible emissions from the TDS dunnage incinerator with respect to standards of 0.2 gr/scf and No. 1 Ringlemann. The waste charging rate was 500 lb/hr. The measured particulate emissions for the two required test runs were 0.113 and 0.190 gr/scf. The observed visible emission was essentially zero on the Ringlemann Scale.

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AIR POLLUTION ENGINEERING SOURCE SAMPLING SURVEY NO. 99-6-72
ACCEPTANCE TEST OF TDS DUNNAGE INCINERATOR
TOOELE ARMY DEPOT
TOOELE, UTAH
10 MARCH 1972

1. REFERENCE. AR 11-21, Environmental Pollution Abatement, 3 November 1967.

2. PURPOSE. To evaluate particulate and visible emissions from the Transportable Disposal System (TDS) dunnage incinerator at a dunnage charging rate of 500 lb/hr with respect to standards of 0.2 grain per standard cubic foot (gr/scf) and No. 1 Ringlemann cited in paragraph 1-7, AR 11-21.

3. BACKGROUND.

a. Transportable Disposal System. The TDS is a complex of four incinerators and support facilities designed for the disposal of chemical agents and chemical agent-filled munitions. The four incinerators are an agent incinerator for the disposal of GB, VX, and mustard: a deactivation incinerator for the disposal of munitions after removal of the chemical agent: a metal parts incinerator for decontamination of metal parts, containers, etc; and a dunnage incinerator for disposal of wood dunnage.

b. Dunnage Incinerator. The dunnage incinerator was designed and fabricated by Wasteco Incorporated, Tigard, Oregon, to incinerate wood dunnage at a rate of 500 lb/hr. It has primary, mixing, and secondary chambers; a 500,000 Btu/hr No. 2 fuel oil-fired burner in the primary chamber for preheating and ignition of waste: two temperature controlled 550,000 Btu/hr No. 2 fuel oil-fired burners in the mixing chamber: and a spray-impingement type water scrubber. The induced draft fan is located at the base of a fiberglass stack with an inside diameter of 17.5 inches and an overall length of 17 feet.

c. Air Pollution Standards and Acceptance Criteria.

(1) Department of the Army facilities are required to comply with the most stringent air pollution standards prescribed by either AR 11-21 or other Federal authority or by the applicable state or local authority. The applicable emission standards for operation of the dunnage incinerator in Utah are:

(a) The particulate emission of 0.2 gr/scf of dry flue gas corrected to 12 percent CO_2, excluding the CO_2 contributed by auxiliary fuel, cited in paragraph 1-7e(2), AR 11-21. The standard conditions are 70°F and one atmosphere pressure.

(b) The visible emission of 20 percent opacity (No. 1 Ringlemann) or less which is not to be exceeded for more than three minutes in any one hour cited in paragraph 1-7a(1)(a), AR 11-21.

(2) Utah does not have a particulate emission standard for incinerators and its visible emission standard is equivalent to the one in AR 11-21.[1]

(3) Particulate is defined as any material, except uncombined water, which is suspended in a gas stream as a liquid or solid at standard conditions of 70°F and one atmosphere pressure, whose emission is evaluated using sampling and analytical methods prescribed for testing incinerators at Federal facilities.[2]

4. DISCUSSION.

a. Test Methods. The sampling and analytical methods used were identical to those specified for evaluation of incinerators at Federal Facilities[2] with the exception that carbon dioxide, oxygen, nitrogen,

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[1] "Code of Air Conservation Regulations," Utah State Board of Health, 24 January 1972.

[2] "Specifications for Incinerator Testing at Federal Facilities," USPHS Publication (Oct 67) and Addendum thereto (Dec 67), DHEW.

and carbon monoxide determinations were made with a Fisher-Hamilton gas partitioner. This method was chosen over the Orsat method because the analytical chemists in this Agency have proven it to be the more accurate of the two methods. These methods are briefly described in Appendix A.

b. Results.

(1) The test and operating data are summarized in the Table, page 4.

(a) The measured particulate emissions, 0.113 and 0.190 gr/scf of dry flue gas corrected to 12 percent carbon dioxide from the waste, for the two test runs are less than the 0.2 gr/scf standard at the waste charging rate of 500 lb/hr.

(b) During each test run a visible emission of No. 3 Ringlemann was observed for 40-45 seconds following one of the incremental charges. This emission appeared to be associated with operator charging technique (since the incremental charges were uniform and a visible emission did not accompany each charge) and should for the most part be eliminated after operating personnel gain experience with the incinerator. The average observed visible emission over each 60-minute test run was essentially zero on the Ringlemann Scale and therefore did not exceed the No. 1 Ringlemann standard.

(2) The ramifications of the above test results are:

(a) The dunnage incinerator can be operated at test conditions and not exceed the applicable particulate and visible emission standards for its operation in Utah of 0.2 gr/scf and No. 1 Ringlemann cited in paragraph 1-7, AR 11-21.

(b) If the dunnage incinerator is used in another state with a particulate emission standard more stringent than 0.2 gr/scf (i.e. Colorado[3]), it will have to be retested to determine the operating conditions, including waste charging rate, at which it will meet the more stringent standard.

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[3] Regulation I, "Emission Control Regulations for Particulates, Smokes, and Sulfur Oxides for the State of Colorado," Colorado Department of Health, Denver, Colorado, adopted 14 January 1971, effective 15 March 1971.

USAEHA-EA Air Pollution Engr Source Sampling Surv No. 99-6-72, Acceptance Test of TDS Dunnage Incinerator, Tooele AD, Utah, 10 Mar 72

TABLE

SUMMARY OF TEST DATA

Parameter	Preliminary Run Burners Only	Test Run No. 1	Test Run No. 2
Operating Data:			
Waste charging rate, lb/hr	0	500 (4 @ 125 lb)	500 (4 @ 125 lb)
Mixing chamber temperature, °F	737	1448	1462
Primary chamber draft, in. H_2O	-0.5	-0.1	-0.1
Scrubber flow rate, gpm	25	25	25
Fuel consumption, gal/hr	17.06	4.81	5.36
Stack Gas Data:			
Temperature, °F	312	382	362
Velocity, ft/min	2995	3264	3342
Flow rate, scf/min	2840	2834	2969
Percent moisture	14.0	26.6	25.4
Percent CO_2 waste (dry volume)	-	2.3	2.0
Percent CO_2 burners (dry volume)	2.1	0.7	0.7
Percent O_2 (dry volume)	18.2	18.0	17.7
Percent N_2 (dry volume)	79.7	79.2	79.6
Percent CO (dry volume)	0.0	0.0	0.0
Emission Data:			
Particulate concentration, gr/scf	-	0.022	0.032
Particulate concentration, gr/scf of dry flue gas corrected to 12% CO_2 from waste	-	0.113	0.190
Particulate emission rate, lb/hr	-	0.39	0.61
Average visible emission, % opacity	0	0	0

(3) Completed data and calculation forms[2] for the two test runs are in Appendix B.

5. CONCLUSION. Particulate and visible emissions from the dunnage incinerator do not exceed the standards governing its operation in Utah at test operating conditions.

6. RECOMMENDATION. Proceed with the planned use of the dunnage incinerator in the South Area, Tooele Army Depot, at a dunnage charging rate of 500 lb/hr or less.

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Director, Environmental Quality

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[2] "Specifications for Incinerator Testing at Federal Facilities," USPHS Publication (Oct 67) and Addendum thereto (Dec 67), DHEW.

APPENDIX A

SAMPLING AND ANALYTICAL METHODS

1. SAMPLING METHODS.

a. Particulate.

(1) Particulate was collected by isokinetic train sampling according to Federal specifications for incinerator testing.[2] The sampling train consisted of a 0.25-inch probe tip, stainless steel probe with heated glass liner, glass cyclone, filter housing and a tared Gelman Type A glass fiber filter, four Greenburg-Smith impingers immersed in an ice bath, vacuum pump, and calibrated orifice.

(2) Isokinetic sampling conditions were attained by regulating a bypass valve on the vacuum pump so the velocity of sample gas entering the probe tip equalled the velocity of the stack gas at the sampling point. Stack gas velocity was determined using an S-type pitot tube and draft gauge. A nomograph was used to determine the isokinetic sampling rate from values for dry gas meter temperature; probe tip diameter; and stack gas static pressure, velocity pressure, temperature, and moisture content.

(3) The particulate sampling location was eight stack gas diameters downstream from the connection of the induced draft fan to the stack, and four stack diameters upstream from the top of the stack. The stack gas velocity over the stack cross-section at this location did not vary by a factor of more than 2:1; therefore, particulate samples were collected at the point of average velocity.[2]

b. Carbon Dioxide.

(1) Gas samples for carbon dioxide, carbon monoxide, oxygen, and nitrogen analyses were collected by proportional sampling (sampling rate proportional to stack gas flow rate at the sampling point) in a Saran bag.[2]

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2 "Specifications for Incinerator Testing at Federal Facilities," USPHS Publication (Oct 67) and Addendum thereto (Dec 67), DHEW.

(2) The sampling port was located immediately upstream from the scrubber.

2. ANALYTICAL METHODS.

a. Particulate. Analytical methods specified for the evaluation of incinerators at Federal facilities[2] were used for particulates. Separate weighings were made for particulates collected in the probe and cyclone, on the filter, in the impinger washings, and for the organic particulates extracted with ether and chloroform from the impinger solutions. These weighings were combined to determine the total particulate emission. Acetone was used as the washing solution.

b. Carbon Dioxide. A Fisher-Hamilton gas partitioner was used to determine the percent carbon dioxide, carbon monoxide, oxygen, and nitrogen in the gas samples collected by proportional sampling.

c. Moisture. The volume of water condensed in the first three impingers plus the moisture absorbed by silica gel in the final impinger of the particulate sampling train were combined to determine moisture content of the stack gas.

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2 "Specifications for Incinerator Testing at Federal Facilities," USPHS Publication (Oct 67) and Addendum thereto (Dec 67), DHEW.

APPENDIX B

DATA AND CALCULATION FORMS [2]

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2 "Specifications for Incinerator Testing at Federal Facilities," USPHS Publication (Oct 67) and Addendum thereto (Dec 67), DHEW.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
National Center for Air Pollution Control

FORM APPROVED
BUDGET BUREAU
NO. 68R-1056
APPROVAL EXPIRES
Jan. 1973

SUMMARY OF RESULTS

Incinerator Test

Run No. 1

1. Name of firm Edgewood Arsenal, Maryland
2. Location of plant South Area, Tooele Army Depot, Utah
3. Type of incinerator Wasteco Inc.
4. Control equipment Scrubber
5. Sampling point location 17.5-in Stack, 12 ft. Above I.D. Fan
6. Material incinerated Wood Dunnage
7. Weight of material incinerated 500 lb
8. Pollutants sampled Particulate
9. Time of particulate test:

   Date 10 March 1972, Begin 1435, End 1535

Operating Variables

10. Scrubber pressure drop, in. H_2O 0.3
11. Scrubber H_2O rate, gpm 25
12. Primary chamber draft, in. H_2O Overfire -0.1 Underfire NM
13. Secondary chamber temperature, °F 1448
14. Stack temperature (T_{hd}), °F 382

NCAP-16 (12/67)

Emission Data

15. Stack flow rate (V_{db}), scfm 2080

16. Water vapor in stack gas (V_{cg}), % by volume 26.6

17. Excess air at sampling point (V_{bl}), % 614

	grains/cf at stack conditions	grains/scf	grains/scf at 12 % CO_2 *	lb/hr
18. Particulate - probe, cyclone	C_{as} = 0.002	C_{am} = 0.005	C_{ap} = 0.024	C_{av} = 0.089
19. Particulate - probe, cyclone, filter	C_{at} = 0.007	C_{an} = 0.018	C_{aq} = 0.092	C_{aw} = 0.321
20. Total particulate (includes impinger catch)	C_{au} = 0.008	C_{ao} = 0.022	C_{ar} = 0.113	C_{ax} = 0.392

21. Percent isokinetic for particulate train I_{ax} = 105

22. CO_2 in stack gas from burners**, % volume (dry) V_{bn} = 0.7

23. CO_2 in stack gas from waste, % volume (dry) V_{ba} = 2.3

24. O_2 in stack gas from waste and burners, % volume (dry) V_{bh} = 18.0

25. CO in stack gas from waste and burners, % volume (dry) V_{bg} = 0.0

26. N_2 in stack gas from waste and burners, % volume (dry) V_{bi} = 79.2

27. Sticky paper, particles/in.^{2} 60 microns and above NM

28. Sticky paper, particles/min. 60 microns and above NM

Legend: NM - not measured
scf = Standard cubic foot, i.e., dry gas at 70°F and 29.92 in. Hg.
Stack conditions: Stack temperature and stack pressure including moisture.

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* Correction to 12 % CO_2 made using % CO_2 from waste only.

** % CO_2 from burner corrected to test conditions.

NCA.-16 (12/67)

Part 2, p. 1 of 2

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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NO. 68R-1056
APPROVAL EXPIRES
Jan. 1973

SUMMARY OF TEST DATA

Date 10 March 1972 Run No. 1

Particulate Sampling Train

1. Sampling nozzle diameter, in.	D_{av} = 0.25
2. Sampling time, min.	T_{av} = 60
3. Sample gas volume - meter condition, cf	V_{ac} = 33.67
4. Average meter temperature, ^oF	T_{ai} = 89
5. Average orifice pressure drop, in. H_2O	P_{af} = 0.88
6. Particulate collected - probe and cyclone, mg	W_{aj} = 8.0
7. Particulate collected - probe, cyclone and filter, mg	W_{ak} = 31.0
8. Particulate collected - total, mg	W_{al} = 37.9

Velocity Traverse - Burner Only

9. Stack area, in.^{2}	S_{dd} = 240.4
10. Average stack pressure, in. Hg (absolute)	P_{hc} = 0.0
11. Average stack temperature, ^oF	T_{hd} = 312
12. Average $\sqrt{\text{velocity head x stack temperature}}$	S_{he} = 18.00
13. Moisture in stack gas from burners, % by volume	V_{hi} = 14.0

Velocity Traverse During Test - Burner and Waste

14. Stack area, in.^{2}	S_{dd} = 240.4
15. Average stack pressure, in. Hg (absolute)	P_{di} = 0.0
16. Average stack temperature, ^oF	T_{df} = 382
17. Average $\sqrt{\text{velocity head x stack temperature}}$	S_{de} = 19.17

Stack Moisture Content

18. Total water collected by train, ml	V_{ce} = 206.3

NCAP-17 (12/67)

Orsat Analysis - Burner Only

19. CO_2, % volume (dry) V_{bb} = 2.1
20. CO, % volume (dry) V_{bc} = 0.0
21. O_2, % volume (dry) V_{bd} = 18.2
22. N_2, % volume (dry) V_{be} = 79.7

Orsat Analysis - Burners and Waste

23. CO_2, % volume (dry) V_{bf} = 3.0
24. CO, % volume (dry) V_{bg} = 0.0
25. O_2, % volume (dry) V_{bh} = 18.0
26. N_2, % volume (dry) V_{bi} = 79.2

Incinerator Operating Data

27. Fraction of test time all burners are operating G_{bm} = NM

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PARTICULATE SAMPLING TRAIN DATA AND CALCULATIONS

Nozzle diameter (D_{av}), in. = 0.25

Barometric pressure (P_{aa}), in. Hg = 24.81

Sampling point location Stack Run No. 1

Clock time	Point No.	Gas Meter: Reading (V_{ac}) cf	Gas Meter: Temp. in °F	Gas Meter: Temp. out °F	Orifice Δ P in. H_2O
0	3	969.01	-	-	-
10	3	974.59	94	81	0.83
20	3	980.19	95	82	0.83
30	3	985.82	95	83	0.85
40	3	991.42	96	84	0.85
50	3	997.31	95	84	0.95
60	3	1003.37	97	84	0.95
		(DGM CF = 0.98)			

Net time min		Net	Average	Average	Average
(T_{aw}) = 60		(V_{ac}) = 33.67	(T_{ad}) = 95	T_{ae}) = 83	(P_{af}) = 0.88

(1) A. Average meter temperature = $\frac{T_{ad} + T_{ae}}{2} = T_{ai}$ = 89

(2) B. Dry gas sample volume @ standard conditions, cf

$$= 17.7 \times V_{ac} \times \frac{P_{aa} + \frac{P_{af}}{13.6}}{(T_{ai} + 460)} = V_{ab} =$$ 26.84

Laboratory Data

Particulate - probe and cyclone (W_{aj}), mg = 8.0

Particulate - probe, cyclone, and filter (W_{ak}), mg = 31.0

Particulate - total (includes impinger washings) (W_{al}), mg = 57.9

Particulate Concentration Calculations

In grains/scf

(3) A. Particulate - probe and cyclone, grains/scf

$$C_{am} = 0.0154 \times \frac{W_{aj}}{V_{ab}} =$$ 0.0040

(4) B. Particulate - probe, cyclone, and filter, grains/scf

$$C_{am} = \frac{0.0154 \times W_{ak}}{V_{ab}} =$$ 0.0177

(5) C. Particulate - total, grains/scf
(Go to Part 6, page 1)

$$C_{ao} = \frac{0.0154 \times W_{al}}{V_{ab}} =$$ 0.0217

In grains/scf @ 12 % CO_2

(17) D. Particulate - probe and cyclone, grains/scf @ 12 % CO_2

$$C_{ap} = C_{am} \times \frac{12}{V_{ba}} =$$ 0.024

(18) E. Particulate - probe, cyclone, and filter, grains/scf @ 12 % CO_2

$$C_{aq} = C_{an} \times \frac{12}{V_{ba}} =$$ 0.092

(19) F. Particulate - total, grains/scf @ 12 % CO_2

$$C_{ar} = C_{ao} \times \frac{12}{V_{ba}} =$$ 0.113

In grains/cf @ stack conditions

(20) G. Particulate - probe and cyclone, grains/cf @ stack conditions

$$C_{as} = \frac{17.7 \times C_{am} \times P_{di} \times Mch}{(T_{df} + 460)} =$$ 0.0019

(21) H. Particulate - probe, cyclone, and filter, grains/cf @ stack conditions

$$C_{at} = \frac{17.7 \times C_{an} \times P_{di} \times Mch}{(T_{df} + 460)} =$$ 0.0069

(22) I. Particulate - total, grains/cf @ stack conditions

$$C_{au} = \frac{17.7 \times C_{ao} \times P_{di} \times Mch}{(T_{df} + 460)} =$$ 0.0084

In lb/hr

(23) J. Particulate - probe and cyclone, lb/hr

$$C_{av} = 0.00857 \times C_{am} \times V_{db} =$$ 0.089

(24) K. Particulate - probe, cyclone, and filter, lb/hr

$$C_{aw} = 0.00857 \times C_{an} \times V_{db} =$$ 0.321

(25) L. Particulate - total, lb/hr

$$C_{ax} = 0.00857 \times C_{ao} \times V_{db} =$$ 0.392

(26) M. $\% \text{ isokinetic} = \frac{1032 \times (T_{df} + 460) \times V_{ab}}{V_{dh} \times T_{aw} \times P_{di} \times M_{ch} \times (D_{av})^2} = I_{ax} =$ 105

(Go to Part 7, p. 1)

V_{ba} from Orsat data and calculation sheet (part 7).

V_{db}, T_{df}, V_{dh}, P_{di}, from velocity data and calculation sheet for test (Part 5).

M_{ch} from moisture content data and calculation sheet (Part 6).

D_{av} from particulate sampling train data and calculation sheet (Part 3).

Part 4, p. 1 of 3 DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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VELOCITY TRAVERSE DATA AND CALCULATION SHEET

(Burners Only)

Date *10 March 1972* Time *1027-1057* Run No. *A-0*

Sampling point location *Stack*

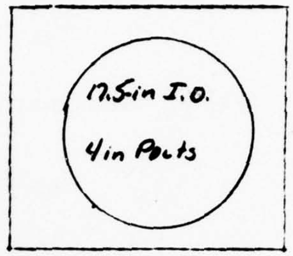
Stack area (S_{dd}), in.^{2} *240.4*

Wet bulb temperature (T_{hj}), °F *NM*

Dry bulb temperature (T_{hk}), °F *NM*

Barometric pressure (P_{hl}), in. Hg absolute = *24.85*

Note: Calculations for S-type pitot tube, C = 0.85



Drawing of stack cross section

Point No.	Distance from ref. point, in.	Stack press. (P_{hm}) in. Hg. (gage)	Stack Temperature (T_{hd}), °F	(T_{hd} + 460), °R	Velocity head (V_a), in. H_2O	V_a x (T_{hd} + 460) *√Δp*	$\sqrt{V_a \times (T_{hd} + 460)}$
1	4.6				0.25	0.500	
2	5.8				0.32	0.565	
3	7.4	Max √Δp =	0.678	= 1.36	0.39	0.625	
4	9.6	Min √Δp	0.500		0.43	0.655	
5	15.8	1.36 < 2.0 ∴ sampling @			0.44	0.664	
6	18.1	single point permitted.			0.44	0.664	
7	19.7	Use point no. 3.			0.42	0.647	
8	20.9				0.39	0.625	
9	4.6				0.27	0.520	
10	5.8				0.35	0.591	
11	7.4				0.39	0.625	
12	9.6				0.43	0.655	
13	15.8				0.46	0.678	
14	18.1				0.45	0.670	
15	19.7				0.44	0.664	
16	20.9				0.40	0.632	
						Σ√Δp / 16 = 0.624	
		Avg = ____	Avg = ____				Avg (S_{he}) = ____

in. Hg (abs) =

(P_{hc}) = P_{hm} + P_{hl} = ______

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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National Center for Air Pollution Control

FORM APPROVED
BUDGET BUREAU
NO. 68R-1056
APPROVAL EXPIRES
Jan. 1973

VELOCITY TRAVERSE DATA AND CALCULATION SHEET
(Burners Only)

Date 10 March 1972 Time 1027-1057 Run No. Pre

Sampling point location Stack

Stack area (S_{dd}), in.^{2} 240.4

Wet bulb temperature (T_{hj}), °F NM

Dry bulb temperature (T_{hk}), °F NM

Barometric pressure (P_{hl}), in. Hg absolute = 24.85

Note: Calculations for S-type pitot tube, C = 0.85

Drawing of stack cross section

Point No.	Distance from ref. point, in.	Stack press. (P_{hm}) in. Hg. (gage)	Stack Temperature (T_{hd}), °F	Stack Temperature (T_{hd} + 460), °R	Velocity head (V_a), in. H_2O	V_a x (T_{hd} + 460)	$\sqrt{V_a \times (T_{hd} + 460)}$
3	7.4	0.0	315	775	0.42	325.50	18.04
3	7.4	0.0	310	770	0.42	323.40	17.98
3	7.4	0.0	310	770	0.42	323.40	17.98
		Avg = 0.0	Avg = 312				Avg (S_{he}) = 18.00

in. Hg (abs) =

(P_{hc}) = P_{hm} + P_{hl} = 24.85

NCAP-19 (12/67)

(9) A. Moisture in stack gas, from wet and dry bulb temperatures using psychrometric charts (V_{hi}), % = 14.0 (condenser method, part 6)

(10) B. Mole fraction of dry gas

$$= \frac{100-V_{hi}}{100} = M_{hg} = \underline{0.86}$$

(11) C. Stack velocity @ P_{hc} and T_{hd} (stack conditions, includes moisture), fpm

$$= 4350 \times S_{he} \left[\frac{1}{P_{hc} \times (M_{bk} \times M_{hg} + 18(1-M_{hg}))}\right]^{1/2} = V_{hf} \underline{2995}$$

(12) D. Stack volume @ standard conditions, scfm

$$= \frac{0.123 \times V_{hf} \times S_{dd} \times P_{hc} \times M_{hg}}{(T_{hd} + 460)} = V_{hh} = \underline{2442}$$

(Go to Part 5, p. 2)

M_{bk} from Orsat data and calculation sheet (Part 7).

Part 5, p. 1 of 2

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VELOCITY DATA AND CALCULATION SHEET FOR TEST

(Burners and Waste)

Date 10 March 1972 Time 1435-1535

Sampling point location Stack Run No. 1

Stack area (S_{dd}), in.^{2} 240.4

Note: Calculations for S-type pitot tube, C = 0.85

Drawing of stack cross section

Point No.	Distance from ref. point, in.	Stack press. (P_{dj}), in. Hg (gage)	Stack temperature (T_{df}), °F	Stack temperature (T_{df} + 460), °R	Velocity head (V_b), in. H_2O	V_b x (T_{df} + 460)	$\sqrt{V_b \times (T_{df} + 460)}$
3	7.4	0.0	410	870	0.43	374.10	19.34
3	7.4	0.0	390	850	0.43	365.50	19.12
3	7.4	0.0	385	845	0.44	371.80	19.28
3	7.4	0.0	370	830	0.44	365.20	19.11
3	7.4	0.0	370	830	0.43	356.90	18.89
3	7.4	0.0	365	825	0.45	371.25	19.27
		Avg = 0.0	Avg = 382				Avg (S_{de}) = 19.17

in. Hg abs) =

(P_{di}) = P_{dj} + P_{aa} = 24.81

P_{aa} from particulate sampling train sheet (Part 3).

NCAP-20 (12/67)

(13) A. Stack velocity @ P_{di} and T_{df} (stack conditions), fpm

$$= 4350 \times S_{de} \times \left[\frac{1}{P_{di} \times M_{ca}}\right]^{1/2} = V_{dh}$$ 3264

(14) B. Stack volume @ standard conditions, scfm

$$= 0.123 \times \frac{V_{dh} \times S_{dd} \times M_{ch} \times P_{di}}{(T_{df} + 460)} = V_{db} =$$ 2080

(Go to Part 7, p. 2.)

M_{ca}, M_{ch} from stack moisture data and calculation sheet (Part 6).

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STACK MOISTURE CONTENT DATA AND CALCULATIONS FOR TEST

Date 10 March 1972

Run No.	Pre	1		
H_2O condensed in impingers (V_{cb}), ml	49.0	193.7		
H_2O absorbed by silica gel (V_{cd}), ml	4.0	12.6		
Total H_2O collected $= V_{ce} = (V_{cb} + V_{cd})$, ml	53.0	206.3		
Vol of H_2O vapor @ 70°F and 29.92 in. Hg = $0.0474 \times V_{ce}$ $= (V_{cf})$, cf	2.50	9.73		
Moisture in stack gas $= (V_{cg})$, % (from formula below)	14.0	26.6		
Mole fraction dry gas, $= (M_{ch})$ (from formula below)	0.860	0.734		
Molecular weight of stack gas (M_{ca}) (from formula below)	27.5	26.3		

(6) A. Moisture in stack gas (V_{cg}), %

$$= \frac{100 \times V_{cf}}{V_{ab} + V_{cf}}$$

(7) B. Mole fraction dry gas (M_{ch})

$$= \frac{100 - V_{cg}}{100}$$

NCAP-21 (12/67)

(8) C. Molecular weight of stack gas

$$M_{ca} = M_{bj} \times M_{ch} + 18\ (1 - M_{ch})$$

(Go to Part 4, p. 2.)

V_{ab} from particulate data and calculation sheet (Part 3).

M_{bj} from Orsat data sheet (Part 7).

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ORSAT DATA AND CALCULATION SHEET

Orsat Analysis - Burner Only (From bag sample)

Sampling point location Influent to Scrubber

Date 10 March 1972 Time 1027- 1055

	Analysis 1	Analysis 2	Analysis 3	Avg	x = mole.wt	wt/mole (dry)
CO_2 (V_{bb}), % vol (dry)				2.1	44/100	0.92
CO (V_{bc}), % vol (dry)				0.0	28/100	+0.00
O_2 (V_{bd}), % vol (dry)				18.2	32/100	+5.82
N_2 (V_{be}), % vol (dry)				79.7	28/100	+22.32

M_{bk} = Avg molecular wt of dry stack gas = 29.06

Orsat Analysis for Test - Waste and Burners (From bag sample)

Date 10 March 1972 Time 1435-1535 Run No. 1

Sampling point location Influent to Scrubber

	Analysis 1	Analysis 2	Analysis 3	Avg	x = mole wt	wt/mole (dry)
CO_2 (V_{bf}) % vol (dry)				3.0	44/100	1.32
CO (V_{bg}). % vol (dry)				0.0	28/100	+ 0.00
O_2 (V_{bh}), % vol (dry)				18.0	32/100	+ 5.76
N_2 (V_{bi}), % vol (dry)				79.2	28/100	+22.18

M_{bj} = Avg molecular wt of dry stack gas = 29.26

NCAP-22 (12/67)

(28) A. Excess air, %

$$= \frac{100 \times (V_{bh} - \frac{V_{bg}}{2})}{0.264 \times V_{bi} - (V_{bh} - \frac{V_{bg}}{2})} = V_{bl} = \underline{619}$$

(Transfer all answers to summary of results)

(15) B.* CO_2 contributed by burner, % by volume of stack gas corrected to test conditions.

$$V_{bn} = V_{bb} \times \frac{V_{hh}}{V_{db}} \times G_{bm} = \frac{(2.0)(2442)(4.81)}{(2084)(12.06)} \qquad \underline{0.7}$$

(16) B. CO_2 in stack gas from waste, % vol (dry)
(Go to Part 3, p. 2)

$$= V_{bf} - V_{bn} = V_{ba} = \qquad \underline{2.3}$$

V_{db} from velocity data and calculation sheet for test (Part 5).

V_{hh} from velocity traverse data and calculation sheets (Part 4).

G_{bm} from incinerator data and calculation sheet (Part 10).

Note: Above calculation corrects CO_2 of burner to stack test conditions.

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* Note: If CO_2 from burners is determined from an analysis of the natural gas flow, the following equation can be used in place of equations (15)and (16) to calculate (V_{ba}).

Z = CO_2 from burners, scfm (Determine from natural gas flow rate) —

$$V_{ba} = \frac{V_{db} \times V_{bf} - (Z \times G_{bm} \times 100)}{V_{db}} = \qquad —$$

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POUNDS PER HOUR EMISSION CALCULATION

Total particulate collected by train, grams	W_{1a} =	0.0579
Area of sampling nozzle, in.^{2}	W_{1b} =	0.049
Area of stack, in.^{2}	W_{1c} =	240.4
Time of particulate test, min.	W_{1d} =	60

Emissions, lbs/hr

$$= \frac{0.132 \times W_{1a} \times W_{1c}}{W_{1b} \times W_{1d}} = \qquad C_{ay} = 0.41$$

Note: Sufficient data and calculations should be included to show that the particulate train was operated within 10 percent of isokinetic conditions. Comparison of the probe sampling velocity to the stack gas velocity will be sufficient for this purpose. To make this comparison it will be necessary to measure:

1. Stack temperature
2. Stack velocity
3. Sampled gas volume and temperature
4. Moisture in samoled gas

Part 9, p. 1 of 1

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STICKY PAPER DATA AND CALCULATIONS

Date 10 March 1972

Stack area, in.^{2} 240.4

Sampling point location -

Run No. 1

Time	Part/in.^{2}/min > 60 microns	Part/min >60 microns
	Avg NM	Avg NM

Note: Particles/min = stack area x part/in.^{2}/min.

NCAP-26 (12/67)

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INCINERATOR OPERATING DATA AND CALCULATION SHEET

Date 10 March 1972

Run No. 1

Clock time	Material charged, lb	Primary chamber draft: Overfire, in. H_2O	Primary chamber draft: Underfire, in. H_2O (Optional)	Secondary chamber Temp. oF	Stack opacity %	Comments
0	125		NM		0	
10		-0.1		1400	0	
15	125			1500	0	>20% opacity for
20		-0.1			0	45 sec w/charge
30	125	-0.15		1400	0	
40		-0.1		1410	0	4.81 gal DF 2 used
45	125				0	in 60 min run 1.
50		-0.1		1510	0	2.53 gal DF 2 used
60		-0.1		1470	0	in 30 min Pre run.
	Net = 500	Avg = -0.1	Avg = NM	Avg = 1448	Avg = 0	

Fraction of time all burners are operating (G_{bm}) = NM

NCAP-27 (12/67)

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SUMMARY OF RESULTS

Incinerator Test

Run No. 2

1. Name of firm Edgewood Arsenal, Maryland
2. Location of plant South Area, Tooele Army Depot, Utah
3. Type of incinerator Westero Inc.
4. Control equipment Scrubber
5. Sampling point location 17.5-in Stack, 12 ft Above I.D. Fan.
6. Material incinerated Wood Dunnage
7. Weight of material incinerated 500 lb
8. Pollutants sampled Particulate
9. Time of particulate test:

Date 10 March 1972, Begin 1555, End 1655

Operating Variables

10. Scrubber pressure drop, in. H_2O 0.3
11. Scrubber H_2O rate, gpm 25
12. Primary chamber draft, in. H_2O Overfire -0.1 Underfire NM
13. Secondary chamber temperature, ^oF 1462
14. Stack temperature (T_{hd}), ^oF 362

NCAP-16 (12/67)

Emission Data

15. Stack flow rate (V_{dp}).scfm — 2215
16. Water vapor in stack gas (V_{cq}), % by volume — 25.4
17. Excess air at sampling point (V_{bl}), % — 534

	grains/cf at stack conditions	grains/scf	grains/scf at 12 % CO_2 *	lb/hr
18. Particulate - probe, cyclone	C_{as} = 0.002	C_{am} = 0.004	C_{ap} = 0.024	C_{av} = 0.076
19. Particulate - probe, cyclone, filter	C_{at} = 0.011	C_{an} = 0.028	C_{aq} = 0.169	C_{aw} = 0.532
20. Total particulate (includes impinger catch)	C_{au} = 0.013	C_{ao} = 0.032	C_{ar} = 0.190	C_{ax} = 0.607

21. Percent isokinetic for particulate train — I_{ax} = 105
22. CO_2 in stack gas from burners**, % volume (dry) — V_{bn} = 0.7
23. CO_2 in stack gas from waste, % volume (dry) — V_{ba} = 2.0
24. O_2 in stack gas from waste and burners, % volume (dry) — V_{bh} = 17.7
25. CO in stack gas from waste and burners, % volume (dry) — V_{bq} = 0.0
26. N_2 in stack gas from waste and burners, % volume (dry) — V_{bi} = 79.6
27. Sticky paper, particles/in.^{2} 60 microns and above — NM
28. Sticky paper, particles/min. 60 microns and above — NM

Legend: NM - not measured
scf = Standard cubic foot, i.e., dry gas at 70°F and 29.92 in. Hg.
Stack conditions: Stack temperature and stack pressure including moisture.

* Correction to 12 % CO_2 made using % CO_2 from waste only.

** % CO_2 from burner corrected to test conditions.

NCA-10 (12/67)

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SUMMARY OF TEST DATA

Date 10 March 1972 Run No. 2

Particulate Sampling Train

1.	Sampling nozzle diameter, in.	D_{av} =	0.25
2.	Sampling time, min.	T_{aw} =	60
3.	Sample gas volume - meter condition, cf	V_{ac} =	36.02
4.	Average meter temperature, °F	T_{ai} =	91
5.	Average orifice pressure drop, in. H_2O	P_{af} =	1.02
6.	Particulate collected - probe and cyclone, mg	W_{aj} =	8.0
7.	Particulate collected - probe, cyclone and filter, mg	W_{ak} =	52.4
8.	Particulate collected - total, mg	W_{al} =	58.6

Velocity Traverse - Burner Only

9.	Stack area, in.^{2}	S_{dd} =	240.4
10.	Average stack pressure, in. Hg (absolute)	P_{hc} =	0.0
11.	Average stack temperature, °F	T_{hd} =	312
12.	Average $\sqrt{\text{velocity head x stack temperature}}$	S_{he} =	18.00
13.	Moisture in stack gas from burners, % by volume	V_{hi} =	14.0

Velocity Traverse During Test - Burner and Waste

14.	Stack area, in.^{2}	S_{dd} =	240.4
15.	Average stack pressure, in. Hg (absolute)	P_{di} =	0.0
16.	Average stack temperature, °F	T_{df} =	362
17.	Average $\sqrt{\text{velocity head x stack temperature}}$	S_{de} =	19.62

Stack Moisture Content

18.	Total water collected by train, ml	V_{ce} =	206.9

NCAP-17 (12/67)

Orsat Analysis - Burner Only

19.	CO_2, % volume (dry)	V_{bb} = 2.1
20.	CO, % volume (dry)	V_{bc} = 0.0
21.	O_2, % volume (dry)	V_{bd} = 18.2
22.	N_2, % volume (dry)	V_{be} = 79.7

Orsat Analysis - Burners and Waste

23.	CO_2, % volume (dry)	V_{bf} = 2.7
24.	CO, % volume (dry)	V_{bg} = 0.0
25.	O_2, % volume (dry)	V_{bh} = 17.7
26.	N_2, % volume (dry)	V_{bi} = 79.6

Incinerator Operating Data

27.	Fraction of test time all burners are operating	G_{bm} = NM

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PARTICULATE SAMPLING TRAIN DATA AND CALCULATIONS

Nozzle diameter (D_{av}), in. = 0.25

Barometric pressure (P_{aa}), in. Hg = 24.80

Sampling point location Stack Run No. 2

Clock time	Point No.	Gas Meter: Reading (V_{ac}) cf	Gas Meter: Temp. in °F	Gas Meter: Temp. out °F	Orifice Δ P in. H_2O
0	3	11.80	-	-	-
10	3	17.89	94	83	1.00
20	3	23.94	94	83	1.00
30	3	30.10	96	83	1.05
40	3	36.24	100	84	1.05
50	3	42.38	99	85	1.00
60	3	48.56	102	87	1.02
		(DGM CF = 0.98)			

Net time min		Net	Average	Average	Average
(T_{aw}) = 60		(V_{ac}) = 36.02	(T_{ad}) = 98	T_{ae}) = 84	(P_{af}) = 1.02

(1) A. Average meter temperature = $\frac{T_{ad} + T_{ae}}{2} = T_{ai}$ = 91

(2) B. Dry gas sample volume @ standard conditions, cf

$$= 17.\overset{64}{7} \times V_{ac} \times \frac{P_{aa} + \frac{P_{af}}{13.6}}{(T_{ai} + 460)} = V_{ab} =$$ 28.60

Laboratory Data

Particulate - probe and cyclone (W_{aj}), mg = 8.0

Particulate - probe, cyclone, and filter (W_{ak}), mg = 52.4

Particulate - total (includes impinger washings) (W_{al}), mg = 58.6

Particulate Concentration Calculations

In grains/scf

(3) A. Particulate - probe and cyclone, grains/scf

$$C_{am} = 0.0154 \times \frac{W_{aj}}{V_{ab}} =$$ 0.0043

(4) B. Particulate - probe, cyclone, and filter, grains/scf

$$C_{am} = \frac{0.0154 \times W_{ak}}{V_{ab}} =$$ 0.0282

(5) C. Particulate - total, grains/scf
(Go to Part 6, page 1)

$$C_{ao} = \frac{0.0154 \times W_{al}}{V_{ab}} =$$ 0.0316

In grains/scf @ 12 % CO_2

(17) D. Particulate - probe and cyclone, grains/scf @ 12 % CO_2

$$C_{ap} = C_{am} \times \frac{12}{V_{ba}} =$$ 0.026

(18) E. Particulate - probe, cyclone, and filter, grains/scf @ 12 % CO_2

$$C_{aq} = C_{an} \times \frac{12}{V_{ba}} =$$ 0.169

(19) F. Particulate - total, grains/scf @ 12 % CO_2

$$C_{ar} = C_{ao} \times \frac{12}{V_{ba}} =$$ 0.190

In grains/cf @ stack conditions

(20) G. Particulate - probe and cyclone, grains/cf @ stack conditions

$$C_{as} = \frac{17.7 \times C_{am} \times P_{di} \times Mch}{(T_{df} + 460)} = \quad 0.0016$$

(21) H. Particulate - probe, cyclone, and filter, grains/cf @ stack conditions

$$C_{at} = \frac{17.7 \times C_{an} \times P_{di} \times Mch}{(T_{df} + 460)} = \quad 0.0112$$

(22) I. Particulate - total, grains/cf @ stack conditions

$$C_{au} = \frac{17.7 \times C_{ao} \times P_{di} \times Mch}{(T_{df} + 460)} = \quad 0.0127$$

In lb/hr

(23) J. Particulate - probe and cyclone, lb/hr

$$C_{av} = 0.00357 \times C_{am} \times V_{db} = \quad 0.076$$

(24) K. Particulate - probe, cyclone, and filter, lb/hr

$$C_{aw} = 0.00857 \times C_{an} \times V_{db} = \quad 0.532$$

(25) L. Particulate - total, lb/hr

$$C_{ax} = 0.00857 \times C_{ao} \times V_{db} = \quad 0.607$$

(26) M. % isokinetic $= \frac{1032 \times (T_{df} + 460) \times V_{ab}}{V_{dh} \times T_{aw} \times P_{di} \times M_{ch} \times (D_{av})^2} = I_{ax} =$ 105

(Go to Part 7, p. 1)

V_{ba} from Orsat data and calculation sheet (part 7).

V_{db}, T_{df}, V_{dh}, P_{di}, from velocity data and calculation sheet for test (Part 5).

M_{cn} from moisture content data and calculation sheet (Part 6).

D_{av} from particulate sampling train data and calculation sheet (Part 3).

[illegible]

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VELOCITY TRAVERSE DATA AND CALCULATION SHEET

(Burners Only)

Date 10 March 1972 Time 1027-1057 Run No. Ro

Sampling point location Stack

Stack area (S_{dd}), in.^{2} 240.4

Wet bulb temperature (T_{hj}), °F NM

Dry bulb temperature (T_{hk}), °F NM

Barometric pressure (P_{hl}), in. Hg absolute = 24.85

Note: Calculations for S-type pitot tube, C = 0.85

Drawing of stack cross section

Point No.	Distance from ref. point, in.	Stack press. (P_{hm}) in. Hg. (gage)	Stack Temperature (T_{hd}), °F	(T_{hd} + 460), °R	Velocity head (V_a), in. H_2O	V_a x (T_{hd} + 460)	$\sqrt{V_a \times (T_{hd} + 460)}$
3	7.4	0.0	315	775	0.42	325.50	18.04
3	7.4	0.0	310	770	0.42	323.40	17.98
3	7.4	0.0	310	770	0.42	323.40	17.98
		Avg = 0.0	Avg = 312				Avg (S_{he}) = 18.00

in. Hg (abs) =

(P_{hc}) = P_{hm} + P_{hl} = 24.85

(9) A. Moisture in stack gas, from wet and dry bulb temperatures using psychrometric charts (V_{hi}), % = 14.0 (condenser method, part 6)

(10) B. Mole fraction of dry gas

$$= \frac{100-V_{hi}}{100} = M_{hg} = \underline{0.86}$$

(11) C. Stack velocity @ P_{hc} and T_{hd} (stack conditions, includes moisture), fpm

$$= 4350 \times S_{he} \left[\frac{1}{P_{hc} \times (M_{bk} \times M_{hg} + 18(1-M_{hg}))} \right]^{1/2} = V_{hf} \; \underline{2995}$$

(12) D. Stack volume @ standard conditions, scfm

$$= \frac{0.123 \times V_{hf} \times S_{dd} \times P_{hc} \times M_{hg}}{(T_{hd} + 460)} = V_{hh} = \underline{2442}$$

(Go to Part 5, p. 2)

M_{bk} from Orsat data and calculation sheet (Part 7).

Part 5, p. 1 of 2

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VELOCITY DATA AND CALCULATION SHEET FOR TEST

(Burners and Waste)

Date 10 March 1972 Time 1555-1655

Sampling point location Stack Run No. 2

Stack area (S_{dd}), in.^{2} 240.4

Note: Calculations for S-type pitot tube, C = 0.85

Drawing of stack cross section

Point No.	Distance from ref. point, in.	Stack press. (P_{di}), in. Hg (gage)	Stack temperature (T_{df}), °F	(T_{df}+ 460), °R	Velocity head (V_b), in. H_2O	V_bx (T_{df}+ 460)	$\sqrt{V_b x (T_{df}+ 460)}$
3	7.4	0.0	375	835	0.46	384.1	19.60
3	7.4	0.0	355	815	0.46	374.9	19.36
3	7.4	0.0	365	825	0.48	396.0	19.90
3	7.4	0.0	365	825	0.48	396.0	19.90
3	7.4	0.0	360	820	0.46	377.2	19.42
3	7.4	0.0	355	815	0.47	383.0	19.57
		Avg = 0.0	Avg = 362				Avg (S_{de}) = 19.62

in. Hg abs) =

(P_{di}) = P_{dj} + P_{aa} = 24.80

P_{aa} from particulate sampling train sheet (Part 3).

NCAP-20 (12/67)

(13) A. Stack velocity @ P_{di} and T_{df} (stack conditions), fpm

$$= 4350 \times S_{de} \times \left[\frac{1}{P_{di} \times M_{ca}}\right]^{1/2} = V_{dh}$$ 3341

(14) B. Stack volume @ standard conditions, scfm

$$= 0.123 \times \frac{V_{dh} \times S_{dd} \times M_{ch} \times P_{di}}{(T_{df} + 460)} = V_{db} =$$ 2215

(Go to Part 7, p. 2.)

M_{ca}, M_{ch} from stack moisture data and calculation sheet (Part 6).

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FORM APPROVED
BUDGET BUREAU
NO. 68R-1056
APPROVAL EXPIRES
Jan. 1973

STACK MOISTURE CONTENT DATA AND CALCULATIONS FOR TEST

Date 10 March 1972

Run No.	Pre	2		
H_2O condensed in impingers (V_{cb}), ml	49.0	194.8		
H_2O absorbed by silica gel (V_{cd}), ml	4.0	12.1		
Total H_2O collected $= V_{ce} = (V_{cb} + V_{cd})$, ml	53.0	206.9		
Vol of H_2O vapor @ 70°F and 29.92 in. Hg $= 0.0474 \times V_{ce}$ $= (V_{cf})$, cf	2.50	9.76		
Moisture in stack gas $= (V_{cg})$, % (from formula below)	14.0	25.4		
Mole fraction dry gas, $= (M_{ch})$ (from formula below)	0.860	0.746		
Molecular weight of stack gas (M_{ca}) (from formula below)	25.7	26.3		

(6) A. Moisture in stack gas (V_{cg}), %

$$= \frac{100 \times V_{cf}}{V_{ab} + V_{cf}}$$

(7) B. Mole fraction dry gas (M_{ch})

$$= \frac{100 - V_{cg}}{100}$$

(8) C. Molecular weight of stack gas

$$M_{ca} = M_{bj} \times M_{ch} + 18 (1 - M_{ch})$$

(Go to Part 4, p. 2.)

V_{ab} from particulate data and calculation sheet (Part 3).

M_{bj} from Orsat data sheet (Part 7).

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ORSAT DATA AND CALCULATION SHEET

Orsat Analysis - Burner Only (From bag sample)

Sampling point location Influent to Scrubber

Date 10 March 1972 Time 1027-1057

	Analysis 1	Analysis 2	Analysis 3	Avg	x = mole.wt	wt/mole (dry)
CO_2 (V_{bb}), % vol (dry)				2.1	44/100	0.92
CO (V_{bc}), % vol (dry)				0.0	28/100	+ 0.00
O_2 (V_{bd}), % vol (dry)				18.2	32/100	+ 5.82
N_2 (V_{be}), % vol (dry)				79.7	28/100	+ 22.32

M_{bk} = Avg molecular wt of dry stack gas = 29.06

Orsat Analysis for Test - Waste and Burners (From bag sample)

Date 10 March 1972 Time 1555-1655 Run No. 2
Sampling point location Influent to Scrubber

	Analysis 1	Analysis 2	Analysis 3	Avg	x = mole wt	wt/mole (dry)
CO_2 (V_{bf}) % vol (dry)				2.7	44/100	1.19
CO (V_{bg}). % vol (dry)				0.0	28/100	+ 0.00
O_2 (V_{bh}), % vol (dry)				17.7	32/100	+ 5.66
N_2 (V_{bi}), % vol (dry)				79.6	28/100	+ 22.30

M_{bj} = Avg molecular wt of dry stack gas = 29.15

NCAP-22 (12/67)

(28) A. Excess air, %

$$= \frac{100 \times (V_{bh} - \frac{V_{bg}}{2})}{0.264 \times V_{bi} - (V_{bh} - \frac{V_{bg}}{2})} = V_{bl} = \underline{\quad 534 \quad}$$

(Transfer all answers to summary of results)

(15) B.* CO_2 contributed by burner, % by volume of stack gas corrected to test conditions.

$$V_{bn} = V_{bb} \times \frac{V_{hh}}{V_{db}} \times G_{bm} = \frac{(2.1)(2442)(5.36)}{(2215)(17.06)} \qquad \underline{\quad 0.7 \quad}$$

(16) B. CO_2 in stack gas from waste, % vol (dry)
(Go to Part 3, p. 2)

$$= V_{bf} - V_{bn} = V_{ba} = \qquad \underline{\quad 2.0 \quad}$$

V_{db} from velocity data and calculation sheet for test (Part 5).

V_{hh} from velocity traverse data and calculation sheets (Part 4).

G_{bm} from incinerator data and calculation sheet (Part 10).

Note: Above calculation corrects CO_2 of burner to stack test conditions.

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* Note: If CO_2 from burners is determined from an analysis of the natural gas flow, the following equation can be used in place of equations (15)and (16) to calculate (V_{ba}).

Z = CO_2 from burners, scfm (Determine from natural gas flow rate) —

$$V_{ba} = \frac{V_{db} \times V_{bf} - (Z \times G_{bm} \times 100)}{V_{db}} = \qquad —$$

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POUNDS PER HOUR EMISSION CALCULATION

Total particulate collected by train, grams	W_{1a} = 0.0586
Area of sampling nozzle, $in.^2$	W_{1b} = 0.049
Area of stack, $in.^2$	W_{1c} = 240.4
Time of particulate test, min.	W_{1d} = 60

Emissions, lbs/hr

$$= \frac{0.132 \times W_{1a} \times W_{1c}}{W_{1b} \times W_{1d}} = \qquad C_{ay} = 0.63$$

Note: Sufficient data and calculations should be included to show that the particulate train was operated within 10 percent of isokinetic conditions. Comparison of the probe sampling velocity to the stack gas velocity will be sufficient for this purpose. To make this comparison it will be necessary to measure:

1. Stack temperature
2. Stack velocity
3. Sampled gas volume and temperature
4. Moisture in sampled gas

NCAP-40 (12/67)

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STICKY PAPER DATA AND CALCULATIONS

Date 10 March 1972

Stack area, in.^{2} 240.4

Sampling point location —

Run No. 2

Time	Part/in.^{2}/min > 60 microns	Part/min >60 microns
	Avg NM	Avg NM

Note: Particles/min = stack area x part/in.^{2}/min.

NCAP-26 (12/67)

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INCINERATOR OPERATING DATA AND CALCULATION SHEET

Date 10 March 1972

Run No. 2

Clock time	Material charged, lb	Primary chamber draft: Overfire, in. H_2O	Primary chamber draft: Underfire, in. H_2O (Optional)	Secondary chamber Temp. oF	Stack opacity %	Comments
0	125		NM		0	
10		-0.1		1440	0	
15	125				0	> 20% opacity for
20		-0.1		1600	0	40 sec w/charge
30	125	-0.1		1410	0	
40		-0.1		1450	0	5.36 gal DF2 in
45	125				0	60-min run no. 2
50		-0.1		1420	0	
60		-0.1		1450	0	
	Net = 500	Avg = -0.1	Avg = NM	Avg = 1462	Avg = 0	

Fraction of time all burners are operating (G_{bm}) = NM

NCAP-27 (12/67)

DEFINITIONS

Standard conditions - 70°F and 29.92 in. Hg

scf - Standard cubic foot of dry gas @ 70°F and 29.92 in. Hg

scfm - Standard cubic foot per minute of dry gas @ 70°F and 29.92 in.Hg

Stack conditions - stack temperature, pressure, and moisture.

LIST OF SYMBOLS

Part 3. Particulate sampling train data and calculation sheet

C_{am}, Particulate-probe and cyclone, grains/scf

C'_{an}, particulate-probe, cyclone and filter, grains/scf

C_{ao}, Particulate-total, grains/scf

C_{ap}, particulate-probe, cyclone and filter, grains/scf @ 12 % CO_2

C_{aq}, particulate-probe, cyclone and filter, grains/scf @ 12 % CO_2

C_{ar}, particulate-total, grains scf 12 % CO_2

C_{as}, particulate-probe and cyclone, grains/scf @ stack conditions

C_{at}, particulate-probe, cyclone and filter, grains/cf @ stack conditions

C_{au}, particulate-total particulate, grains/cf @ stack conditions

C_{av}, particulate - probe and cyclone, lb/hr

C_{aw}, particulate - probe, cyclone and filter, lb/hr

C_{ax}, particulate - total, lb/hr

D_{av}, sampling nozzle diameter, in.

P'_{aa}, barometric pressure, in.Hg (Absolute)

P_{af}, orifice pressure drop, in. H_2O

T_{ad}, gas meter inlet temperature, ^oF

T_{ae}, gas meter exit temperature, ^oF

T_{ai}, average gas meter temperature, ^oF

T_{aw}, net time of test, minutes

T_{ax}, percent isokinetic

V_{ab}, volume of dry gas sampled @ standard conditions, ft^3

V_{ac}, Volume of dry gas sampled @ meter conditions, ft^3

W_{aj}, particulate-probe and cyclone, mg

W_{ak}, particulate-probe, cyclone and filter, mg

W_{al}, particulate - total, mg

Part 4. Velocity traverse data and calculation sheet(burners only)

M_{hg}, mole fraction dry gas

P_{hc}, stack pressure, in.Hg. (absolute)

P_{hl}, barometric pressure, in. Hg.(absolute)

P_{hm}, stack pressure, in. Hg. (gage)

S_{dd}, stack area, $in.^2$

S_{he}, average $\sqrt{\text{Velocity head x stack temperature}}$.

T_{hd}, average stack temperature, ^oF

T_{hj}, wet bulb temperature, ^oF

T_{hk}, dry bulb temperature, ^oF

V_a, Velocity head of stack gas (burner only) in. H_2O

V_{hf}, stack gas velocity, fpm @ stack conditions

V_{hh}, stack gas volume @ standard conditions, scfm

V_{hi}, moisture in stack gas by volume, %

Part 5. Velocity data and calculation sheet for test (burners and waste)

P_{di}, stack pressure, in Hg (absolute)

P_{dj}, stack pressure, in. Hg (gage)

S_{dd}, stack area, in^2

S_{de}, average $\sqrt{\text{Velocity head x stack temperature}}$

T_{df}, stack temperature, ^oF

V_b, velocity head of stack gas burner and waste, in. H_2O

V_{db}, stack gas volume @ standard conditions, scfm

V_{dh}, stack velocity @ stack conditions, fpm

Part 6. Stack moisture content data and calculation sheet

M_{ca}, molecular weight of stack gas

M_{ch}, mole fraction of dry gas

V_{cb}, H_2O condensed in impingers, ml

V_{cd}, H_2O absorbed silica gel, ml

V_{ce}, total H_2O collected, ml

V_{cf}, volume of water vapor collected, cu ft @ standard conditions

V_{cg}, moisture in stack gas by volume, %

Part 7. Orsat data and calculation sheet

G_{bm}, fraction of test time all burners are operating

M_{bj}, molecular weight of dry stack gas (waste and burner)

M_{bk}, molecular weight of dry stack gas (burner only)

V_{ba}, % CO_2 from waste (dry basis)

V_{bb}, % CO_2 from burner (dry basis)

V_{bc}, % CO from burner (dry basis)

V_{bd}, % O_2 from burner (dry basis)

V_{be}, % N_2 from burner (dry basis)

V_{bf}, % CO_2 from waste and burner (dry basis)

V_{bg}, % CO from waste and burner (dry basis)

V_{bh}, % O_2 from waste and burner (dry basis)

V_{bi}, % N_2 from waste and burner (dry basis)

V_{bl}, % excess air at sampling point

V_{bn}, CO_2 contributed by burner, % by volume of stack gas corrected to test conditions