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EVALUATION OF THE IMPACTS OF INCINERATOR WASTE FEED CUTOFFS

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ABSTRACT

A series of pilot-scale incineration tests was performed at the Environmental Protection Agency's (EPA's) Incineration Research Facility (IRF). The tests evaluated whether increased emissions of a waste's principal organic hazardous constituents (POHCs), hazardous constituent trace metals, particulate, or HCl occur when a hazardous waste incinerator is operated sufficiently close to its permit limits that these permit limits are routinely exceeded, with the result that the associated waste feed cutoff (WFCO) system repeatedly stops waste feed to the incinerator. In the tests, a synthetic solid hazardous waste feed (consisting of a POHC liquid mixture combined with a clay absorbent spiked with arsenic, barium, cadmium, chromium, and lead) was batch-fed to the rotary kiln incineration system (RKS) at the IRF via a fiberpack drum ram feeder. The POHC liquid was also fed through the kiln burner. Seven tests were performed. These included two (duplicate) baseline tests simulating acceptable operation within typical permit conditions, two tests in which repeated WFCOs were triggered by scrubber system operation out of permit condition, two tests in which repeated WFCOs were triggered by scrubber exit CO spikes of several hundred ppm, and a baseline test with reduced waste feedrate. The failures of the venturi/packed-column scrubber system that were tested were reduced venturi scrubber pressure drop caused by induced draft fan failure and decreased scrubber liquor flow to the scrubber system caused by recirculation pump failure. Repeated, large CO spikes were caused by reducing incinerator air flows to below the levels needed to completely satisfy the oxygen demand in the puff of devolatilized POHC that occurs with each batch of solid waste charged, and by overcharging solid waste.

Test program results show that none of the tested incinerator operating modes, which resulted in repeated WFCOs, caused increased POHC, trace metal, or HCl emissions. POHC concentrations, emission rates, and destruction and removal efficiencies (DREs) measured in the scrubber exit flue gas for all repeated WFCO tests were within the range measured for the two baseline tests. Similarly, trace metal concentrations, emission rates, and distributions among incinerator discharges for all repeated WFCO tests could not be differentiated from the baseline tests. Scrubber HCl collection efficiencies were constant, at 99.8% to 99.9% for all tests. Emission levels varied only with chlorine feedrate to the RKS.

Scrubber particulate collection efficiencies were relatively constant from test to test, ranging from 77% to 89%. Scrubber exit particulate levels in the scrubber failure tests were no greater than in the baseline tests. Scrubber exit particulate levels were increased in the high CO WFCO tests because of increased scrubber inlet particulate levels at constant collection efficiency.

Overall, test results suggest that the permit requirement to terminate waste feed whenever a permit-specified operating limit is exceeded is an appropriate protection against increased incinerator emissions of POHCs, trace metals, and HCl. Only particulate emissions increases, perhaps to double the baseline, routine operation levels, were measured in these tests. These increases were not associated with scrubber system failures but, instead, with increased scrubber inlet particulate from the high CO production modes tested.

Although the test program was performed in the pilot-scale RKS at the IRF with synthetic hazardous waste feed, past experience has shown that the RKS represents a good model for typical

at nominally 10% and the target afterburner exit gas temperature was 1,093°C (2,000°F), with flue gas O_2 at nominally 8%. In addition to Tests 1a and 1b, Test 5 was added to the test program as a low feedrate baseline test. All other conditions for Test 5 were to be the same as for Tests 1a and 1b with the exception that the synthetic waste per charge and corresponding solid waste feedrate were reduced.

Test 2 evaluated the incremental HCl and trace metal emissions resulting from WFCO triggered by low venturi scrubber pressure drop. For this test, an automatic WFCO interlock, which stopped waste feed when the venturi scrubber pressure drop fell below 4.5 kPa (18 in WC), was programmed into the RKS process control system. The RKS was set to steady operation at the conditions of the baseline test. After 20 minutes of normal operation and just after a drum charge entered the kiln, the venturi scrubber pressure drop was rapidly decreased by shutting off the scrubber system induced draft fan. This caused the venturi scrubber pressure drop to fall below the interlock setpoint of 4.5 kPa (18 in WC) and the process control system halted waste feed by preventing further drum charging and interrupting liquid waste feed to the kiln burner. After 20 minutes, venturi scrubber pressure drop was returned to 6.2 kPa (25 in WC) by restarting the induced draft fan. As soon as the waste feed permissive signal occurred, liquid and solid waste feed were restarted. The cycle was repeated after about 40 minutes of returned operation at baseline conditions. The full cycle was repeated four times so that flue gas samples over four WFCO events could be collected during the test.

Test 3 evaluated the incremental HCl and trace metal emissions associated with WFCO triggered by low scrubber system scrubber liquor flow. Scrubber liquor for both the venturi and packed-column scrubbers is supplied via a common delivery system. In this test, an automatic WFCO interlock, which stopped waste feed when the scrubber liquor inlet flowrate to the venturi scrubber or to the packed-column scrubber dropped below preset limits, was programmed into the RKS process control system. This test proceeded exactly as Test 2 except that, instead of reducing venturi scrubber pressure drop, scrubber liquor recirculation to both the venturi scrubber and the packed-column scrubber was stopped. Scrubber liquor flow to both scrubbers remained off for 20 min, and then was restarted and set to routine operation levels. Waste feed was restarted as soon as a feed permissive signal occurred. After about a 40-min time interval at returned baseline operation, the WFCO cycle was repeated. Four cycles were tested over the test day.

Tests 4a and 4b evaluated the incremental emissions associated with WFCO triggered by elevated CO emissions. For these tests an automatic WFCO interlock, which prevented both liquid and solid waste feed when instantaneous scrubber exit flue gas CO levels exceeded 100 ppm was programmed. Thus, if scrubber exit CO levels spiked at above 100 ppm after a solid waste batch charge, the WFCO interlock terminated liquid waste feed through the kiln burner and prevented further solid waste charging. After scrubber exit CO levels fell below 100 ppm, liquid and solid waste feed was restarted and continued until a solid waste batch charge caused another scrubber exit CO spike.

Two different excessive CO tests were performed. For Test 4a the baseline waste feed regimen was used. However, air flow to both the kiln and the afterburner was reduced to a rate that resulted in the average availability of excess air over a charge cycle, but a rate that was insufficient to satisfy the peak oxygen demand following a solid waste batch charge. A CO spike of about 1-min resulted. For Test 4b, air flows to both the kiln and afterburner were set to levels closer to, through still below those used in the baseline tests. However, the solid waste feed charge size and corresponding feedrate was greater than that used in the other tests, and the solid waste formulation contained more POHC mixture than that used for the other tests.

Routine scrubber exit CO spikes were indeed experienced during the high CO tests, as desired. Twenty-two spikes were experienced during the volatile organic emissions sampling period during Test 4a, seven of which drove the scrubber exit CO monitor to a full-scale reading of 650 ppm. Less frequent CO spikes were experienced for Test 4b. Eleven scrubber exit spikes

occurred over the volatile organic emissions sampling period during this test. Only two of these drove the scrubber exit CO monitor to full scale. The other spikes were about 200 ppm or less.

Sampling and Analysis

In addition to obtaining synthetic solid and liquid waste feed, kiln ash, and pre- and post-test scrubber liquor samples, the sampling protocol for all tests included sampling the flue gas at the afterburner exit and at the scrubber system exit for trace metals, using the EPA multiple metals train, and particulate and HCl, using Method 5. In addition, the scrubber exit flue gas was sampled for the volatile POHCs using, Method 0030. The stack downstream of the secondary APCS was also sampled for particulate and HCl, using Method 5.

The Method 0030 samples were analyzed for the volatile POHCs, and the multiple metals train samples were analyzed for the five test trace metals. In addition, the synthetic solid waste feed, kiln ash, and pre- and post-test scrubber liquor samples were analyzed for the test POHCs and trace metals.

TEST RESULTS

POHC Analysis Results and DREs

Table I summarizes the measured flue gas concentrations and corresponding emission rates and POHC DREs for each of the tests. The data in Table I show that toluene concentrations in the scrubber exit flue gas ranged from 12 to 88 μg/dscm, tetrachloroethene concentrations ranged from 1.5 to 14 μg/dscm, and chlorobenzene concentrations ranged from 1.5 to 9.8 μg/dscm. The highest concentrations for all three POHCs were measured in the repeat baseline test, Test 1b. The lowest toluene concentration was measured in the high CO from reduced air flow test, Test 4a. The lowest tetrachloroethene and chlorobenzene concentrations were measured in Test 3, the scrubber liquor flow failure test. Flue gas concentrations for these two POHCs were, however,

Table I. Scrubber exit flue gas POHC concentrations and POHC DREs.

Parameter	Toluene	Tetrachloroethene	Chlorobenzene
Test 1a: Baseline			
Scrubber exit gas			
Concentration, μg/dscm	32	3.7	3.0
Emission rate, mg/hr	70	8.0	6.5
Feedrate, kg/hr			
Solid feed	3.90	0.86	0.77
Liquid feed	4.86	0.83	0.76
Total feed	8.76	1.69	1.53
DRE, %	99.99920	99.99952	99.99957
Test 1b: Repeat baseline			
Scrubber exit gas			
Concentration, μg/dscm	88	14	9.8
Emission rate, mg/hr	170	26	19
Feedrate, kg/hr			
Solid feed	4.07	1.18	0.83
Liquid feed	5.26	0.73	0.90
Total feed	9.33	1.91	1.73
DRE, %	99.9982	99.9986	99.9989

(continued)

Table I. Scrubber exit flue gas POHC concentrations and POHC DREs (continued).

Parameter	Toluene	Tetrachloroethene	Chlorobenzene
Test 2: Scrubber fan failure			
Scrubber exit flue gas			
Concentration, μg/dscm	40	7.0	3.6
Emission rate, mg/hr	67	12	6.0
Feedrate, kg/hr			
Solid feed	2.47	0.70	0.48
Liquid feed	2.50	0.38	0.43
Total feed	4.97	1.08	0.91
DRE, %	99.9987	99.9989	99.99933
Test 3: Scrubber liquor flow failure			
Scrubber exit flue gas			
Concentration, μg/dscm	14	1.5	1.5
Emission rate, mg/hr	27	3.0	3.0
Feedrate, kg/hr			
Solid feed	2.73	0.49	0.53
Liquid feed	2.80	0.44	0.47
Total feed	5.53	0.93	1.00
DRE, %	99.99951	99.99967	99.99970
Test 4a: High CO, reduced air flow			
Scrubber exit flue gas			
Concentration, μg/dscm	12	1.7	1.7
Emission rate, mg/hr	15	2.1	2.1
Feedrate, kg/hr			
Solid feed	3.35	0.59	0.60
Liquid feed	3.28	0.54	0.53
Total feed	6.63	1.13	1.13
DRE, %	99.99977	99.99981	99.99981
Test 4b: High CO, increased charge mass			
Scrubber exit flue gas			
Concentration, μg/dscm	33	4.1	3.8
Emission rate, mg/hr	61	7.5	7.0
Feedrate, kg/hr			
Solid feed	8.52	2.07	1.49
Liquid feed	3.30	1.97	1.27
Total feed	11.82	4.04	2.76
DRE, %	99.99948	99.99981	99.99974
Test 5: Low feedrate baseline			
Scrubber exit flue gas			
Concentration, μg/dscm	22	4.6	1.9
Emission rate, mg/hr	32	6.7	2.8
Feedrate, kg/hr			
Solid feed	1.58	0.28	0.28
Liquid feed	2.69	0.46	0.46
Total feed	4.27	0.74	0.74
DRE, %	99.99925	99.99909	99.99962

comparably low in Test 4a. Flue gas POHC concentrations for all three POHC in the other high CO test, Test 4b, were comparable to those measured in the baseline test, Test 1a.

Corresponding DREs as measured at the scrubber exit ranged from 99.9982% to 99.99977% for toluene, from 99.9986% to 99.99981% for tetrachloroethene, and 99.9989% to 99.99981% for chlorobenzene. Again, the lowest DREs for all three POHCs occurred in the repeat baseline test (1b). The highest DREs for all three POHCs occurred in the high CO, reduced air flow test (4a). POHC DREs for the high CO, increased charge mass test (4b) were comparable to, though uniformly greater than, those measured in Test 1a, the baseline test.

The data in Table 1 clearly show that repeatedly exceeding an instantaneous 100 ppm CO limit at the exit of the APCS via the two mechanisms tested did not cause increased POHC flue gas concentrations or emission rates, nor decreased POHC DRE.

No POHC was detected in any test kiln ash or scrubber liquor sample.

Trace Metal Analysis Results

Table II summarizes the trace metal concentrations in each test program sample analyzed. The data in the table show that measurable concentrations of barium, cadmium, chromium, and lead were found in each of the pretest scrubber liquor samples. Arsenic was not detected in any pretest scrubber liquor sample. Each of the test metals was found in each of the kiln ash, posttest scrubber liquor, and flue gas samples as well. The data in Table II also show no significant test-to-test variations in scrubber exit flue gas metal concentrations for any of the test metals. Thus, within the concentration variability range of the duplicate baseline test metals, it appears that none of the tested WFCO operating modes significantly affected the concentration of metals in the scrubber exit flue gas. Similarly, metals emissions rates were apparently not significantly different for the WFCO tests when compared with the baseline tests.

Table III summarizes the test metal distributions among the three incineration system discharges: the kiln ash, scrubber liquor, and scrubber exit flue gas. The distribution fractions in Table III have been normalized to the total amount of each metal measured in all the discharge streams analyzed. Thus, these normalized values represent fractions that would have resulted had mass balance closure in each case been 100%. Use of the distribution fractions normalized in this manner allows clearer data interpretation for variations caused by test variables, because variable mass balance closure is removed as a source of test-to-test data variability. In other words, because variable and less than perfect mass balance closure is typically experienced, the use of normalized distributions represents a best attempt to quantify metal partitioning phenomena. Actual achieved mass balance closures ranged from 35% to 146% and averaged 62%. These levels are in the range typically achieved at the IRF.

The data in Table III show that barium and chromium were relatively nonvolatile in all of the tests. Greater than 98% of the barium in the discharges and 96% of the chromium in the discharges was accounted for by the kiln ash. Less than 1% of the barium and chromium was measured in the scrubber exit flue gas, with about 1% of the barium and 1% to 2% of the chromium measured in the scrubber liquor. Arsenic and lead were more volatile in the tests, though still predominantly nonvolatile Nominally 80% to 90% of the arsenic was measured in the kiln ash discharge for all tests except the low feedrate baseline test, where it was 65% to 72% for no readily apparent reason. Between 3% and 14% of the arsenic was measured in the scrubber exit flue gas for all tests. Comparable, to slightly larger, fractions of arsenic were measured in the scrubber liquor. Nominally 80% to 95% of the lead was measured in the kiln ash discharge for all tests. About 3% to 10% of the lead was measured in the scrubber exit flue gas, and 1% to 12% in the scrubber liquor. Cadmium exhibited even more volatile behavior than arsenic and lead in all tests. Nominally 20% to 66% of the cadmium was accounted for in the kiln ash discharge. Comparable amounts, 20% to 70%, were accounted for in the scrubber exit flue gas. Only 13% or less of the cadmium was accounted for in the scrubber liquor.

Table II. Trace metal analysis results.

Sample	Arsenic[a]	Barium	Cadmium	Chromium	Lead[a]
Test 1a (6/4/92), Baseline					
Solid waste feed, mg/kg	29	454	15	215	77
Kiln ash, mg/kg	24	465	1.7	330	76
Afterburner exit flue gas, μg/dscm	52-62	20	190	240	90-98
Scrubber exit flue gas, μg/dscm	14-32	4	115	18	155-170
Pretest scrubber liquor, mg/L	<0.05	0.28	0.03	0.07	0.43
Posttest scrubber liquor, mg/L	0.20	0.47	0.14	1.0	0.29
Test 1b (6/19/92), Repeat baseline					
Solid waste feed, mg/kg	29	503	16	250	106
Kiln ash, mg/kg	21	498	11	373	103
Afterburner exit flue gas, μg/dscm	69-79	30	210	215	86-94
Scrubber exit flue gas, μg/dscm	12-31	9	63	13-17	160
Pretest scrubber liquor, mg/L	<0.05	0.22	0.05	0.11	0.26
Posttest scrubber liquor, mg/L	0.53	1.3	0.53	1.1	2.7
Test 2 (6/9/92), Scrubber fan failure					
Solid waste feed, mg/kg	36	433	16	192	91
Kiln ash, mg/kg	26	503	10	603	107
Afterburner exit flue gas, μg/dscm	43-52	17	97	120	56-64
Scrubber exit flue gas, μg/dscm	8-25	6	56	14	41-54
Pretest scrubber liquor, mg/L	<0.05	0.19	0.03	0.07	0.10
Posttest scrubber liquor, mg/L	0.29	0.71	0.16	0.82	0.54
Test 3 (6/11/92), Scrubber liquor flow failure					
Solid waste feed, mg/kg	37	479	17	380	98
Kiln ash, mg/kg	24	503	10	340	104
Afterburner exit flue gas, μg/dscm	64-73	58	130	140	58-79
Scrubber exit flue gas, μg/dscm	6-28	9	42	14-17	18-36
Pretest scrubber liquor, mg/L	<0.05	0.14	0.02	0.03	0.14
Posttest scrubber liquor, mg/L	0.16	0.36	0.07	0.26	0.17
Test 4a (6/23/92), High CO, reduced air flow					
Solid waste feed, mg/kg	24	408	12.5	207	59
Kiln ash, mg/kg	20	510	1.7	225	67
Afterburner exit flue gas, μg/dscm	175-185	30	47	190	145-155
Scrubber exit flue gas, μg/dscm	23-34	10	130	18	40-67
Pretest scrubber liquor, mg/L	<0.05	0.23	0.04	0.12	0.19
Posttest scrubber liquor, mg/L	0.21	0.26	0.10	0.25	0.15
Test 4b (4/29/92), High CO, increased charge mass					
Solid waste feed, mg/kg	33	515	16	192	76
Kiln ash, mg/kg	35	783	10	524	111
Afterburner exit flue gas, μg/dscm	140-150	75	240	620	420
Scrubber exit flue gas, μg/dscm	21-38	18	96	37	94-110
Pretest scrubber liquor, mg/L	<0.10	0.21	0.03	0.03	0.49
Posttest scrubber liquor, mg/L	0.21	0.63	0.21	0.79	1.5
Test 5 (6/25/92), Low feedrate baseline					
Solid waste feed, mg/kg	31	450	15	330	110
Kiln ash, mg/kg	18	510	12	400	100
Afterburner exit flue gas, μg/dscm	61-71	12	96	41	52-60
Scrubber exit flue gas, μg/dscm	8-28	9	53	16	17-33
Pretest scrubber liquor, mg/L	<0.05	0.22	0.02	0.05	0.14
Posttest scrubber liquor, mg/L	0.26	0.44	0.12	0.42	0.32

[a]Flue gas ranges arise when a metal is detected in only one of the two sampling train samples analyzed. The lower level in the range assumes nondetects present at zero concentration, the upper level assumes nondetects present at the detection limit.

Table III. Normalized trace metal distributions.

	Distribution, % of metal measured				
	Arsenic	Barium	Cadmium	Chromium	Lead
Test 1a (6/4/92), Baseline					
Kiln ash	87-91	99.5	19	97.4	88-90
Scrubber exit flue gas	3-7	0.1	71	0.3	10-11
Scrubber liquor	6	0.4	10	2.3	<1
Total	100	100	100	100	100
Test 1b (6/19/92), Repeat baseline					
Kiln ash	84-88	99.0	66	98.6	84
Scrubber exit flue gas	3-7	0.1	22	0.3	8
Scrubber liquor	9	0.9	12	1.1	8
Total	100	100	100	100	100
Test 2 (6/9/92), Scrubber fan failure					
Kiln ash	79-85	98.4	54	98.1	90
Scrubber exit flue gas	3-10	0.2	37	0.3	5
Scrubber liquor	11-12	1.4	9	1.6	5
Total	100	100	100	100	100
Test 3 (6/11/92), Scrubber liquor flow failure					
Kiln ash	77-85	98.8	60	98.0	95-97
Scrubber exit flue gas	3-13	0.2	34	0.6	2-4
Scrubber liquor	10-12	1.0	6	1.4	1
Total	100	100	100	100	100
Test 4a (6/23/92), High CO, reduced air flow					
Kiln ash	81-83	99.7	18	98.6	94-97
Scrubber exit flue gas	5-7	0.1	71	0.4	3-5
Scrubber liquor	12	0.2	11	1.0	<1
Total	100	100	100	100	100
Test 4b (4/29/92), High CO, increased charge mass					
Kiln ash	82-86	98.8	43	97.0	80-81
Scrubber exit flue gas	6-10	0.3	44	0.7	7-8
Scrubber liquor	8	0.9	13	2.3	12
Total	100	100	100	100	100
Test 5 (6/25/92), Low feedrate baseline					
Kiln ash	65-72	98.7	56	97.4	92-94
Scrubber exit flue gas	5-14	0.3	34	0.5	2-4
Scrubber liquor	21-23	1.0	10	2.1	4
Total	100	100	100	100	100

The data in Table III show no repeatedly significant difference in metals distributions from test to test for any of the metals, within the degree of data variability exhibited in the two baseline tests, within the precision of the measurements, or both. This suggests that metals partitioning among the incinerator discharges was relatively unaffected by the different tested operating conditions leading to repeated WFCOs.

Table IV summarizes the apparent scrubber collection efficiencies for the metals. Apparent scrubber collection efficiencies are calculated by assuming that the sum of the amount of metal measured in the two scrubber discharges (the scrubber liquor and the scrubber exit flue gas) was

Table IV. Apparent scrubber trace metal collection efficiencies.

	Apparent scrubber collection efficiency,[a] %				
	As	Ba	Cd	Cr	Pb
Test 1a (6/4/92), Baseline	48-68	88	13	89	<3
Test 1b (6/19/92), Repeat baseline	54-76	89	35	80-84	51
Test 2 (6/9/92), Scrubber fan failure	54-79	90	20	85	46-54
Test 3 (6/11/92), Scrubber liquor flow failure	46-81	80	16	67-71	15-26
Test 4a (6/23/92), High CO, reduced air flow	64-73	69	14	72	< 15
Test 4b (4/29/92), High CO, increased charge mass	45-60	78	22	76	59-63
Test 5 (6/25/92), Low feedrate baseline	61-84	81	23	79	49-65

[a](Scrubber liquor fraction)/(scrubber liquor fraction + scrubber exit flue gas fraction).

the amount of metal in the scrubber inlet flue gas. Thus, apparent scrubber collection efficiency is calculated as (scrubber liquor fraction)/(scrubber liquor fraction + scrubber exit flue gas fraction).

Data in Table IV show that the venturi/packed column scrubber system was nominally 70% to 90% efficient in collecting barium and chromium. Arsenic apparent collection efficiencies were perhaps as low as 45% to 64% Cadmium apparent collection efficiencies were lower, in the 13% to 35% range. Lead apparent collection efficiencies were highly variable. Within the range of variability in the data, however, no test-to-test differences in collection efficiencies are apparent. This suggest that none of the repeated WFCOs tested affected scrubber metals collection efficiencies.

Particulate and HCl Emission Data

Table V summarizes the particulate levels measured at the afterburner exit (scrubber inlet) and scrubber exit. The data in the table show that afterburner exit particulate levels ranged from 48 to 98 mg/dscm, corrected to 7% O_2, for the two baseline, the two scrubber failure, and the low feedrate baseline tests, Tests 1a, 1b, 2, 3, and 5. Afterburner exit particulate levels were apparently increased, ranging from 133 to 148 mg/dscm, for the two high CO WFCO tests. This is probably because of a combination of increased kiln ash entrainment into the combustion gas, as well as some flue gas soot formed during the high CO tests. Significant soot formation was evident during both high CO tests in visual observations of the kiln combustion gas and the substantial darkening of the scrubber liquor with collected soot.

Scrubber exit particulate levels were reduced to the 8 to 15 mg/dscm at 7% O_2 for Tests 1a, 1b, 2, 3, and 5. Scrubber exit particulate levels were essentially the same for the two scrubber failure tests as for the two baseline and the low feedrate baseline tests. Thus, the two scrubber failure modes tested with WFCO resulted in no apparent increased particulate emissions.

Scrubber exit particulate emissions for the two high CO WFCO tests were slightly higher, at 17 and 26 mg/dscm at 7% O_2. These are probably because of the higher scrubber inlet loadings for the two tests. Table 5 also notes the particulate removal efficiencies of the scrubber system, calculated based on the scrubber inlet (afterburner exit) and exit levels measured. Removal efficiencies were not significantly different from test to test, ranging from 77% to 89%.

Table VI summarizes the HCl levels measured in the flue gas at the three locations sampled. As shown in the table, afterburner exit HCl levels ranged from 325 to 1,130 ppm with the test-to-

Table V. Flue gas particulate levels.

Test		Date	Flue gas particulate, mg/dscm at 7% O_2		Scrubber removal efficiency, %
			Afterburner exit	Scrubber exit	
1a:	Baseline	6/4/92	98	15	85
1b:	Repeat baseline	6/19/92	52	12	77
2:	Scrubber fan failure	6/9/92	81	10	88
3:	Scrubber liquor flow failure	6/11/92	67	9	87
4a:	High CO, reduced airflow	6/23/92	148	17	89
4b:	High CO, increased charge mass	4/29/92	133	26	80
5:	Low feedrate baseline	6/25/92	48	8	83

Table VI. Flue gas HCl levels.

Test	Afterburner exit			Scrubber exit			Scrubber efficiency, %
	HCl concentration,		HCl emission rate, g/hr	HCl concentration,		HCl emission rate, g/hr	
	mg/dscm	ppm		mg/dscm	ppm		
Test 1a (6/4/92), Baseline	1,100	724	1,980	1.6	1.1	3.4	99.8
Test 1b (6/19/92), Repeat baseline	1,090	718	1,950	2.2	1.4	4.2	99.8
Test 2 (6/9/92), Scrubber fan failure	545	359	990	0.8	0.5	1.3	99.9
Test 3 (6/11/92), Scrubber liquor flow failure	494	325	916	0.9	0.6	1.7	99.8
Test 4a (6/23/92), High CO, reduced airflow	1,640	1,080	2,250	2.3	1.5	2.9	99.9
Test 4b (4/29/92), High CO, increased charge mass	1,710	1,130	2,850	2.4	1.6	4.5	99.8
Test 5 (6/25/92), Low feedrate baseline	638	420	1,110	1.2	0.8	1.8	99.8

test variations in chlorine feedrate as determined by waste feedrate and chlorine content. Scrubber exit HCl levels were reduced to 0.5 to 1.6 ppm. Relatively constant scrubber HCl collection efficiencies, at 99.8% to 99.9%, were measured. The two scrubber failure modes tested, with attendant WFCO, apparently did not result in increased HCl emissions or decreased scrubber HCl collection efficiency.

CONCLUSIONS

Test program results show that none of the incinerator operating modes tested, which resulted in repeated WFCOs, caused increased hazardous constituent or HCl emissions. The DREs

for the three test POHCs (toluene, tetrachloroethene, and chlorobenzene) ranged from 99.9982% to 99.99981% over the test program. The lowest DREs were measured in one of the two baseline tests (Test 1b). The highest DREs were measured in the repeated CO spike test in which CO spikes were produced by reducing the combustion air flowrate to the incinerator from the baseline test levels. The other CO spike test, in which CO spikes were produced by increasing the mass and heat content of each batch charge of solid waste to an overcharge situation, had POHC DREs comparable to the other baseline test (Test 1a). POHC DREs for the two scrubber system failure tests, one in which venturi scrubber pressure drop was repeatedly reduced by shutting off the scrubber induced draft fan (fan failure) and the other in which scrubber liquor flow was stopped by shutting off the scrubber system recirculation pump, were also comparable to those measured in the baseline tests.

Within the variability in the test-to-test trace metal data, none of the repeated WFCO operating modes tested resulted in increased flue gas metals emissions. Scrubber exit flue gas concentrations and emissions rates of arsenic, barium, cadmium, chromium, and lead for the two scrubber failure and two high CO WFCO tests were not significantly different than those for the baseline tests. Trace metal distributions among the three incinerator discharge streams (kiln ash, scrubber liquor, and scrubber exit flue gas) and scrubber trace metal collection efficiencies were not significantly different from baseline to WFCO tests, again within the test-to-test data variability and the precision of the metals analysis methods.

Flue gas HCl concentrations and emission rates at the scrubber exit varied only with the feedrate of chlorine in the wastes fed to the incinerator. Scrubber HCl collection efficiencies were 99.8% to 99.9% for all tests and were not reduced with any scrubber failure or high CO operating mode tested.

Flue gas particulate levels at the scrubber exit were in the 8 to 15 mg/dscm at 7% O_2 range for all tests except the two high CO WFCO tests. Flue gas particulate levels at the scrubber exit for the two scrubber failure WFCO tests were lower than levels measured in the two baseline tests. Scrubber exit particulate levels were higher, at 17 and 26 mg/dscm, for the two high CO WFCO tests. These, however, were the result of increased scrubber inlet particulate levels for these two tests. Scrubber particulate collection efficiency was relatively constant at 77% to 89% from test to test.

The higher inlet particulate levels for the high CO WFCO tests probably resulted from a combination of increased entrainment of solids from the kiln into the kiln exit combustion gas and soot formed during the incomplete combustion environment resulting in the CO spikes. The increased entrainment results from the high intensity puff of incompletely combusted organics associated with kiln overcharging used to produce the high CO.

Overall, test results suggest that the permit requirement to terminate waste feed whenever a permit-specified operating limit is exceeded is an appropriate protection against increased incinerator emissions of POHCs, trace metals, and HCl. Only particulate emissions increases (of perhaps double the baseline, routine operation levels) were measured in these tests. Further, these increases were not associated with APCS failures but with increased APCS inlet particulate levels arising from combustion conditions associated with repeated CO spikes.

Barium and chromium exhibited nonvolatile behavior in all the tests performed. Greater than 98% of the barium and 96% of the chromium measured in incinerator discharges was accounted for in the kiln ash. Arsenic and lead exhibited more volatile behavior. The kiln ash discharge accounted for 80% to 90% of the arsenic measured in the discharges for all tests except the low feedrate baseline test, Test 5 which was 65% to 72%. Nominally 80% to 95% of the lead measured in the incinerator discharges was in the kiln ash. Cadmium was even more volatile in all tests; 18% to 66% of the cadmium in the discharges was accounted for in the kiln ash. These observations are consistent with past IRF metal partitioning experience.

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16. ABSTRACT

A series of pilot-scale incineration tests was performed at the EPA's Incineration Research Facility (IRF) to evaluate whether increased emissions of regulated pollutants could occur when an incinerator's automatic waste feed cutoff (WFCO) system repeatedly stops waste feed to the incinerator. Seven tests were performed in the rotary kiln incineration system with at the IRF. These included duplicate baseline tests simulating acceptable operation, two tests with WFCOs triggered by scrubber system failures, two tests with scrubber exit CO spikes of several hundred ppm, and a baseline test with reduced waste feedrate.

Test program results show that none of the tested incinerator operating modes caused significant increased POHC, trace metal, or HCl emissions. POHC destruction and removal efficiencies (DREs) for all repeated WFCO tests were within the range measured for the two baseline tests. Similarly, trace metal emission rates and distributions among incinerator discharges for all repeated WFCO tests could not be differentiated from the baseline tests. Scrubber HCl collection efficiencies were constant, at 99.8% to 99.9% for all tests. Scrubber exit particulate levels in the scrubber failure tests were no greater than in the baseline tests. However, they were increased to as much as double the baseline test levels in the high-CO tests because of increased scrubber inlet particulate at constant collection efficiency. Overall, test results suggest that the permit requirement to terminate waste feed whenever a permit-specified operating limit is exceeded apparently prevents significantly increased incinerator emissions of POHCs, trace metals, and HCl; particulate emissions can increase, however.

17. KEY WORDS AND DOCUMENT ANALYSIS

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