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Background Report Reference

AP-42 Section Number: 2.3

Background Chapter: 4

Reference Number: 12

Title: Report on a Stack Sampling Program to Measure the Emissions of Selected Trace Organic Compounds, Particulates, Heavy Metals, and HCl from the Royal Jubilee Hospital Incinerator, Victoria, British Columbia.

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Environmental Protection Programs
Directorate

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APPENDIX D

BR 2,3
#12
4.0

SAMPLING AND ANALYTICAL PROCEDURES

ENTROPY

SIGNATURE _____ DATE _____ CHECKED _____ DATE _____

PROJECT _____ JOB NO. _____

SUBJECT _____ SHEET _____ OF _____ SHEETS

ROYAL JUBILEE HOSPITAL INCINERATOR

VICTORIA, BC

2/22/83 - 3/3/83

Consumat Model C-760 pathological incinerator
controlled air principle. 2 stage combustion61. ft³ feed box w/ hydraulic ram

batch feed about every 5 min 150 LB PLASTIC / DAY

primary chamber 9' x 12' = 763 ft³

800 lb. loading oil burners used to ignite

combustion rate controlled by air ~~flow~~ rate

1400°F air flow rate is below stoichiometric rate

secondary stack 29" i.d.

excess air 400% - 475% BUT MOSTLY FROM DILUTION AFTER
COMBUSTION

TABLE 3 - SUMMARY OF PROCESS OPERATIONS

| ROYAL JURILEE HOSPITAL INCINERATOR | | | | | | | |
|------------------------------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| DATE (1983) | Feb. 23 | Feb. 24 | Feb. 25 | Feb. 28 | March 1 | March 2 | March 3 |
| RUN NUMBER | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| GENERAL PROCESS DATA | | | | | | | |
| BURN PERIOD * | 0945-1501 | 0930-1500 | 0935-1435 | 1025-1500 | 0940-1422 | 0953-1500 | 0945-1230 |
| GARRAGE FED (kg) | 3948 | 5266 | 5001 | 5316 | 4658 | 4386 | 2263 |
| SAMPLING PERIOD | 1053-1508 | 1103-1528 | 1015-1445 | 1047-1501 | 0953-1403 | 1015-1425 | 1007-1212 |
| FED DURING SAMPLING (kg) | 3036 | 3875 | 3976 | 4155 | 3836 | 3691 | 1827 |
| FEED RATE DURING SAMPLING (kg/h) | 714 | 876 | 882 | 984 | 918 | 888 | 876 |
| VOLUME BOTTOM ASH (m3) | 1.4 | 2.0 | 2.0 | 1.7 | 1.3 | 1.5 | 0.8 |
| OIL USED (L) | 750 | 700 | 400 | 450 | 450 | 450 | 150 |
| AVERAGE PROCESS TEMPERATURES (°C) | | | | | | | |
| PRIMARY CHAMBER | 701 | 745 | 763 | 727 | 775 | 767 | n.a. |
| SECONDARY CHAMBER | 909 | 900 | 918 | 926 | 922 | 942 | n.a. |
| COLD SIDE HEAT EXCHANGER | 294 | 340 | 324 | 328 | 334 | 337 | n.a. |
| SECONDARY STACK | 153 | 167 | 152 | 149 | 155 | 158 | 161 |

* The Burn Period is time from firing the first load to the time of the last load (does not include burn down).

TABLE 4 - SUMMARY OF STACK TESTING DATA

| | | Feb. 23 | Feb. 24 | Feb. 25 | Feb. 28 | March 1 | March 2 | March 3 |
|------------------------------------|--|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| ROYAL JUBILEE HOSPITAL INCINERATOR | | | | | | | | |
| DATE (1983) | | | | | | | | |
| SAMPLING DATA | | | | | | | | |
| RUN NUMBER | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| TYPE | | Part/HCl | Dioxin | Dioxin | Dioxin | Dioxin | PAH/PCB | Part/HCl |
| SAMPLING PERIOD | | 1053-1508 | 1103-1528 | 1015-1445 | 1047-1501 | 0953-1403 | 1015-1425 | 1007-1212 |
| TEST DURATION (min) | | 240 | 240 | 240 | 240 | 240 | 240 | 120 |
| SAMPLE VOLUME (m ³)* | | 3.39 | 3.55 | 3.50 | 3.56 | 3.39 | 3.39 | 1.70 |
| ISO KINETICITY (%) | | 95.8 | 105.2 | 101.2 | 99.0 | 99.9 | 100.1 | 98.1 |
| STACK GAS DATA | | | | | | | | |
| VELOCITY (m/s) | | 11.7 | 11.8 | 11.5 | 11.4 | 11.7 | 11.8 | 12.1 |
| FLOWRATE (m ³ /min)* | | 200 | 192 | 195 | 202 | 199 | 199 | 202 |
| TEMPERATURE (°C) | | 153 | 161 | 152 | 149 | 155 | 158 | 161 |
| MOISTURE (vol %) | | 6.3 | 9.5 | 6.8 | 4.0 | 5.7 | 6.0 | 6.2 |
| CO ₂ (vol % - dry) | | 3.2 | 3.1 | 3.5 | 3.4 | 3.2 | 2.9 | 3.4 |
| O ₂ (vol % - dry) | | 17.0 | 17.3 | 17.1 | 17.2 | 17.2 | 17.5 | 17.0 |
| N ₂ (vol % - dry) | | 79.8 | 79.6 | 79.4 | 79.4 | 79.6 | 79.6 | 79.6 |
| MOL. WEIGHT | | 29.19 | 29.19 | 29.24 | 29.23 | 29.20 | 29.16 | 29.22 |
| EXCESS AIR (%) | | 402.2 | 446.6 | 425.3 | 438.7 | 432.9 | 476.4 | 407.3 |

* Values reported are on a dry basis corrected to standard conditions of 25°C and 760 mmHg.

TABLE 5 - SUMMARY OF PARTICULATE AND HCl TEST RESULTS

| ROYAL JUBILEE HOSPITAL INCINERATOR | | |
|---------------------------------------|-----------|-----------|
| DATE (1983) | Feb. 23 | March 3 |
| SAMPLING DATA | | |
| RUN NUMBER | 1 | 7 |
| SAMPLING PERIOD | 1053-1508 | 1007-1212 |
| TEST DURATION (min) | 240 | 120 |
| SAMPLE VOLUME (m ³)* | 3.39 | 1.70 |
| ISOKINETICITY (%) | 95.8 | 98.1 |
| STACK GAS DATA | | |
| VELOCITY (m/s) | 11.7 | 12.1 |
| FLOWRATE (m ³ /min)* | 200 | 202 |
| TEMPERATURE (°C) | 153 | 161 |
| MOISTURE (%) | 6.3 | 6.2 |
| EXCESS AIR (%) | 402.2 | 407.3 |
| PROCESS DATA | | |
| AMOUNT WASTE FED (kg) | 3036 | 1827 |
| WASTE FEED RATE (kg/hr) | 714 | 876 |
| PARTICULATE RESULTS | | |
| AMOUNT COLLECTED (mg) | 169.5 | 112.0 |
| CONCENTRATION | | |
| - MEASURED (mg/m ³)* | 49.9 | 65.9 |
| - CORR. 50% E.A. (mg/m ³) | 167.1 | 222.9 |
| EMISSION RATE (kg/hr) | 0.60 | 0.80 |
| EMISSION FACTOR (g/kg waste) | 0.84 | 0.91 |
| HCl RESULTS | | |
| AMOUNT COLLECTED (mg) | 1490 | 1140 |
| CONCENTRATION | | |
| - MEASURED (mg/m ³)* | 438.2 | 670.6 |
| - CORR. 50% E.A. (mg/m ³) | 1467 | 2268 |
| (ppm) | 983 | 1520 |
| EMISSION RATE (kg/hr) | 5.3 | 8.0 |
| EMISSION FACTOR (g/kg waste) | 7.4 | 9.1 |

*Values reported are on a dry basis corrected to standard conditions of 25°C and 760 mm Hg.

TABLE 6 HEAVY METAL TEST RESULTS - STACK SAMPLES

| | Amount Collected | | Concentration* | | Emission Rate | |
|---------------|------------------|-----------------|----------------------------|------------------|------------------|-------------------|
| | Run 1 | Run 7 | Run 1 | Run 7 | Run 1 | Run 7 |
| | (mg) | | (mg/m ³) | | (g/hr) | |
| Ca | 25.62 | 27.31 | 7.56 | 16.06 | 90.7 | 194.6 |
| Na | 20.74 | 19.28 | 6.12 | 11.34 | 73.4 | 137.4 |
| Al | 19.84 | 23.28 | 5.85 | 13.69 | 70.2 | 165.9 |
| K | 13.85 | 16.01 | 4.09 | 9.42 | 49.1 | 114.2 |
| Zn | 10.26 | 7.55 | 3.03 | 4.44 | 36.4 | 53.8 |
| Mg | 7.57 | 8.34 | 2.23 | 4.91 | 26.8 | 59.5 |
| Fe | 7.57 | 8.34 | 2.23 | 4.91 | 26.8 | 59.5 |
| Si | 3.28 | 1.44 | 0.87 | 0.85 | 0.8 | 7.7 |
| | (μ g) | | (μ g/m ³) | | (mg/hr) | |
| Bi | 904 | 554 | 266.7 | 325.9 | 3200.4 | 3949.9 |
| Cu | 372 | 454 | 109.7 | 267.1 | 1316.4 | 3237.3 |
| S | 20 | 20 | 5.6 | 120.8 | 502.8 | 1076.3 |
| Sn | 142 | 151 | 41.9 | 88.8 | 502.8 | 1076.3 |
| Mn | 141 | 48 | 41.6 | 28.2 | 499.2 | 341.8 |
| Cr | 126 | 120 | 37.2 | 70.6 | 446.4 | 855.7 |
| Pb | 83 | 12 | 24.5 | 7.1 | 294.0 | 86.1 |
| Sb | 46 | 40 | 13.6 | 23.5 | 163.2 | 284.8 |
| As | 45 | 34 | 13.2 | 18.2 | 158.5 | 232.6 |
| Ag | 36 | 16 | 10.6 | 9.4 | 127.2 | 113.9 |
| Li | 17 | 10 | 5.0 | 5.9 | 60.0 | 71.5 |
| Mo | 10 | 11 | 3.0 | 6.5 | 36.0 | 78.8 |
| Sr | 9 | 57 | 2.7 | 33.5 | 32.4 | 406.0 |
| Rb | 6 | 4 | 1.8 | 2.4 | 21.6 | 29.1 |
| Ta | 6 | ND | 1.8 | | 21.6 | |
| Se | 5 | 5 | 1.5 | 2.9 | 18.0 | 35.1 |
| Co | 3.0 | 4.5 | 0.9 | 2.6 | 10.8 | 31.5 |
| Hg | 2.8 | 1.6 | 0.8 | 0.9 | 9.6 | 10.9 |
| Ca | 2.3 | 2.3 | 0.7 | 1.4 | 8.4 | 17.0 |
| V | 0.3 | 0.2 | 0.1 | 0.1 | 1.2 | 1.2 |
| Be | ND | ND | | | | |
| W | ND | ND | | | | |
| U | ND | ND | | | | |
| As | ND | ND | | | | |
| Te | ND | ND | | | | |

ND = not detected

* Concentrations are reported at dry and standard conditions (25°C and 760 mm Hg) but have not been corrected for excess air.

The dioxin and furan stack sampling results are presented in Table 8. These results are reported for five homologues - tetrachloro, pentachloro, hexachloro, heptachloro and octachloro. The total PCDD and PCDF reported are the sum of these five specific homologues and therefore exclude any of the monochloro, dichloro or trichloro groups which were not analyzed.

With the exception of the octachloro homologue, there were more furans than dioxins found in the source emission samples. A listing of the average concentrations and emission rates over all four test runs is given in Table 9 below.

TABLE 9 AVERAGE CONCENTRATIONS AND EMISSION RATES OF DIOXINS AND FURANS

| Homologue | Concentration (ng/m ³) | | Emission rate (µg/h) | |
|------------|------------------------------------|-------|----------------------|---------|
| | Dioxin | Furan | Dioxin | Furan |
| Tetra CD- | ND | 27.0 | ND | 319.0 |
| Penta CD- | 15.7 | 46.2 | 183.3 | 544.6 |
| Hexa CD- | 13.8 | 42.9 | 162.6 | 505.7 |
| Hepta CD- | 16.7 | 25.7 | 197.1 | 304.8 |
| Octa CD- | 22.8 | 13.8 | 269.4 | 163.5 |
| TOTAL PCDD | 68.9 | 155.6 | 811.2 | 1,837.5 |

The average concentration of polychlorinated dibenzofurans was 155.6 ng/m³ amounting to an emission rate of 1,837.5 µg/h. The average concentration of polychlorinated dibenzo-p-dioxins was 68.9 ng/m³ for an emission rate of 811.2 µg/h. Generally, the incinerator was emitting about twice as much furans as dioxins during the testing period. As all of the isomers in each of the five homologous groups were not quantified it would be difficult to describe the significance of these results in terms of toxicity. However, one significant fact is apparent. There were no detectable amounts of the tetrachloro-dioxin homologue which contains 2,3,7,8-TCDD - the most toxic dioxin congener.

4.5.1.2 PCB and PAH. The PCB and PAH results, obtained from Run 6 on March 2, 1983, are given in Tables 10 and 11 respectively. Data are reported in terms of the amount collected, the concentration and the emission rate.

TABLE 10 PCB TEST RESULTS

| ROYAL JUBILEE HOSPITAL INCINERATOR | | | |
|------------------------------------|---------------------------------------|---|---|
| Component | Amount Collected (μg) | Concentration ($\mu\text{g}/\text{m}^3$) | Emission Rate (mg/h) |
| Aroclor 1242 (3Cl - 5Cl) | 3.41 | 1.01 | 12.06 |
| Aroclor 1260 (5Cl - 8Cl) | 3.96 | 1.17 | 13.97 |
| Total PCB | 7.37 | 2.17 | 25.91 |

The PCB data have been clarified into the low chlorinated biphenyls (based on an Aroclor 1242 standard), the high chlorinated biphenyls (based on the Aroclor 1260 standard), and the total PCB which are the sum of these two groups. The distribution of total PCB in the sampling train is given in Figure 6. The majority (> 90%) was found in the back-half of the sampling train suggesting that the PCB in the stack emissions exist primarily in the gaseous state. Also significant, is the fact that the back-up glycol impingers collected almost three times more PCB than the Amberlite cartridges. This suggests that the Amberlite is relatively inefficient for PCB sampling. Further, since most was found in the impingers, there is the possibility that some of the PCB in the stack samples may have escaped collection in the train. A large amount of PCB were also found in the back-half glassware rinse. All these facts suggest that a different sampling train using impingers as the primary collection media for PCB, would be preferred over the Amberlite system used during this study.

The PAH results are reported for 23 individual PAH compounds. Of these 23 compounds analyzed for, a total of 13 were not detected. Of the remaining 10 PAH which were found, the emission rates varied from 1 to 8 mg/h. The sampling train was very efficient in trapping all of the PAH identified. All of the PAH were found in the back-half of the train which means they all were emitted from the source in the gaseous state. Further, all of the PAH were found in the Amberlite cartridges. There were none detected in the condensate trap, the impingers or the back-half glassware rinse.

4.5.2 **Ash Samples.** The fly ash and bottom ash samples, collected on February 28, were analyzed for dioxins and furans. A listing of these results for the five homologues and total PCDD/PCDF is given in Table 12. There was very little dioxins or furans found

TABLE 12
DIOXIN AND FURAN RESULTS - ASH SAMPLES

| Compound Sample Code | ROYAL JUBILEE HOSPITAL INCINERATOR | | | | FURAN | | | |
|----------------------------|------------------------------------|--------|-----|-----|-------|--------|-----|------|
| | A | B | C | D | A | B | C | D |
| CONCENTRATION (ng/g) | | | | | | | | |
| Tetra (T ₄ CD-) | 6.3 | 125.8 | 0.1 | ND | 32.9 | 937.5 | 1.0 | 0.7 |
| Penta (P ₅ CD-) | 26.6 | 489.1 | 0.2 | ND | 70.1 | 1599.0 | 1.1 | 1.3 |
| Hexa (H ₆ CD-) | 87.0 | 933.8 | 0.4 | 0.3 | 61.8 | 1732.8 | 0.7 | 3.0 |
| Hepta (H ₇ CD-) | 45.6 | 997.7 | 0.4 | 0.5 | 96.2 | 840.5 | 0.4 | 4.5 |
| Octa (OCD-) | 93.6 | 3931.5 | 0.5 | 1.9 | 36.8 | 760.2 | 0.4 | 1.7 |
| Total (PCD-) | 259.1 | 6477.9 | 1.6 | 2.7 | 297.5 | 5868.5 | 3.6 | 11.2 |

ND = not detected, < 0.05 ng/g

Sample Description

- A- Fly ash collected from the walls of the duct leading from the heat exchanger to the low temp stack
- B- Fly ash collected from the bottom of the duct leading from the heat exchanger to the low temp stack
- C- Composite of bottom ash collected from regions 1, 2, 3, 4, 5, 7, 8 in Figure 4
- D- Bottom ash collected from region 6 in Figure 4.