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# Hazardous Waste Combustion in a CFBC

Presentation to 48th IEA Meeting

Vienna, Austria

24th May 2004

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# The Sydney Tar Ponds

- Canada biggest environmentally contaminated site
- 700,000 tons of tarry sludge deposit in streams from Sydney Steel over an 80 year period
  - High concentrations of PAH, some CDD/F Contamination

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# Sydney Tar Ponds

- Tars and Sludge gathered in a series of lagoons
- For the last two decades covered with water
  - But out of site is not out of mind
  - High leukemia and other health problems
- Also, the home of a failed FBC solution

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# Solutions and Initiatives

- Possible solutions include
  - Reviving the twin FBC incinerators
  - Burning material in Point Aconi (5-10% mixture)
- Build Completely new facilities
- Federal Government has now committed $450M to solve the problem

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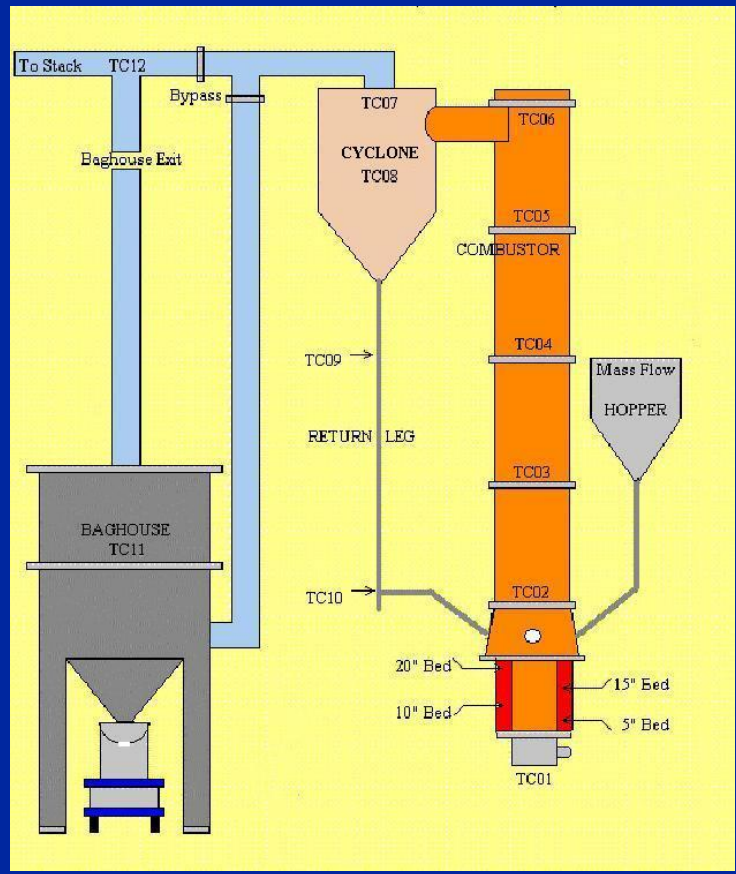
# RFP for solutions to Sydney Tar Ponds Problems in 2002

- CETC with Colmac Resources Ltd one of two “winners” to provide solutions
- Sludges were mixed with coal in a 10:90% mixture
- Tests carried out in CETC 100 mm CFBC Pilot Plant
- Premixed Limestone used for trials (90-92% $CaCO_3$)
- The fate of the heavy metals/PAHs critical to the success of the tests.



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# 20 gallons of Sludge Sample shipped in 45 gallon drum

- 20 gallons sludge shipped in 45 gallon drum
- Consists of coarse to fine grained sand, silt and tar
- Contaminants include PAH, PCB, heavy metals other organics, coal tar and raw sewage
- Average PAH 6000 mg/kg, PCB < 5 mg/kg
- Sample had average 54% moisture higher than 40% planned
- Sludge mixed with coal 10:90 sludge: coal and 0.25 kg of $CaCO_3$ mixed to give Ca:S molar ratio of 2.2

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# Typical Organic Sludge Components (mg/kg)

| | | | |
|---|---|---|---|
| Benzene | 55 | Benzo (a) anthracene | 169 |
| Toluene | 100 | Benzo (a) pyrene | 145 |
| ethylbenzene | 15 | Benzo (b) fluoranthracene | 263 |
| xylenes | 64 | Dibenzo (a,h) anthracene | 31 |
| $C_6$-$C_{10}$ aliphatics | 830 | Indo (1,2, 3-cd) pyrene | 74 |
| C10-C21 | 18,400 | Napthalene | 827 |
| C21-C32 | 30,900 | Phenanthrene | 587 |
| PCB | 3 | Pyrene | 337 |
| Total PAH | 4064 | | |

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# Typical Metals (mg/kg)

| | | | |
|---|---|---|---|
| Percent moisture | 38% | Fe | 29,400 |
| Al | 8,650 | Pb | 204 |
| As | 48 (12) | Mo | 6 |
| Ba | 100 | Ni | 12.6 |
| Be | 1.1 | Se | 2.7 |
| Cd | 1(22) | Zn | 368(360) |
| Cr | 27 | V | 18 |
| Co | 5.6(300) | Hg | 1.4 |
| Cu | 91 | | |

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# Proximate Analysis

| | Piney Creek Coal | Tar Ponds Sludge | Coal:Sludge | Fuel:$CaCO_3$ |
|---|---|---|---|---|
| Moisture | 1.8 | 51 | 1.7 | 1.4 |
| Ash | 27.6 | 20.62 | 27.3 | 37.8 |
| Fixed Carbon | 41.2 | - | 29.8 | 34.0 |

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# Ultimate Analysis & Calorific Value

| | Piney Creek Coal | Tar Ponds Sludge | Coal:Sludge | Fuel:$CaCO_3$ |
|---|---|---|---|---|
| Carbon | 55.5 | 18.4 | 56.4 | 45.2 |
| Hydrogen | 3.7 | 7.4 | 3.9 | 3.0 |
| Nitrogen | 1.1 | 0.6 | 1.0 | 0.8 |
| Sulphur | 3.6 | 1.1 | 3.2 | 1.9 |
| Oxygen (by diff.) | 6.8 | - | 6.9 | 9.9 |
| Calorific Value MJ/kg | 23.14 | 22.6 | 23.44 | 17.34 |

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# Test Conditions

- Three tests were run
- Standard gas analysis was done along with
  - PCBs, PCDD/DF, PAH measured by EPA method 23
  - HCl by EPA method 50
  - Metals and Particulates by EPA method 29
  - Grab samples also taken for total hydrocarbons
  - Tests were very steady with mean temperature of 855-859ºC

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# Test Conditions

| | | | |
|---|---|---|---|
| Fuel feed rate (kg/h) | 5.0±0.04 | 5.3 ±0.15 | 5.3 ±0.11 |
| Total fuel mix fed during stack gas sampling (kg) | 14.0 | 21.3 | 16.4 |
| Gas vel. (bed) (m/s) | 1.5 ±0.2 | 1.9 ±0.2 | 1.8 ± 0.2 |
| Gas vel. (riser) (m/s) | 2.8 ±0.2 | 2.7 ±0.2 | 2.6 ±0.2 |
| Av. Bed temp. (ºC) | 859 ±3.8 | 857 ±5.8 | 856 ±5.9 |
| Av. Comb. temp. (ºC) | 858 ±5.6 | 860 ±15.8 | 835 ±21.6 |
| Total air (kg/h) | 23.3 ±2.1 | 22.6 ±1.7 | 22.5 ±1.4 |

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# Gas Emissions

| | Run 1 | Run 2 | Run 3 |
|---|---|---|---|
| $O_2$ % | 4.0 ±0.56 | 3.3 ±0.67 | 2.98 ±0.67 |
| $CO_2$ % | 15.1 ±0.43 | 15.9 ±0.63 | 16.1 ±0.62 |
| CO ppm | 1217 ±114 | 1623 ±429 | 2214 ±559 |
| $SO_2$ ppm | 342 ±71 | 405 ±192 | 319 ±68 |
| $NO_x$ ppm | 179 ±12 | 199 ±22 | 154 ±24 |

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# Other Emission Results

| | Run 1 | Run 2 | Run 3 |
|---|---|---|---|
| Ca:S | 2.2 | 2.2 | 2.2 |
| $\eta_{SO2}$ | 89.9±3.0 | 89.0 ±6.0 | 91.3 ±2.4 |
| Fuel N to $NO_x$ % | 5.97 ±0.91 | 6.11 ±1.1 | 4.73 ±1.0 |
| Hg µg/$m^3$ | 0.042 | | |
| Particulate matter mg/$m^3$ | 2.87 | | |

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# Hydrocarbons by GC and other emissions

- With the exception of hexane plus which was 0.2 and 0. 1 for runs 1 and 3 respectively all other hydrocarbons were below detection limits (<100 ppm)
  - Includes CH4, C2H6, C3H8, C2H4, C3H6, C2H2, n and iso-butane etc.
  - HCl was 0.79 mg/$m^3$
  - All heavy metals in stack gases were at acceptable levels

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# VOC from Run 2

- Most detectable levels of VOCs in the flue gas were below detection limits
- Detectable VOCs were benzene (82 and 39 µg/m$^3$ for cartridges 1&3 respectively) and toluene (9.6 and 6.4 µg/m$^3$ for cartridges 1&3 respectively)
- For comparison Garcia et al., 1992 report benzene concentrations of 20 µg/m$^3$ and toluene concentrations of 63 µg/m$^3$ for a PF plant firing Coal, while limits from an industrial CFBC were 9.0 µg/m$^3$ for benzene and 1.4 µg/m$^3$ for toluene

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# PCDD/Fs

- Concentration of all 17 2,3,7,8 substituted congeners was 11 pg/$m^3$
- Total PCDD/F were 496 pg/$m^3$ (cf with industrial CFBC of 405 pg/$m^3$ )
- TEQ of PCDD/F was 0.011 pg/$m^3$ (cf with industrial CFBC boiler burning coal with 5.6 pg/$m^3$ )
- Minibed will be able to reach the new “2008” gas release limit (TEQ 0.032 ng/$m^3$)

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# Conclusions

- Sulphur capture efficiencies were achieved of 89-90% with Ca:S molar ratio of 2.2, fuel NOx emissions were good, and CO levels reasonable for this type of small CFBC
- PCBs and PAH emissions were all comparable or lower than seen with industrial CFBC, despite the nature of the fuel
- Benzene and toluene were relatively high
- Dioxin and Furan emissions are also acceptable
- The Sydney Tar Ponds Sludge can be burnt in a CFBC