CONTRACT NO. A932-126
FINAL REPORT
APRIL 1996

Atmospheric Pollutant Emission Factors From Open Burning of Agricultural and Forest Biomass by Wind Tunnel Simulations

Volume 2: Results, Cereal Crop Residues

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

AIR RESOURCES BOARD
Research Division

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Volume 2
Results, Cereal Crop Residues

Prepared for:

California Air Resources Board
Research Division
2020 L Street
Sacramento, CA 95814

Prepared by:

B.M. Jenkins, Principal Investigator
Department of Biological and Agricultural Engineering, University of California, Davis

S.Q. Turn, R.B. Williams, M. Goronea, H. Abd-el-Fattah, J. Mehlschau, N. Raubach
Department of Biological and Agricultural Engineering, University of California, Davis

D.P.Y. Chang, M. Kang
Department of Civil and Environmental Engineering, University of California, Davis

S.V. Teague, O.G. Raabe
Institute for Toxicology and Environmental Health, University of California, Davis

D.E. Campbell, T.A. Cahill
Air Quality Group, Crocker Nuclear Laboratory, University of California, Davis

L. Pritchett, J. Chow
Desert Research Institute, University of Nevada System, Reno

A. Daniel Jones
Facility for Advanced Instrumentation, University of California, Davis

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Table 3.1.1.1

Fuel and Ash Analyses

Run Date	30-Apr-92	30-Apr-92
Fuel Type	Rice Straw	Rice Straw
Sample Type	Fuel	Ash
Ultimate Analysis		
(% dry weight)		
C		7.36
H		0.70
N		0.15
Elemental Analysis		
(% by weight dry basis)		
N		0.30
P		0.19
K		3.49
Ca		1.17
Mg		0.60
Na		0.39
Cl		0.37
(mg/kg dry weight)		
S		620
B		17
Zn		82
Mn		2,700
Fe		1,290
Cu		16
Si		
Total (% dry weight)		15.04
Proximate Analysis		
(% dry weight)		
Ash	17.23	86.56
Volatiles	69.85	9.24
Fixed Carbon	12.91	4.20
Higher Heating Value		
(MJ/kg dry weight)	15.5065	3.6690

Table 3.1.1.2. Operating conditions and concentrations, rice straw, 30 April 92.

Fuel:	Rice Straw	Date of Test:	30-Apr-92
		Configuration:	CRNF
Fuel Loading Rate (g/sq.m w.b.):	680		
Total Fuel Consumption (kg w.b.)	133.4		
Total Ash Recovered (kg w.b.)	27.6		
Ash Fraction (w.b.)	0.21		

	Traverse 1	Traverse 2	Traverse 3
Mean Values			
Air Temperature (°C)	35.72	37.48	36.03
Air Relative Humidity (%)	21.99	15.90	18.77
Inlet Air Temperature (°C)	30.35	31.50	29.82
Stack Temperature (°C)	53.15	56.89	58.26
Impinger Outlet Temperature (°C)	20.86	21.22	22.14
Fire Spreading Rate (m/min)	0.66	0.72	0.67
Stack Gas Velocity (m/s)	1.94	1.85	1.81
Gas and PM Concentrations (less background)			
CO (ppmv)	129.55	58.57	67.99
NO (ppmv)	4.64	5.14	5.44
NOx (ppmv)	5.61	5.92	6.26
SO2 (ppmv)	1.24	1.27	1.32
HC (ppmv as CH4 by GC)	5.16	3.82	5.48
CH4 (ppmv by GC)	3.68	2.99	2.83
NMHC (ppmv as CH4 by GC)	1.48	0.83	2.65
CO2 (ppmv by GC)	2,022	1,893	2,180
Total S (ppmv as SO2)	1.83	1.78	1.93
PM (mg/cu.m)	11.50	13.27	
PM10 (mg/cu.m)	10.81	12.87	
PM2.5 (mg/cu.m)	9.20	11.61	

Table 3.1.1.3. Mass balance, rice straw, 30 April 92.

Fuel: Rice Straw

Date of Test: 30-Apr-92

Configuration: CRNF

Mass Balance

	Traverse 1	Traverse 2	Traverse 3
Total Conveyor Travel (m)	31.61	34.42	32.15
Fuel Moisture Content (% w.b.)	10.1	10.8	8.4
Fuel Loading Rate (g/sq.m d.b.)	611	607	623
Total Fuel Consumption (g w.b.)	26,203	28,532	26,650
Total Fuel Consumption (g d.b.)	23,556	25,451	24,412
Residual Ash (g w.b.)	5,433	5,916	5,526
Fuel Vaporized (g w.b.)	20,770	22,617	21,125
Fuel Consumption Rate (g/s w.b.)	9.10	9.91	9.25
Fuel Consumption Rate (g/s d.b.)	8.18	8.84	8.48
Ash Generation Rate (g/s w.b.)	1.89	2.05	1.92
Fuel Vaporization Rate (g/s w.b.)	7.21	7.85	7.33
Stack Gas Density (kg/cu.m)	1.0832	1.0709	1.0664
Stack Gas Flow Rate (cu.m/s)	2.89	2.75	2.69
Stack Gas Mass Flow Rate (kg/s)	3.13	2.94	2.87
Inlet Air Mass Flow Rate (kg/s)	3.12	2.93	2.86
Overall Air-Fuel Ratio (w.b.)	342.85	295.93	309.56
Overall Air-Fuel Ratio (d.b.)	381.36	331.75	337.95

Table 3.1.1.4. Emission factors, rice straw, 30 April 92 (integrated basis)

Fuel: Rice Straw | Date of Test: 30-Apr-92 | Configuration: CRNF

Emission Factors (% fuel dry weight)

Integrated Basis

	Traverse 1	Traverse 2	Traverse 3	Average
CO	4.767	1.878	2.233	2.959
NO	0.184	0.176	0.191	0.184
NOx (as NO2)	0.341	0.311	0.336	0.330
SO2	0.099	0.093	0.099	0.097
HC (as CH4 by GC)	0.109	0.070	0.102	0.094
CH4 (by GC)	0.078	0.055	0.053	0.062
NMHC (as CH4 by GC)	0.031	0.015	0.049	0.032
CO2 (by GC)	117.239	95.540	112.065	108.281
Total S (as SO2)	0.153	0.129	0.144	0.142
SO2/Total S	0.64	0.72	0.68	0.68
PM	0.366	0.368		0.367
PM10	0.344	0.357		0.350
PM2.5	0.293	0.322		0.307
MMAD (μm)	0.127	0.083		0.105
σ	8.579	4.985		

Table 3.1.1.5. Emission factors, rice straw, 30 April 92 (average basis).

Fuel: Rice Straw | Date of Test: 30-Apr-92 | Configuration: CRNF

Emission Factors (% fuel dry weight)

Average Basis

	Traverse 1	Traverse 2	Traverse 3	Average
CO	4.781	1.881	2.224	2.962
NO	0.183	0.177	0.191	0.184
NOx (as NO2)	0.340	0.313	0.336	0.330
SO2	0.105	0.093	0.098	0.099
HC (as CH4 by GC)	0.109	0.070	0.102	0.094
CH4 (by GC)	0.078	0.055	0.053	0.062
NMHC (as CH4 by GC)	0.031	0.015	0.049	0.032
CO2 (by GC)	117.239	95.540	112.065	108.281
Total S (as SO2)	0.154	0.131	0.145	0.143
SO2/Total S	0.68	0.71	0.68	0.69
PM	0.366	0.368		0.367
PM10	0.344	0.357		0.350
PM2.5	0.293	0.322		0.307
MMAD (μm)	0.127	0.083		0.105
σ	8.579	4.985		

Table 3.1.1.6. Carbon balance.

Date of Test: Fuel	30-Apr-92 Rice Straw Traverse 1	30-Apr-92 Rice Straw Traverse 2	30-Apr-92 Rice Straw Traverse 3
Carbon Balance			
Dry Fuel Consumption Rate (g/s)	8.18	8.84	8.48
Ash Generation Rate (g/s)	1.89	2.05	1.92
Ash Fraction (% dry basis)	23.11	23.19	22.64
Fuel Carbon Concentration* (%)	37.96	37.96	37.96
Residual Ash Carbon Concentration (%)	7.36	7.36	7.36
Carbon released to stack (g/s)	2.97	3.20	3.08
Maximum CO2 emission factor (%)	132.95	132.93	133.08
Stack Gas Density (kg/cubic meter)	1.08	1.07	1.07
Average CO2 concentration (ppmv)	2,022	1,893	2,180
Average CO concentration (ppmv)	129.55	58.57	67.99
Average THC concentration (ppmv as CH4)	5.16	3.82	5.48
PM Concentration** (mg/cubic meter)	11.50	13.27	12.39
PM Carbon Concentration† (%)	39.44	39.44	39.44
PM Carbon (mg/cubic meter)	4.54	5.23	4.88
Stack Gas Temperature (°C)	53.15	56.89	58.26
Impinger Temperature (°C)	20.86	21.22	22.14
PM molar concentration (ppm)	9.12	10.53	9.86
Estimated Average Stack Gas Velocity (m/s)	2.06	2.48	2.07
Emission Factors (% Average Basis):			
CO2	117.239	95.54	112.065
CO	4.781	2.224	2.224
HC (as CH4)	0.109	0.07	0.102
PM**	0.366	0.368	0.367
Emission Factors (% Integrated Basis):			
CO2	117.239	95.54	112.065
CO	4.767	1.878	2.233
HC (as CH4)	0.109	0.07	0.102
PM**	0.366	0.368	0.367
Closure (% Average Basis)	94	75	87
Closure (% Integrated Basis)	94	74	87

*Fuel analysis from run of 9 June 92

**Average of Traverses 1 and 2 used for Traverse 3.

†No analysis for run of 30 April 92. Average concentration from run of 9 June 92.

Table 3.1.1.7. Nitrogen balance

Date of Test:	30-Apr-92	30-Apr-92	30-Apr-92
Fuel	Rice Straw Traverse 1	Rice Straw Traverse 2	Rice Straw Traverse 3
Nitrogen Balance			
Fuel Nitrogen Concentration* (% dry weight)	0.60	0.60	0.60
Ash Nitrogen Concentration (% weight)	0.30	0.30	0.30
Emission Factors (% Average Basis):			
NOx (as NO2)	0.340	0.313	0.336
PM	0.366	0.368	0.367
Emission Factors (% Integrated Basis):			
NOx (as NO2)	0.341	0.311	0.336
NO3- Concentration of PM† (% weight)	0.149	0.149	0.149
NH4+ Concentration of PM† (% weight)	1.429	1.429	1.429
Nitrogen Concentration of PM (%)	1.145	1.145	1.145
Fuel Nitrogen (mg/s)	49.08	53.04	50.88
Ash Nitrogen (mg/s)	5.67	6.15	5.76
Nitrogen as NOx (mg/s Average Basis)	8.46	8.42	8.67
Nitrogen as NOx (mg/s Integrated Basis)	8.49	8.37	8.67
Nitrogen as PM (mg/s Average Basis)	0.34	0.37	0.36
Nitrogen as NOx+PM (mg/s Average Basis)	8.81	8.79	9.03
Nitrogen as NOx+PM (mg/s Integrated Basis)	8.83	8.74	9.03
NOx+PM Nitrogen/Fuel Nitrogen (Average)	0.179	0.166	0.177
NOx+PM Nitrogen/Fuel Nitrogen (Integrated)	0.180	0.165	0.177
Ash Nitrogen/Fuel Nitrogen	0.116	0.116	0.113
Ash+NOx+PM Nitrogen/Fuel Nitrogen (Average)	0.295	0.282	0.291
Ash+NOx+PM Nitrogen/Fuel Nitrogen (Integrated)	0.295	0.281	0.291

*Fuel analysis from run of 9 June 92

†No analysis for run of 30 April 92. Average concentration from run of 9 June 92.

Table 3.1.1.8. Sulfur balance.

Date of Test:	30-Apr-92	30-Apr-92	30-Apr-92
Fuel	Rice Straw Traverse 1	Rice Straw Traverse 2	Rice Straw Traverse 3
Sulfur Balance			
Fuel Sulfur Concentration* (mg/kg dry weight)	668	668	668
Ash Sulfur Concentration (mg/kg weight)	620	620	620
Emission Factors (% Average Basis)			
SO2	0.105	0.093	0.098
PM	0.366	0.368	0.367
Emission Factors (% Integrated Basis)			
SO2	0.099	0.093	0.099
Sulfur Concentration of PM† (% weight)	1.016	1.016	1.016
Fuel Sulfur (mg/s)	5.46	5.91	5.66
Ash Sulfur (mg/s)	1.17	1.27	1.19
Sulfur as SO2 (mg/s Average Basis)	4.29	4.11	4.16
Sulfur as SO2 (mg/s Integrated Basis)	4.05	4.11	4.20
Sulfur as PM (mg/s Average Basis)	0.30	0.33	0.32
Sulfur as SO2+PM (mg/s Average Basis)	4.60	4.44	4.47
Sulfur as SO2+PM (mg/s Integrated Basis)	4.35	4.44	4.51
SO2+PM Sulfur/Fuel Sulfur (Average Basis)	0.842	0.752	0.789
SO2+PM Sulfur/Fuel Sulfur (Integrated Basis)	0.797	0.752	0.797
Ash Sulfur/Fuel Sulfur	0.214	0.215	0.210
Closure (% Average Basis)	106	97	100
Closure (% Integrated Basis)	101	97	101

*Fuel analysis from run of 9 June 92

†No analysis for run of 30 April 92. Average concentration from run of 9 June 92.

Table 3.1.1.9. Water balance.

Estimated Stack Humidity

Fuel	Rice Straw
Configuration	CRNF
Date of Test	30-Apr-92

	Traverse 1	Traverse 2	Traverse 3
Ambient Air Temperature °C)	36	37	36
Ambient Air Relative Humidity (%)	22	16	19
Air Temperature (K)	309	311	309
Saturation Pressure (Pa)	5,856	6,447	5,956
Vapor Pressure (Pa)	1,288	1,025	1,118
Air Dew Point Temperature (°C)	10.7	7.4	8.6
Ambient Volume Fraction Water Vapor	0.0127	0.0101	0.0110
Ambient Mass Fraction Water Vapor	0.0079	0.0063	0.0068
Fuel Burning Rate (g/s wet basis)	9.10	9.91	9.25
Fuel Moisture Content (%)	10.1	10.8	8.4
Ash Fraction (wet basis)	0.21	0.21	0.21
Fuel Hydrogen Content (%)	5.65	5.65	5.65
Ash Hydrogen Content (%)	0.70	0.70	0.70
Moisture Evaporated (g/s)	0.92	1.07	0.78
Water of Combustion (g/s)	4.04	4.36	4.19
Total Fuel Water Added (g/s)	4.96	5.43	4.96
Inlet Air Mass Flowrate (g/s)	3,120	2,930	2,860
Inlet Air Water Vapor Flowrate (g/s)	25	18	20
Total Stack Water Vapor Flowrate (g/s)	30	24	25
Stack Gas Mass Flowrate (g/s)	3,127	2,938	2,867
Mass Fraction Water Vapor in Stack	0.0095	0.0081	0.0086
Volume Fraction Water Vapor in Stack	0.0152	0.0131	0.0138
Stack Vapor Pressure (Pa)	1,544	1,324	1,398
Stack Temperature (°C)	53	57	58
Stack Temperature (K)	326	330	331
Stack Saturation Pressure (Pa)	14,415	17,243	18,392
Stack Relative Humidity (%)	11	8	8
Stack Dew Point Temperature (°C)	13.5	11.2	12.0
Impinger Outlet Temperature (°C)	20.9	21.2	22.1
Volume Stack Gas Sampled for PM (L)	426	437	
Estimated Impinger/Desiccant Weight Gain (g)	4.8	4.3	

Totals:

	Estimated	Measured
Total Impinger/Desiccant Weight Gain (g)	9.1	ND
Estimated/Measured Weight Gain		

Table 3.1.1.10. Power balance.

Date of Test: Fuel	30-Apr-92 Rice Straw Traverse 1	30-Apr-92 Rice Straw Traverse 2	30-Apr-92 Rice Straw Traverse 3
Power Balance			
Fuel Heating Value (MJ/kg dry weight)	15.5065	15.5065	15.5065
Ash Heating Value (MJ/kg dry weight)	3.6690	3.6690	3.6690
Average Energy Release Rate (kW)	119.9	129.6	124.5
Products of Incomplete Combustion (kW)			
CO	4.0	2.0	1.9
THC (as CH4)	0.5	0.3	0.5
PM	0.4	0.4	0.4
Heat Release Rate (kW)	115.1	126.8	121.7
Fireline Intensity (kW/m)	94.4	104.0	99.8
Stack Gas Flow (kg/s)	3.13	2.94	2.87
Stack Gas Temperature (°C)	53.15	56.89	58.26
Inlet Temperature (°C)	30.35	31.50	29.82
Sensible Power at Top of Stack (kW)	71.8	75.1	82.1
Tunnel Dissipation (kW)	43.3	51.7	39.5

Table 3.1.1.11
VOC Concentrations (ppbv)

Date	30-Apr-92	30-Apr-92
Fuel	Rice Straw	Rice Straw
Traverse	Traverse 1	Traverse 2
Acetic acid		
Propanone (acetone)		
Methyl ester acetic acid (methylacetate)		
Butane		
Dimethyloxirane		
Pentene		
Methylbutanone (isopropylmethyl ketone)		
Furancarboxaldehyde (furfural)		
Benzene	13.1	8.3
Dimethylbutane		
Hexane		
Phenol		
Dimethylfuran		
2-methyl 2-cyclopenten-1-one		
2-chloro phenol		
Toluene	2.4	1.7
Benzonitrile		
Benzaldehyde		
Methylphenol (hydroxy toluene)		
Styrene	1.6	1.5
Xylene	0.7	
Trimethylpentane		
Benzofuran		
Methoxymethylphenol (creosol)		
Naphthalene		
C10H12		
Alpha-pinene		
Camphene		
Δ3-Carene		
Limonene		
No match r.t. (6.7)		
No match r.t. (8.51)		
No match r.t. (8.71)		
No match r.t. (8.73)		
No match r.t.(6.4)		
No match r.t.(8.5)		

Table 3.1.1.12.
VOC Emission Factors (mg/kg)

Date	30-Apr-92	30-Apr-92
Fuel	Rice Straw	Rice Straw
Traverse	Traverse 1	Traverse 2
Fuel Consumption Rate (g/s d.b)	4.44	0.95
Stack Gas Mass Flow Rate (kg/s)	4.00	2.50
Acetic acid		
Propanone (acetone)		
Methyl ester acetic acid (methylacetate)		
Butane		
Dimethyloxirane		
Pentene		
Methylbutanone (isopropylmethyl ketone)		
Furancarboxaldehyde (furfural)		
Benzene	14	7
Dimethylbutane		
Hexane		
Phenol		
Dimethylfuran		
2-methyl 2-cyclopenten-1-one		
2-chloro phenol		
Toluene	3	2
Benzonitrile		
Benzaldehyde		
Methylphenol (hydroxy toluene)		
Styrene	2	2
Xylene	1	
Trimethylpentane		
Benzofuran		
Methoxymethylphenol (creosol)		
Naphthalene		
Unknown		
Alpha-pinene		
Camphene		
Δ3-Carene		
Limonene		

Figure 3.1.1.1. Upstream air conditions, 30 April 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 30-Apr-92

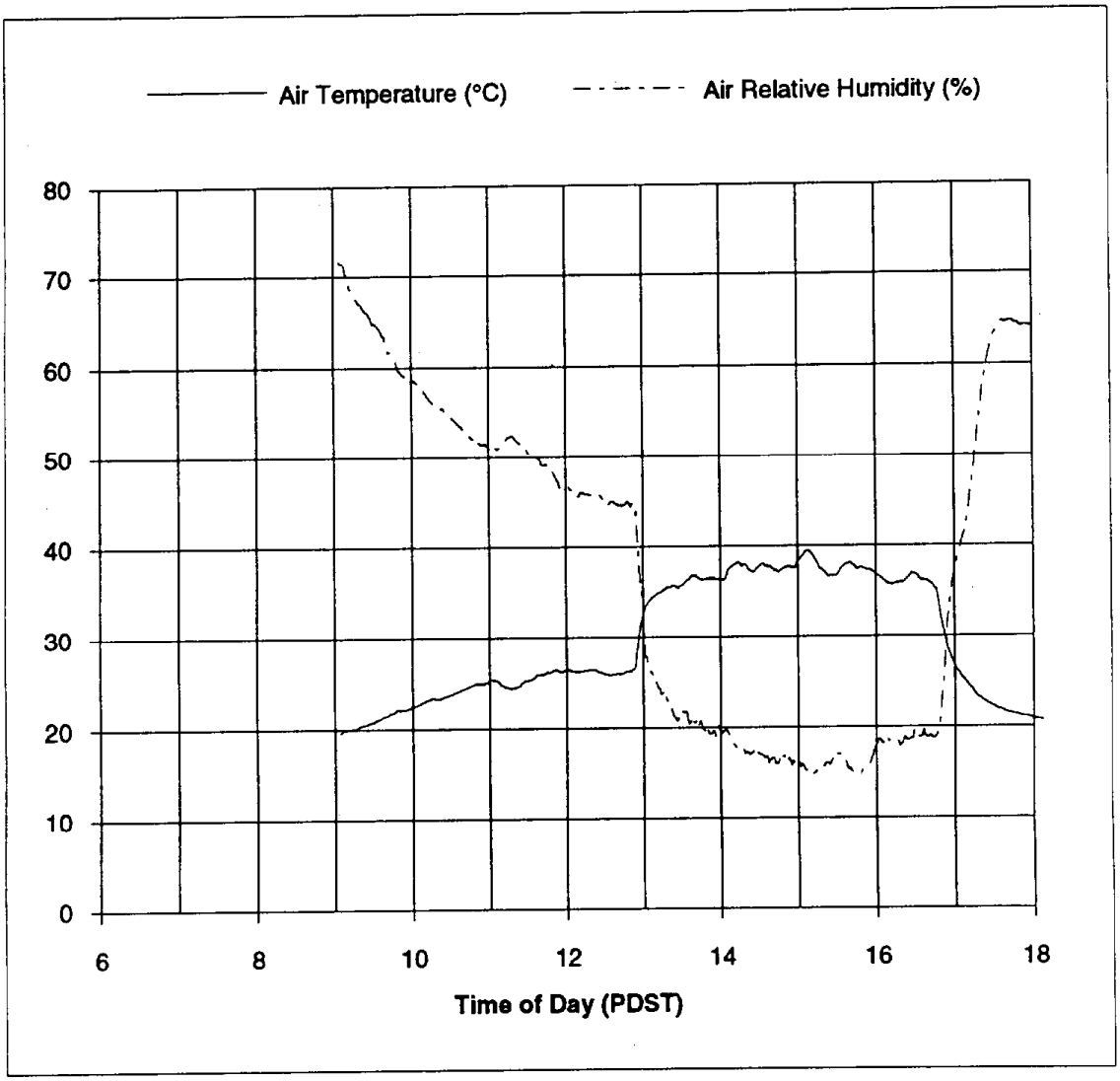


Figure 3.1.1.2. Air temperature and relative humidity from CIMIS station.

Fuel: Rice Straw Date of Test: 30-Apr-92

Configuration: CRNF

Hourly Average CIMIS Data for Davis, California

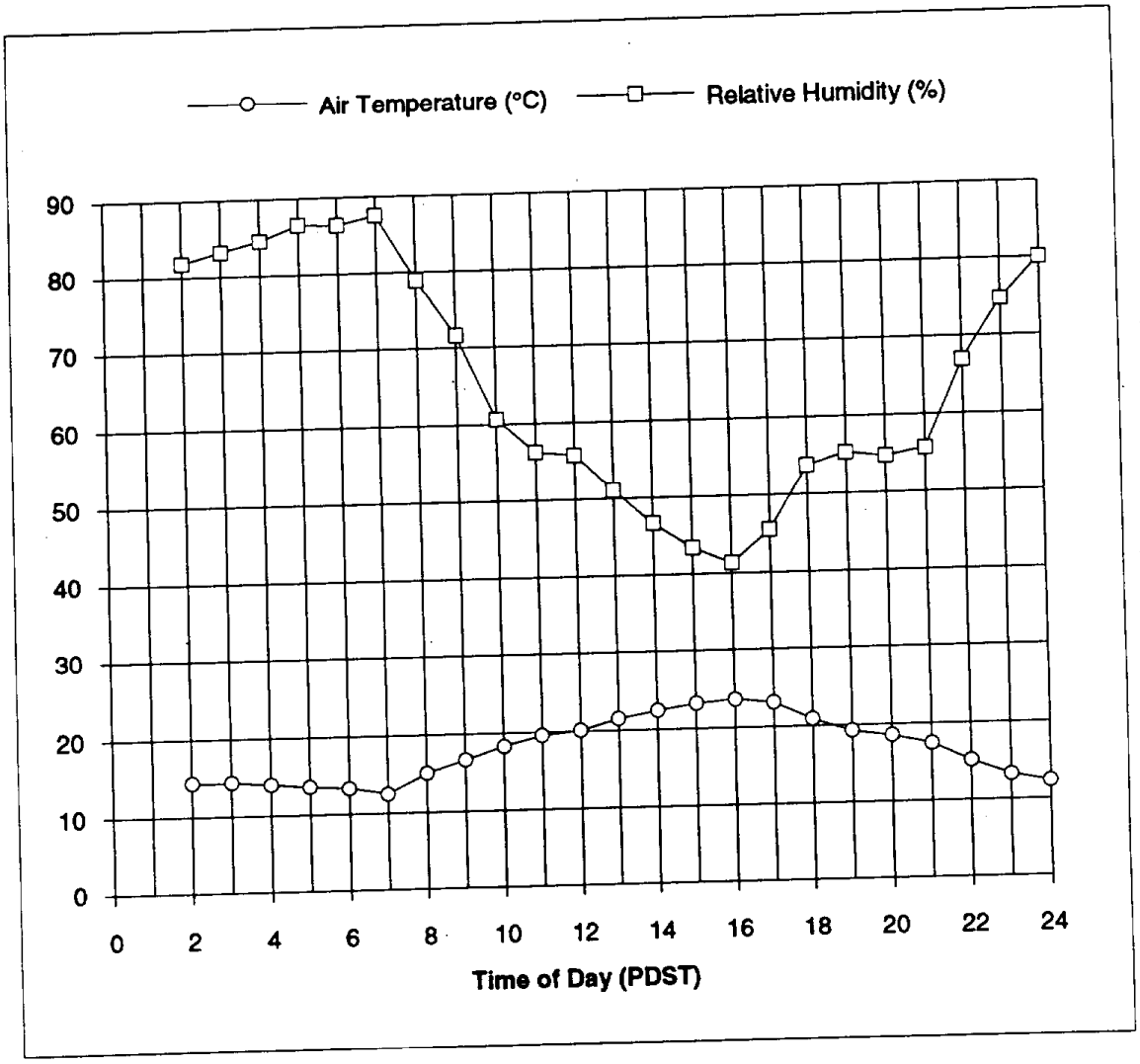


Figure 3.1.1.3. Wind speed from CIMIS station.

Fuel: Rice Straw Date of Test: 30-Apr-92

Configuration: CRNF

Hourly Average CIMIS Data for Davis, California

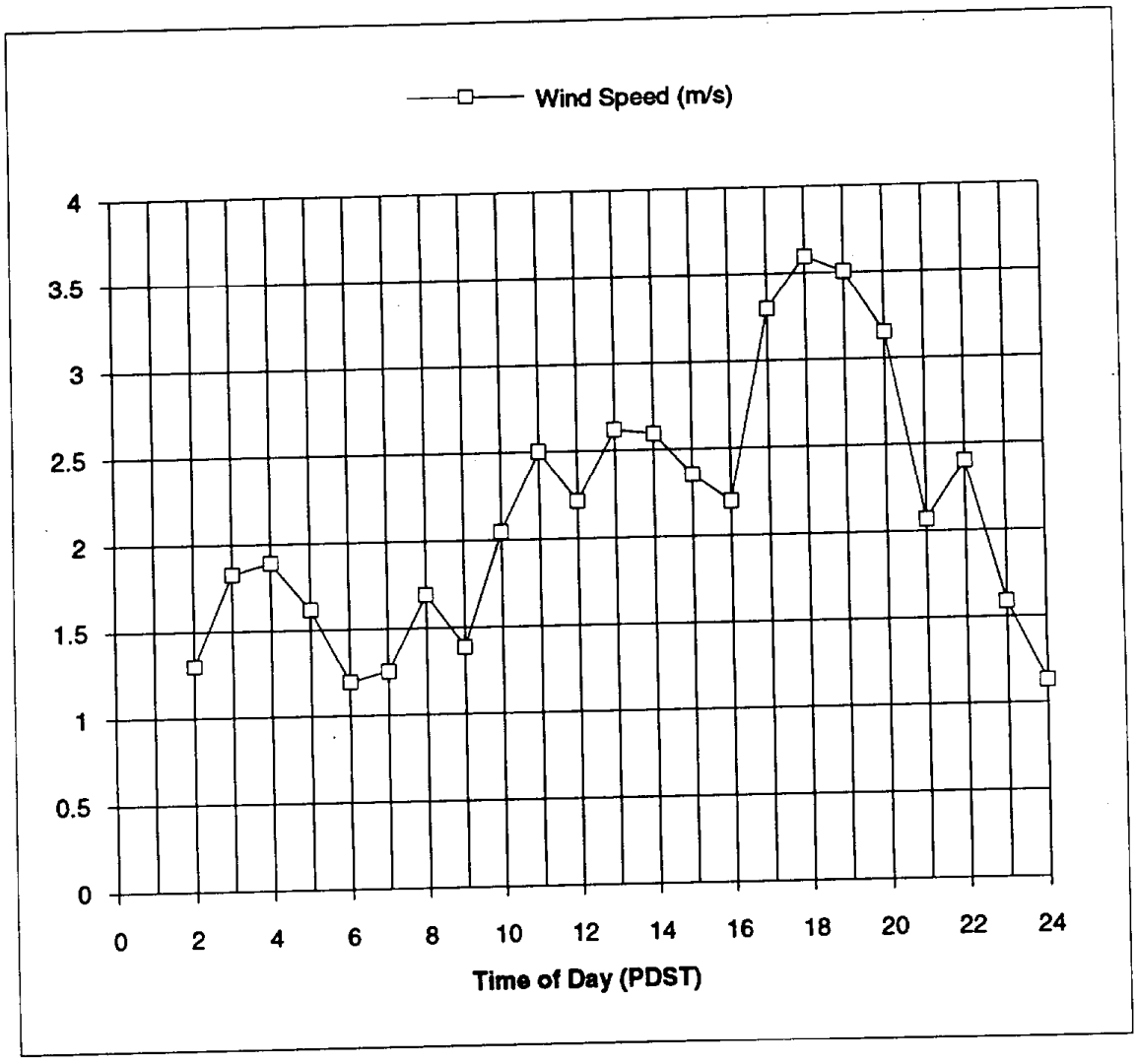


Figure 3.1.1.4. Wind direction and solar radiation from CIMIS station.

Fuel: Rice Straw Date of Test: 30-Apr-92

Configuration: CRNF

Hourly Average CIMIS Data for Davis, California

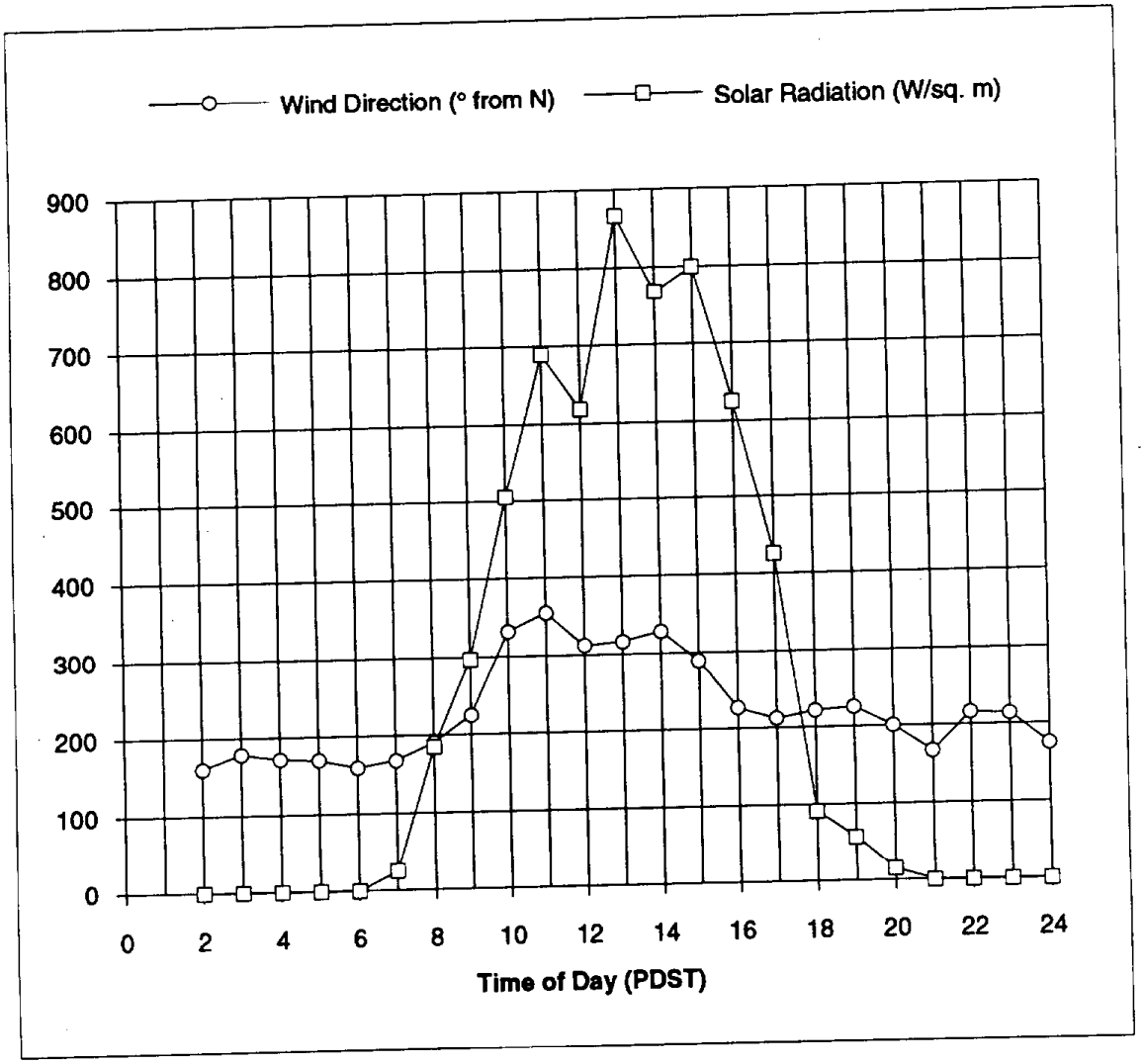


Figure 3.1.1.5. Inlet air, stack gas, and impinger outlet temperatures, 30 April 92.

Fuel Type: Rice Straw
Configuration: CRNF
Test Date 30-Apr-92

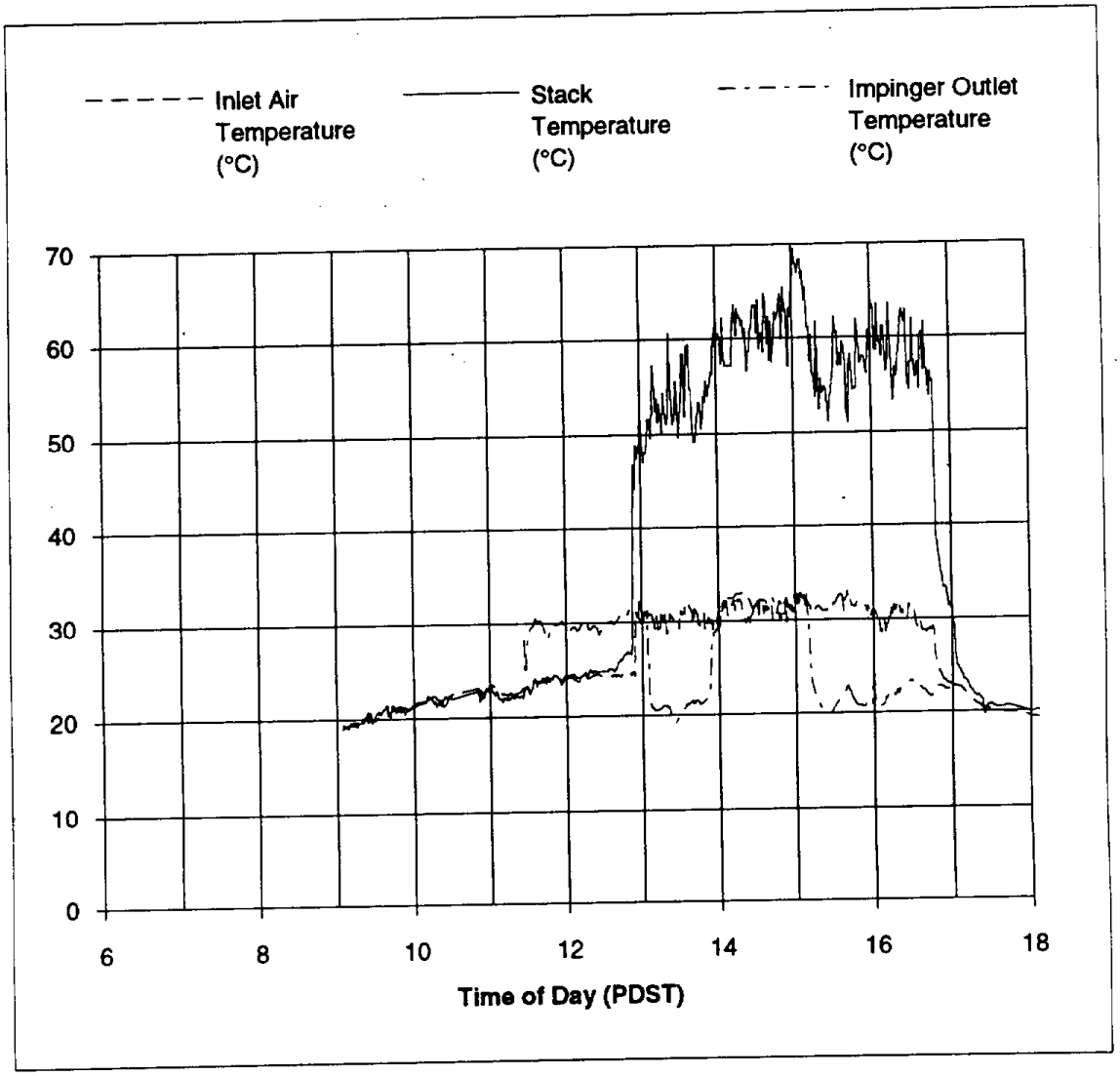


Figure 3.1.1.6. Conveyor speed and stack gas velocity, 30 April 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 30-Apr-92

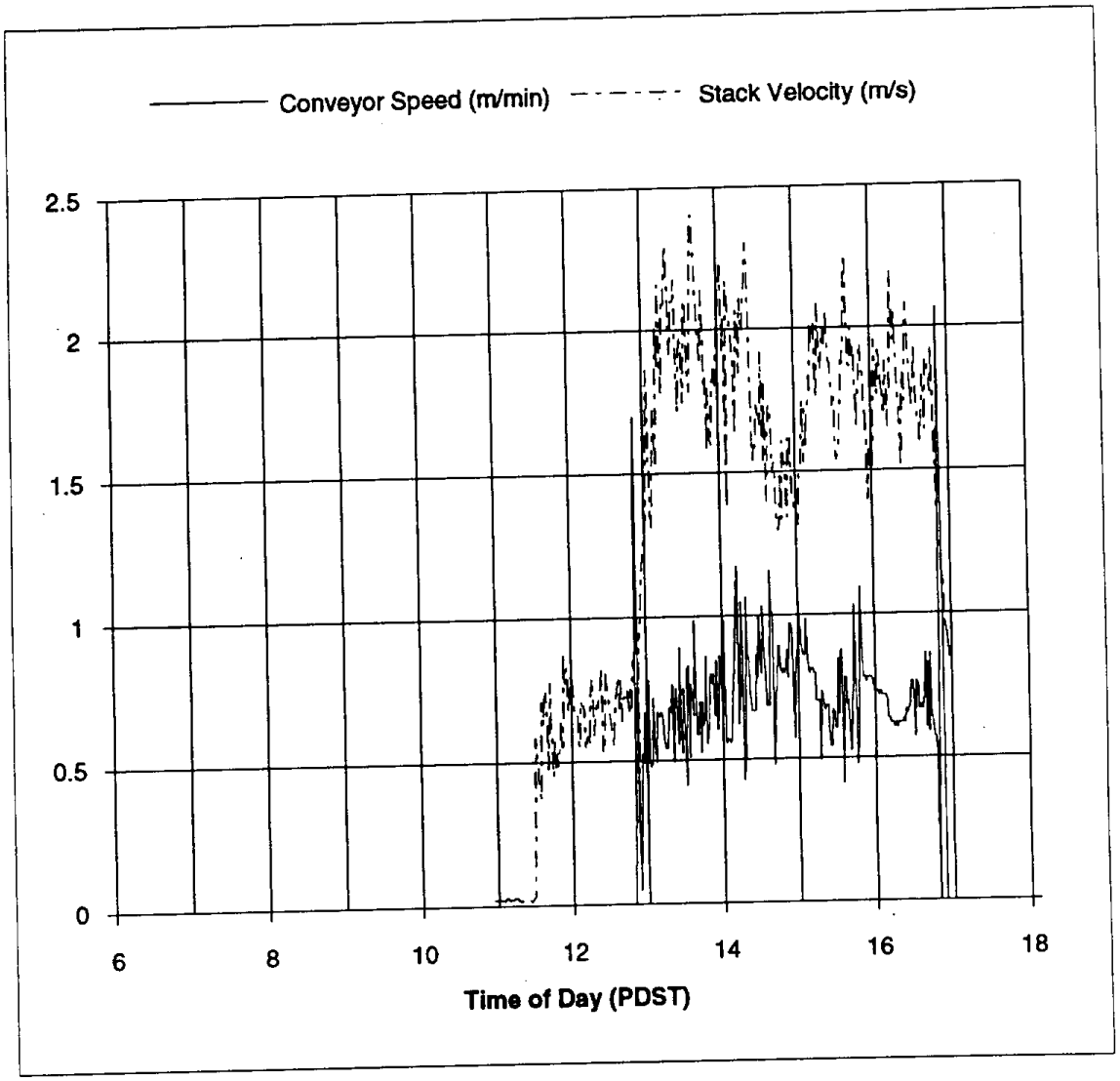


Figure 3.1.1.7. Conveyor speed with 10 min moving average, 30 April 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 30-Apr-92

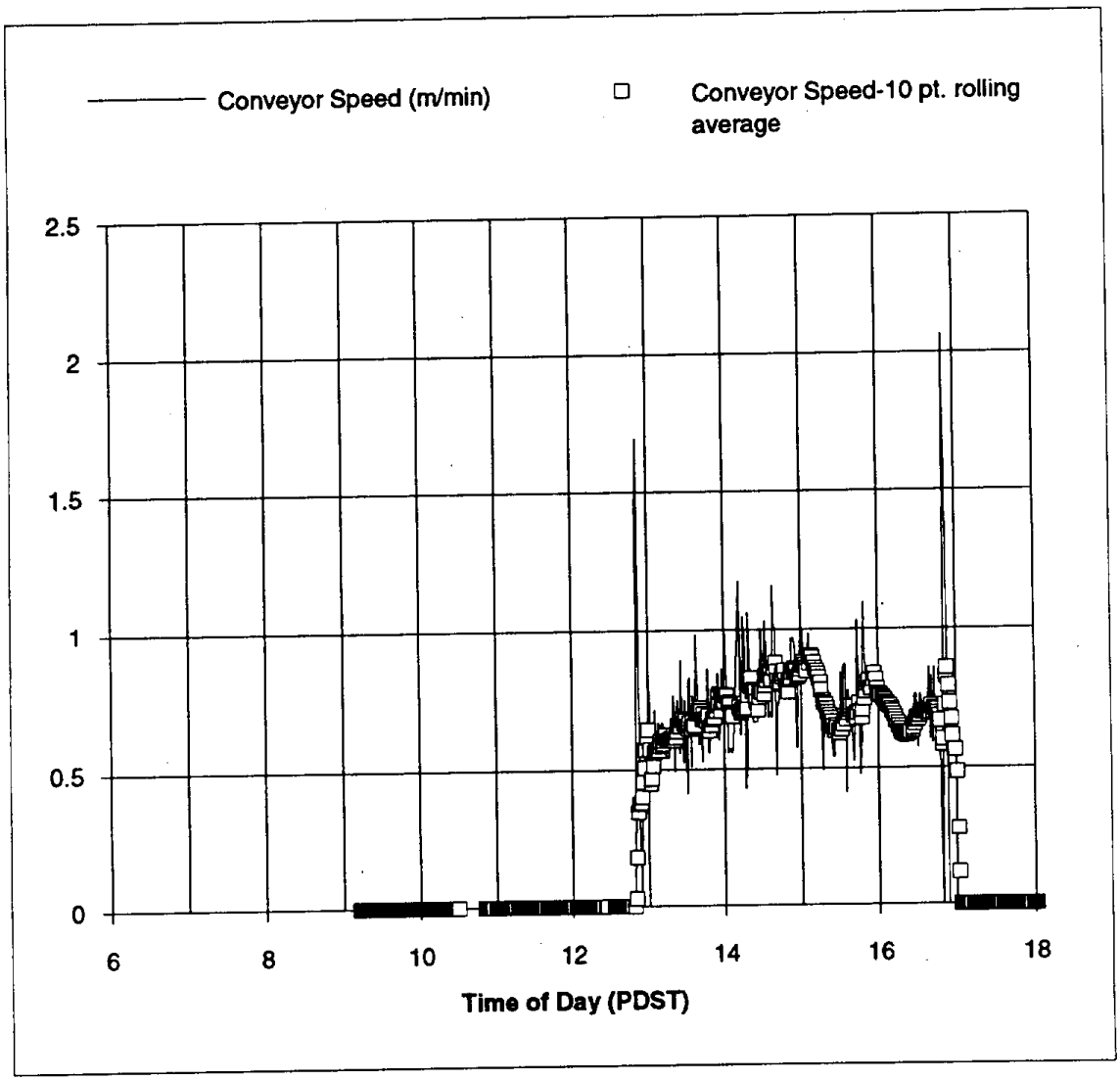


Figure 3.1.1.8. Conveyor travel, 30 April 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 30-Apr-92

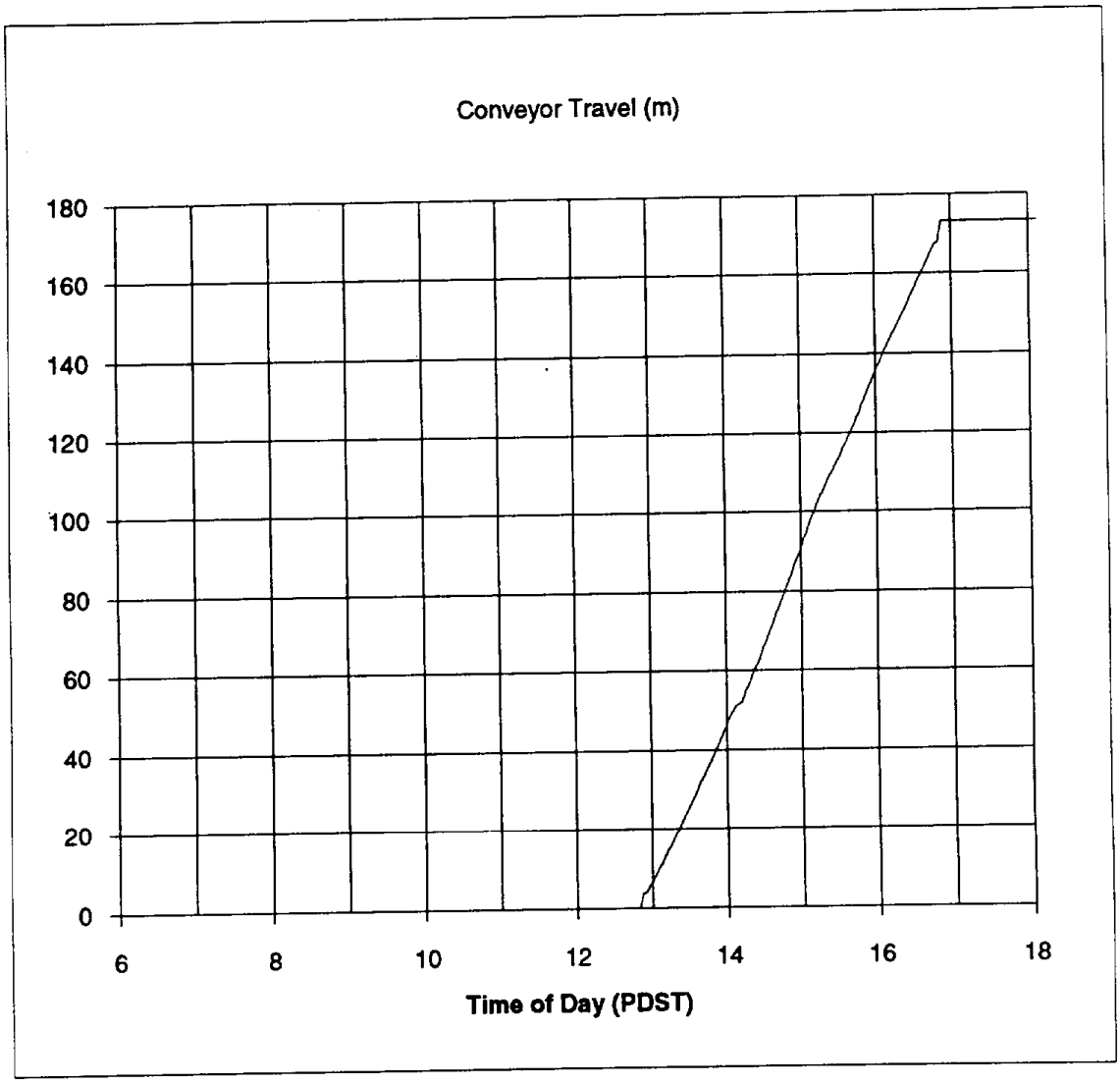


Figure 3.1.1.9. CO concentration in stack gas, 30 April 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 30-Apr-92

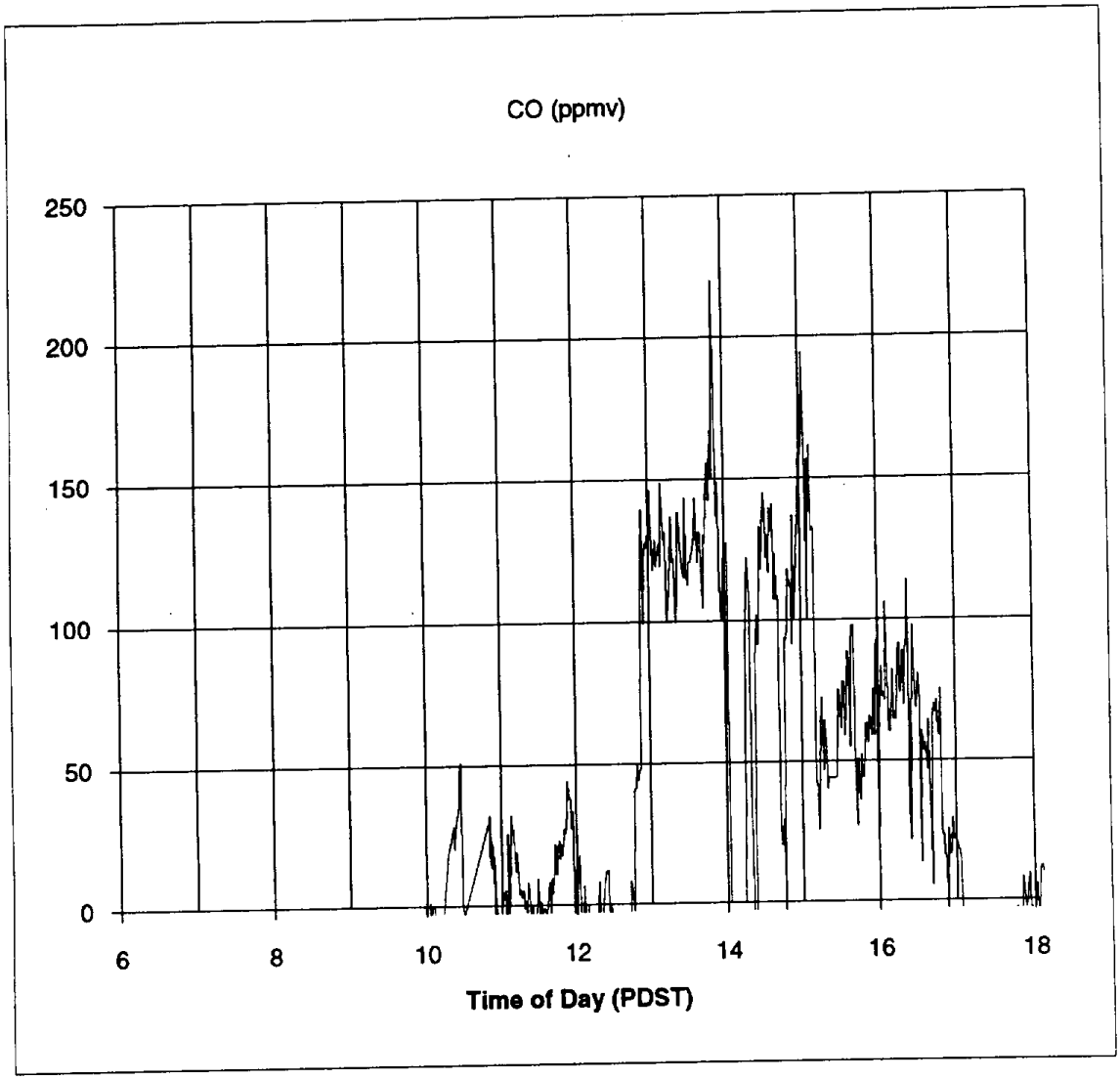


Figure 3.1.1.10. NO and NOx concentrations in stack gas, 30 April 92.

Fuel Type: Rice Straw
Configuration: CRNF
Test Date 30-Apr-92

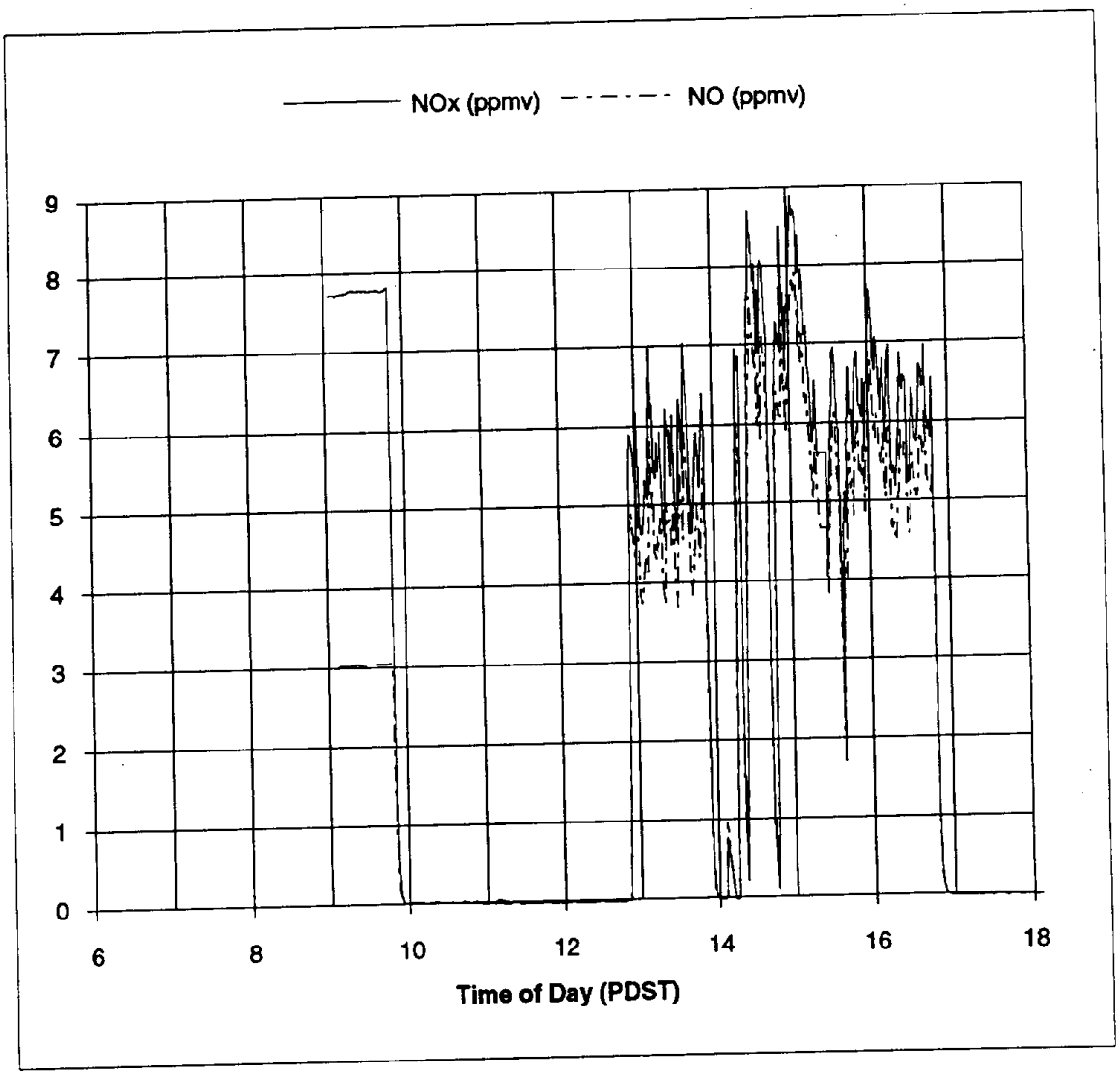


Figure 3.1.1.11. SO2 concentrations in stack gas, 30 April 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 30-Apr-92

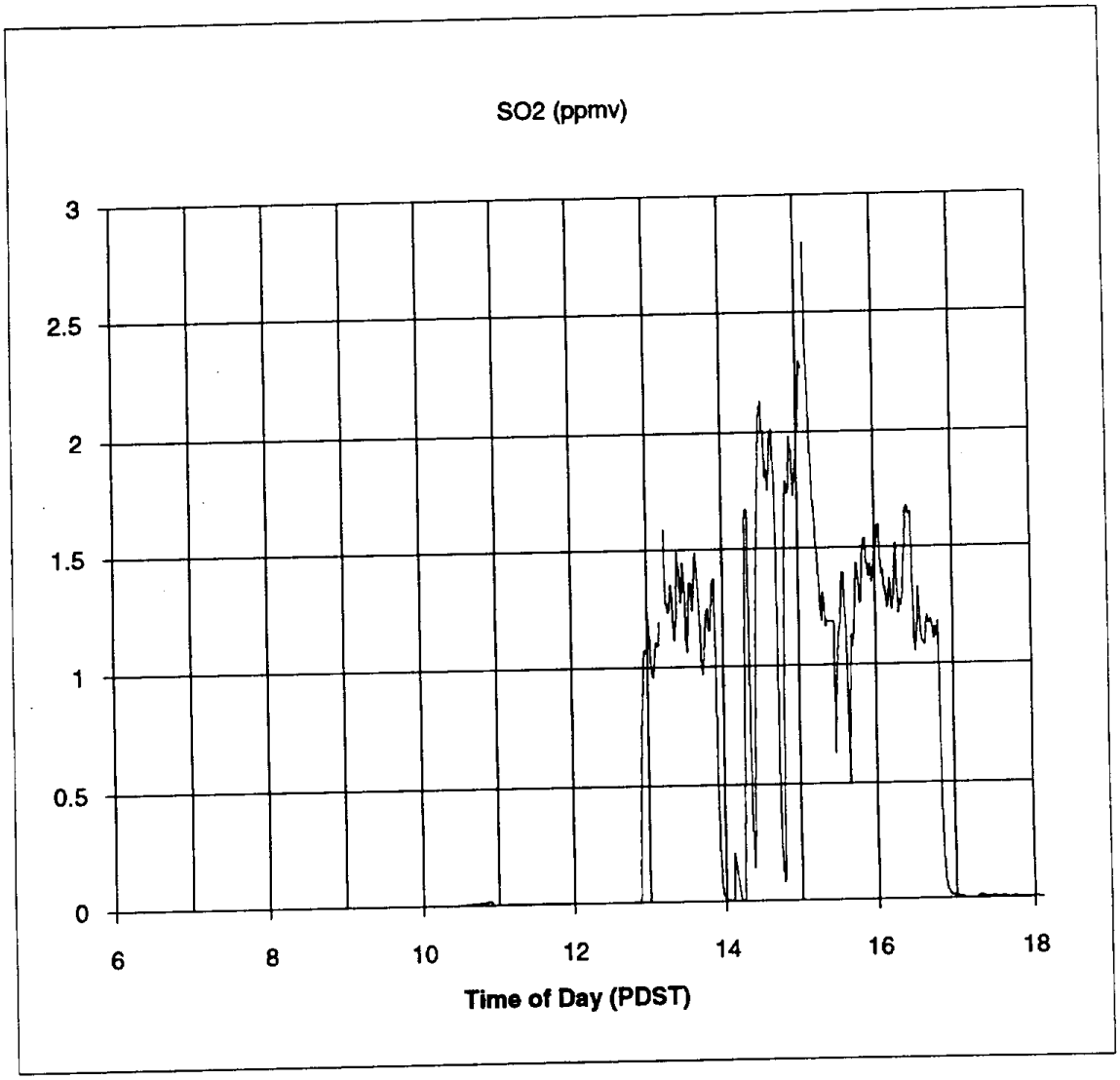


Figure 3.1.1.12. Total sulfur concentration in stack gas, 30 April 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 30-Apr-92

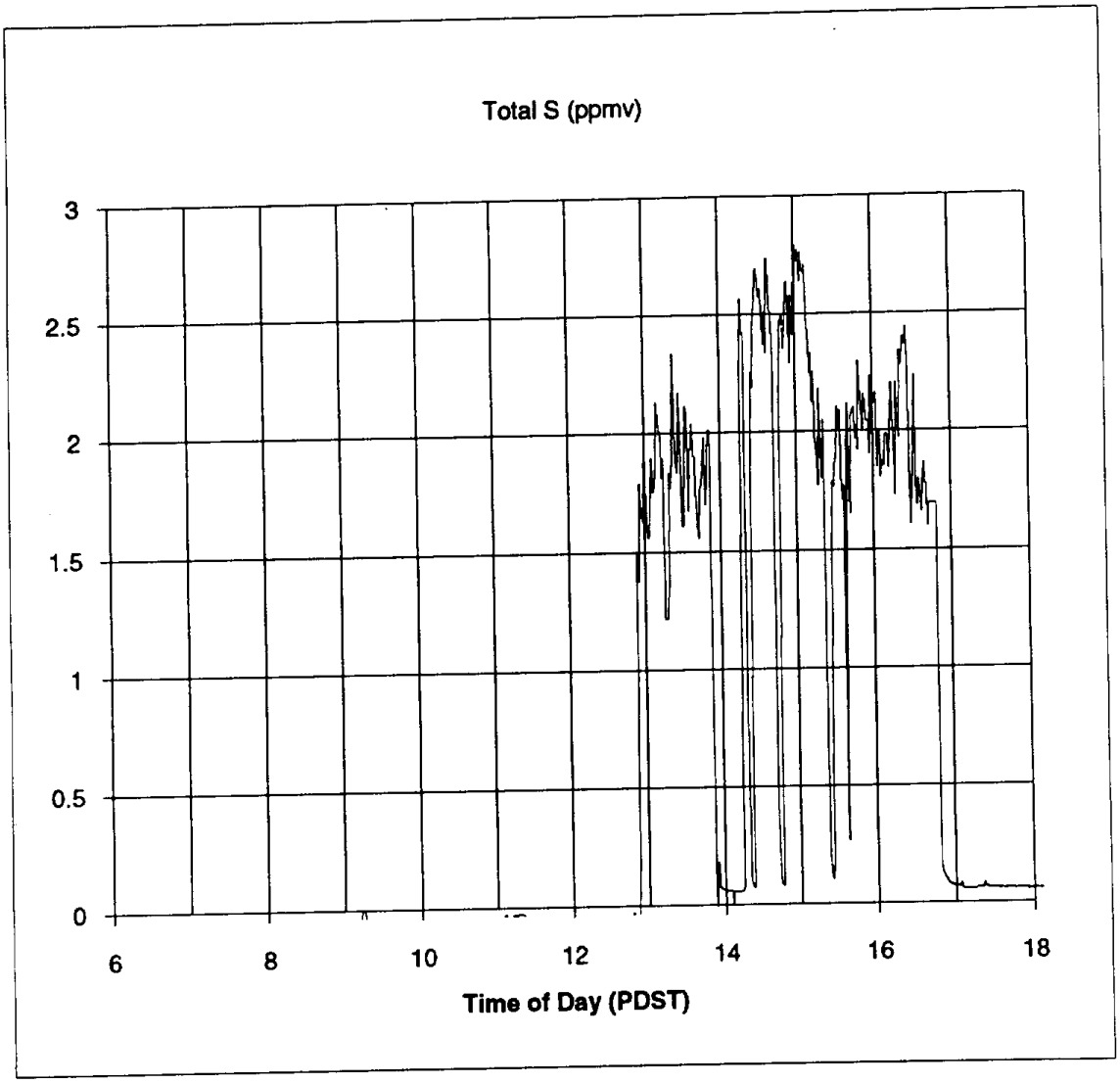


Figure 3.1.1.13. Particle size distribution, traverse 1, 30 April 92.

Fuel: Rice Straw

Date of Test: 30-Apr-92

Configuration: CRNF

Particle Size Distribution

Traverse 1:

Stage	ECD (μm)	Weight (mg)	Cum. Wt (mg)	Cum. Fraction
1	14.20	0.6	6.8	1.000
2	7.96	0.4	6.2	0.912
3	4.24	0.4	5.8	0.853
4	2.24	0.2	5.4	0.794
5	1.29	0.3	5.2	0.765
6	0.76	0.4	4.9	0.721
7	0.40	0.4	4.5	0.662
filter	0.00	4.1	4.1	0.603

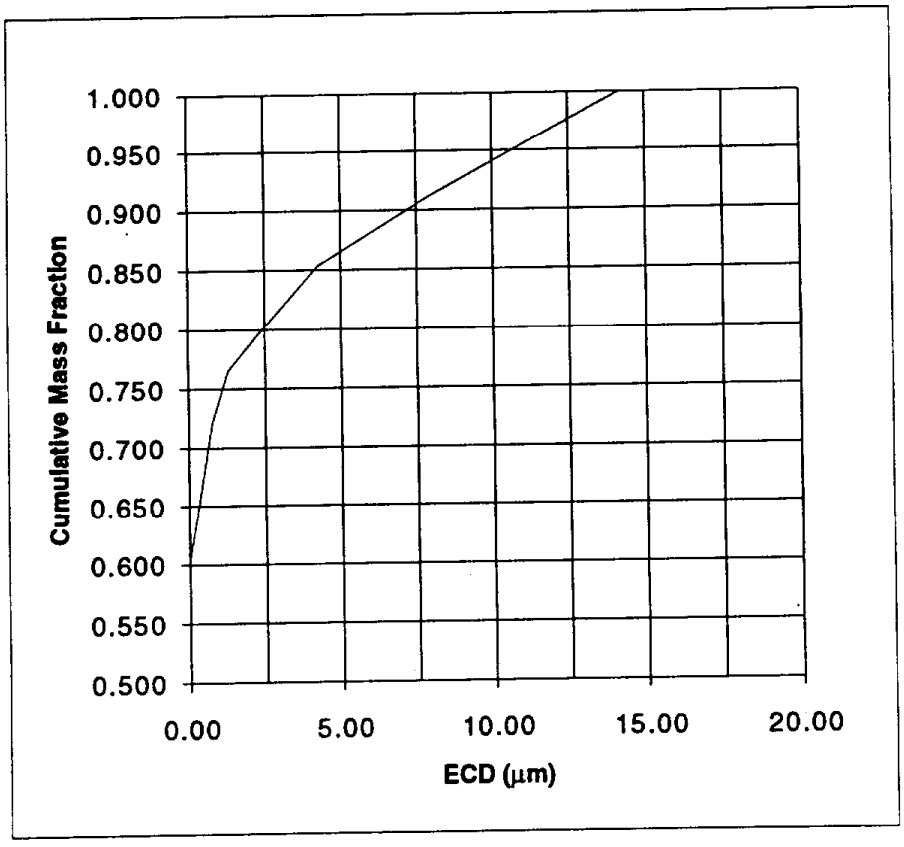


Figure 3.1.1.14. Particle size distribution, traverse 2, 30 April 92.

Fuel: Rice Straw

Date of Test: 30-Apr-92
Configuration: CRNF

Particle Size Distribution
Traverse 2:

Stage	ECD (μm)	Weight (mg)	Cum. Wt (mg)	Cum. Fraction
1	14.42	0.3	6.4	1.000
2	8.08	0.3	6.1	0.953
3	4.31	0.2	5.8	0.906
4	2.28	0.2	5.6	0.875
5	1.31	0.2	5.4	0.844
6	0.77	0.4	5.2	0.813
7	0.40	0.3	4.8	0.750
filter	0.00	4.5	4.5	0.703

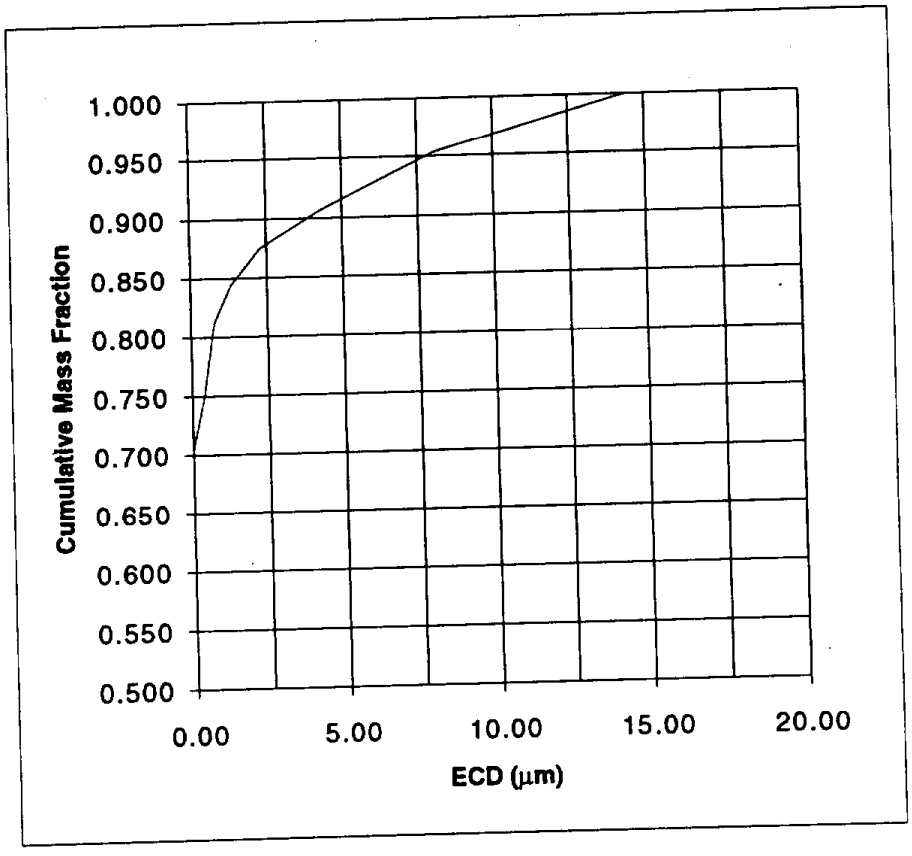


Figure 3.1.1.15. Nitrogen balance.
Date of Test: 30-Apr-92
Fuel Rice Straw

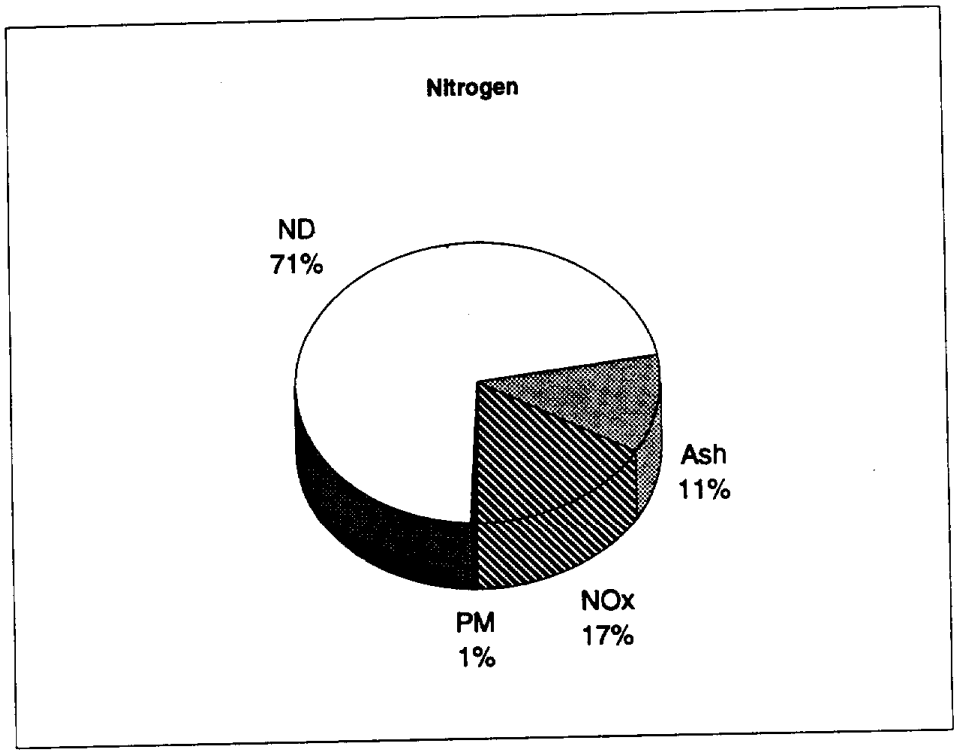


Figure 3.1.1.16. Sulfur balance.
Date of Test: 30-Apr-92
Fuel Rice Straw

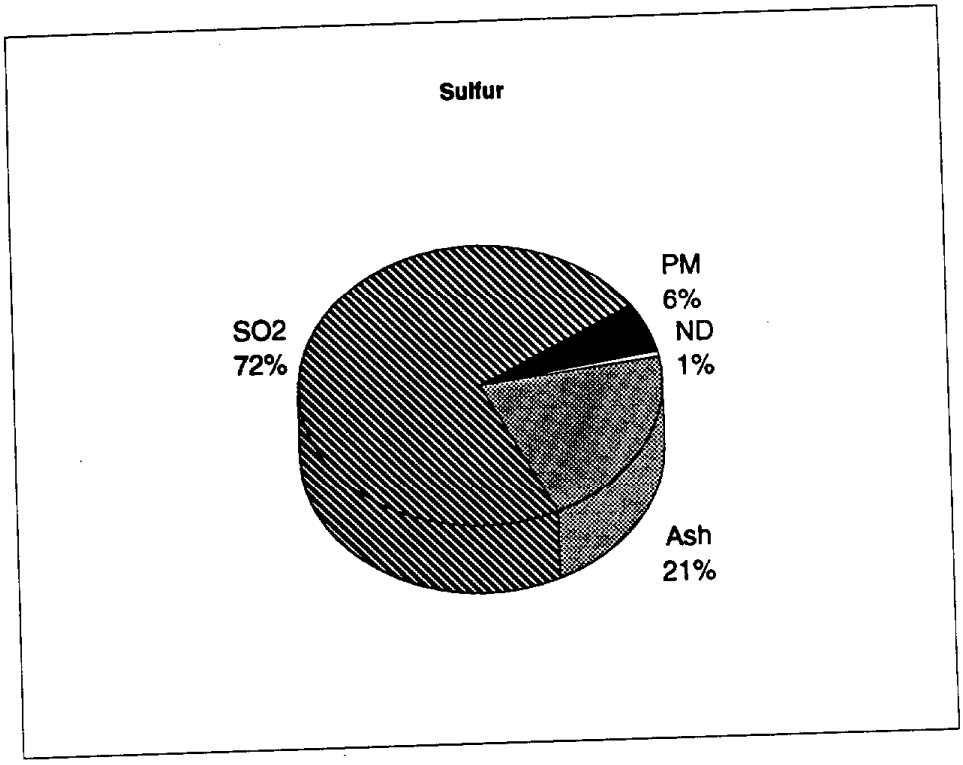


Table 3.1.2.1

Fuel and Ash Analyses

Run Date	9-Jun-92	9-Jun-92
Fuel Type	Rice Straw	Rice Straw
Sample Type	Fuel	Ash
Ultimate Analysis		
(% dry weight)		
C	37.96	9.93
H	5.65	0.80
N	0.54	0.20
Elemental Analysis		
(% by weight dry basis)		
N	0.60	0.33
P	0.05	0.28
K	0.93	3.62
Ca	0.24	1.12
Mg	0.16	0.63
Na	0.07	0.43
Cl	0.22	0.56
(mg/kg dry weight)		
S	668	859
B	8	16
Zn	25	75
Mn	552	3,150
Fe	336	1,190
Cu	6	10
Si		
Total (% dry weight)	46.04	18.23
Proximate Analysis		
(% dry weight)		
Ash	16.15	86.38
Volatiles	71.04	9.89
Fixed Carbon	12.80	3.73
Higher Heating Value		
(MJ/kg dry weight)	15.7392	3.8034

Table 3.1.2.2. Operating conditions and concentrations*, rice straw, 9 June 92.

Fuel:	Rice Straw	Date of Test:	9-Jun-92
		Configuration:	CRNF
Fuel Loading Rate (g/sq.m w.b.):	680		
Total Fuel Consumption (kg w.b.)	246.3		
Total Ash Recovered (kg w.b.)	50.0		
Ash Fraction (w.b.)	0.20		

Total filters for PM installed improperly.

	Traverse 1	Traverse 2	Traverse 3
Mean Values			
Air Temperature (°C)	27.99	31.36	34.05
Air Relative Humidity (%)	43.10	35.82	29.23
Inlet Air Temperature (°C)	34.34	36.79	38.96
Stack Temperature (°C)	67.02	73.89	84.27
Impinger Outlet Temperature (°C)	20.05	22.60	29.30
Fire Spreading Rate (m/min)	0.91	0.90	1.15
Stack Gas Velocity (m/s)	1.87	1.95	1.98
Gas and PM Concentrations (less background)			
CO (ppmv)	80.03	82.16	108.59
NO (ppmv)	7.64	7.29	8.72
NOx (ppmv)	8.63	8.15	9.51
SO2 (ppmv)	1.49	1.41	1.71
HC (ppmv as CH4 by GC)	4.89	4.10	5.18
CH4 (ppmv by GC)	4.17	3.58	4.57
NMHC (ppmv as CH4 by GC)	0.73	0.53	0.61
CO2 (ppmv by GC)	2652	3695	3629
Total S (ppmv as SO2)	2.41	2.28	2.54
PM* (mg/cu.m)	5.49	5.61	2.87
PM10* (mg/cu.m)	5.27	5.39	2.72
PM2.5* (mg/cu.m)	4.82	5.14	2.41

*Total filters installed improperly. See Table 3.1.2.3 for corrected values.

Table 3.1.2.3. Operating conditions and concentrations, rice straw, 9 June 92.

Fuel:	Rice Straw	Date of Test:	9-Jun-92
		Configuration:	CRNF
Fuel Loading Rate (g/sq.m w.b.):	680		
Total Fuel Consumption (kg w.b.)	246.3		
Total Ash Recovered (kg w.b.)	50.0		
Ash Fraction (w.b.)	0.20		

Total filters for PM installed improperly.

	Traverse 1	Traverse 2	Traverse 3
Mean Values			
Air Temperature (°C)	27.99	31.36	34.05
Air Relative Humidity (%)	43.10	35.82	29.23
Inlet Air Temperature (°C)	34.34	36.79	38.96
Stack Temperature (°C)	67.02	73.89	84.27
Impinger Outlet Temperature (°C)	20.05	22.60	29.30
Fire Spreading Rate (m/min)	0.91	0.90	1.15
Stack Gas Velocity (m/s)	1.87	1.95	1.98
Gas and PM Concentrations (less background)			
CO (ppmv)	80.03	82.16	108.59
NO (ppmv)	7.64	7.29	8.72
NOx (ppmv)	8.63	8.15	9.51
SO2 (ppmv)	1.49	1.41	1.71
HC (ppmv as CH4 by GC)	4.89	4.10	5.18
CH4 (ppmv by GC)	4.17	3.58	4.57
NMHC (ppmv as CH4 by GC)	0.73	0.53	0.61
CO2 (ppmv by GC)	2652	3695	3629
Total S (ppmv as SO2)	2.41	2.28	2.54
PM* (mg/cu.m)	11.65	9.50	15.06
PM10* (mg/cu.m)	11.18	9.26	14.34
PM2.5* (mg/cu.m)	10.24	8.74	12.65

*Total filters installed improperly. PM concentrations from cascade impactor.

Table 3.1.2.4. Mass balance, rice straw, 9 June 92.

Fuel: Rice Straw

Date of Test: 9-Jun-92

Configuration: CRNF

Mass Balance

	Traverse 1	Traverse 2	Traverse 3
Total Conveyor Travel (m)	43.70	43.08	55.15
Fuel Moisture Content (% w.b.)	8.6	9.1	8.3
Fuel Loading Rate (g/sq.m d.b.)	622	618	624
Total Fuel Consumption (g w.b.)	36,231	35,718	45,720
Total Fuel Consumption (g d.b.)	33,115	32,468	41,925
Residual Ash (g w.b.)	7,356	7,252	9,283
Fuel Vaporized (g w.b.)	28,875	28,466	36,437
Fuel Consumption Rate (g/s w.b.)	12.58	12.40	15.87
Fuel Consumption Rate (g/s d.b.)	11.50	11.27	14.56
Ash Generation Rate (g/s w.b.)	2.55	2.52	3.22
Fuel Vaporization Rate (g/s w.b.)	10.03	9.88	12.65
Stack Gas Density (kg/cu.m)	1.0390	1.0184	0.9888
Stack Gas Flow Rate (cu.m/s)	2.78	2.90	2.94
Stack Gas Mass Flow Rate (kg/s)	2.89	2.95	2.91
Inlet Air Mass Flow Rate (kg/s)	2.88	2.94	2.89
Overall Air-Fuel Ratio (w.b.)	228.92	237.34	182.34
Overall Air-Fuel Ratio (d.b.)	250.46	261.10	198.85

Table 3.1.2.5. Emission factors, rice straw, 9 June 92 (Integrated basis).

Fuel: Rice Straw Date of Test: 9-Jun-92

Configuration: CRNF

Emission Factors (% of fuel mass d.b.)

Integrated Basis

	Traverse 1	Traverse 2	Traverse 3	Average
CO	1.929	2.092	2.087	2.036
NO	0.199	0.198	0.185	0.194
NOx (as NO2)	0.344	0.340	0.311	0.332
SO2	0.082	0.082	0.078	0.081
HC (as CH4 by GC)	0.068	0.059	0.057	0.061
CH4 (by GC)	0.058	0.052	0.050	0.053
NMHC (by GC)	0.010	0.008	0.007	0.008
CO2 (by GC)	101.131	146.870	109.966	119.322
Total S (as SO2)	0.133	0.132	0.113	0.126
SO2/Total S	0.62	0.62	0.70	0.64
PM*	0.243	0.208	0.257	0.236
PM10*	0.233	0.203	0.245	0.227
PM2.5*	0.214	0.192	0.216	0.207
MMAD (μm)	0.163	0.083	0.064	0.103
σ	6.952	4.997	4.762	

*Total filters installed improperly. PM concentrations from cascade impactor.

Table 3.1.2.6. Emission factors, rice straw, 9 June 92 (average basis).

Fuel: Rice Straw | Date of Test: 9-Jun-92 | Configuration: CRNF

Emission Factors (% of fuel mass d.b.)

Average Basis

	Traverse 1	Traverse 2	Traverse 3	Average
CO	1.942	2.078	2.094	2.038
NO	0.199	0.197	0.180	0.192
NOx (as NO2)	0.344	0.339	0.301	0.328
SO2	0.083	0.082	0.075	0.080
HC (as CH4 by GC)	0.068	0.059	0.057	0.061
CH4 (by GC)	0.058	0.052	0.050	0.053
NMHC (by GC)	0.010	0.008	0.007	0.008
CO2 (by GC)	101.131	146.870	109.966	119.322
Total S (as SO2)	0.134	0.132	0.112	0.126
SO2/Total S	0.62	0.62	0.67	0.63
PM*	0.243	0.208	0.257	0.236
PM10*	0.233	0.203	0.245	0.227
PM2.5*	0.214	0.192	0.216	0.207
MMAD (μm)	0.163	0.083	0.064	0.103
σ	6.952	4.997	4.762	

*Total filters installed improperly. PM concentrations from cascade impactor.

Table 3.1.2.7. Carbon balance.

Date of Test: Fuel	9-Jun-92 Rice Straw Traverse 1	9-Jun-92 Rice Straw Traverse 2	9-Jun-92 Rice Straw Traverse 3
Carbon Balance			
Dry Fuel Consumption Rate (g/s)	11.50	11.27	14.56
Ash Generation Rate (g/s)	2.55	2.52	3.22
Ash Fraction (% dry basis)	22.17	22.36	22.12
Fuel Carbon Concentration (%)	37.96	37.96	37.96
Residual Ash Carbon Concentration (%)	9.93	9.93	9.93
Carbon released to stack (g/s)	4.11	4.03	5.21
Maximum CO2 emission factor (%)	131.11	131.05	131.13
Stack Gas Density (kg/cubic meter)	1.04	1.02	0.99
Average CO2 concentration (ppmv)	2,652	3,695	3,629
Average CO concentration (ppmv)	80.03	82.16	108.59
Average THC concentration (ppmv as CH4)	4.89	4.10	5.18
PM Concentration* (mg/cubic meter)	11.65	9.50	15.06
PM Carbon Concentration** (%)	39.44	40.98	37.90
PM Carbon (mg/cubic meter)	4.59	3.89	5.71
Stack Gas Temperature (°C)	67.02	73.89	84.27
Impinger Temperature (°C)	20.05	22.60	29.30
PM molar concentration (ppm)	9.21	7.87	11.80
Estimated Average Stack Gas Velocity (m/s)	2.34	1.70	2.28
Emission Factors (% Average Basis):			
CO2	101.131	146.87	109.966
CO	1.942	2.078	2.094
HC (as CH4)	0.068	0.059	0.057
PM*	0.243	0.208	0.257
Emission Factors (% Integrated Basis):			
CO2	101.131	146.87	109.966
CO	1.929	2.092	2.087
HC (as CH4)	0.068	0.059	0.057
PM*	0.243	0.208	0.257
Closure (% Average Basis)	80	115	87
Closure (% Integrated Basis)	80	115	87

*PM concentrations from cascade impactor

**Average of Traverses 2 and 3 used for Traverse 1.

Table 3.1.2.8. Nitrogen balance

Date of Test:	9-Jun-92	9-Jun-92	9-Jun-92
Fuel	Rice Straw Traverse 1	Rice Straw Traverse 2	Rice Straw Traverse 3
Nitrogen Balance			
Fuel Nitrogen Concentration (% dry weight)	0.60	0.60	0.60
Ash Nitrogen Concentration (% weight)	0.33	0.33	0.33
Emission Factors (% Average Basis):			
NOx (as NO2)	0.344	0.339	0.301
PM*	0.243	0.208	0.257
Emission Factors (% Integrated Basis):			
NOx (as NO2)	0.344	0.34	0.311
NO3- Concentration of PM** (% weight)	0.1490	0.1852	0.1128
NH4+ Concentration of PM** (% weight)	1.4291	1.208	1.650
Nitrogen Concentration of PM (%)	1.145	0.982	1.309
Fuel Nitrogen (mg/s)	69.00	67.62	87.36
Ash Nitrogen (mg/s)	8.42	8.32	10.63
Nitrogen as NOx (mg/s Average Basis)	12.04	11.63	13.34
Nitrogen as NOx (mg/s Integrated Basis)	12.04	11.66	13.78
Nitrogen as PM (mg/s Average Basis)	0.32	0.23	0.49
Nitrogen as NOx+PM (mg/s Average Basis)	12.36	11.86	13.83
Nitrogen as NOx+PM (mg/s Integrated Basis)	12.36	11.89	14.27
NOx+PM Nitrogen/Fuel Nitrogen (Average)	0.179	0.175	0.158
NOx+PM Nitrogen/Fuel Nitrogen (Integrated)	0.179	0.176	0.163
Ash Nitrogen/Fuel Nitrogen	0.122	0.123	0.122
Ash+NOx+PM Nitrogen/Fuel Nitrogen (Average)	0.301	0.298	0.280
Ash+NOx+PM Nitrogen/Fuel Nitrogen (Integrated)	0.301	0.299	0.285

*PM concentrations from cascade impactor

**Average of Traverses 2 and 3 used for Traverse 1.

Table 3.1.2.9. Sulfur balance.

Date of Test: Fuel	9-Jun-92 Rice Straw Traverse 1	9-Jun-92 Rice Straw Traverse 2	9-Jun-92 Rice Straw Traverse 3
Sulfur Balance			
Fuel Sulfur Concentration (mg/kg dry weight)	668	668	668
Ash Sulfur Concentration (mg/kg weight)	859	859	859
Emission Factors (% Average Basis)			
SO2	0.083	0.082	0.075
PM*	0.243	0.208	0.257
Emission Factors (% Integrated Basis)			
SO2	0.082	0.082	0.078
Sulfur Concentration of PM** (% weight)	1.017	1.165	0.868
Fuel Sulfur (mg/s)	7.68	7.53	9.73
Ash Sulfur (mg/s)	2.19	2.16	2.77
Sulfur as SO2 (mg/s Average Basis)	4.77	4.62	5.46
Sulfur as SO2 (mg/s Integrated Basis)	4.72	4.62	5.68
Sulfur as PM (mg/s Average Basis)	0.28	0.27	0.32
Sulfur as SO2+PM (mg/s Average Basis)	5.06	4.89	5.78
Sulfur as SO2+PM (mg/s Integrated Basis)	5.00	4.89	6.00
SO2+PM Sulfur/Fuel Sulfur (Average Basis)	0.658	0.650	0.595
SO2+PM Sulfur/Fuel Sulfur (Integrated Basis)	0.651	0.650	0.617
Ash Sulfur/Fuel Sulfur	0.285	0.288	0.284
Closure (% Average Basis)	94	94	88
Closure (% Integrated Basis)	94	94	90

*PM concentrations from cascade impactor

**Average of Traverses 2 and 3 used for Traverse 1.

Table 3.1.2.10. Water balance.

Estimated Stack Humidity

Fuel	Rice Straw
Configuration	CRNF
Date of Test	9-Jun-92

	Traverse 1	Traverse 2	Traverse 3
Ambient Air Temperature °C)	28	31	34
Ambient Air Relative Humidity (%)	43	36	29
Air Temperature (K)	301	305	307
Saturation Pressure (Pa)	3,780	4,589	5,339
Vapor Pressure (Pa)	1,629	1,644	1,561
Air Dew Point Temperature (°C)	14.3	14.5	13.7
Ambient Volume Fraction Water Vapor	0.0161	0.0162	0.0154
Ambient Mass Fraction Water Vapor	0.0100	0.0101	0.0096
Fuel Burning Rate (g/s wet basis)	12.58	12.40	15.87
Fuel Moisture Content (%)	8.6	9.1	8.3
Ash Fraction (wet basis)	0.20	0.20	0.20
Fuel Hydrogen Content (%)	5.65	5.65	5.65
Ash Hydrogen Content (%)	0.80	0.80	0.80
Moisture Evaporated (g/s)	1.08	1.13	1.32
Water of Combustion (g/s)	5.67	5.55	7.17
Total Fuel Water Added (g/s)	6.75	6.68	8.49
Inlet Air Mass Flowrate (g/s)	2,880	2,940	2,890
Inlet Air Water Vapor Flowrate (g/s)	29	30	28
Total Stack Water Vapor Flowrate (g/s)	35	36	36
Stack Gas Mass Flowrate (g/s)	2,890	2,950	2,903
Mass Fraction Water Vapor in Stack	0.0123	0.0123	0.0124
Volume Fraction Water Vapor in Stack	0.0198	0.0198	0.0200
Stack Vapor Pressure (Pa)	2,005	2,008	2,031
Stack Temperature (°C)	67	74	84
Stack Temperature (K)	340	347	357
Stack Saturation Pressure (Pa)	27,390	36,835	56,228
Stack Relative Humidity (%)	7	5	4
Stack Dew Point Temperature (°C)	17.6	17.6	17.8
Impinger Outlet Temperature (°C)	20.1	22.6	29.3
Volume Stack Gas Sampled for PM (L)	492	410	418
Estimated Impinger/Desiccant Weight Gain (g)	7.3	6.0	6.1

Totals:

	Estimated	Measured
Total Impinger/Desiccant Weight Gain (g)	19.4	24.4
Estimated/Measured Weight Gain	0.80	

Table 3.1.2.11. Power balance.

Date of Test:	9-Jun-92	9-Jun-92	9-Jun-92
Fuel	Rice Straw Traverse 1	Rice Straw Traverse 2	Rice Straw Traverse 3
Power Balance			
Fuel Heating Value (MJ/kg dry weight)	15.7392	15.7392	15.7392
Ash Heating Value (MJ/kg dry weight)	3.8034	3.8034	3.8034
Average Energy Release Rate (kW)	171.3	167.8	216.9
Products of Incomplete Combustion (kW)			
CO	2.3	2.4	3.1
THC (as CH4)	0.4	0.4	0.5
PM*	0.4	0.3	0.5
Heat Release Rate (kW)	168.2	164.7	212.9
Fireline Intensity (kW/m)	138.0	135.1	174.6
Stack Gas Flow (kg/s)	2.89	2.95	2.91
Stack Gas Temperature (°C)	67.02	73.89	84.27
Inlet Temperature (°C)	34.34	36.79	38.96
Sensible Power at Top of Stack (kW)	95.0	110.1	132.6
Tunnel Dissipation (kW)	73.2	54.6	80.3

*PM concentrations from cascade impactor

Table 3.1.2.12. Mass concentrations (%) from DRI filter samples

Date	9-Jun-92		9-Jun-92	
Fuel	Rice Straw		Rice Straw	
Configuration	CRNF		CRNF	
Size Fraction	PM2.5		PM10	
Teflon Filter ID	ABTT005		ABTT006	
Quartz Filter ID	ABTQ005		ABTQ006	
Teflon Field Sample Flag				
Quartz field sample field				
Teflon mass sample flag	f3		f3	
Quartz mass sample flag				
Anions sample flag				
Ammonium analysis flag				
Sodium ion analysis flag				
Magnesium ion analysis flag				
Potassium ion analysis flag				
Carbon analysis flag				
XRF analysis flag	f3		f3	
		±Uncertainty		±Uncertainty
Teflon sample volume (m^3)	0.20	0.01	0.20	0.01
Quartz sample volume (m^3)	0.20	0.01	0.20	0.01
Teflon mass concentration (µg/m^3)	6,715	345	8,990	456

	Concentration (%)	±Uncertainty	Concentration (%)	±Uncertainty	PM2.5/PM10
Cl-	21.6920	1.8057	17.5041	1.4507	1.24
NO3-	0.2010	0.0546	0.1852	0.0415	1.09
SO4=	4.7195	0.5043	3.7087	0.3846	1.27
NH4+	1.5546	0.1232	1.2082	0.0946	1.29
Na+	2.1694	0.1874	1.6593	0.1427	1.31
K+	14.9372	1.1354	11.3555	0.8587	1.32
C(org)	14.4346	1.5883	10.6260	1.1727	1.36
C(oht)	11.5767	1.9550	9.2311	1.5444	1.25
C(e)	40.3292	3.8376	30.3560	2.8809	1.33
C(eht)	1.1541	0.7111	1.3904	0.8541	0.83
C	54.7548		40.9820		1.34
Al	0.0000	0.1055	0.0000	0.1113	
Si	1.1978	0.1072	5.6503	0.4060	0.21
P	0.0000	0.2855	0.0000	0.2251	
S	1.6223	0.1682	1.1648	0.1269	1.39
Cl	26.9385	1.9326	21.3030	1.5194	1.26
K	26.2048	1.8785	19.5219	1.3914	1.34
Ca	0.1869	0.3013	1.2078	0.1145	0.15
Ti	0.0000	0.0359	0.0046	0.0270	0.00
V	0.0000	0.0157	0.0000	0.0118	
Cr	0.0015	0.0042	0.0042	0.0025	0.36
Mn	0.0493	0.0043	0.2893	0.0208	0.17
Fe	0.0373	0.0091	0.2459	0.0189	0.15
Co	0.0011	0.0020	0.0014	0.0040	0.79
Ni	0.0009	0.0020	0.0024	0.0011	0.38
Cu	0.0034	0.0016	0.0035	0.0012	0.97
Zn	0.0901	0.0067	0.0698	0.0052	1.29
Ga	0.0012	0.0037	0.0017	0.0028	0.71
As	0.0024	0.0049	0.0022	0.0036	1.09
Se	0.0024	0.0018	0.0015	0.0013	1.60
Br	0.0996	0.0074	0.0766	0.0057	1.30
Rb	0.0295	0.0029	0.0223	0.0022	1.32
Sr	0.0021	0.0016	0.0104	0.0014	0.20
Y	0.0013	0.0030	0.0004	0.0022	3.25
Zr	0.0031	0.0024	0.0019	0.0018	1.63
Mo	0.0032	0.0054	0.0018	0.0039	1.78
Pd	0.0000	0.0278	0.0000	0.0204	
Ag	0.0000	0.0307	0.0074	0.0237	0.00
Cd	0.0040	0.0323	0.0070	0.0247	0.57
In	0.0097	0.0357	0.0044	0.0276	2.20
Sn	0.0030	0.0448	0.0000	0.0340	
Sb	0.0000	0.0513	0.0000	0.0385	
Ba	0.0767	0.1711	0.0837	0.1266	0.92
La	0.0000	0.2230	0.0058	0.1631	0.00
Au	0.0029	0.0072	0.0021	0.0054	1.38
Hg	0.0021	0.0051	0.0015	0.0037	1.40
Tl	0.0001	0.0047	0.0013	0.0035	0.08
Pb	0.0090	0.0047	0.0071	0.0035	1.27
U	0.0018	0.0067	0.0001	0.0050	18.00
Sum of measured species	115.2679	4.9880	93.7427	3.7758	1.23

Table 3.1.2.13. Element ratios from DRI filter samples.

Date	9-Jun-92	9-Jun-92	
Fuel	Rice Straw	Rice Straw	
Configuration	CRNF	CRNF	
Size Fraction	PM2.5	PM10	PM2.5/PM10
Teflon Filter ID	ABTT005	ABTT006	
Quartz Filter ID	ABTQ005	ABTQ006	
Cl-/Cl	0.81	0.82	0.98
K+/K	0.57	0.58	0.98
Sulfate S/Total S	0.97	1.06	0.91
C(org)/C	0.26	0.26	1.02
Cl/K	1.03	1.09	0.94
Cl-/K+	1.45	1.54	0.94
Cl-/Na+	10.00	10.55	0.95
S/K	0.06	0.06	1.04
S/Na+	0.75	0.70	1.07
Al/Si	0.00	0.00	

Table 3.1.2.14. Emission factors (mg/kg) from DRI filter samples.

Date	9-Jun-92		9-Jun-92		
Fuel	Rice Straw		Rice Straw		
Configuration	CRNF		CRNF		
Size Fraction	PM2.5		PM10		
Teflon Filter ID	ABTT005		ABTT006		
Quartz Filter ID	ABTQ005		ABTQ006		
Start Time	14:01				
Stop Time	14:21				
Start Time					Traverse 2
End Time					9.500
Elapsed Time (minutes)	20				9.260
PM (mg/m^3, cascade impactor)					8.740
PM10 (mg/m^3, cascade impactor)					0.208
PM2.5 (mg/m^3, cascade impactor)					0.203
PM emission factor (%)					0.192
PM10 emission factor (%)					
PM2.5 emission factor (%)					
		±Uncertainty		±Uncertainty	
Teflon sample volume (m^3)	0.20	0.01	0.20	0.01	
Quartz sample volume (m^3)	0.20	0.01	0.20	0.01	
Teflon mass concentration (mg/m^3)	6.715	0.345	8.990	0.456	
Teflon mass/Total mass	0.768		0.971		
	Emission (mg/kg)	±Uncertainty	Emission (mg/kg)	±Uncertainty	PM2.5/PM10
Cl-	361.3204	34.6694	379.0516	29.4492	0.95
NO3-	3.3480	1.0483	4.0105	0.8425	0.83
SO4=	78.6120	9.6826	80.3120	7.8074	0.98
NH4+	25.8947	2.3654	26.1636	1.9204	0.99
Na+	36.1354	3.5981	35.9322	2.8968	1.01
K+	248.8067	21.7997	245.9036	17.4316	1.01
C(org)	240.4350	30.4954	230.1062	23.8058	1.04
C(oht)	192.8313	37.5360	199.8997	31.3513	0.96
C(e)	671.6075	73.6819	657.3598	58.4823	1.02
C(eht)	19.2237	13.6531	30.1091	17.3382	0.64
C	912.0424	0.0000	887.4660	0.0000	1.03
Al	0.0000	2.0256	0.0000	2.2594	
Si	19.9516	2.0582	122.3574	8.2418	0.16
P	0.0000	5.4816	0.0000	4.5695	
S	27.0224	3.2294	25.2238	2.5761	1.07
Cl	448.7105	37.1059	461.3169	30.8438	0.97
K	436.4894	36.0672	422.7471	28.2454	1.03
Ca	3.1132	5.7850	26.1549	2.3244	0.12
Ti	0.0000	0.6893	0.0996	0.5481	0.00
V	0.0000	0.3014	0.0000	0.2395	
Cr	0.0250	0.0806	0.0910	0.0508	0.27
Mn	0.8212	0.0826	6.2648	0.4222	0.13
Fe	0.6213	0.1747	5.3250	0.3837	0.12
Co	0.0183	0.0384	0.0303	0.0812	0.60
Ni	0.0150	0.0384	0.0520	0.0223	0.29
Cu	0.0566	0.0307	0.0758	0.0244	0.75
Zn	1.5008	0.1286	1.5115	0.1056	0.99
Ga	0.0200	0.0710	0.0368	0.0568	0.54
As	0.0400	0.0941	0.0476	0.0731	0.84
Se	0.0400	0.0346	0.0325	0.0264	1.23
Br	1.6590	0.1421	1.6588	0.1157	1.00
Rb	0.4914	0.0557	0.4829	0.0447	1.02
Sr	0.0350	0.0307	0.2252	0.0284	0.16
Y	0.0217	0.0576	0.0087	0.0447	2.50
Zr	0.0516	0.0461	0.0411	0.0365	1.25
Mo	0.0533	0.1037	0.0390	0.0792	1.37
Pd	0.0000	0.5338	0.0000	0.4141	
Ag	0.0000	0.5894	0.1602	0.4811	0.00
Cd	0.0666	0.6202	0.1516	0.5014	0.44
In	0.1616	0.6854	0.0953	0.5603	1.70
Sn	0.0500	0.8602	0.0000	0.6902	
Sb	0.0000	0.9850	0.0000	0.7816	
Ba	1.2776	3.2851	1.8125	2.5700	0.70
La	0.0000	4.2816	0.1256	3.3109	0.00
Au	0.0483	0.1382	0.0455	0.1096	1.06
Hg	0.0350	0.0979	0.0325	0.0751	1.08
Tl	0.0017	0.0902	0.0282	0.0711	0.06
Pb	0.1499	0.0902	0.1538	0.0711	0.98
U	0.0300	0.1286	0.0022	0.1015	13.85
Sum of measured species	1,920	96	2,030	72	0.95

Table 3.1.2.15. Mass concentrations (%) from DRI filter samples

Date		9-Jun-92		9-Jun-92	
Fuel		Rice Straw		Rice Straw	
		CRNF		CRNF	
Size Fraction	PM2.5		PM10		
Teflon Filter ID	ABTT007		ABTT008		
Quartz Filter ID	ABTQ007		ABTQ008		
Teflon Field Sample Flag					
Quartz field sample field					
Teflon mass sample flag			f3		
Quartz mass sample flag					
Anions sample flag					
Ammonium analysis flag					
Sodium ion analysis flag					
Magnesium ion analysis flag					
Potassium ion analysis flag					
Carbon analysis flag					
XRF analysis flag	f3		f3		
		±Uncertainty		±Uncertainty	
Teflon sample volume (m^3)	0.15	0.01	0.15	0.01	
Quartz sample volume (m^3)	0.15	0.01	0.15	0.01	
Teflon mass concentration (µg/m^3)	11,220	570	12,947	656	
	Concentration (%)	±Uncertainty	Concentration (%)	±Uncertainty	PM2.5/PM10
Cl-	27.0602	2.2435	24.3318	2.0141	1.11
NO3-	0.1087	0.0427	0.1128	0.0373	0.96
SO4=	3.8195	0.4041	3.3256	0.3507	1.15
NH4+	2.0544	0.1538	1.6499	0.1237	1.25
Na+	1.4223	0.1230	1.2579	0.1085	1.13
K+	18.9020	1.4306	16.1364	1.2190	1.17
C(org).	15.5351	1.6229	15.1110	1.5572	1.03
C(oht)	12.6604	2.0600	12.8669	2.0663	0.98
C(e)	25.7576	2.4439	22.7909	2.1609	1.13
C(eht)	0.7071	0.4373	1.3182	0.8063	0.54
C	41.2927		37.9019		1.09
Al	0.0000	0.1136	0.0000	0.1102	
Si	0.1320	0.1752	3.1818	0.2341	0.04
P	0.0000	0.3361	0.0000	0.2994	
S	1.0302	0.1625	0.8677.	0.1431	1.19
Cl	32.2827	2.3043	28.7716	2.0493	1.12
K	30.8311	2.1993	26.4814	1.8851	1.16
Ca	0.1101	0.3534	0.8867	0.1196	0.12
Ti	0.0054	0.0285	0.0000	0.0251	
V	0.0034	0.0125	0.0000	0.0110	
Cr	0.0022	0.0026	0.0041	0.0023	0.54
Mn	0.0283	0.0028	0.2343	0.0169	0.12
Fe	0.0189	0.0071	0.2636	0.0199	0.07
Co	0.0000	0.0015	0.0003	0.0042	0.00
Ni	0.0012	0.0012	0.0023	0.0011	0.52
Cu	0.0052	0.0013	0.0040	0.0011	1.30
Zn	0.0391	0.0031	0.0367	0.0029	1.07
Ga	0.0000	0.0029	0.0010	0.0025	0.00
As	0.0026	0.0038	0.0020	0.0033	1.30
Se	0.0014	0.0020	0.0010	0.0017	1.40
Br	0.1253	0.0091	0.1119	0.0081	1.12
Rb	0.0481	0.0040	0.0415	0.0035	1.16
Sr	0.0012	0.0017	0.0067	0.0012	0.18
Y	0.0008	0.0031	0.0013	0.0027	0.62
Zr	0.0000	0.0025	0.0021	0.0017	0.00
Mo	0.0000	0.0042	0.0000	0.0036	
Pd	0.0000	0.0235	0.0076	0.0205	0.00
Ag	0.0013	0.0263	0.0087	0.0234	0.15
Cd	0.0000	0.0276	0.0000	0.0242	
In	0.0000	0.0299	0.0036	0.0266	0.00
Sn	0.0091	0.0371	0.0000	0.0318	
Sb	0.0000	0.0423	0.0000	0.0371	
Ba	0.0282	0.1360	0.1040	0.0792	0.27
La	0.0000	0.1757	0.0189	0.1533	0.00
Au	0.0038	0.0052	0.0000	0.0046	
Hg	0.0010	0.0040	0.0020	0.0035	0.50
Tl	0.0019	0.0038	0.0013	0.0033	1.46
Pb	0.0058	0.0037	0.0047	0.0032	1.23
U	0.0000	0.0080	0.0000	0.0070	
Sum of measured species	109.5984	4.3770	101.9753	3.8863	1.07

Table 3.1.2.16. Element ratios from DRI filter samples.

Date	9-Jun-92	9-Jun-92	
Fuel	Rice Straw	Rice Straw	
Configuration	CRNF	CRNF	
Size Fraction	PM2.5	PM10	PM2.5/PM10
Teflon Filter ID	ABTT007	ABTT008	
Quartz Filter ID	ABTQ007	ABTQ008	
Cl-/Cl	0.84	0.85	0.99
K+/K	0.61	0.61	1.01
Sulfate S/Total S	1.24	1.28	0.97
C(org)/C	0.38	0.40	0.94
Cl/K	1.05	1.09	0.96
Cl-/K+	1.43	1.51	0.95
Cl-/Na+	19.03	19.34	0.98
S/K	0.03	0.03	1.02
S/Na+	0.72	0.69	1.05
Al/Si	0.00	0.00	

Table 3.1.2.17. Emission factors (mg/kg) from DRI filter samples.

Date	9-Jun-92		9-Jun-92		
Fuel	Rice Straw CRNF		Rice Straw CRNF		
Size Fraction	PM2.5		PM10		
Teflon Filter ID	ABTT007		ABTT008		
Quartz Filter ID	ABTQ007		ABTQ008		
Start Time	15:57				
Stop Time	16:12				
Start Time					
End Time					
Elapsed Time (minutes)	15				Traverse 3
PM (mg/m^3 by total filter)					15.060
PM10 (from DRI impactor)					14.340
PM2.5 (from DRI impactor)					12.650
PM emission factor (%)					0.257
PM10 emission factor (%)					0.245
PM2.5 emission factor (%)					0.216
		±Uncertainty		±Uncertainty	
Teflon sample volume (m^3)	0.15	0.01	0.15	0.01	
Quartz sample volume (m^3)	0.15	0.01	0.15	0.01	
Teflon mass concentration (mg/m^3)	11.220	0.570	12.947	0.656	
Teflon mass/Total mass	0.887		0.903		
	Emission (mg/kg)	±Uncertainty	Emission (mg/kg)	±Uncertainty	PM2.5/PM10
Cl-	533.3110	48.4596	584.5819	49.3455	0.91
NO3-	2.1423	0.9223	2.7101	0.9139	0.79
SO4=	75.2759	8.7286	79.8990	8.5922	0.94
NH4+	40.4888	3.3221	39.6395	3.0307	1.02
Na+	28.0311	2.6568	30.2216	2.6583	0.93
K+	372.5266	30.9010	387.6839	29.8655	0.96
C(org)	306.1707	35.0546	363.0482	38.1514	0.84
C(oht)	249.5152	44.4960	309.1328	50.6244	0.81
C(e)	507.6389	52.7882	547.5611	52.9421	0.93
C(eht)	13.9358	9.4457	31.6703	19.7544	0.44
C	813.8096	0.0000	910.6093	0.0000	0.89
Al	0.0000	2.4538	0.0000	2.6999	
Si	2.6015	3.7843	76.4441	5.7355	0.03
P	0.0000	7.2598	0.0000	7.3353	
S	20.3035	3.5100	20.8469	3.5060	0.97
Cl	636.2377	49.7729	691.2499	50.2079	0.92
K	607.6291	47.5049	636.2269	46.1850	0.96
Ca	2.1699	7.6334	21.3033	2.9302	0.10
Ti	0.1064	0.6156	0.0000	0.6150	
V	0.0670	0.2700	0.0000	0.2695	
Cr	0.0434	0.0562	0.0985	0.0564	0.44
Mn	0.5577	0.0605	5.6292	0.4141	0.10
Fe	0.3725	0.1534	6.3331	0.4876	0.06
Co	0.0000	0.0324	0.0072	0.1029	0.00
Ni	0.0236	0.0259	0.0553	0.0270	0.43
Cu	0.1025	0.0281	0.0961	0.0270	1.07
Zn	0.7706	0.0670	0.8817	0.0711	0.87
Ga	0.0000	0.0626	0.0240	0.0613	0.00
As	0.0512	0.0821	0.0481	0.0809	1.07
Se	0.0276	0.0432	0.0240	0.0417	1.15
Br	2.4695	0.1966	2.6884	0.1985	0.92
Rb	0.9480	0.0864	0.9971	0.0858	0.95
Sr	0.0236	0.0367	0.1610	0.0294	0.15
Y	0.0158	0.0670	0.0312	0.0662	0.50
Zr	0.0000	0.0540	0.0505	0.0417	0.00
Mo	0.0000	0.0907	0.0000	0.0882	
Pd	0.0000	0.5076	0.1826	0.5023	0.00
Ag	0.0256	0.5681	0.2090	0.5733	0.12
Cd	0.0000	0.5962	0.0000	0.5929	
In	0.0000	0.6458	0.0865	0.6517	0.00
Sn	0.1793	0.8014	0.0000	0.7791	
Sb	0.0000	0.9137	0.0000	0.9090	
Ba	0.5558	2.9376	2.4986	1.9404	0.22
La	0.0000	3.7951	0.4541	3.7559	0.00
Au	0.0749	0.1123	0.0000	0.1127	
Hg	0.0197	0.0864	0.0481	0.0858	0.41
Tl	0.0374	0.0821	0.0312	0.0809	1.20
Pb	0.1143	0.0799	0.1129	0.0784	1.01
U	0.0000	0.1728	0.0000	0.1715	
Sum of measured species	2,160	95	2,450	84	0.88

Table 3.1.2.18
VOC Concentrations (ppbv)

Date	9-Jun-92	9-Jun-92	9-Jun-92
Fuel	Rice Straw	Rice Straw	Rice Straw
Traverse	Traverse 1	Traverse 2	Traverse 3
Acetic acid			
Propanone (acetone)			
Methyl ester acetic acid (methylacetate)			
Butane			
Dimethyloxirane			
Pentene			
Methylbutanone (isopropylmethyl ketone)			
Furancarboxaldehyde (furfural)	36.3	25.9	33.9
Benzene			
Dimethylbutane			
Hexane			
Phenol			
Dimethylfuran			
2-methyl 2-cyclopenten-1-one			
2-chloro phenol	19	14.3	25.6
Toluene			
Benzonitrile			
Benzaldehyde			
Methylphenol (hydroxy toluene)	7.7	5	10
Styrene	4.2	2.9	6.8
Xylene			
Trimethylpentane			
Benzofuran			
Methoxymethylphenol (creosol)			
Naphthalene			
C10H12			
Alpha-pinene			
Camphene			
Δ3-Carene			
Limonene			
No match r.t. (6.7)			
No match r.t. (8.51)			
No match r.t. (8.71)			
No match r.t. (8.73)			
No match r.t.(6.4)			
No match r.t.(8.5)			

Table 3.1.2.19.
VOC Emission Factors (mg/kg)

Date	9-Jun-92	9-Jun-92	9-Jun-92
Fuel	Rice Straw	Rice Straw	Rice Straw
Traverse	Traverse 1	Traverse 2	Traverse 3
Fuel Consumption Rate (g/s d.b)	11.50	11.27	14.56
Stack Gas Mass Flow Rate (kg/s)	2.89	2.95	2.91
Acetic acid			
Propanone (acetone)			
Methyl ester acetic acid (methylacetate)			
Butane			
Dimethyloxirane			
Pentene			
Methylbutanone (isopropylmethyl ketone)			
Furancarboxaldehyde (furfural)			
Benzene	25	18	18
Dimethylbutane			
Hexane			
Phenol			
Dimethylfuran			
2-methyl 2-cyclopenten-1-one			
2-chloro phenol			
Toluene	15	12	16
Benzonitrile			
Benzaldehyde			
Methylphenol (hydroxy toluene)			
Styrene	7	5	7
Xylene	4	3	5
Trimethylpentane			
Benzofuran			
Methoxymethylphenol (creosol)			
Naphthalene			
Unknown			
Alpha-pinene			
Camphene			
Δ3-Carene			
Limonene			

Table 3.1.2.20. PAH emission factors, rice straw, 9 June 1992 (approximate, filters installed improperly).

	Traverse 1 Filter	Traverse 2 Filter	Tubing	Traverse 1 Sorbent	Traverse 2 Sorbent	Impinger Rinsate	Total Traverse 1	Total Traverse 2	Total Average
					µg/kg dry fuel				
Naphthalene	8.5	11.3	9.4	3,336.0	3,217.8	13.8	3,367.7	3,252.3	3,310.0
2-Methyl-naphthalene	0.5	2.4	2.4	255.3	252.7	1.0	259.1	258.4	258.8
Acenaphthylene	1.8	1.6	0.0	405.6	429.9	1.7	409.0	433.1	421.1
Acenaphthene	2.2	2.1	0.0	18.6	20.4	0.0	20.7	22.5	21.6
Fluorene	2.9	1.6	0.0	128.3	163.9	0.0	131.2	165.5	148.4
Phenanthrene	8.6	9.9	12.8	415.1	499.9	1.6	438.1	524.2	481.2
Anthracene	1.5	2.2	0.0	52.6	69.8	0.0	54.1	72.0	63.1
Fluoranthene	4.8	10.5	7.3	101.7	167.4	0.0	113.8	185.2	149.5
Pyrene	10.7	10.6	4.6	72.9	123.7	0.0	88.2	138.9	113.5
Benz[a]-anthracene	20.2	22.3	6.7	0.0	5.5	0.0	26.9	34.5	30.7
Chrysene	21.1	22.2	9.9	3.0	4.7	0.0	34.0	36.9	35.5
Benzo[b]-fluoranthene	37.4	65.7	0.0	0.0	3.0	0.0	37.4	68.7	53.0
Benzo[k]-fluoranthene	20.7	13.5	0.0	0.0	0.0	0.0	20.7	13.5	17.1
Benzo[a]pyrene	18.4	16.6	0.0	0.0	0.0	0.0	18.4	16.6	17.5
Benzo[e]pyrene	22.3	29.1	0.0	0.0	0.0	0.0	22.3	29.1	25.7
Perylene	1.8	5.1	0.0	0.0	0.0	0.0	1.8	5.1	3.5
Benzo[ghi]-perylene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indeno[1,2,3-cd]-pyrene	0.0	22.7	0.0	0.0	0.0	0.0	0.0	22.7	11.3
Dibenz[a,h]-anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	183.5	249.4	53.0	4,789.1	4,958.6	18.1	5,043.7	5,279.1	5,161.4

Zero values indicate not detected.

Figure 3.1.2.1. Ambient air conditions, 9 June 92.

Fuel Type:	Rice Straw	Test Date	9-Jun-92
Configuration:	CRNF		

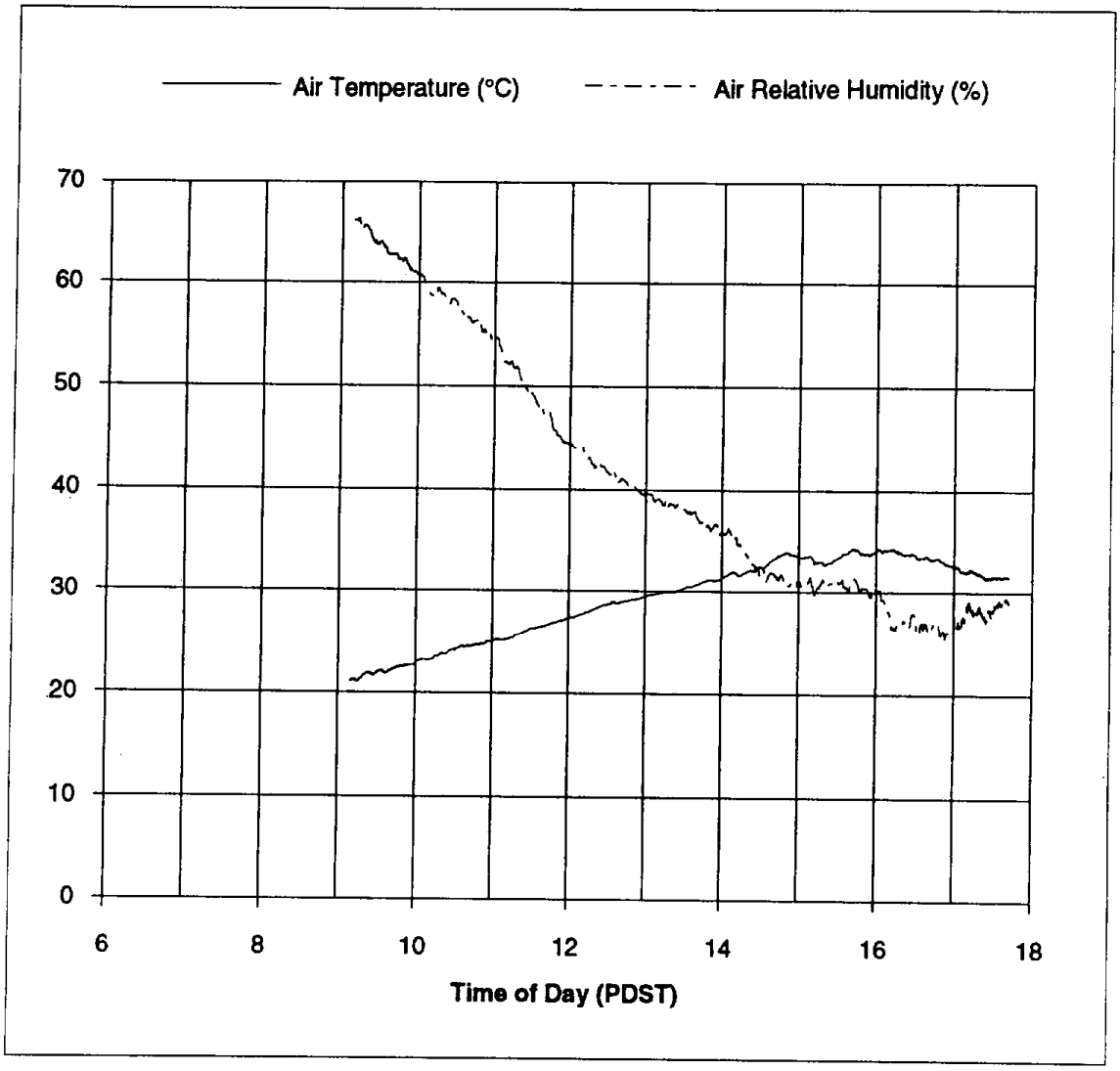


Figure 3.1.2.2. Air temperature and relative humidity from CIMIS station.

Fuel: Rice Straw Date of Test: 9-Jun-92

Configuration: CRNF

Hourly Average CIMIS Data for Davis, California

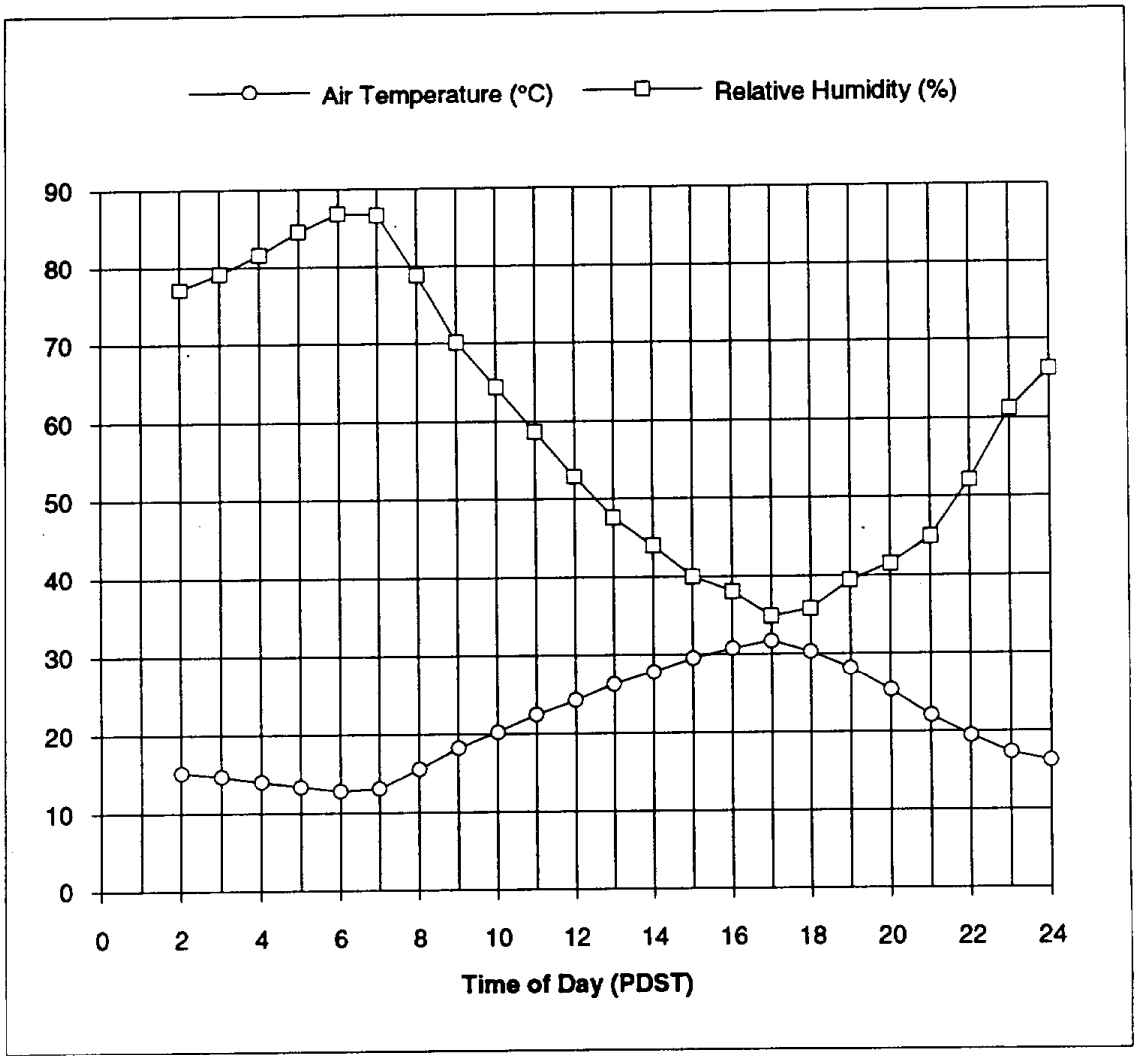


Figure 3.1.2.3. Wind speed from CIMIS station.

Fuel: Rice Straw Date of Test: 9-Jun-92

Configuration: CRNF

Hourly Average CIMIS Data for Davis, California

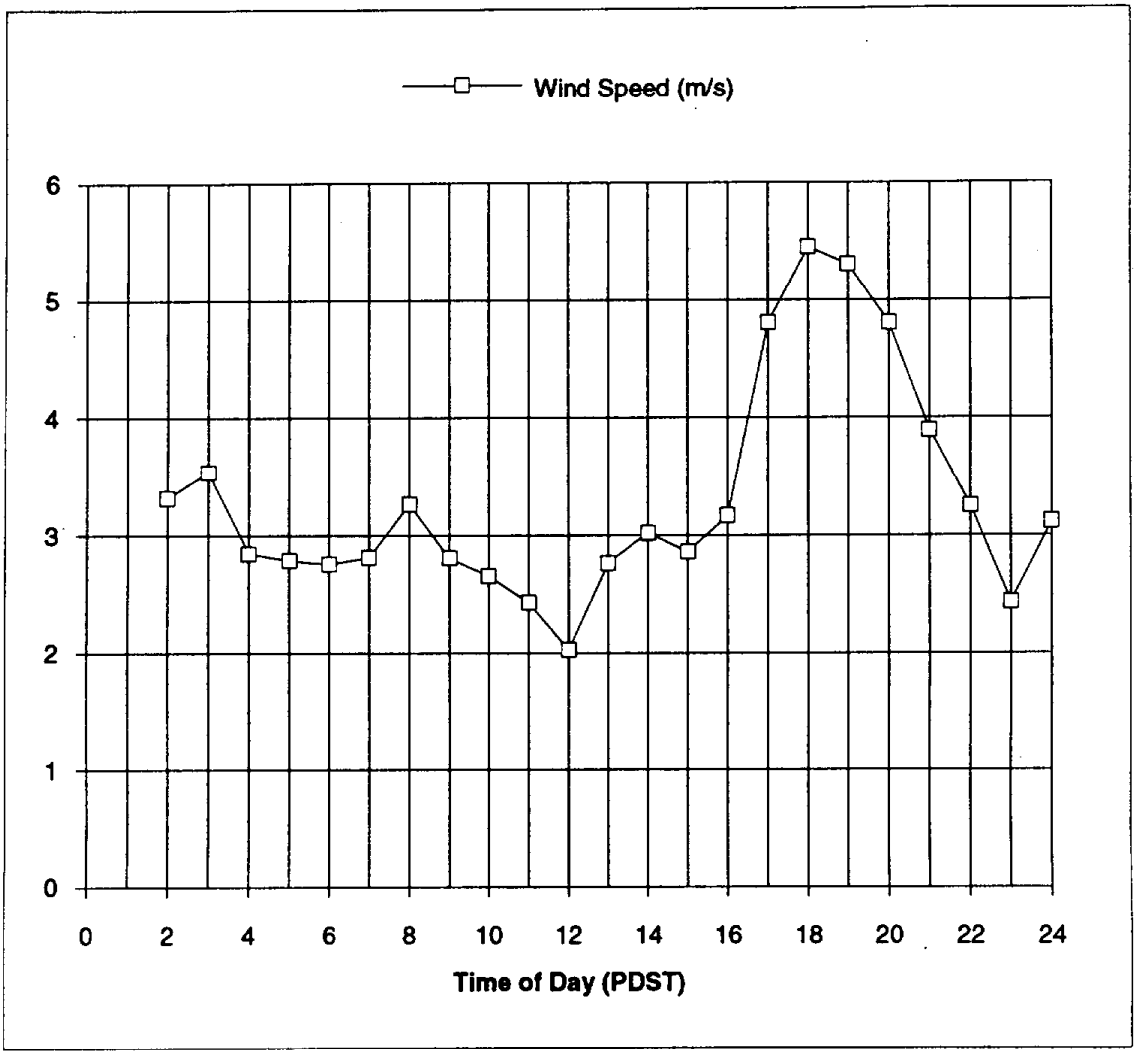


Figure 3.1.2.4. Wind direction and solar radiation from CIMIS station.

Fuel: Rice Straw Date of Test: 9-Jun-92

Configuration: CRNF

Hourly Average CIMIS Data for Davis, California

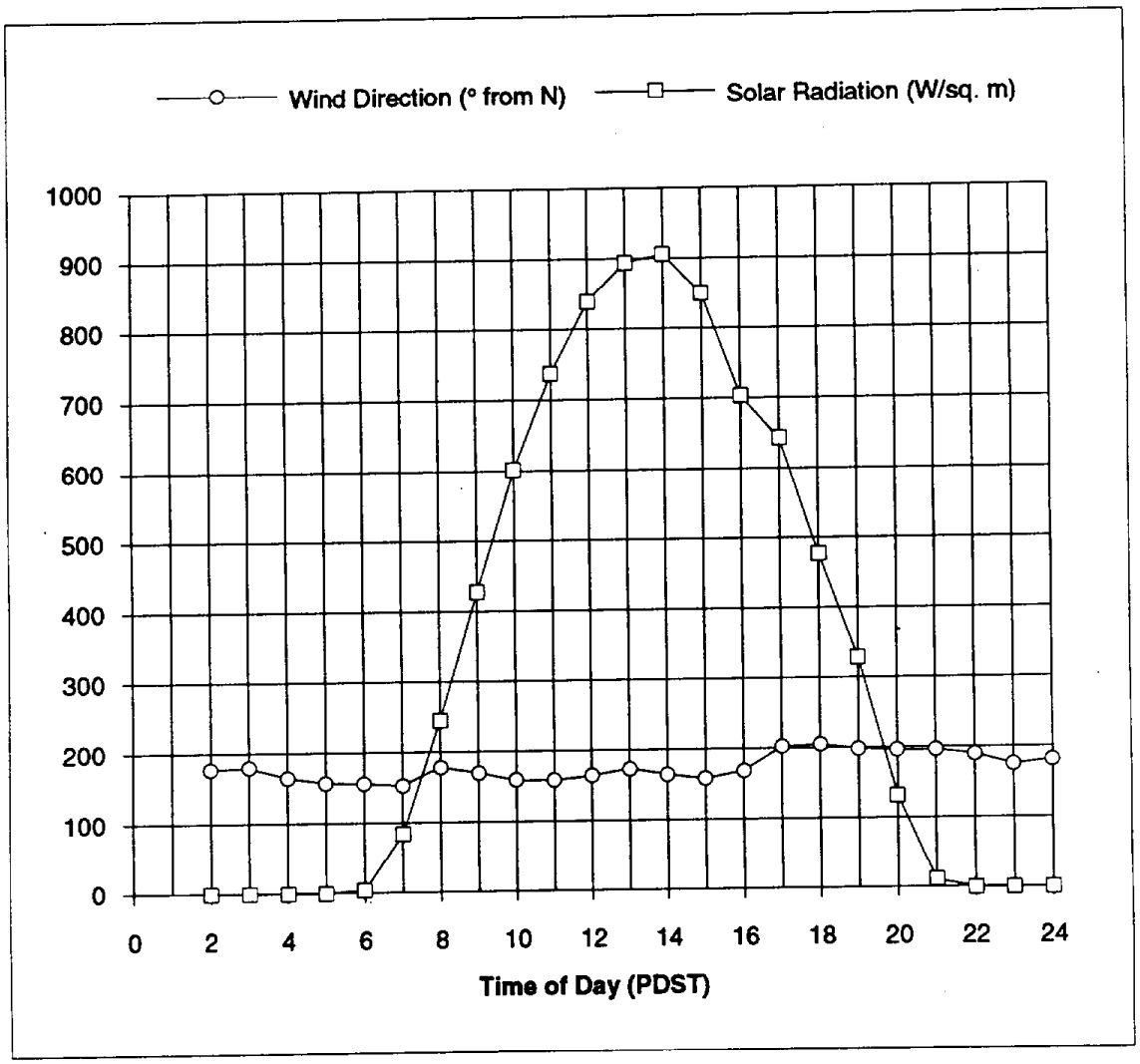


Figure 3.1.2.5. Inlet air, stack gas, and impinger outlet temperatures, 9 June 92.

Fuel Type:	Rice Straw	Test Date	9-Jun-92
Configuration:	CRNF		

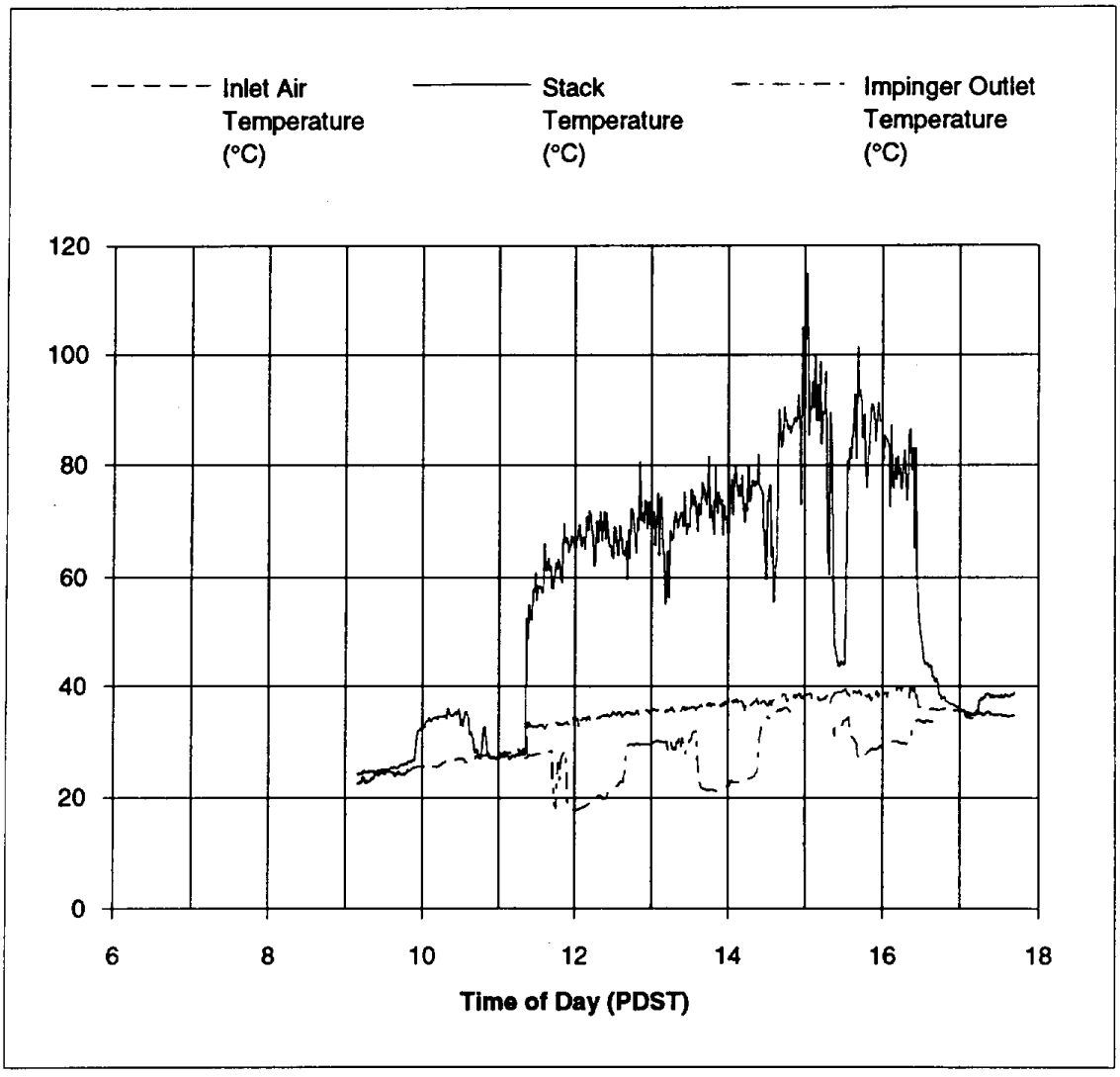


Figure 3.1.2.6. Conveyor speed and stack gas velocity, 9 June 92.

Fuel Type:	Rice Straw	Test Date	9-Jun-92
Configuration:	CRNF		

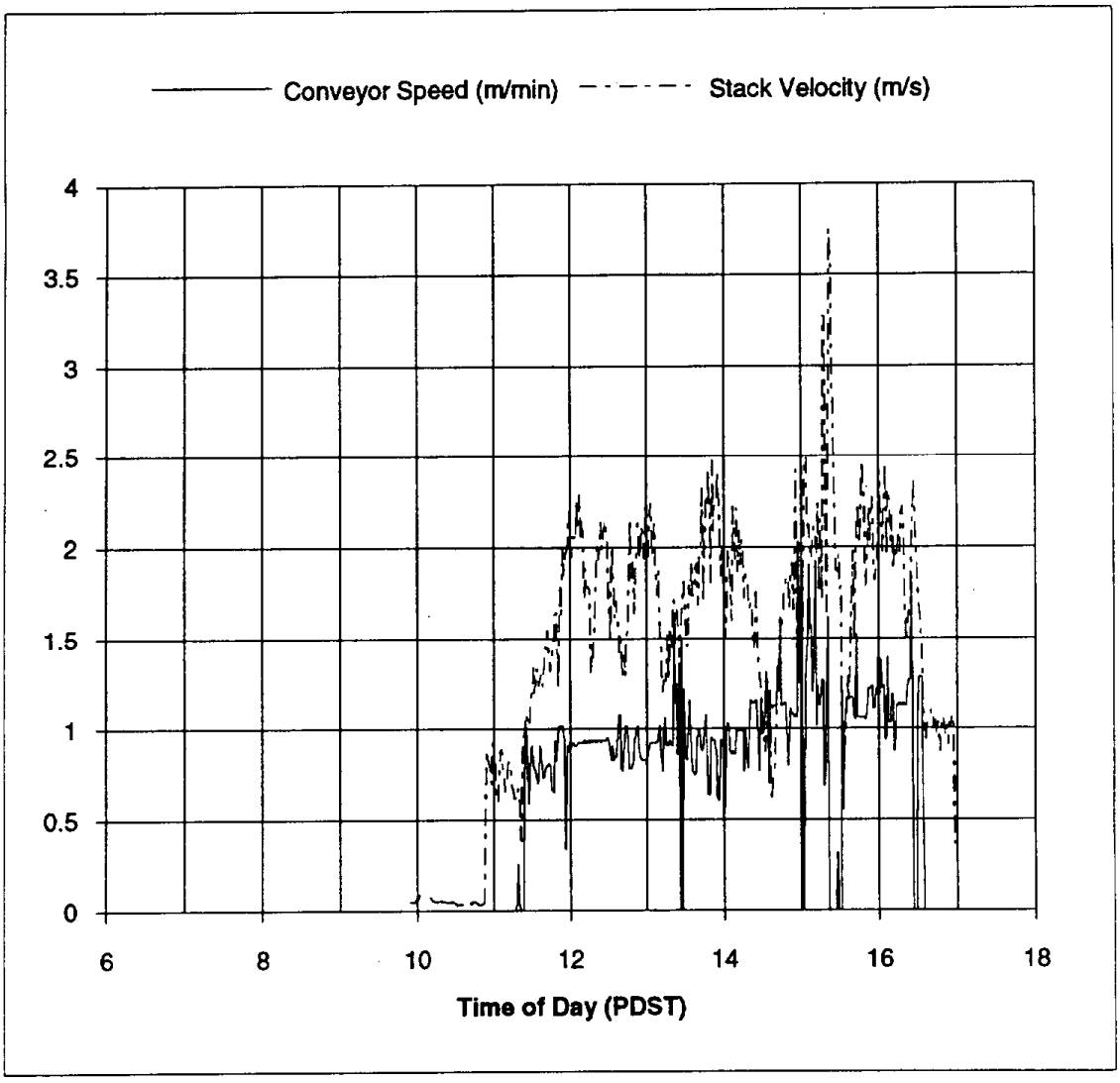


Figure 3.1.2.7. Conveyor speed with 10 min moving average, 9 June 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 9-Jun-92

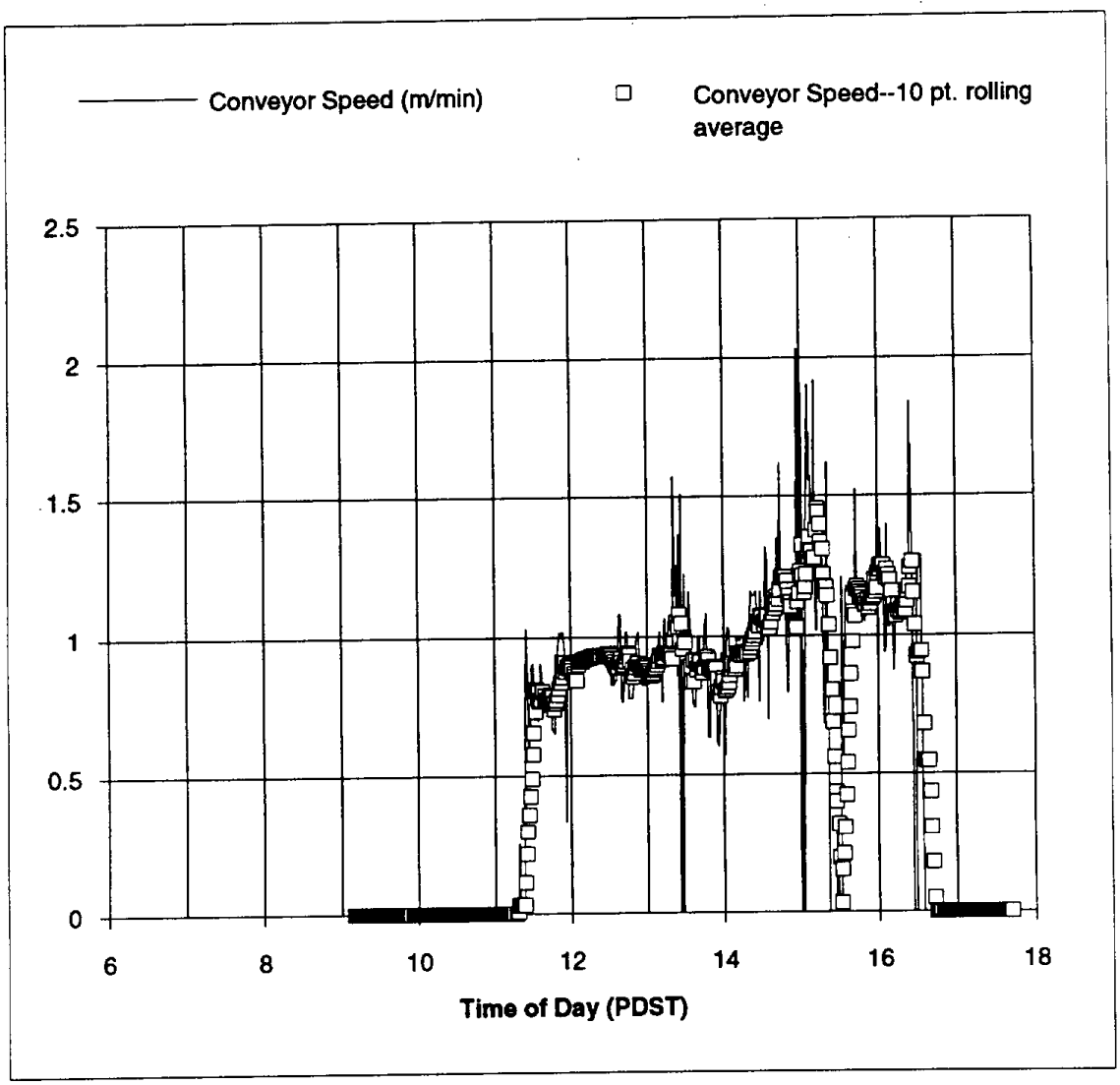


Figure 3.1.2.8. Conveyor travel, 9 June 92.

Fuel Type:	Rice Straw	Test Date	9-Jun-92
Configuration:	CRNF		

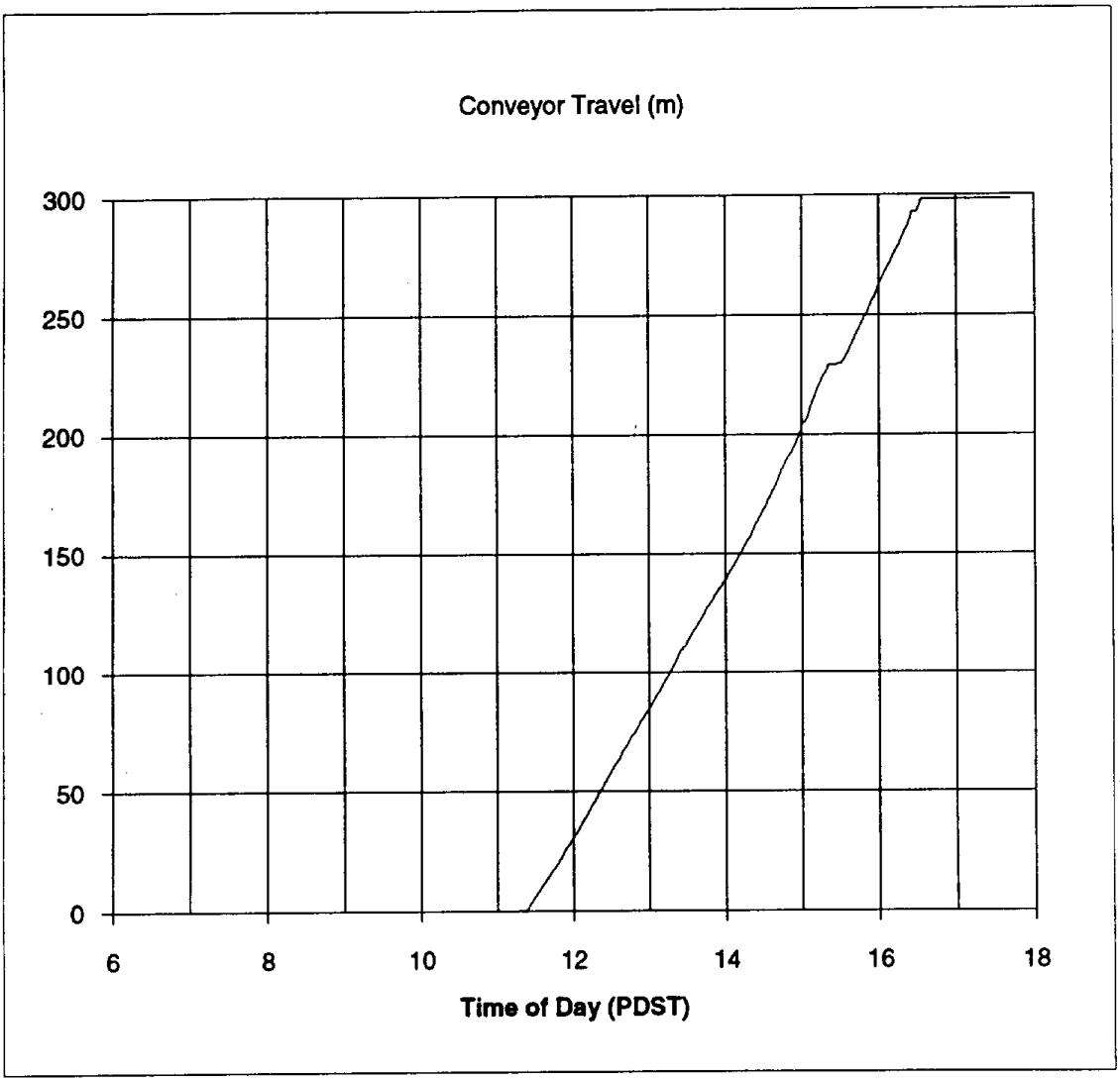


Figure 3.1.2.9. CO concentration in stack gas, 9 June 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 9-Jun-92

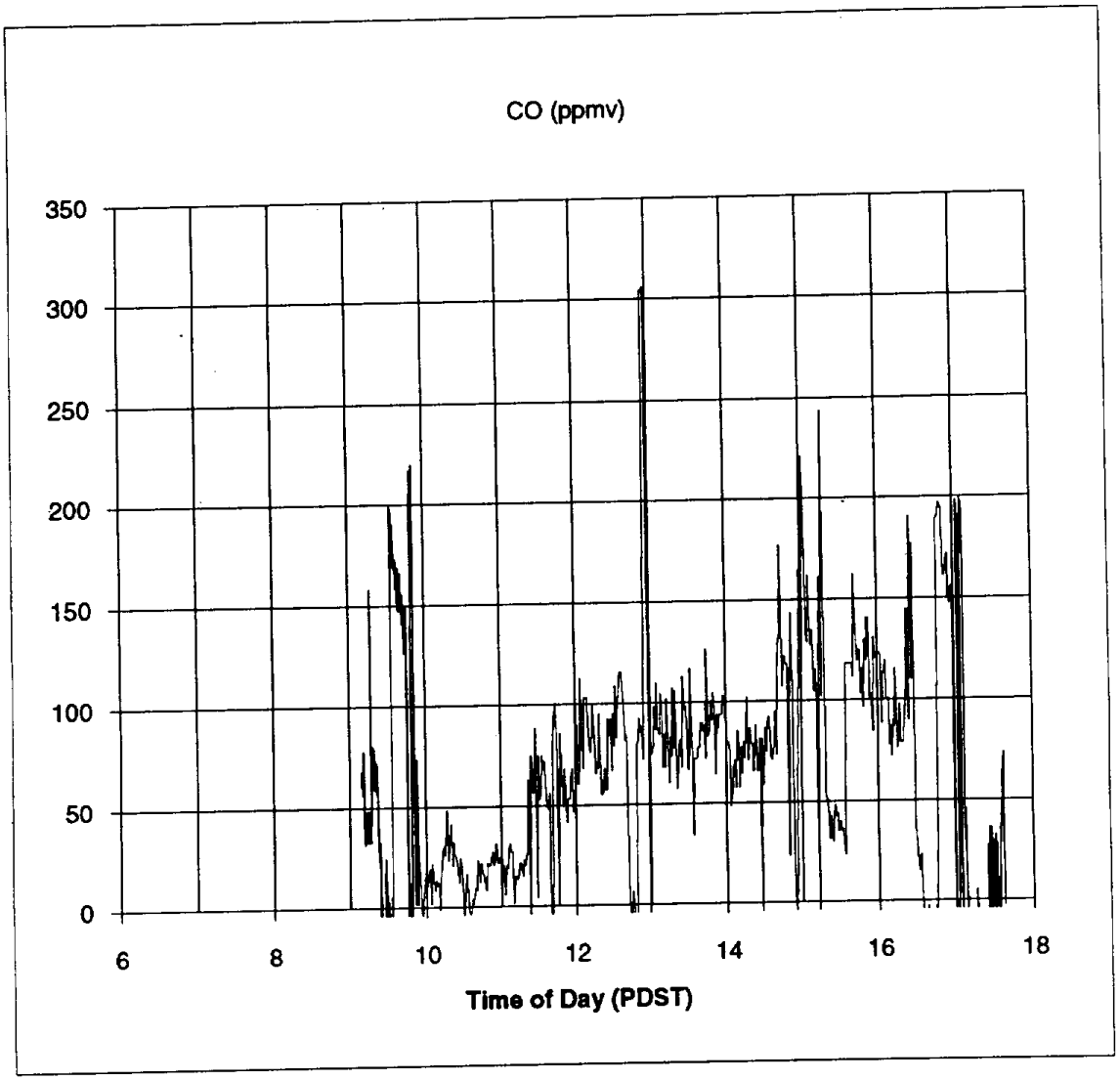


Figure 3.1.2.10. NO and NOx concentrations in stack gas, 9 June 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 9-Jun-92

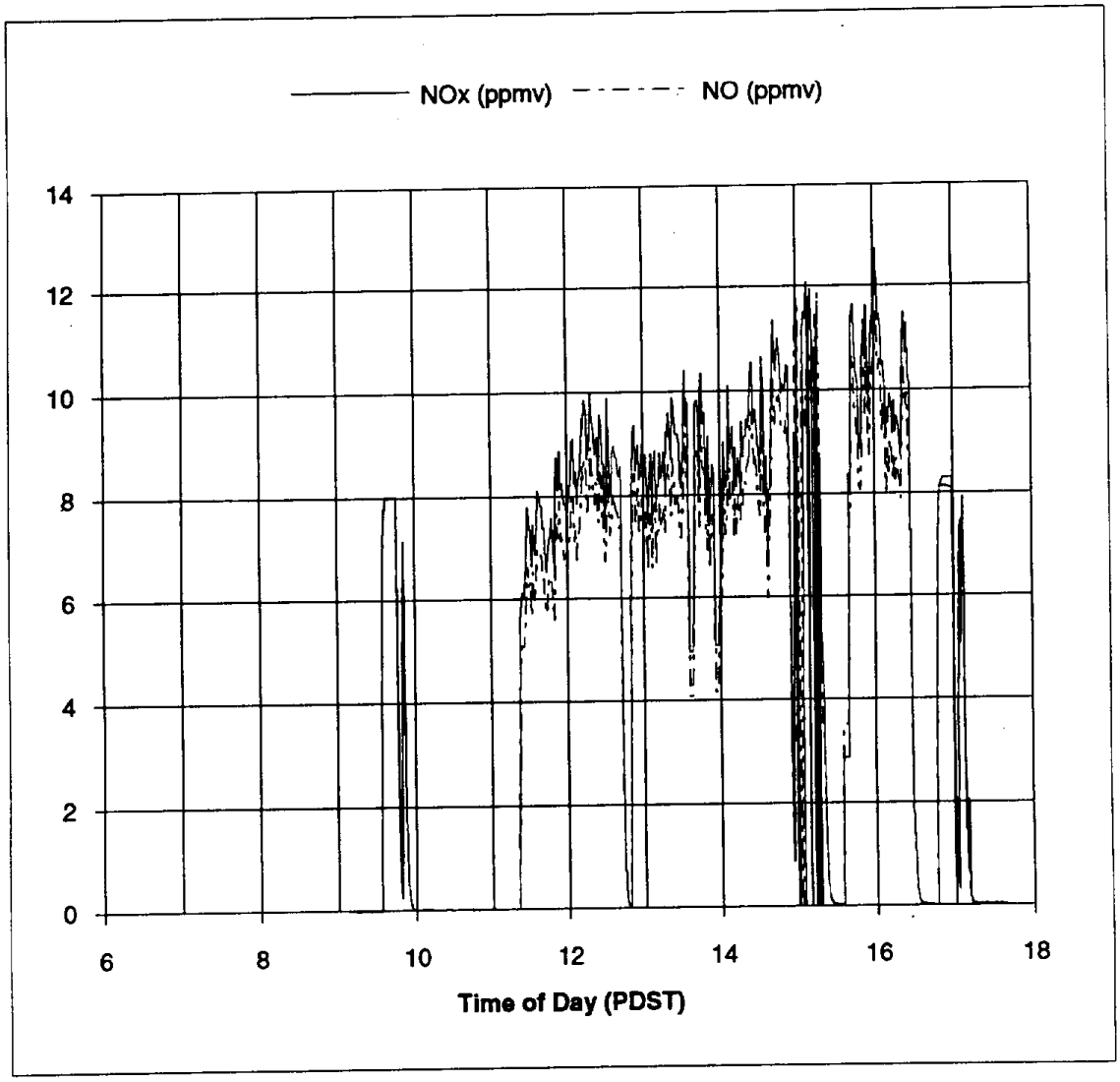


Figure 3.1.2.11. SO2 concentration in stack gas, 9 June 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 9-Jun-92

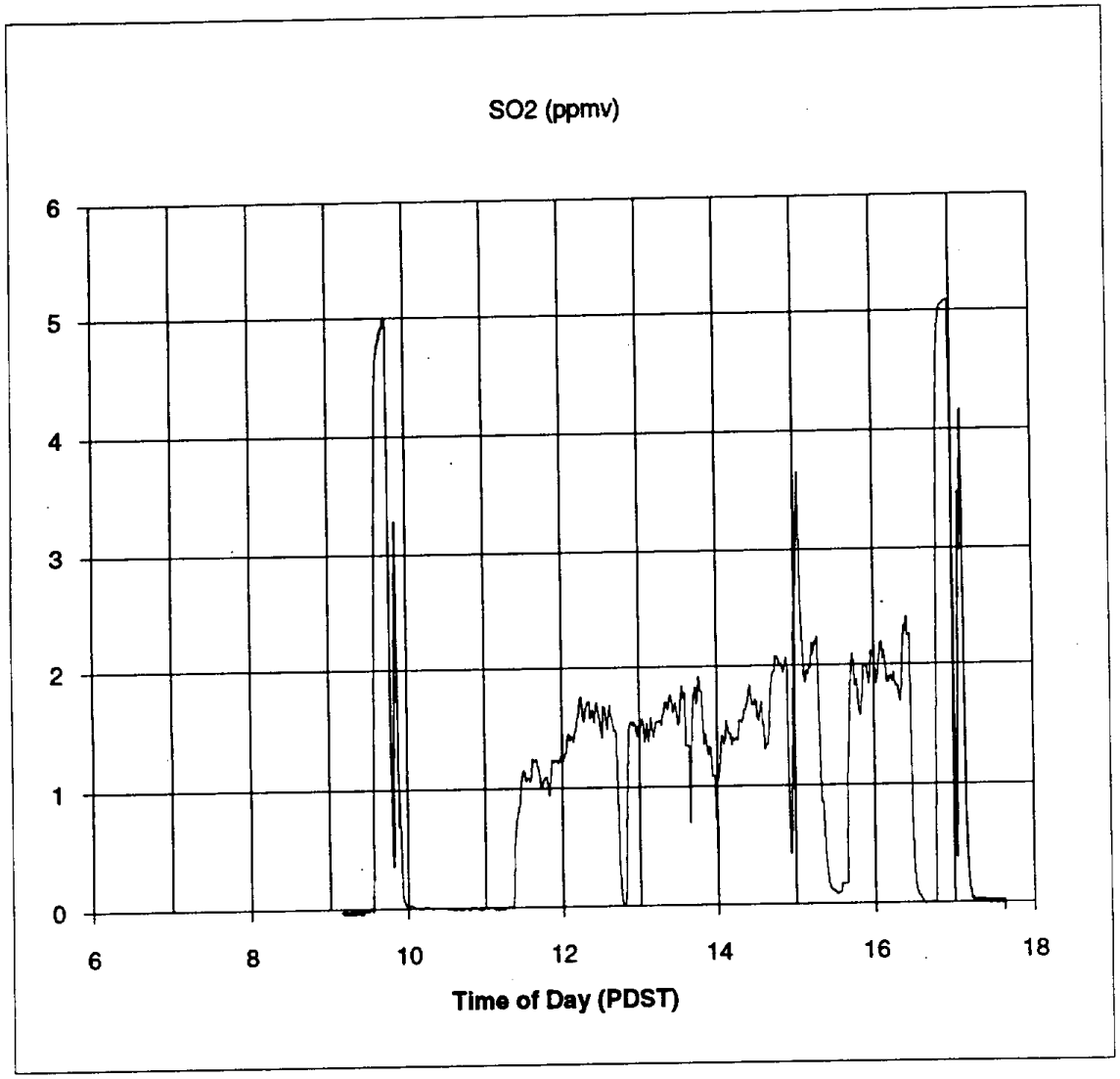


Figure 3.1.2.12. Total sulfur concentration in stack gas, 9 June 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 9-Jun-92

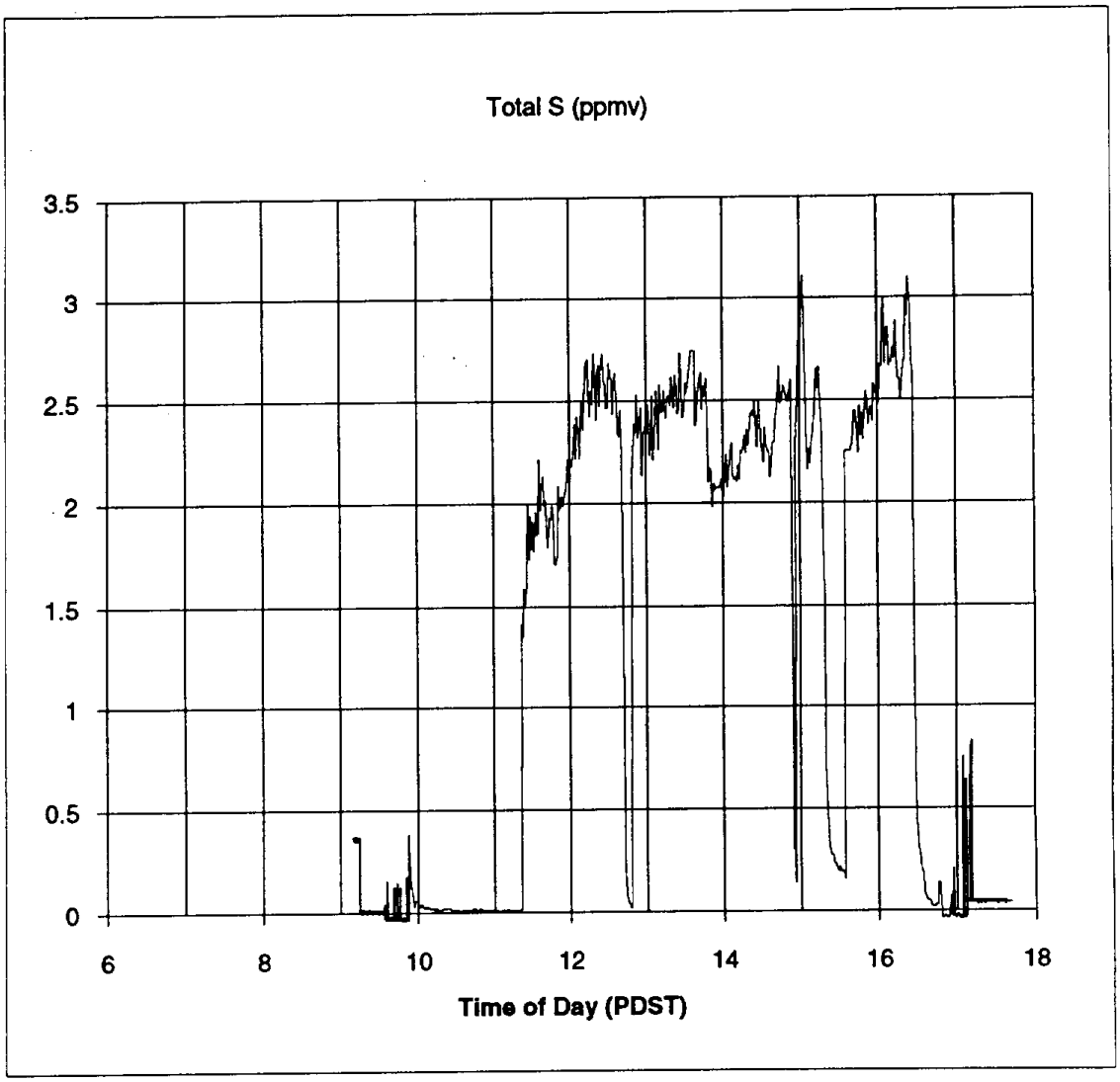


Figure 3.1.2.13. Particle size distribution, traverse 1, 9 June 92.

Fuel: Rice Straw

Date of Test: 9-Jun-92

Configuration: CRNF

Particle Size Distribution
Traverse 1:

Stage	ECD (μm)	Weight (mg)	Cum. Wt (mg)	Cum. Fraction
1	15.06	0.4	9.9	1.000
2	8.43	0.4	9.5	0.960
3	4.50	0.4	9.1	0.919
4	2.38	0.5	8.7	0.879
5	1.37	0.5	8.2	0.828
6	0.81	0.6	7.7	0.778
7	0.42	0.9	7.1	0.717
filter	0.00	6.2	6.2	0.626

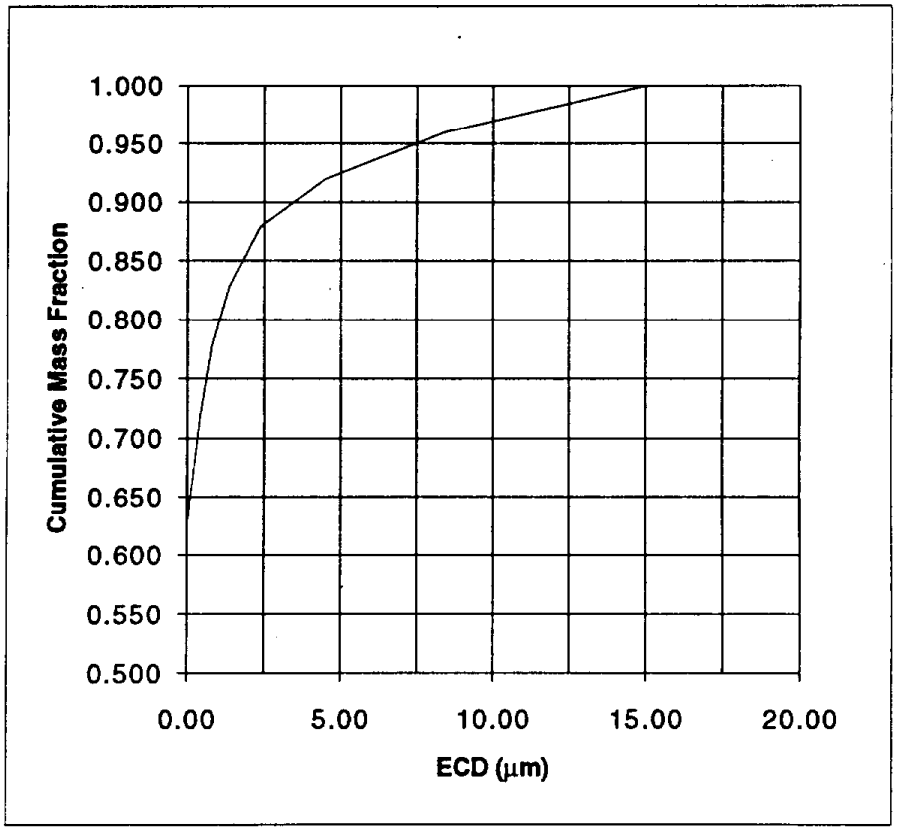


Figure 3.1.2.14. Particle size distribution, traverse 2, 9 June 92.

Fuel: Rice Straw

Date of Test: 9-Jun-92
Configuration: CRNF

Particle Size Distribution
Traverse 2:

Stage	ECD (μm)	Weight (mg)	Cum. Wt (mg)	Cum. Fraction
1	14.76	0.3	8.4	1.000
2	8.27	0.2	8.1	0.964
3	4.41	0.2	7.9	0.940
4	2.33	0.2	7.7	0.917
5	1.34	0.4	7.5	0.893
6	0.79	0.4	7.1	0.845
7	0.41	0.4	6.7	0.798
filter	0.00	6.3	6.3	0.750

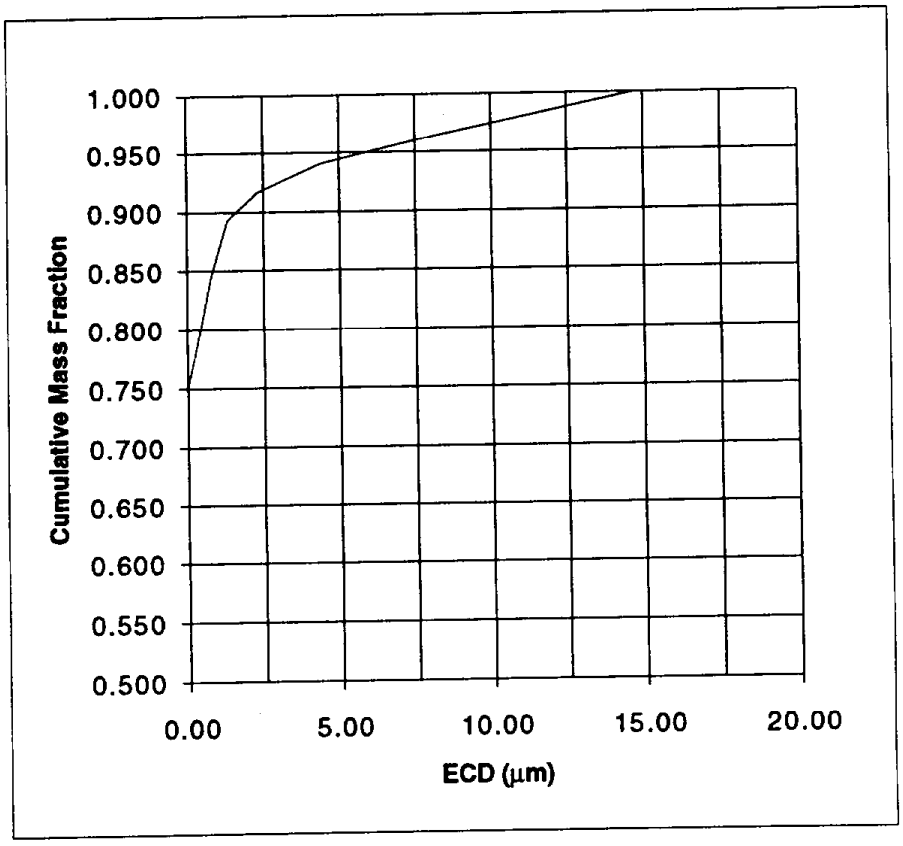


Figure 3.1.2.15. Particle size distribution, traverse 3, 9 June 92.

Fuel: Rice Straw

Date of Test: 9-Jun-92
Configuration: CRNF

Particle Size Distribution
Traverse 3:

Stage	ECD (μm)	Weight (mg)	Cum. Wt (mg)	Cum. Fraction
1	16.17	0.6	11.1	1.000
2	9.06	0.8	10.5	0.946
3	4.83	0.4	9.7	0.874
4	2.55	0.6	9.3	0.838
5	1.47	0.4	8.7	0.784
6	0.86	0.2	8.3	0.748
7	0.45	0.5	8.1	0.730
filter	0.00	7.6	7.6	0.685

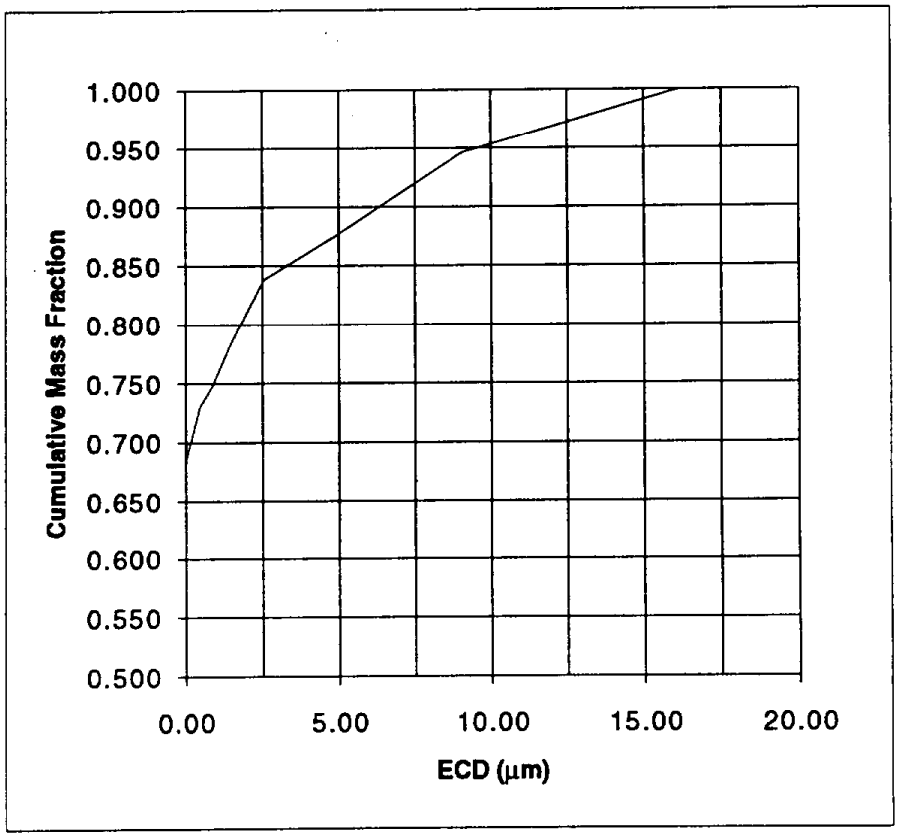


Figure 3.1.2.16. Nitrogen balance.
Date of Test: 9-Jun-92
Fuel Rice Straw

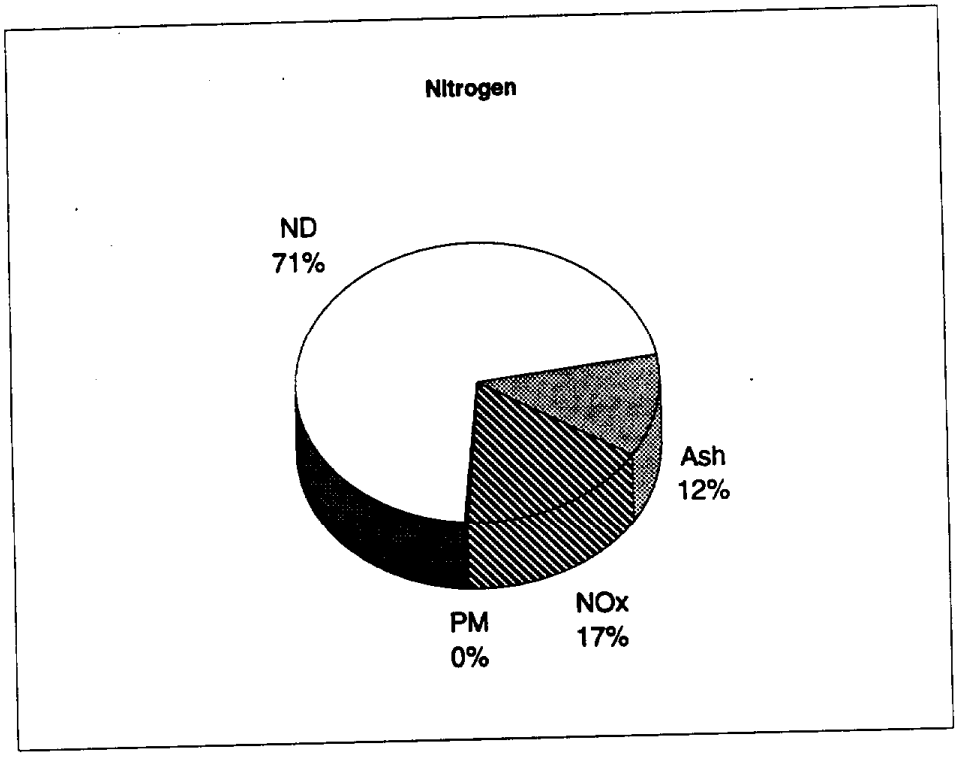


Figure 3.1.2.17. Sulfur balance.
Date of Test: 9-Jun-92
Fuel Rice Straw

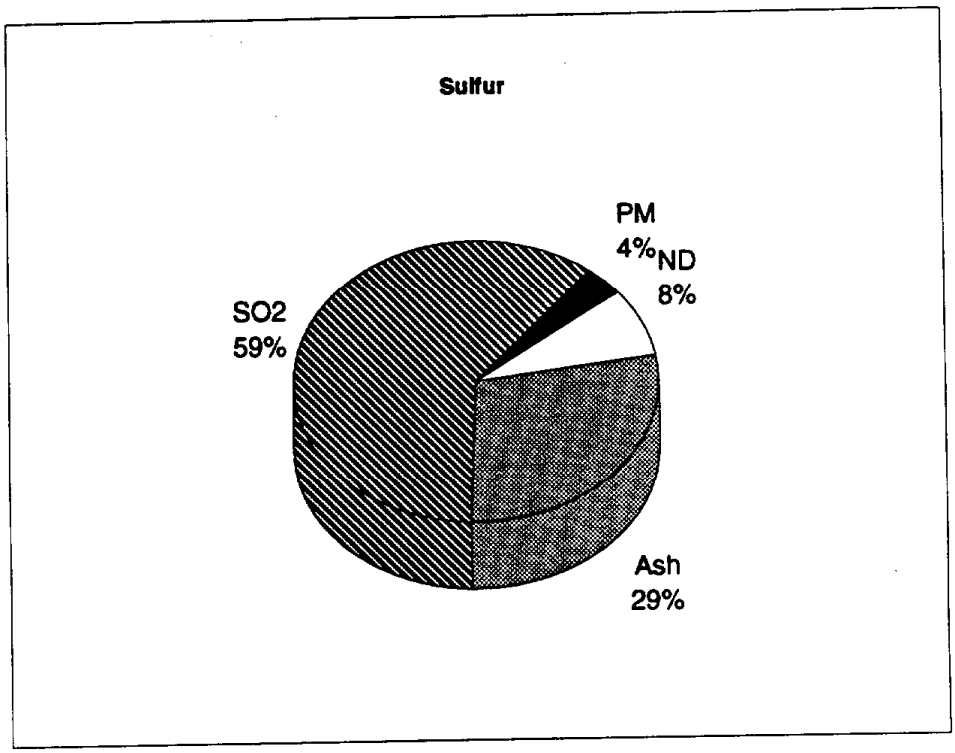


Figure 3.1.2.18. Mass fraction of PAH on primary filter samples, 9 June 1992, rice straw.

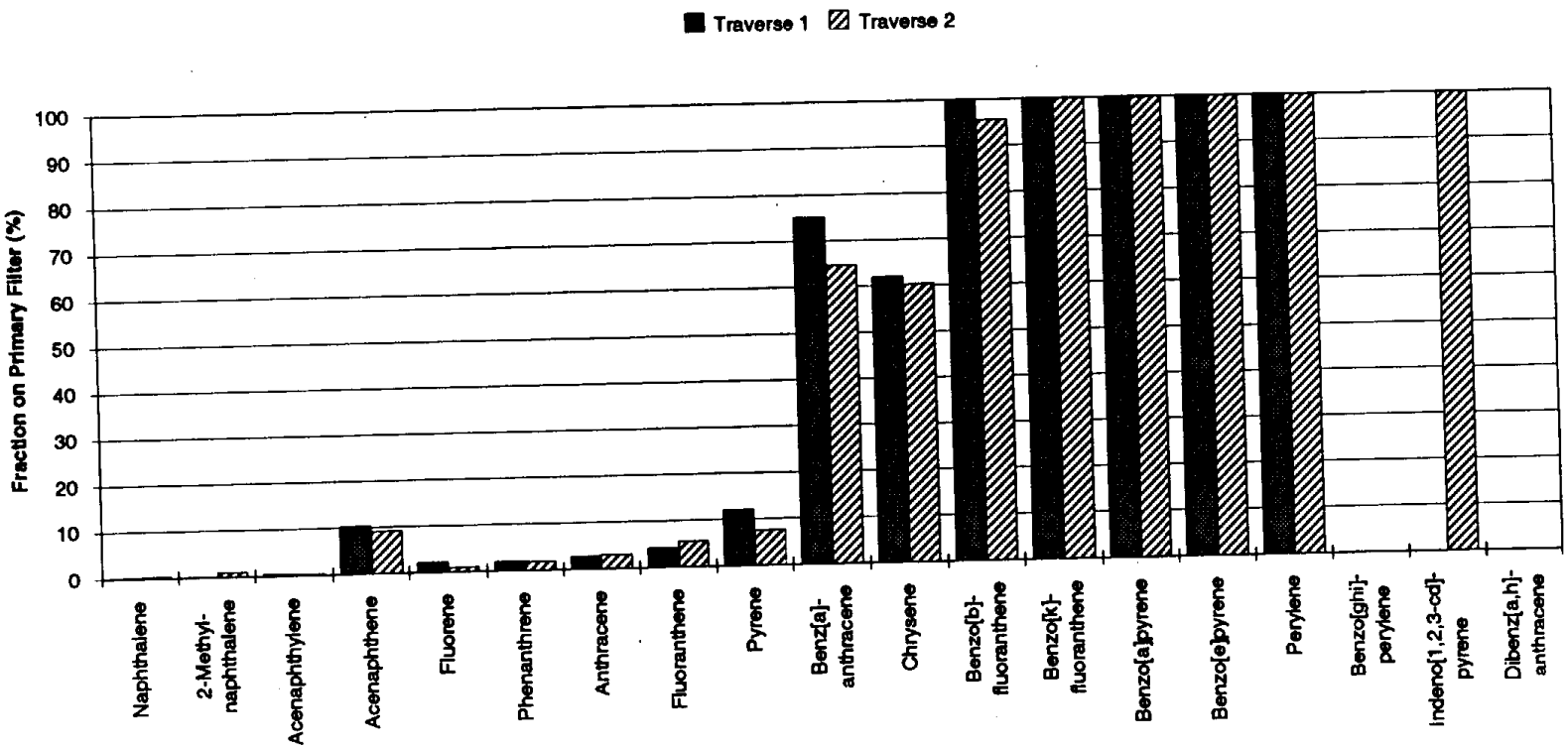


Table 3.1.3.1

Fuel and Ash Analyses

Run Date	10-Jul-92
Fuel Type	Rice Straw
Sample Type	Ash
Ultimate Analysis	
(% dry weight)	
C	9.82
H	0.66
N	0.18
Elemental Analysis	
(% by weight dry basis)	
N	0.32
P	0.20
K	2.79
Ca	1.23
Mg	0.67
Na	0.17
Cl	0.39
(mg/kg dry weight)	
S	830
B	16
Zn	88
Mn	3,790
Fe	702
Cu	10
Si	
Total (% dry weight)	16.79
Proximate Analysis	
(% dry weight)	
Ash	86.05
Volatiles	11.01
Fixed Carbon	2.94
Higher Heating Value	
(MJ/kg dry weight)	2.7250

Table 3.1.3.2. Operating conditions and concentrations, rice straw, 10 July 92.

Fuel:	Rice Straw	Date of Test:	10-Jul-92
		Configuration:	CEWF

Fuel Loading Rate (g/sq.m w.b.):	637
Total Fuel Consumption (kg w.b.)	104.3
Total Ash Recovered (kg w.b.)	23.8
Ash Fraction (w.b.)	0.23

	Traverse 1	Traverse 2
Mean Values		
Air Temperature (°C)	30.45	33.54
Air Relative Humidity (%)	19.97	20.36
Inlet Air Temperature (°C)	34.00	36.76
Stack Temperature (°C)	52.45	55.64
Impinger Outlet Temperature (°C)	20.89	28.05
Fire Spreading Rate (m/min)	0.96	0.94
Stack Gas Velocity (m/s)	2.86	2.91
Gas and PM Concentrations (less background)		
CO (ppmv)	75.42	75.85
NO (ppmv)	3.24	3.20
NOx (ppmv)	4.10	3.99
SO2 (ppmv)	0.58	0.52
HC (ppmv as CH4 by GC)	1.83	1.76
CH4 (ppmv by GC)	1.68	1.64
NMHC (ppmv as CH4 by GC)	0.15	0.13
CO2 (ppmv by GC)	2,286	2,416
Total S (ppmv as SO2)	0.40	0.35
PM (mg/cu.m)	6.07	1.78
PM10 (mg/cu.m)	5.89	1.78
PM2.5 (mg/cu.m)	5.61	1.70

Table 3.1.3.3. Mass balance, rice straw, 10 July 92.

Fuel: Rice Straw

Date of Test: 10-Jul-92

Configuration: CEWF

Mass Balance

	Traverse 1	Traverse 2
Total Conveyor Travel (m)	47.04	45.31
Fuel Moisture Content (% w.b.)	7.7	8.6
Fuel Loading Rate (g/sq.m d.b.)	588	582
Total Fuel Consumption (g w.b.)	36,535	35,191
Total Fuel Consumption (g d.b.)	33,711	32,157
Residual Ash (g w.b.)	8,349	8,041
Fuel Vaporized (g w.b.)	28,186	27,149
Fuel Consumption Rate (g/s w.b.)	12.69	12.22
Fuel Consumption Rate (g/s d.b.)	11.71	11.17
Ash Generation Rate (g/s w.b.)	2.90	2.79
Fuel Vaporization Rate (g/s w.b.)	9.79	9.43
Stack Gas Density (kg/cu.m)	1.0855	1.0749
Stack Gas Flow Rate (cu.m/s)	4.25	4.33
Stack Gas Mass Flow Rate (kg/s)	4.61	4.66
Inlet Air Mass Flow Rate (kg/s)	4.60	4.65
Overall Air-Fuel Ratio (w.b.)	362.76	380.35
Overall Air-Fuel Ratio (d.b.)	393.15	416.23

Table 3.1.3.4. Emission factors, rice straw, 10 July 92 (integrated basis).

Fuel:	Rice Straw	Date of Test:	10-Jul-92
		Configuration:	CEWF

Emission Factors (% of fuel dry weight)

Integrated Basis

	Traverse 1	Traverse 2	Average
CO	2.936	3.047	2.992
NO	0.135	0.138	0.137
NOx (as NO2)	0.263	0.264	0.263
SO2	0.052	0.048	0.050
HC (as CH4 by GC)	0.040	0.041	0.040
CH4 (by GC)	0.036	0.038	0.037
NMHC (by GC)	0.003	0.003	0.003
CO2 (by GC)	136.651	152.884	144.768
Total S (as SO2)	0.036	0.032	0.034
SO2/Total S	1.45	1.50	1.47
PM	0.199	0.063	0.131
PM10	0.193	0.063	0.128
PM2.5	0.184	0.061	0.122
MMAD (μm)	0.085	0.156	0.120
σ	4.141	2.382	

Table 3.1.3.5. Emission factors, rice straw, 10 July 92 (average basis).

Fuel:	Rice Straw	Date of Test:	10-Jul-92
		Configuration:	CEWF

Emission Factors (% of fuel dry weight)

Average Basis

	Traverse 1	Traverse 2	Average
CO	2.869	3.054	2.962
NO	0.132	0.138	0.135
NOx (as NO2)	0.256	0.264	0.260
SO2	0.051	0.048	0.049
HC (as CH4 by GC)	0.040	0.041	0.040
CH4 (by GC)	0.036	0.038	0.037
NMHC (by GC)	0.003	0.003	0.003
CO2 (by GC)	136.651	152.884	144.768
Total S (as SO2)	0.035	0.032	0.034
SO2/Total S	1.44	1.50	1.47
PM	0.199	0.063	0.131
PM10	0.193	0.063	0.128
PM2.5	0.184	0.061	0.122
MMAD (μm)	0.085	0.156	0.120
σ	4.141	2.382	

Table 3.1.3.6. Carbon balance.

Date of Test: Fuel	10-Jul-92 Rice Straw Traverse 1	10-Jul-92 Rice Straw Traverse 2
Carbon Balance		
Dry Fuel Consumption Rate (g/s)	11.71	11.17
Ash Generation Rate (g/s)	2.90	2.79
Ash Fraction (% dry basis)	24.77	24.98
Fuel Carbon Concentration* (%)	37.99	37.99
Residual Ash Carbon Concentration (%)	9.82	9.82
Carbon released to stack (g/s)	4.16	3.97
Maximum CO2 emission factor (%)	130.38	130.30
Stack Gas Density (kg/cubic meter)	1.09	1.07
Average CO2 concentration (ppmv)	2,286	2,416
Average CO concentration (ppmv)	75.42	75.85
Average THC concentration (ppmv as CH4)	1.83	1.76
PM Concentration (mg/cubic meter)	6.07	1.78
PM Carbon Concentration (%)	36.77	36.77
PM Carbon (mg/cubic meter)	2.23	0.65
Stack Gas Temperature (°C)	52.45	55.64
Impinger Temperature (°C)	20.89	28.05
PM molar concentration (ppm)	4.49	1.35
Estimated Average Stack Gas Velocity (m/s)	2.63	2.41
Emission Factors (% Average Basis):		
CO2	136.651	152.884
CO	2.869	3.054
HC (as CH4)	0.04	0.041
PM	0.199	0.063
Emission Factors (% Integrated Basis):		
CO2	136.651	152.884
CO	2.936	3.047
HC (as CH4)	0.04	0.041
PM	0.199	0.063
Closure (% Average Basis)	109	121
Closure (% Integrated Basis)	108	121

*Fuel analysis from run of 14 July 92.

Table 3.1.3.7. Nitrogen balance

Date of Test:	10-Jul-92	10-Jul-92
Fuel	Rice Straw Traverse 1	Rice Straw Traverse 2
Nitrogen Balance		
Fuel Nitrogen Concentration* (% dry weight)	0.70	0.70
Ash Nitrogen Concentration (% weight)	0.32	0.32
Emission Factors (% Average Basis):		
NOx (as NO2)	0.256	0.264
PM	0.199	0.063
Emission Factors (% Integrated Basis):		
NOx (as NO2)	0.263	0.264
NO3- Concentration of PM (% weight)	0.273	0.273
NH4+ Concentration of PM (% weight)	8.386	8.386
Nitrogen Concentration of PM (%)	6.584	6.584
Fuel Nitrogen (mg/s)	81.97	78.19
Ash Nitrogen (mg/s)	9.28	8.93
Nitrogen as NOx (mg/s Average Basis)	9.12	8.97
Nitrogen as NOx (mg/s Integrated Basis)	9.37	8.97
Nitrogen as PM (mg/s Average Basis)	1.53	0.46
Nitrogen as NOx+PM (mg/s Average Basis)	10.66	9.44
Nitrogen as NOx+PM (mg/s Integrated Basis)	10.91	9.44
NOx+PM Nitrogen/Fuel Nitrogen (Average)	0.130	0.121
NOx+PM Nitrogen/Fuel Nitrogen (Integrated)	0.133	0.121
Ash Nitrogen/Fuel Nitrogen	0.113	0.114
Ash+NOx+PM Nitrogen/Fuel Nitrogen (Average)	0.243	0.235
Ash+NOx+PM Nitrogen/Fuel Nitrogen (Integrated)	0.246	0.235

*Fuel analysis from run of 14 July 92.

Table 3.1.3.8. Sulfur balance.

Date of Test:	10-Jul-92	10-Jul-92
Fuel	Rice Straw Traverse 1	Rice Straw Traverse 2
Sulfur Balance		
Fuel Sulfur Concentration* (mg/kg dry weight)	720	720
Ash Sulfur Concentration (mg/kg weight)	830	830
Emission Factors (% Average Basis)		
SO2	0.051	0.048
PM	0.199	0.063
Emission Factors (% Integrated Basis)		
SO2	0.052	0.048
Sulfur Concentration of PM (% weight)	1.073	1.073
Fuel Sulfur (mg/s)	8.43	8.04
Ash Sulfur (mg/s)	2.41	2.32
Sulfur as SO2 (mg/s Average Basis)	2.99	2.68
Sulfur as SO2 (mg/s Integrated Basis)	3.04	2.68
Sulfur as PM (mg/s Average Basis)	0.25	0.08
Sulfur as SO2+PM (mg/s Average Basis)	3.24	2.76
Sulfur as SO2+PM (mg/s Integrated Basis)	3.29	2.76
SO2+PM Sulfur/Fuel Sulfur (Average Basis)	0.384	0.343
SO2+PM Sulfur/Fuel Sulfur (Integrated Basis)	0.391	0.343
Ash Sulfur/Fuel Sulfur	0.285	0.288
Closure (% Average Basis)	67	63
Closure (% Integrated Basis)	68	63

*Fuel analysis from run of 14 July 92.

Table 3.1.3.9. Water balance.

Estimated Stack Humidity

Fuel	Rice Straw
Configuration	CEWF
Date of Test	10-Jul-92

	Traverse 1	Traverse 2
Ambient Air Temperature °C)	30	34
Ambient Air Relative Humidity (%)	20	20
Air Temperature (K)	304	307
Saturation Pressure (Pa)	4,357	5,189
Vapor Pressure (Pa)	870	1,056
Air Dew Point Temperature (°C)	5.0	7.8
Ambient Volume Fraction Water Vapor	0.0086	0.0104
Ambient Mass Fraction Water Vapor	0.0053	0.0065
Fuel Burning Rate (g/s wet basis)	12.69	12.22
Fuel Moisture Content (%)	7.7	8.6
Ash Fraction (wet basis)	0.23	0.23
Fuel Hydrogen Content (%)	5.27	5.27
Ash Hydrogen Content (%)	0.66	0.66
Moisture Evaporated (g/s)	0.98	1.05
Water of Combustion (g/s)	5.38	5.13
Total Fuel Water Added (g/s)	6.36	6.18
Inlet Air Mass Flowrate (g/s)	4,600	4,650
Inlet Air Water Vapor Flowrate (g/s)	25	30
Total Stack Water Vapor Flowrate (g/s)	31	36
Stack Gas Mass Flowrate (g/s)	4,610	4,659
Mass Fraction Water Vapor in Stack	0.0067	0.0078
Volume Fraction Water Vapor in Stack	0.0108	0.0125
Stack Vapor Pressure (Pa)	1,093	1,271
Stack Temperature (°C)	52	56
Stack Temperature (K)	326	329
Stack Saturation Pressure (Pa)	13,932	16,249
Stack Relative Humidity (%)	8	8
Stack Dew Point Temperature (°C)	8.3	10.5
Impinger Outlet Temperature (°C)	20.9	28.1
Volume Stack Gas Sampled for PM (L)	577	619
Estimated Impinger/Desiccant Weight Gain (g)	4.6	5.7

Totals:

	Estimated	Measured
Total Impinger/Desiccant Weight Gain (g)	10.3	10.2
Estimated/Measured Weight Gain	1.01	

Table 3.1.3.10. Power balance.

Date of Test:	10-Jul-92	10-Jul-92
Fuel	Rice Straw	Rice Straw
	Traverse 1	Traverse 2
Power Balance		
Fuel Heating Value (MJ/kg dry weight)	15.7392	15.7392
Ash Heating Value (MJ/kg dry weight)	2.7250	2.7250
Average Energy Release Rate (kW)	176.4	168.2
Products of Incomplete Combustion (kW)		
CO	3.4	3.4
THC (as CH4)	0.3	0.3
PM	0.3	0.1
Heat Release Rate (kW)	172.5	164.4
Fireline Intensity (kW/m)	141.5	134.9
Stack Gas Flow (kg/s)	4.61	4.66
Stack Gas Temperature (°C)	52.45	55.64
Inlet Temperature (°C)	34.00	36.76
Sensible Power at Top of Stack (kW)	85.6	88.5
Tunnel Dissipation (kW)	86.9	75.9

Table 3.1.3.11. Mass concentrations (%) from DRI filter samples

Date	10-Jul-92		10-Jul-92	
Fuel	Rice Straw CEWF		Rice Straw CEWF	
Size Fraction	PM2.5		PM10	
Teflon Filter ID	ABTT015		ABTT016	
Quartz Filter ID	ABTQ015		ABTQ016	
Teflon Field Sample Flag				
Quartz field sample field				
Teflon mass sample flag	i1			
Quartz mass sample flag				
Anions sample flag				
Ammonium analysis flag				
Sodium ion analysis flag				
Magnesium ion analysis flag				
Potassium ion analysis flag				
Carbon analysis flag				
XRF analysis flag				
		±Uncertainty		±Uncertainty
Teflon sample volume (m^3)	0.30	0.02	0.30	0.02
Quartz sample volume (m^3)	0.30	0.01	0.30	0.02
Teflon mass concentration (µg/m^3)	3,373	176	3,890	201

	Concentration (%)	±Uncertainty	Concentration (%)	±Uncertainty	PM2.5/PM10
Cl-	29.5868	2.4839	27.0972	2.2625	1.09
NO3-	0.2905	0.0736	0.2725	0.0637	1.07
SO4=	3.7961	0.2901	3.3181	0.2518	1.14
NH4+	9.8091	0.7329	8.3857	0.7413	1.17
Na+	1.3184	0.1183	1.1683	0.1041	1.13
K+	9.7266	0.7472	8.7208	0.6656	1.12
C(org)	20.2675	2.2217	19.3878	2.0797	1.05
C(oht)	14.9095	2.5377	15.6962	2.6021	0.95
C(e)	18.8745	1.8098	17.3779	1.6614	1.09
C(eht)	0.6288	0.4024	0.8655	0.5375	0.73
C	39.1420		36.7657		1.06
Al	0.0000	0.1276	0.0000	0.1200	
Si	0.1573	0.2000	1.9673	0.1603	0.08
P	0.0000	0.3779	0.0000	0.3450	
S	1.1713	0.1837	1.0728	0.1676	1.09
Cl	36.2467	2.6253	33.0953	2.3835	1.10
K	15.6472	1.1335	14.5331	1.0468	1.08
Ca	0.0514	0.1811	0.2210	0.0590	0.23
Ti	0.0000	0.0490	0.0117	0.0424	0.00
V	0.0000	0.0215	0.0002	0.0186	0.00
Cr	0.0002	0.0059	0.0011	0.0052	0.18
Mn	0.0127	0.0032	0.0835	0.0068	0.15
Fe	0.0369	0.0119	0.2555	0.0211	0.14
Co	0.0001	0.0027	0.0000	0.0046	
Ni	0.0000	0.0029	0.0012	0.0025	0.00
Cu	0.0029	0.0021	0.0028	0.0018	1.04
Zn	0.0304	0.0032	0.0305	0.0030	1.00
Ga	0.0000	0.0053	0.0000	0.0045	
As	0.0008	0.0065	0.0016	0.0056	0.50
Se	0.0004	0.0036	0.0016	0.0031	0.25
Br	0.1178	0.0090	0.1136	0.0085	1.04
Rb	0.0146	0.0027	0.0146	0.0025	1.00
Sr	0.0000	0.0032	0.0012	0.0028	0.00
Y	0.0006	0.0039	0.0019	0.0034	0.32
Zr	0.0061	0.0033	0.0018	0.0041	3.39
Mo	0.0036	0.0080	0.0036	0.0068	1.00
Pd	0.0000	0.0367	0.0000	0.0319	
Ag	0.0000	0.0420	0.0078	0.0372	0.00
Cd	0.0000	0.0438	0.0000	0.0390	
In	0.0032	0.0487	0.0000	0.0436	
Sn	0.0000	0.0603	0.0004	0.0531	0.00
Sb	0.0033	0.0706	0.0149	0.0618	0.22
Ba	0.1379	0.2386	0.0000	0.2062	
La	0.0000	0.3170	0.0314	0.2758	0.00
Au	0.0000	0.0090	0.0000	0.0077	
Hg	0.0019	0.0075	0.0000	0.0063	
Tl	0.0027	0.0070	0.0022	0.0059	1.23
Pb	0.0032	0.0092	0.0037	0.0079	0.86
U	0.0026	0.0077	0.0010	0.0067	2.60
Sum of measured species	104.2160	4.1698	98.0693	3.8408	1.06

Table 3.1.3.12. Element ratios from DRI filter samples.

Date	10-Jul-92	10-Jul-92	
Fuel	Rice Straw	Rice Straw	
Configuration	CEWF	CEWF	
Size Fraction	PM2.5	PM10	PM2.5/PM10
Teflon Filter ID	ABTT015	ABTT016	
Quartz Filter ID	ABTQ015	ABTQ016	
Cl-/Cl	0.82	0.82	1.00
K+/K	0.62	0.60	1.04
Sulfate S/Total S	1.08	1.03	1.05
C(org)/C	0.52	0.53	0.98
Cl/K	2.32	2.28	1.02
Cl-/K+	3.04	3.11	0.98
Cl-/Na+	22.44	23.19	0.97
S/K	0.07	0.07	1.01
S/Na+	0.89	0.92	0.97
Al/Si	0.00	0.00	

Table 3.1.3.13. Emission factors (mg/kg) from DRI filter samples.

Date			10-Jul-92		10-Jul-92	
Fuel			Rice Straw CEWF		Rice Straw CEWF	
Size Fraction	PM2.5			PM10		
Teflon Filter ID	ABTT015			ABTT016		
Quartz Filter ID	ABTQ015			ABTQ016		
Start Time	10:15					
Stop Time	10:45					
Start Time						
End Time						
Elapsed Time (minutes)	30					Traverse 1
PM (mg/m^3 by total filter)						6.070
PM10 (by total filter/impactor)						5.890
PM2.5 (by total filter/impactor)						5.610
PM emission factor (%)						0.199
PM10 emission factor (%)						0.193
PM2.5 emission factor (%)						0.184
		±Uncertainty		±Uncertainty		
Teflon sample volume (m^3)	0.30	0.02	0.30	0.02		
Quartz sample volume (m^3)	0.30	0.01	0.30	0.02		
Teflon mass concentration (mg/m^3)	3.373	0.176	3.890	0.201		
Teflon mass/Total mass	0.601		0.660			
	Emission (mg/kg)	±Uncertainty	Emission (mg/kg)	±Uncertainty	PM2.5/PM10	
Cl-	522.3738	45.7038	533.2718	43.6663	0.98	
NO3-	5.1290	1.3542	5.3628	1.2294	0.96	
SO4=	67.0226	5.3378	65.3001	4.8597	1.03	
NH4+	173.1659	13.4654	165.0302	14.3071	1.05	
Na+	23.2772	2.1767	22.9921	2.0091	1.01	
K+	171.7293	13.7485	171.6250	12.8461	1.00	
C(org)	357.8356	40.8793	381.5511	40.1382	0.94	
C(oht)	263.2367	46.6937	308.9006	50.2205	0.85	
C(e)	333.2413	33.3003	341.9964	32.0650	0.97	
C(eht)	11.1019	7.4042	17.0330	10.3738	0.65	
C	691.0770	0.0000	723.5475	0.0000	0.96	
Al	0.0000	2.3478	0.0000	2.3160		
Si	2.7772	3.6800	38.7164	3.0938	0.07	
P	0.0000	6.9534	0.0000	6.6585		
S	20.6800	3.3801	21.1127	3.2347	0.98	
Cl	639.9586	48.3055	651.3142	46.0016	0.98	
K	276.2613	20.8564	286.0108	20.2032	0.97	
Ca	0.9075	3.3322	4.3493	1.1387	0.21	
Ti	0.0000	0.9016	0.2303	0.8183	0.00	
V	0.0000	0.3956	0.0039	0.3590	0.00	
Cr	0.0035	0.1086	0.0216	0.1004	0.16	
Mn	0.2242	0.0589	1.6433	0.1312	0.14	
Fe	0.6515	0.2190	5.0282	0.4072	0.13	
Co	0.0018	0.0497	0.0000	0.0888		
Ni	0.0000	0.0534	0.0236	0.0483	0.00	
Cu	0.0512	0.0386	0.0551	0.0347	0.93	
Zn	0.5367	0.0589	0.6002	0.0579	0.89	
Ga	0.0000	0.0975	0.0000	0.0869		
As	0.0141	0.1196	0.0315	0.1081	0.45	
Se	0.0071	0.0662	0.0315	0.0598	0.22	
Br	2.0798	0.1656	2.2356	0.1641	0.93	
Rb	0.2578	0.0497	0.2873	0.0483	0.90	
Sr	0.0000	0.0589	0.0236	0.0540	0.00	
Y	0.0106	0.0718	0.0374	0.0656	0.28	
Zr	0.1077	0.0607	0.0354	0.0791	3.04	
Mo	0.0636	0.1472	0.0708	0.1312	0.90	
Pd	0.0000	0.6753	0.0000	0.6157		
Ag	0.0000	0.7728	0.1535	0.7180	0.00	
Cd	0.0000	0.8059	0.0000	0.7527		
In	0.0565	0.8961	0.0000	0.8415		
Sn	0.0000	1.1095	0.0079	1.0248	0.00	
Sb	0.0583	1.2990	0.2932	1.1927	0.20	
Ba	2.4347	4.3902	0.0000	3.9797		
La	0.0000	5.8328	0.6180	5.3229	0.00	
Au	0.0000	0.1656	0.0000	0.1486		
Hg	0.0335	0.1380	0.0000	0.1216		
Tl	0.0477	0.1288	0.0433	0.1139	1.10	
Pb	0.0565	0.1693	0.0728	0.1525	0.78	
U	0.0459	0.1417	0.0197	0.1293	2.33	
Sum of measured species	1,840	77	1,930	71	0.95	

Table 3.1.3.14. Mass concentrations (%) from DRI filter samples

Date	8-Jul-92		8-Jul-92		
Fuel	Rice Straw CEWF		Rice Straw CEWF		
Size Fraction	PM2.5		PM10		
Teflon Filter ID	ABTT011		ABTT012		
Quartz Filter ID	ABTQ011		ABTQ012		
Teflon Field Sample Flag					
Quartz field sample field					
Teflon mass sample flag	f3,w6		f3		
Quartz mass sample flag					
Anions sample flag					
Ammonium analysis flag					
Sodium ion analysis flag					
Magnesium ion analysis flag					
Potassium ion analysis flag					
Carbon analysis flag					
XRF analysis flag	f3				
		±Uncertainty		±Uncertainty	
Teflon sample volume (m^3)	0.30	0.02	0.30	0.02	
Quartz sample volume (m^3)	0.30	0.01	0.30	0.02	
Teflon mass concentration (µg/m^3)	5,350	729	6,773	343	
	Concentration (%)	±Uncertainty	Concentration (%)	±Uncertainty	PM2.5/PM10
Cl-	39.5371	5.9761	32.8949	2.7212	1.20
NO3-	0.2794	0.0602	0.2347	0.0386	1.19
SO4=	2.8863	0.4241	2.4681	0.1842	1.17
NH4+	15.5858	2.2839	12.7235	0.9381	1.22
Na+	0.2826	0.0472	0.2419	0.0256	1.17
K+	9.0550	1.3341	7.6637	0.5788	1.18
C(org)	26.3920	4.2535	18.9988	1.9087	1.39
C(oht)	18.3816	3.7288	15.8846	2.5059	1.16
C(e)	10.4472	1.6534	7.2096	0.6870	1.45
C(eht)	0.8811	0.5558	1.0974	0.6718	0.80
C	36.8392		26.2084		1.41
Al	0.0000	0.1060	0.0000	0.1237	
Si	0.0272	0.1716	1.4756	0.1271	0.02
P	0.0000	0.3370	0.0000	0.3991	
S	0.4447	0.1596	0.4476	0.5199	0.99
Cl	32.5790	4.7269	38.6586	2.7508	0.84
K	9.7875	1.4202	11.3703	0.8093	0.86
Ca	0.0743	0.1139	0.3758	0.0516	0.20
Ti	0.0000	0.0294	0.0008	0.0242	0.00
V	0.0000	0.0129	0.0000	0.0120	
Cr	0.0016	0.0034	0.0047	0.0023	0.34
Mn	0.0183	0.0033	0.1353	0.0099	0.14
Fe	0.0185	0.0078	0.2031	0.0157	0.09
Co	0.0000	0.0015	0.0000	0.0033	
Ni	0.0000	0.0016	0.0029	0.0010	0.00
Cu	0.0032	0.0014	0.0035	0.0011	0.91
Zn	0.0077	0.0017	0.0124	0.0014	0.62
Ga	0.0009	0.0030	0.0016	0.0024	0.56
As	0.0008	0.0035	0.0012	0.0029	0.67
Se	0.0012	0.0020	0.0013	0.0012	0.92
Br	0.0612	0.0090	0.0731	0.0054	0.84
Rb	0.0115	0.0022	0.0121	0.0016	0.95
Sr	0.0006	0.0017	0.0034	0.0011	0.18
Y	0.0006	0.0022	0.0011	0.0018	0.55
Zr	0.0007	0.0026	0.0011	0.0021	0.64
Mo	0.0017	0.0043	0.0000	0.0035	
Pd	0.0000	0.0214	0.0049	0.0188	0.00
Ag	0.0040	0.0251	0.0000	0.0214	
Cd	0.0000	0.0265	0.0000	0.0223	
In	0.0000	0.0286	0.0093	0.0246	0.00
Sn	0.0000	0.0355	0.0015	0.0297	0.00
Sb	0.0000	0.0409	0.0140	0.0343	0.00
Ba	0.1098	0.0956	0.0407	0.1115	2.70
La	0.0380	0.1765	0.0464	0.1451	0.82
Au	0.0012	0.0049	0.0021	0.0040	0.57
Hg	0.0020	0.0041	0.0011	0.0033	1.82
Tl	0.0014	0.0038	0.0001	0.0030	14.00
Pb	0.0017	0.0050	0.0029	0.0031	0.59
U	0.0007	0.0044	0.0025	0.0039	0.28
Sum of measured species	96.1872	7.1168	92.3197	3.7043	1.04

Table 3.1.3.15. Element ratios from DRI filter samples.

Date	8-Jul-92	8-Jul-92	
Fuel	Rice Straw	Rice Straw	
Configuration	CEWF	CEWF	
Size Fraction	PM2.5	PM10	PM2.5/PM10
Teflon Filter ID	ABTT011	ABTT012	
Quartz Filter ID	ABTQ011	ABTQ012	
Cl-/Cl	1.21	0.85	1.43
K+/K	0.93	0.67	1.37
Sulfate S/Total S	2.16	1.84	1.18
C(org)/C	0.72	0.72	0.99
Cl/K	3.33	3.40	0.98
Cl-/K+	4.37	4.29	1.02
Cl-/Na+	139.90	135.99	1.03
S/K	0.05	0.04	1.15
S/Na+	1.57	1.85	0.85
Al/Si	0.00	0.00	

Table 3.1.3.16. Element concentrations (ng/m^3) from CNL filter samples.

Fuel:	Rice
Date:	10-Jul-92
Time:	10:15
Filter ID:	AG-28

Element	Concentration	±Uncertainty
	ng/m^3	
H	44,980	6,200
Na		
Mg	31,200	4,600
Al		
Si	389,230	20,000
P		
S	21,760	1,600
Cl	633,730	32,100
K	396,150	20,100
Ca	59,650	5,200
Ti	280	200
V		
Cr	630	100
Mn	11,440	800
Fe	18,070	1,000
Ni		
Cu	240	100
Zn	820	100
As	90	100
Pb		
Se		
Br	1,970	200
Rb		
Sr		
Zr		

Table 3.1.3.17. Element emission factors (mg/kg) from CNL filter samples.

Fuel:	Rice
Date:	10-Jul-92
Time:	10:15
Filter ID:	AG-28
Fuel rate (g/s)	11.71
Stack gas flow rate (m^3/s)	4.25
Stack Temperature (°C)	52.45
Ambient Temperature (°C)	30.45

Element	Emission factor (mg/kg)	±Uncertainty (mg/kg)
H	15.2	2.1
Na		
Mg	10.6	1.6
Al		
Si	131.7	6.8
P		
S	7.4	0.5
Cl	214.5	10.9
K	134.1	6.8
Ca	20.2	1.8
Ti	0.1	0.1
V		
Cr	0.2	0.0
Mn	3.9	0.3
Fe	6.1	0.3
Ni		
Cu	0.1	0.0
Zn	0.3	0.0
As	0.0	0.0
Pb		
Se		
Br	0.7	0.1
Rb		
Sr		
Zr		

Table 3.1.3.18. Element concentrations (ng/m^3) from CNL filter samples.

Fuel:	Rice
Date:	10-Jul-92
Time:	11:17
Filter ID:	AG-23

Element	Concentration	±Uncertainty
	ng/m^3	
H	218,900	21,100
Na	41,340	25,800
Mg		
Al		
Si	282,320	15,500
P		
S		
Cl	3,331,020	167,800
K	1,004,550	50,900
Ca	53,720	9,500
Ti	1,170	600
V		
Cr	1,260	400
Mn	10,290	900
Fe	25,200	1,500
Ni		
Cu	810	200
Zn	570	100
As	440	200
Pb		
Se		
Br	5,180	400
Rb	1,270	400
Sr		
Zr		

Table 3.1.3.19. Element emission factors (mg/kg) from CNL filter samples.

Fuel:	Rice	
Date:	10-Jul-92	
Time:	11:17	
Filter ID:	AG-23	
Fuel rate (g/s)		11.71
Stack gas flow rate (m^3/s)		4.25
Stack Temperature (°C)		52.45
Ambient Temperature (°C)		30.45

Element	Emission factor (mg/kg)	±Uncertainty (mg/kg)
H	74.1	7.1
Na	14.0	8.7
Mg		
Al		
Si	95.5	5.2
P		
S		
Cl	1,127.3	56.8
K	340.0	17.2
Ca	18.2	3.2
Ti	0.4	0.2
V		
Cr	0.4	0.1
Mn	3.5	0.3
Fe	8.5	0.5
Ni		
Cu	0.3	0.1
Zn	0.2	0.0
As	0.1	0.1
Pb		
Se		
Br	1.8	0.1
Rb	0.4	0.1
Sr		
Zr		

Table 3.1.3.20. Relative element concentrations by stage from DRUM impactor.

Stage 1: 10 - 15 μm

	10-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H				
Na				
Mg				
Al				
Si	4,638.82	256.26	7.4348	1
S	43.22	14.74	0.0693	1
Cl	313.05	35.32	0.5017	1
K	623.94	61.00	1.0000	1
Ca	508.33	64.32	0.8147	1
Ti				
V	17.60	9.00	0.0282	1
Cr				
Mn	79.42	13.89	0.1273	1
Fe	1,066.37	65.37	1.7091	1
Ni				
Cu	3,367.05	178.63	5.3965	1
Zn	2,279.56	133.58	3.6535	1
As				
Se				
Br				
Rb				
Sr				
Pb				

Table 3.1.3.21. Relative element concentrations by stage from DRUM impactor.

Stage 2: 5 - 10 μm

	10-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H				
Na				
Mg				
Al				
Si	4,034.27	216.37	6.5588	0.8697
S				
Cl	458.02	62.74	0.7446	1.4631
K	615.09	53.26	1.0000	0.9858
Ca	534.36	55.47	0.8687	1.0512
Ti				
V				
Cr				
Mn	172.72	17.21	0.2808	2.1748
Fe	510.86	35.68	0.8305	0.4791
Ni	10.77	3.21	0.0175	#DIV/0!
Cu	13.92	4.05	0.0226	0.0041
Zn				
As				
Se				
Br				
Rb				
Sr				
Pb				

Table 3.1.3.22. Relative element concentrations by stage from DRUM impactor.

Stage 3: 2.5 - 5 μm

	10-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H				
Na				
Mg				
Al				
Si	6,612.45	343.79	6.4967	1.4255
S	109.61	20.53	0.1077	2.5362
Cl	998.31	62.58	0.9808	3.1890
K	1,017.82	69.21	1.0000	1.6313
Ca	1,348.54	90.26	1.3249	2.6529
Ti				
V				
Cr				
Mn	297.85	21.26	0.2926	3.7505
Fe	986.39	59.21	0.9691	0.9250
Ni				
Cu				
Zn	36.66	5.32	0.0360	0.0161
As				
Se				
Br				
Rb				
Sr				
Pb				

Table 3.1.3.23. Relative element concentrations by stage from DRUM impactor.

Stage 4: 1.15 - 2.5 μm

	10-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H	920.32	104.89	0.6100	
Na				
Mg				
Al				
Si	3,395.06	181.74	2.2503	0.7319
S				
Cl	1,476.62	88.42	0.9787	4.7169
K	1,508.73	96.58	1.0000	2.4181
Ca	715.46	70.84	0.4742	1.4075
Ti				
V				
Cr				
Mn	120.75	13.37	0.0800	1.5205
Fe	497.54	33.16	0.3298	0.4666
Ni				
Cu				
Zn				
As				
Se				
Br				
Rb				
Sr				
Pb				

Table 3.1.3.24. Relative element concentrations by stage from DRUM impactor.

Stage 5: 0.56 - 1.15 μm

	10-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H	2950.57	262	0.2838	
Na				
Mg				
Al				
Si	1,936.55	109.63	0.1863	0.4175
S				
Cl	10,394.39	535.37	0.9998	33.2039
K	10,396.36	537.26	1.0000	16.6625
Ca				
Ti				
V				
Cr				
Mn	89.70	14.32	0.0086	1.1295
Fe	304.95	22.84	0.0293	0.2860
Ni				
Cu				
Zn				
As				
Se				
Br	47.28	8.11	0.0045	
Rb				
Sr				
Pb				

Table 3.1.3.25. Relative element concentrations by stage from DRUM impactor.

Stage 6: 0.34 - 0.56 μm

	10-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H	2620.9	301.3	0.1538	
Na				
Mg				
Al				
Si	164.91	23.95	0.0097	0.0355
S				
Cl	18,954.01	966.21	1.1126	60.5468
K	17,036.09	869.47	1.0000	27.3042
Ca				
Ti				
V	41.50	10.84	0.0024	2.3580
Cr				
Mn	37.29	8.74	0.0022	0.4696
Fe	80.03	15.89	0.0047	0.0751
Ni				
Cu	27.13	5.16	0.0016	0.0081
Zn	35.84	6.16	0.0021	0.0157
As				
Se				
Br	113.58	17.95	0.0067	
Rb				
Sr				
Pb				

Table 3.1.3.26. Relative element concentrations by stage from DRUM impactor.

Stage 7: 0.24 - 0.34 μm

	10-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H	964.45	106.95	0.1378	
Na				
Mg				
Al				
Si	102.27	18.53	0.0146	0.0220
S				
Cl	7,565.67	397.58	1.0807	24.1678
K	7,000.41	370.63	1.0000	11.2197
Ca				
Ti				
V	28.91	9.11	0.0041	1.6426
Cr				
Mn				
Fe				
Ni				
Cu				
Zn	26.90	6.00	0.0038	0.0118
As				
Se				
Br	49.99	11.32	0.0071	
Rb				
Sr				
Pb				

Table 3.1.3.27. Relative element concentrations by stage from DRUM impactor.

Stage 8: < 0.24 μm

	10-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H	443.96	85.1	0.2820	
Na				
Mg				
Al				
Si	39.72	11.26	0.0252	0.0086
S				
Cl	1,335.05	84.37	0.8481	4.2647
K	1,574.12	93.84	1.0000	2.5229
Ca				
Ti	36.11	9.47	0.0229	
V				
Cr				
Mn	25.19	5.68	0.0160	0.3173
Fe				
Ni	14.98	3.21	0.0095	
Cu				
Zn	15.08	3.74	0.0096	0.0066
As				
Se				
Br				
Rb				
Sr				
Pb				

Table 3.1.3.28
VOC Concentrations (ppbv)

Date	10-Jul-92	10-Jul-92
Fuel	Rice Straw	Rice Straw
Traverse	Traverse 1	Traverse 2
Acetic acid		
Propanone (acetone)		
Methyl ester acetic acid (methylacetate)		
Butane	5.6	5.8
Dimethyloxirane		
Pentene		
Methylbutanone (isopropylmethyl ketone)		
Furancarboxaldehyde (furfural)	25.3	25.1
Benzene		
Dimethylbutane		
Hexane	1.6	1.1
Phenol		
Dimethylfuran		
2-methyl 2-cyclopenten-1-one		
2-chloro phenol	10.1	9.6
Toluene	1.2	1
Benzonitrile	3	2.7
Benzaldehyde		
Methylphenol (hydroxy toluene)	2.6	2.7
Styrene	2.7	2.7
Xylene		
Trimethylpentane	1.4	1.2
Benzofuran		
Methoxymethylphenol (creosol)	1.3	1.1
Naphthalene		
C10H12		
Alpha-pinene		
Camphene		
Δ3-Carene		
Limonene		
No match r.t. (6.7)		
No match r.t. (8.51)	8.7	4.4
No match r.t. (8.71)		
No match r.t. (8.73)		
No match r.t.(6.4)		
No match r.t.(8.5)		

Table 3.1.3.29
VOC Emission Factors (mg/kg)

Date	10-Jul-92	10-Jul-92
Fuel	Rice Straw	Rice Straw
Traverse	Traverse 1	Traverse 2
Fuel Consumption Rate (g/s d.b)	11.71	11.17
Stack Gas Mass Flow Rate (kg/s)	4.61	4.66
Acetic acid		
Propanone (acetone)		
Methyl ester acetic acid (methylacetate)		
Butane		
Dimethyloxirane*	5	6
Pentene		
Methylbutanone (isopropylmethyl ketone)		
Furancarboxaldehyde (furfural)		
Benzene	27	28
Dimethylbutane		
Hexane		
Phenol	2	1
Dimethylfuran		
2-methyl 2-cyclopenten-1-one		
2-chloro phenol		
Toluene	13	13
Benzonitrile	2	1
Benzaldehyde	4	4
Methylphenol (hydroxy toluene)		
Styrene	4	4
Xylene	4	4
Trimethylpentane		
Benzofuran	2	2
Methoxymethylphenol (creosol)		
Naphthalene	2	2
Unknown		
Alpha-pinene		
Camphene		
Δ3-Carene		
Limonene		

*Possible mismatch

Table 3.1.3.30. PAH emission factors, rice straw, 10 July 1992 (zero indicates not detected).

	Traverse 1 Filter	Traverse 2 Filter	Trap/Tubing	Traverse 1 Sorbent	Traverse 2 Sorbent	Impinger Rinsate	Total Traverse 1	Total Traverse 2
					µg/kg dry fuel			
Naphthalene	69.8	0.0	33.4	9,737.9	7,031.9	16.0	9,857.1	7,081.4
2-Methyl-naphthalene	21.6	0.0	4.3	811.1	625.4	3.3	840.4	633.1
Acenaphthylene	2.3	0.0	0.0	1,058.0	883.2	0.6	1,060.9	883.8
Acenaphthene	0.0	0.0	0.0	67.5	56.0	0.0	67.5	56.0
Fluorene	0.0	0.0	0.0	444.9	404.9	0.8	445.7	405.7
Phenanthrene	23.6	41.3	42.2	1,369.9	1,293.3	6.6	1,442.4	1,383.4
Anthracene	5.1	0.0	1.5	239.2	229.6	0.8	246.5	231.8
Fluoranthene	23.6	0.0	20.0	404.6	412.0	1.9	450.2	434.0
Pyrene	24.0	0.0	18.1	297.2	291.6	1.4	340.8	311.1
Benz[a]-anthracene	62.1	0.0	19.8	10.5	14.3	1.7	94.0	35.8
Chrysene	84.2	0.0	23.5	8.1	16.6	0.0	115.9	40.1
Benzo[b]-fluoranthene	154.4	0.0	10.9	0.0	0.0	0.0	165.3	10.9
Benzo[k]-fluoranthene	29.6	0.0	0.0	0.0	0.0	0.0	29.6	0.0
Benzo[a]pyrene	53.2	0.0	0.0	10.3	0.0	0.0	63.5	0.0
Benzo[e]pyrene	68.8	0.0	0.0	12.6	0.0	0.0	81.4	0.0
Perylene	18.0	0.0	0.0	0.0	0.0	0.0	18.0	0.0
Benzo[ghi]-perylene	43.4	0.0	0.0	0.0	0.0	0.0	43.4	0.0
Indeno[1,2,3-cd]-pyrene	45.6	0.0	0.0	0.0	0.0	0.0	45.6	0.0
Dibenz[a,h]-anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	729.5	41.3	173.8	14,471.9	11,258.8	33.1	15,408.3	11,507.0

Figure 3.1.3.1. Ambient air conditions, 10 July 92.

Fuel Type:	Rice Straw	Test Date	10-Jul-92
Configuration:	CEWF		

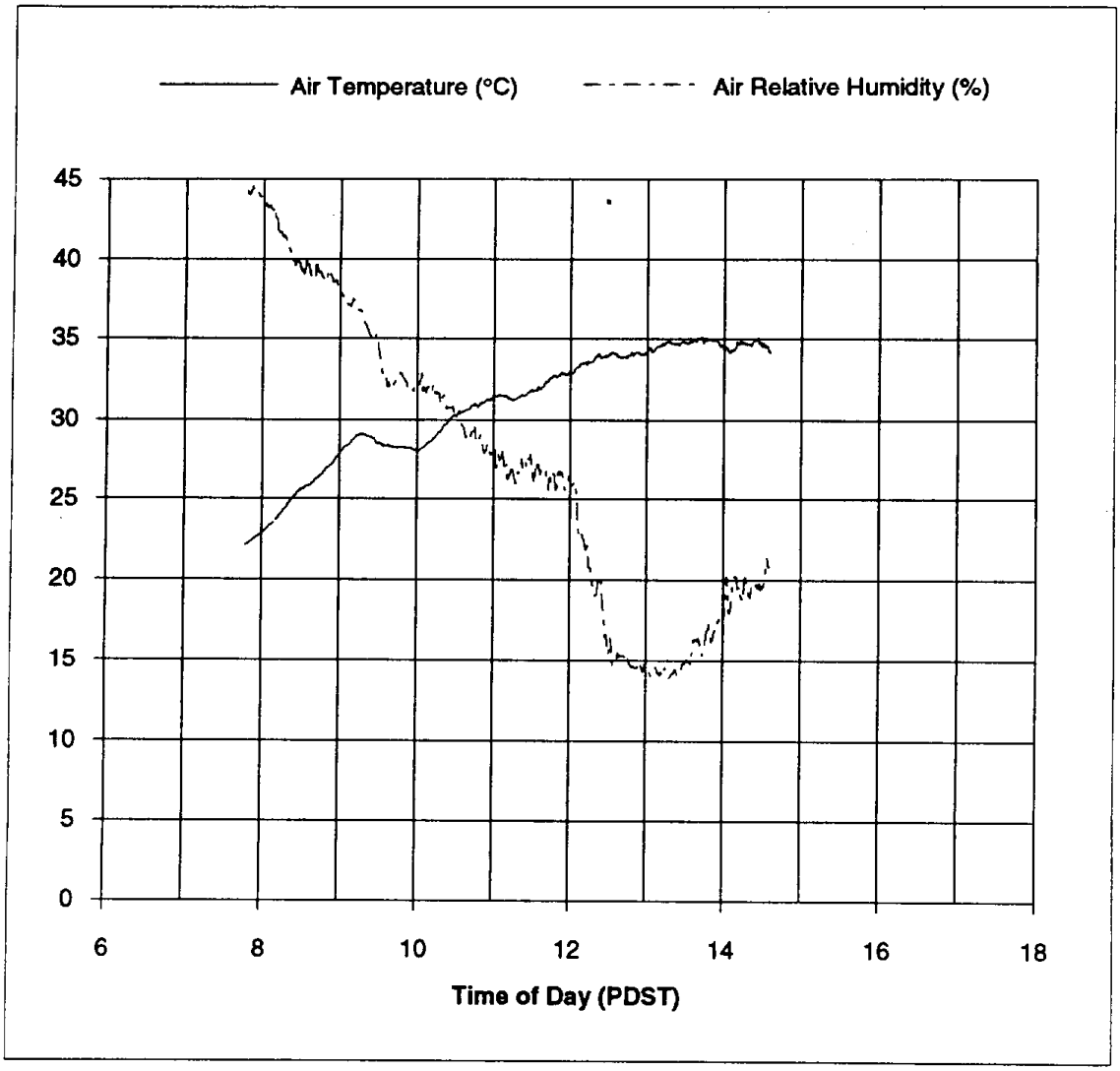


Figure 3.1.3.2. Air temperature and relative humidity from CIMIS station.

Fuel: Rice Straw Date of Test: 10-Jul-92

Configuration: CEWF

Hourly Average CIMIS Data for Davis, California

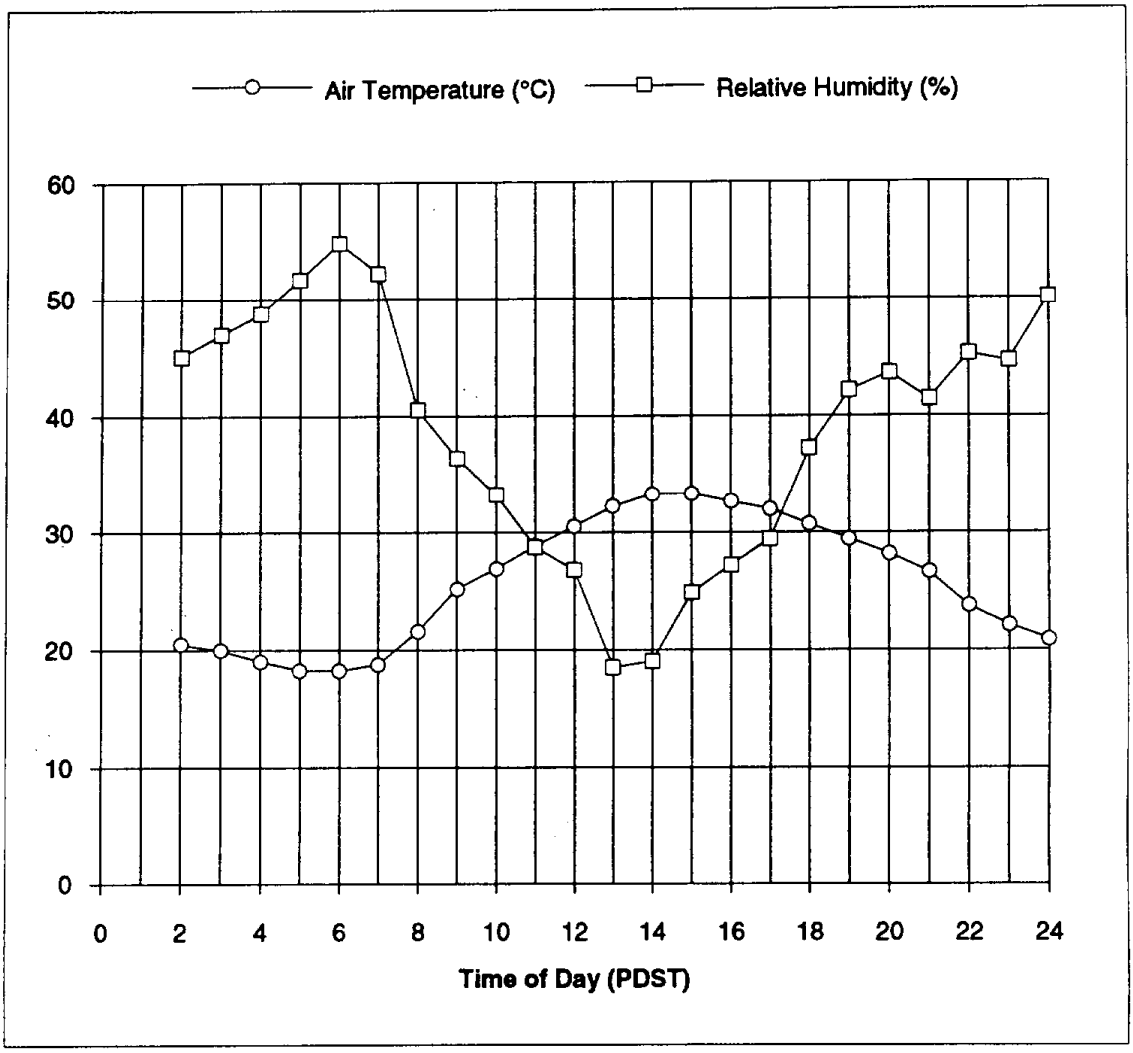


Figure 3.1.3.3. Wind speed from CIMIS station.

Fuel: Rice Straw Date of Test: 10-Jul-92

Configuration: CEWF

Hourly Average CIMIS Data for Davis, California

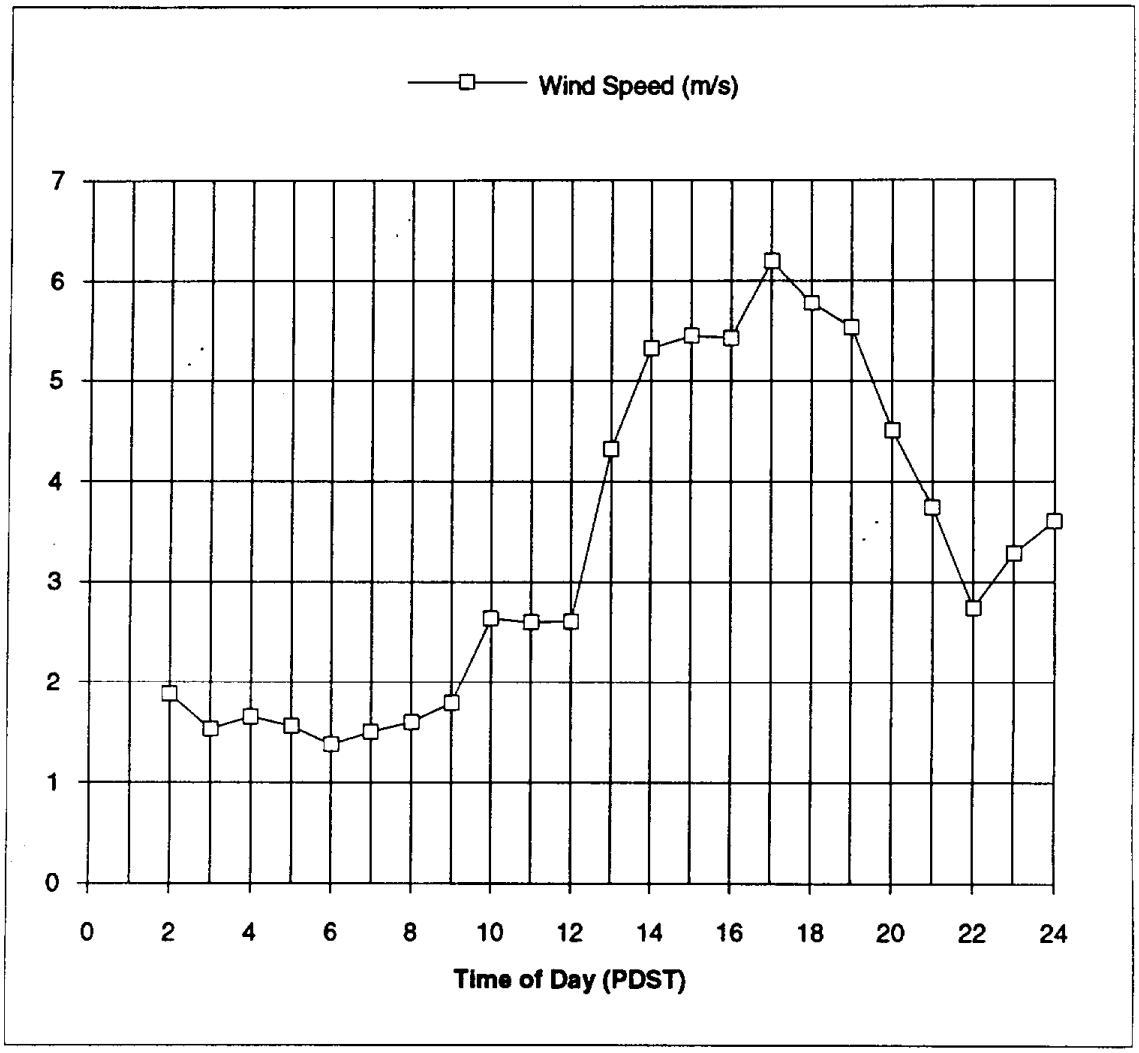


Figure 3.1.3.4. Wind direction and solar radiation from CIMIS station.

Fuel: Rice Straw Date of Test: 10-Jul-92

Configuration: CEWF

Hourly Average CIMIS Data for Davis, California

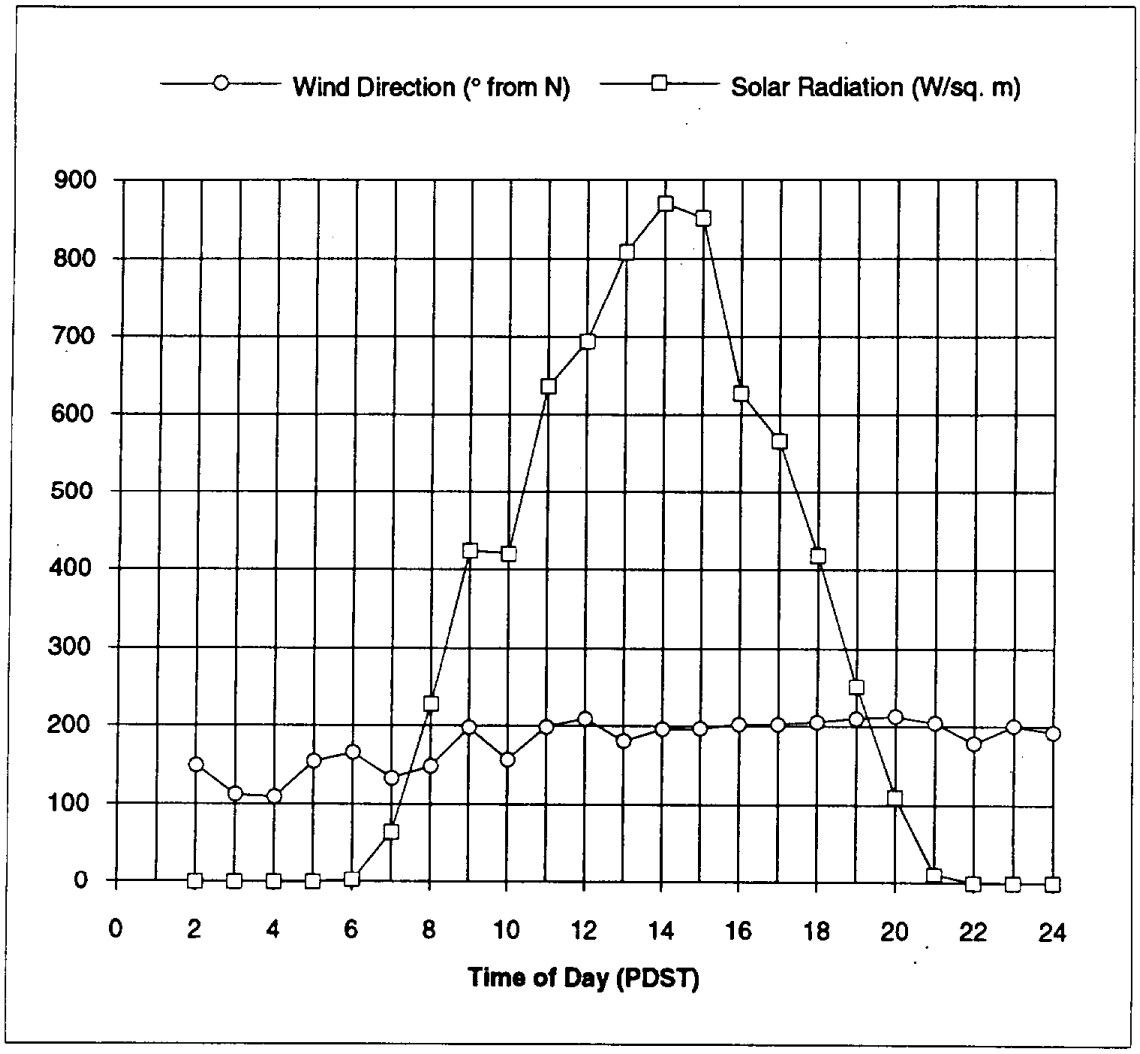


Figure 3.1.3.5. Inlet air, stack gas, and impinger outlet temperatures, 10 July 92.

Fuel Type:	Rice Straw	Test Date	10-Jul-92
Configuration:	CEWF		

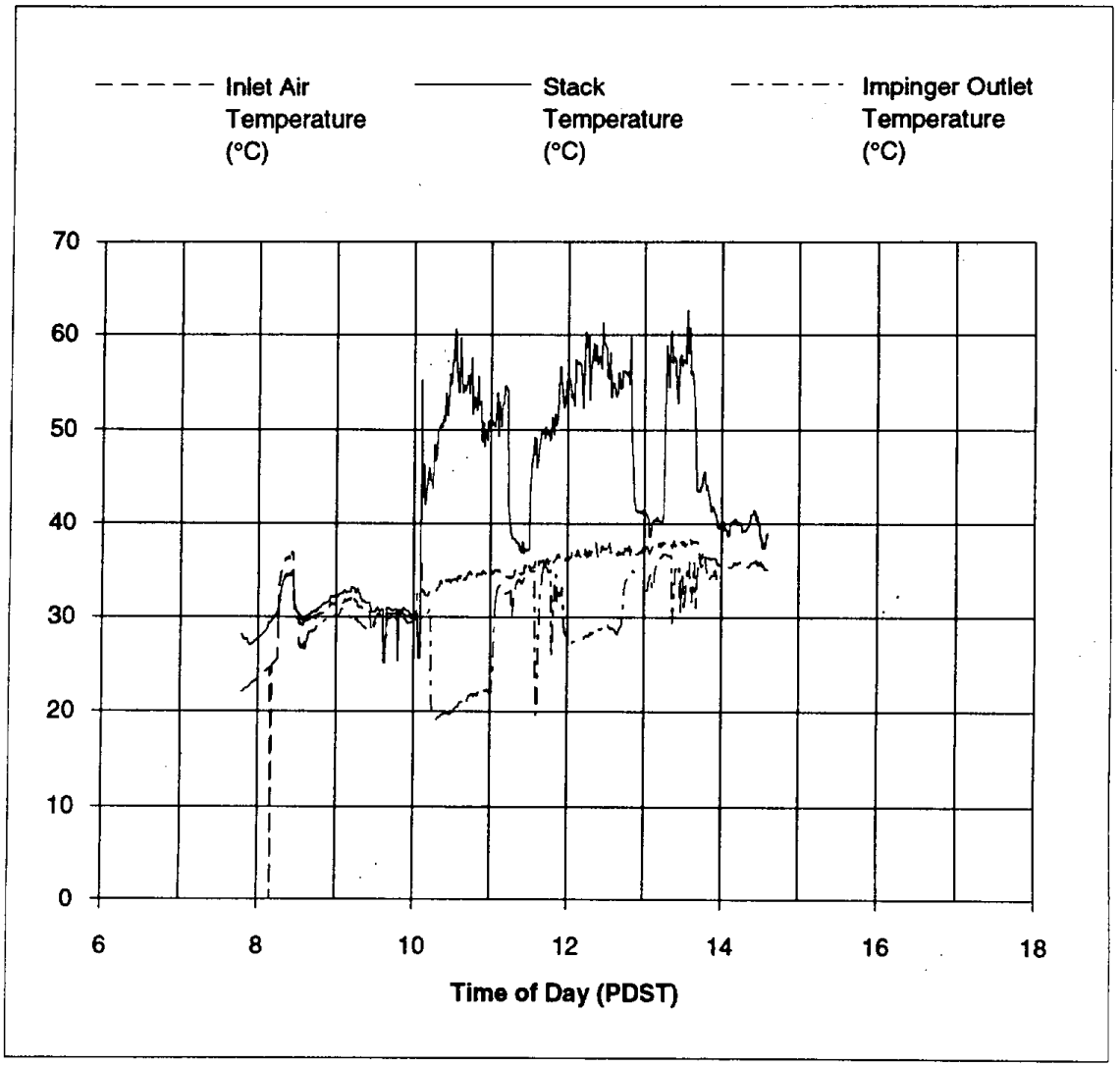


Figure 3.1.3.6. Conveyor speed and stack gas velocity, 10 July 92.

Fuel Type:	Rice Straw	Test Date	10-Jul-92
Configuration:	CEWF		

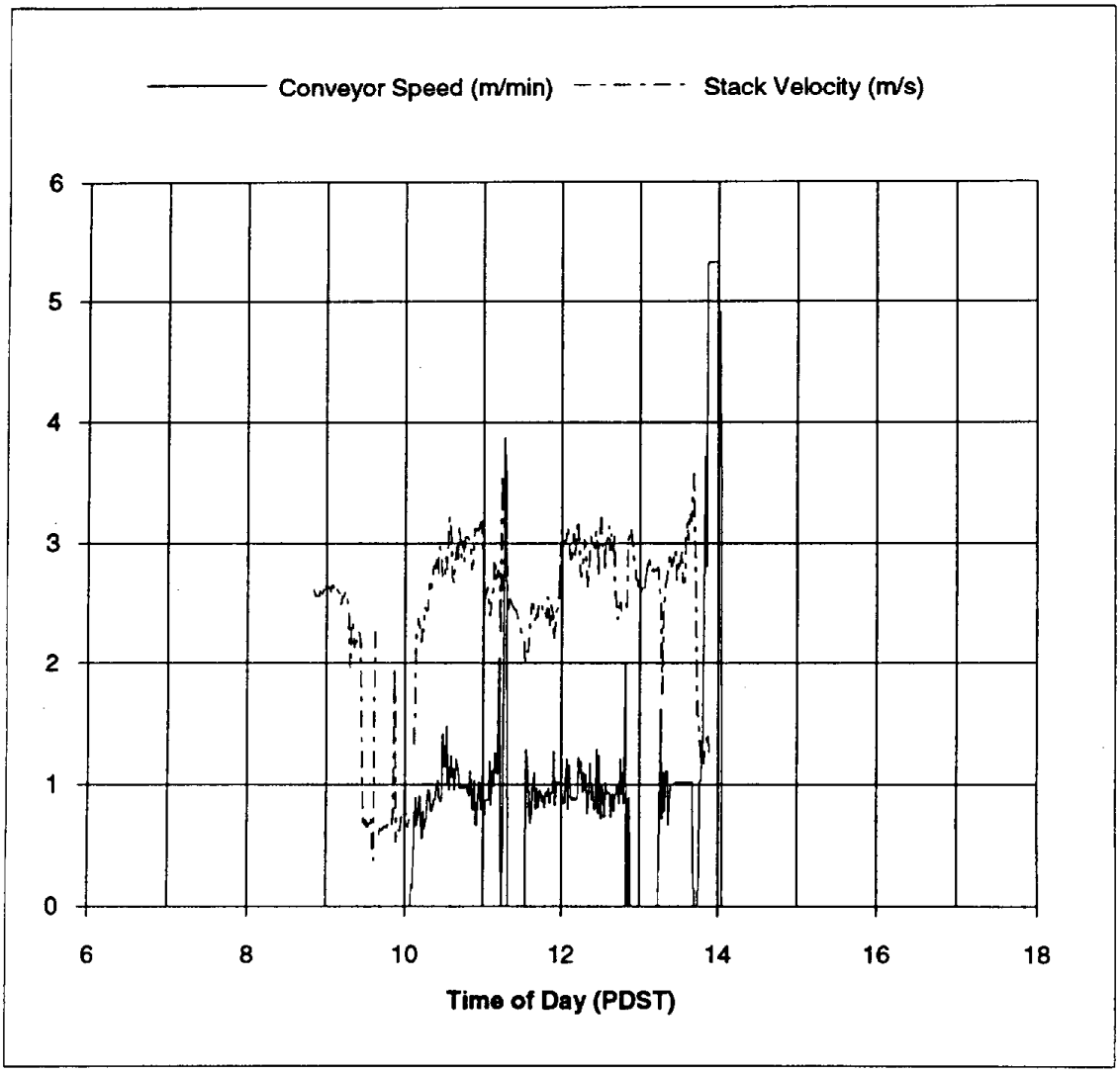


Figure 3.1.3.7. Conveyor speed with 10 min moving average, 10 July 92.

Fuel Type:	Rice Straw	Test Date	10-Jul-92
Configuration:	CEWF		

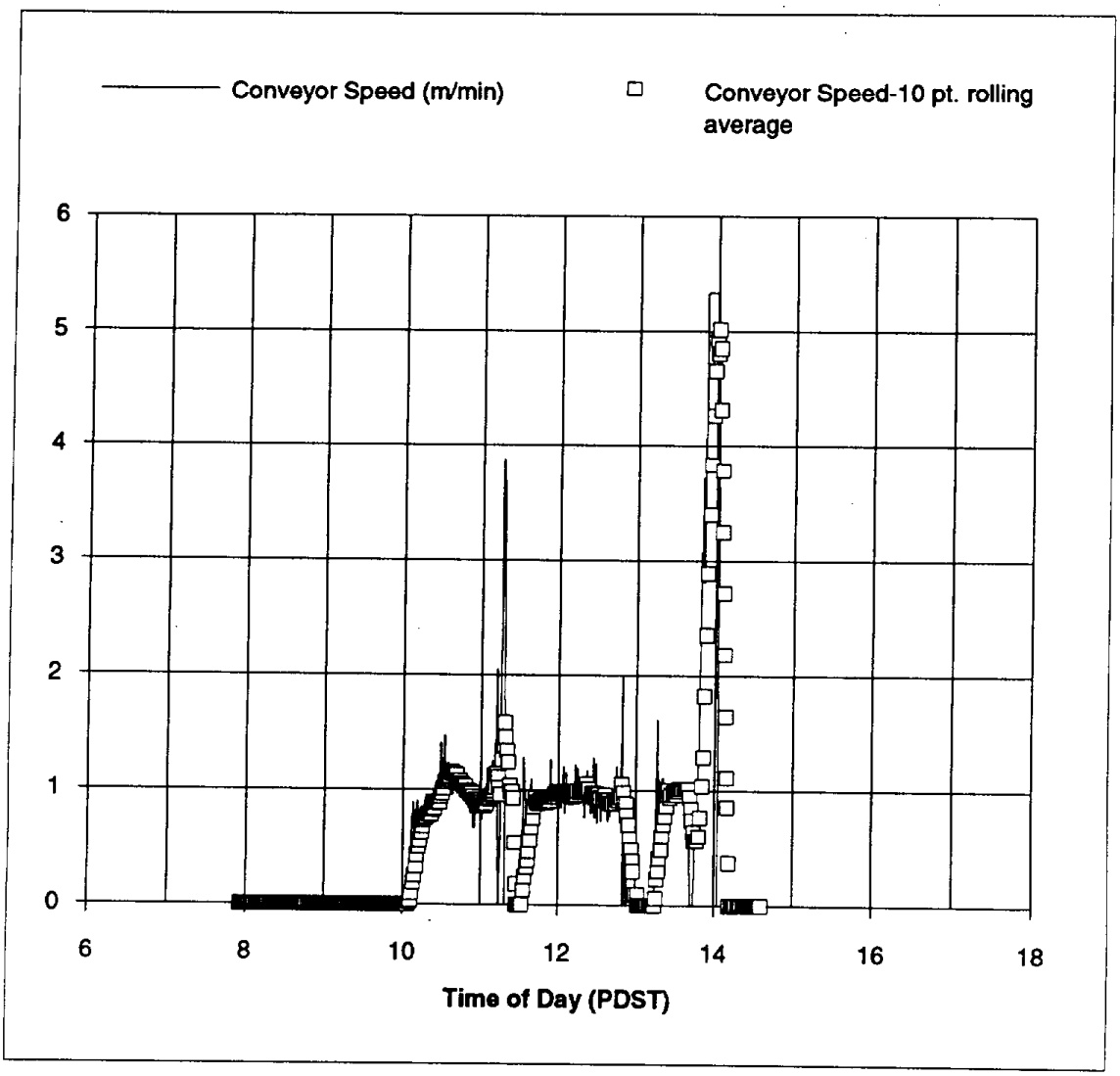


Figure 3.1.3.8. Conveyor travel, 10 July 92.

Fuel Type: Rice Straw
Configuration: CEWF

Test Date 10-Jul-92

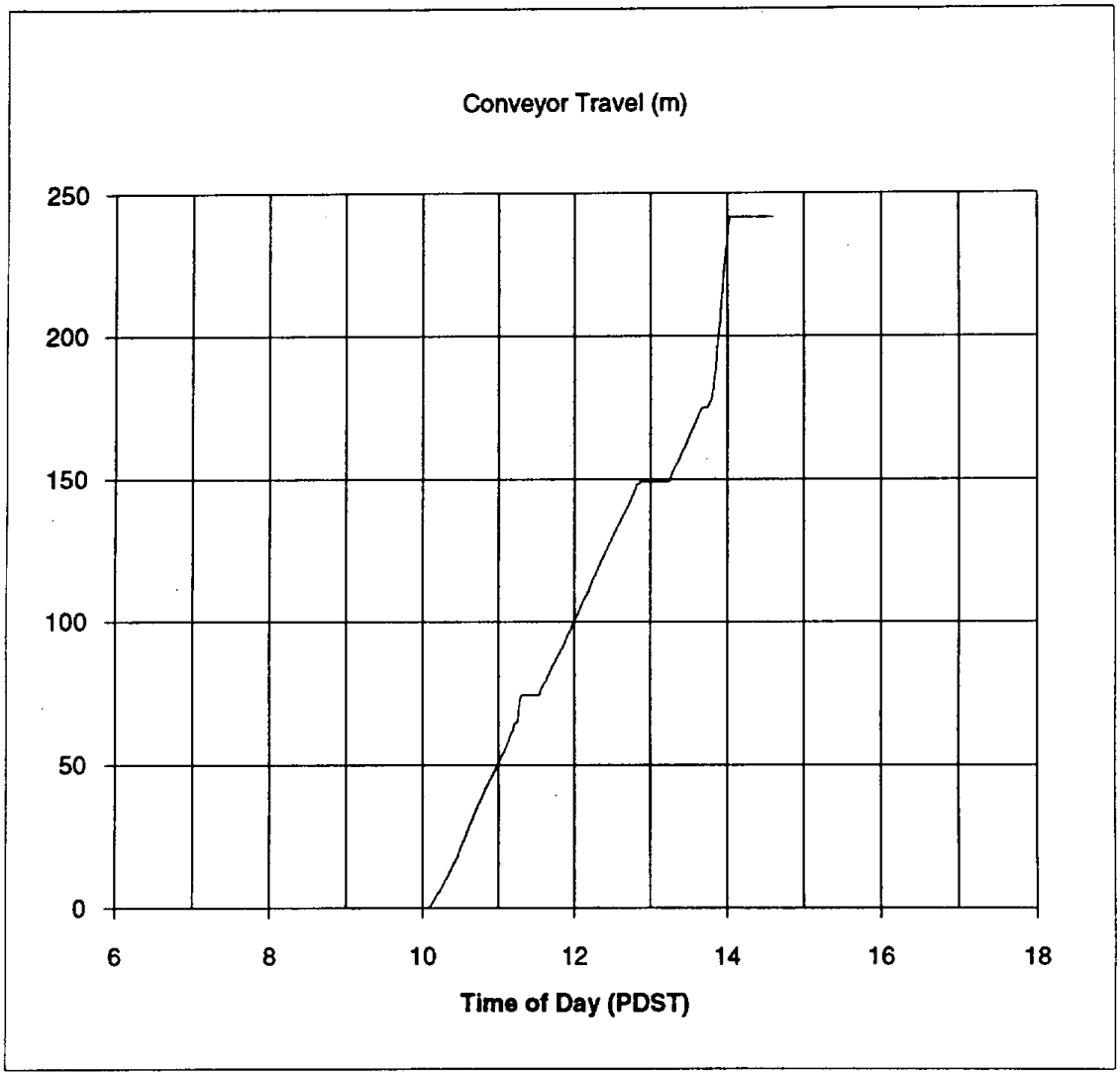


Figure 3.1.3.9. CO concentration in stack gas, 10 July 92.

Fuel Type:	Rice Straw	Test Date	10-Jul-92
Configuration:	CEWF		

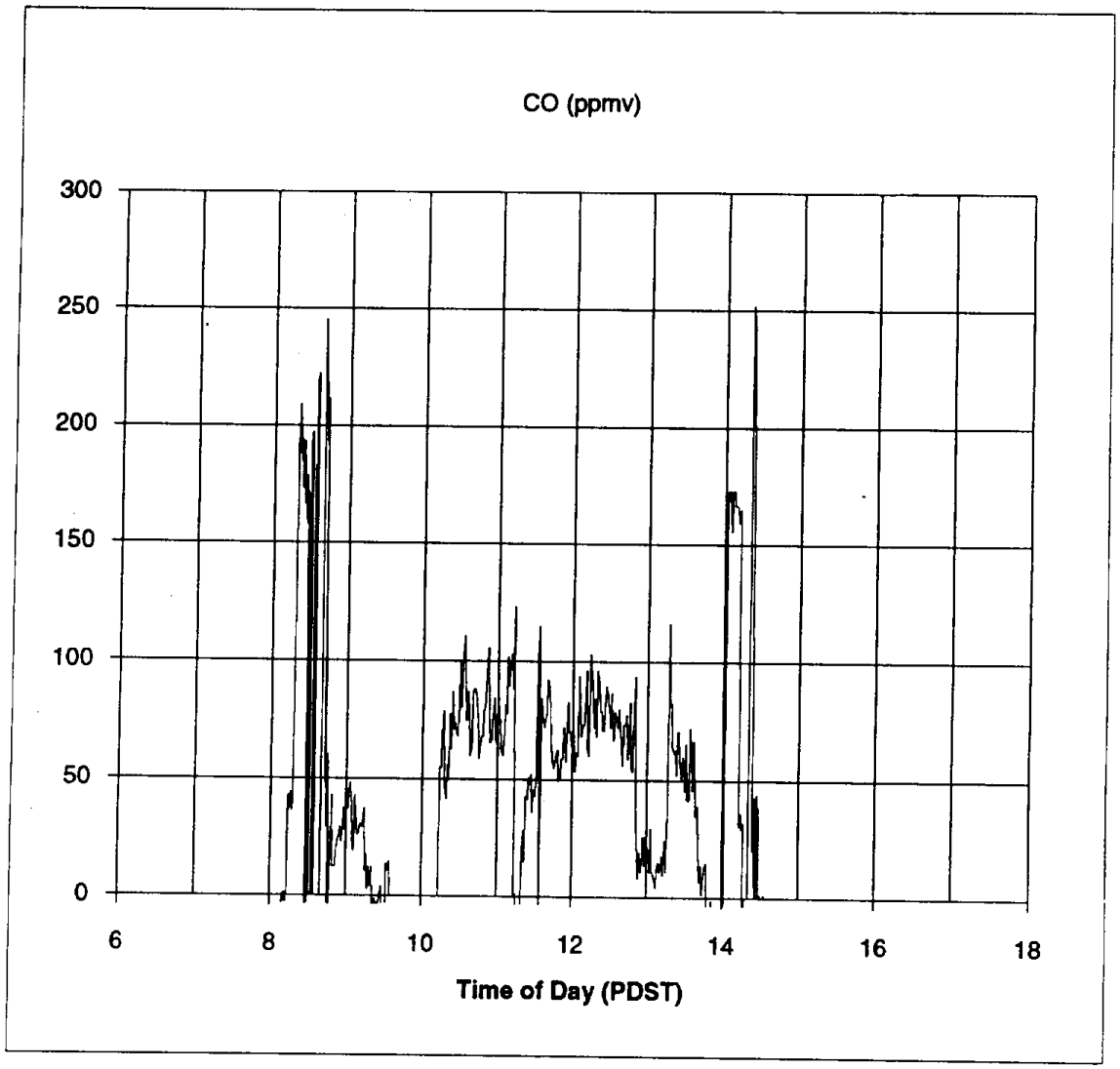


Figure 3.1.3.10. NO and NOx concentrations in stack gas, 10 July 92.

Fuel Type:	Rice Straw	Test Date	10-Jul-92
Configuration:	CEWF		

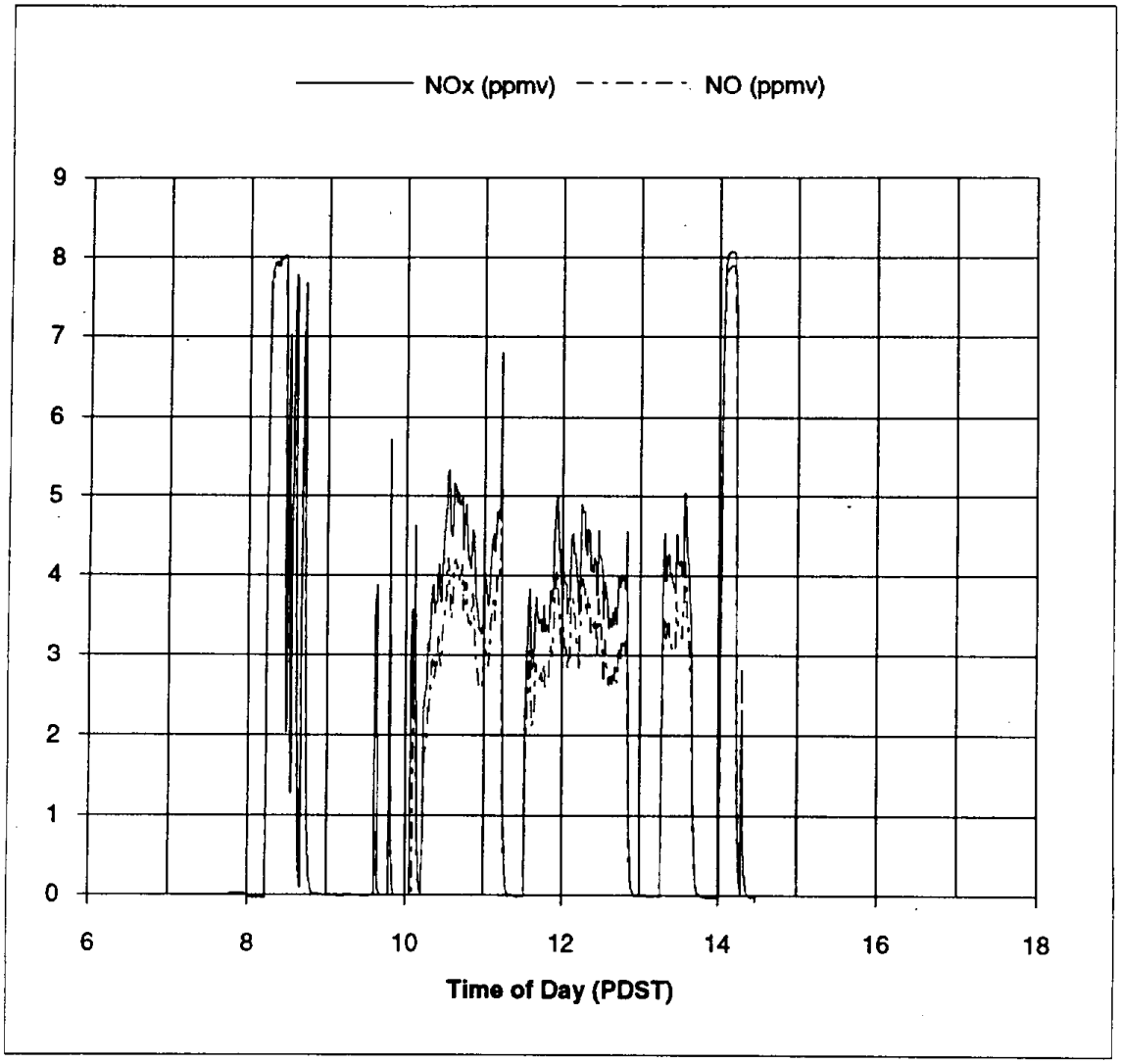


Figure 3.1.3.11. SO2 concentration in stack gas, 10 July 92.

Fuel Type:	Rice Straw	Test Date	10-Jul-92
Configuration:	CEWF		

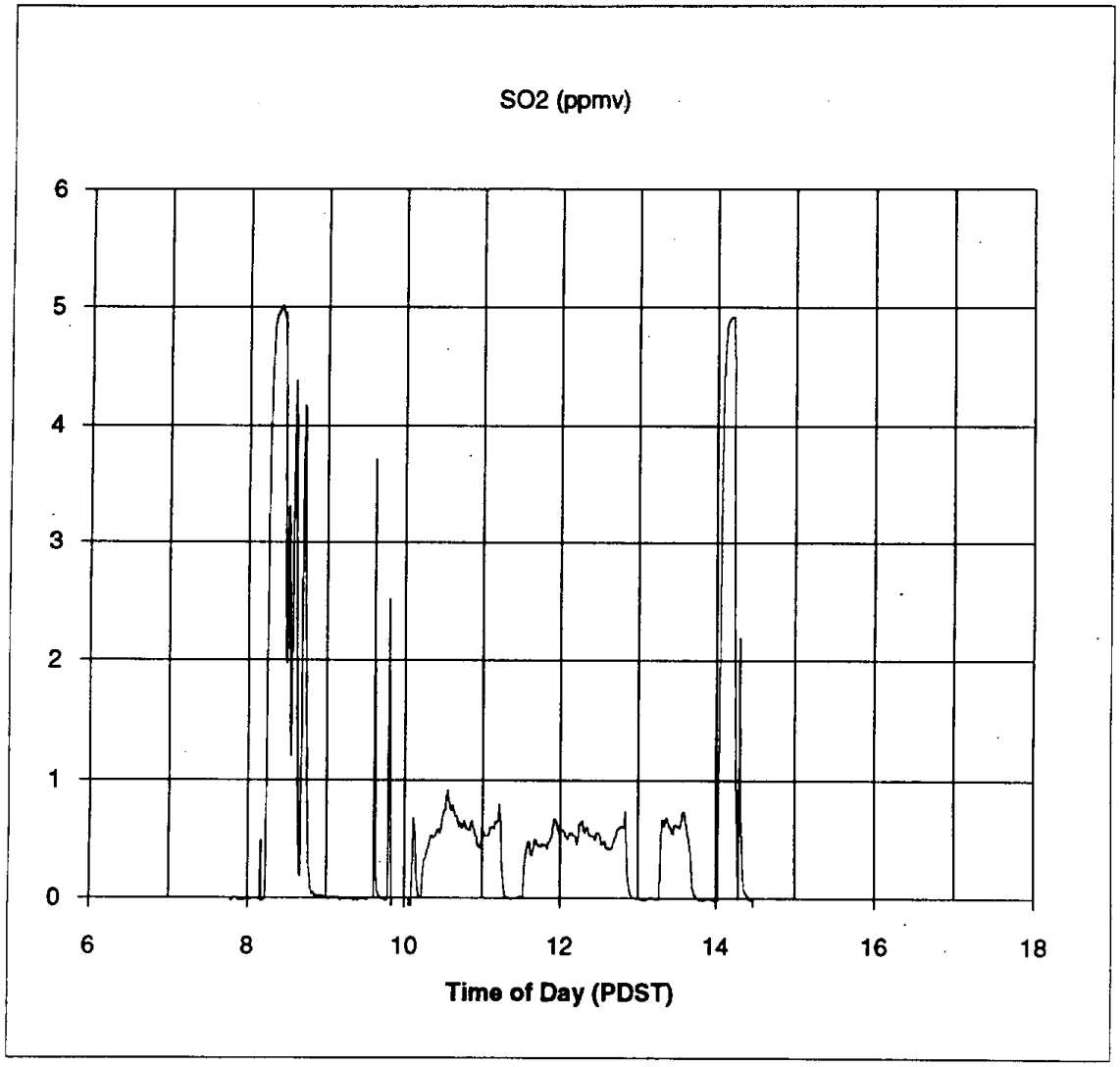


Figure 3.1.3.12. Total sulfur concentration in stack gas, 10 July 92.

Fuel Type:	Rice Straw	Test Date	10-Jul-92
Configuration:	CEWF		

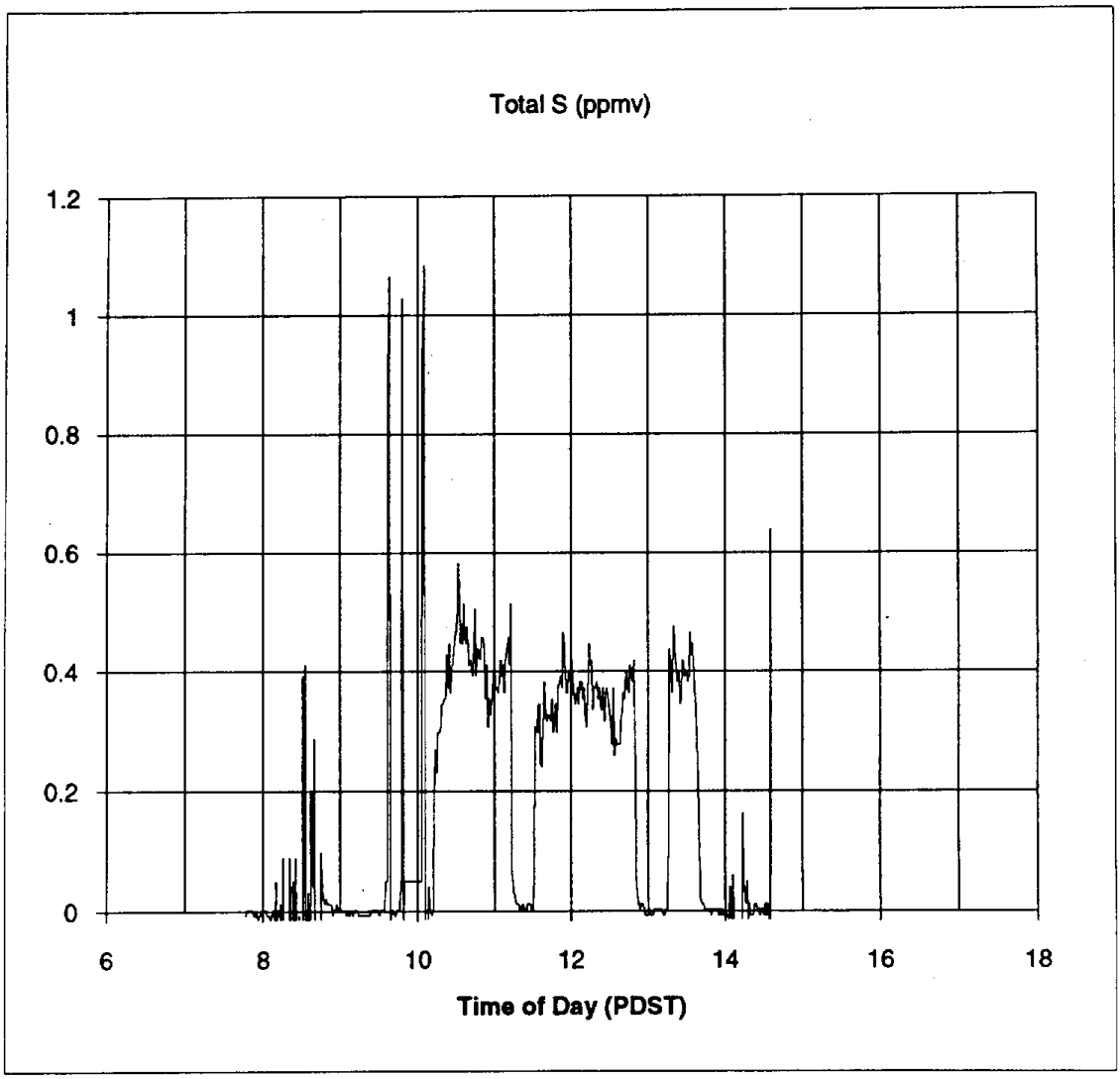


Figure 3.1.3.13. Particle size distribution, traverse 1, 10 July 92.

Fuel:	Rice Straw	Date of Test:	10-Jul-92
		Configuration:	CEWF

Particle Size Distribution
Traverse 1:

Stage	ECD (µm)	Weight (mg)	Cum. Wt (mg)	Cum. Fraction
1	13.89	0.2	4	1.000
2	7.78	0.1	3.8	0.950
3	4.15	0	3.7	0.925
4	2.20	0.1	3.7	0.925
5	1.26	0.2	3.6	0.900
6	0.74	0.2	3.4	0.850
7	0.39	0.2	3.2	0.800
filter	0.00	3	3	0.750

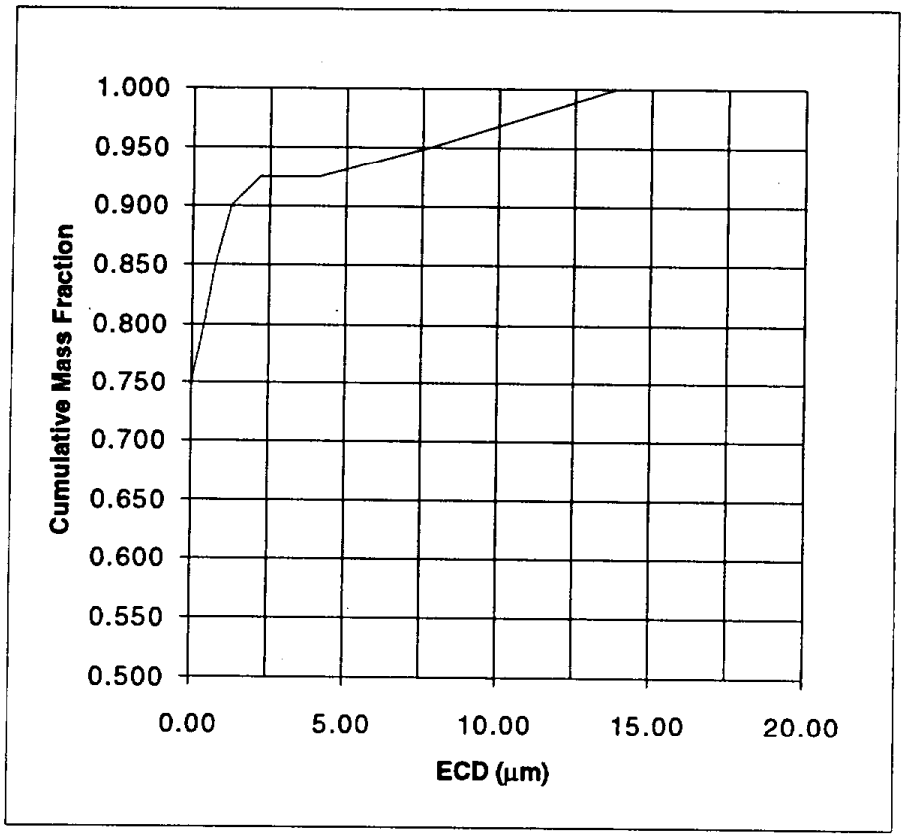


Figure 3.1.3.14. Particle size distribution, traverse 2, 10 July 92.

Fuel: Rice Straw

Date of Test: 10-Jul-92

Configuration: CEWF

Particle Size Distribution
Traverse 2:

Stage	ECD (μm)	Weight (mg)	Cum. Wt (mg)	Cum. Fraction
1	13.61	0	2.2	1.000
2	7.63	0	2.2	1.000
3	4.07	0.1	2.2	1.000
4	2.15	0	2.1	0.955
5	1.24	0	2.1	0.955
6	0.73	0.1	2.1	0.955
7	0.38	0.2	2	0.909
filter	0.00	1.8	1.8	0.818

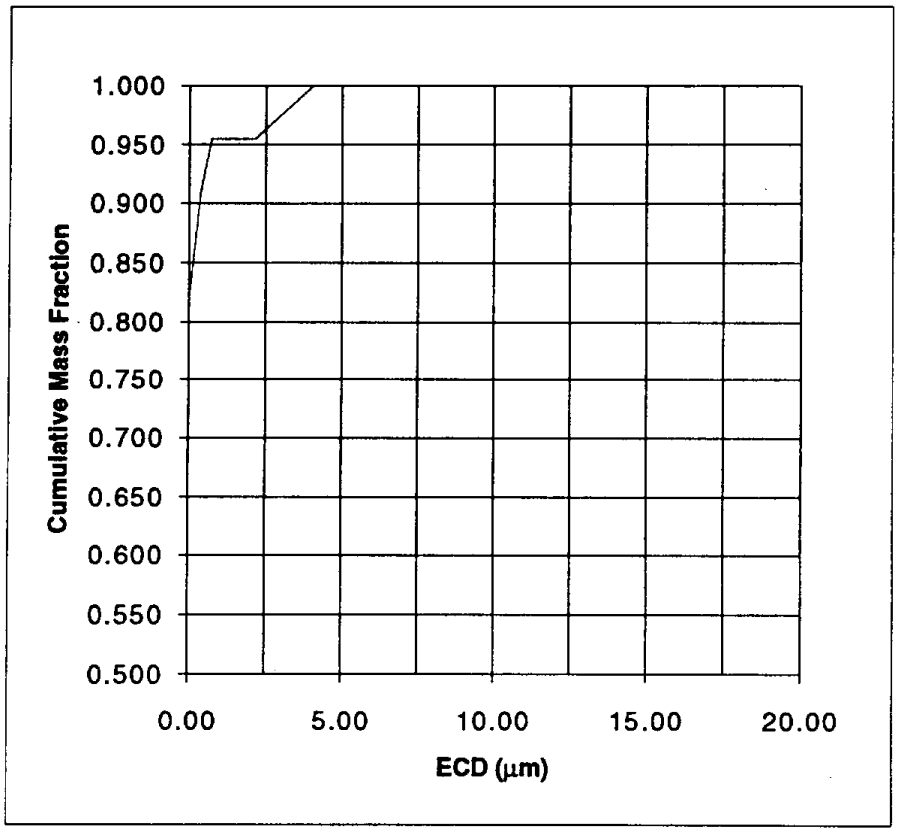


Figure 3.1.3.15. Nitrogen balance.
Date of Test: 10-Jul-92
Fuel Rice Straw

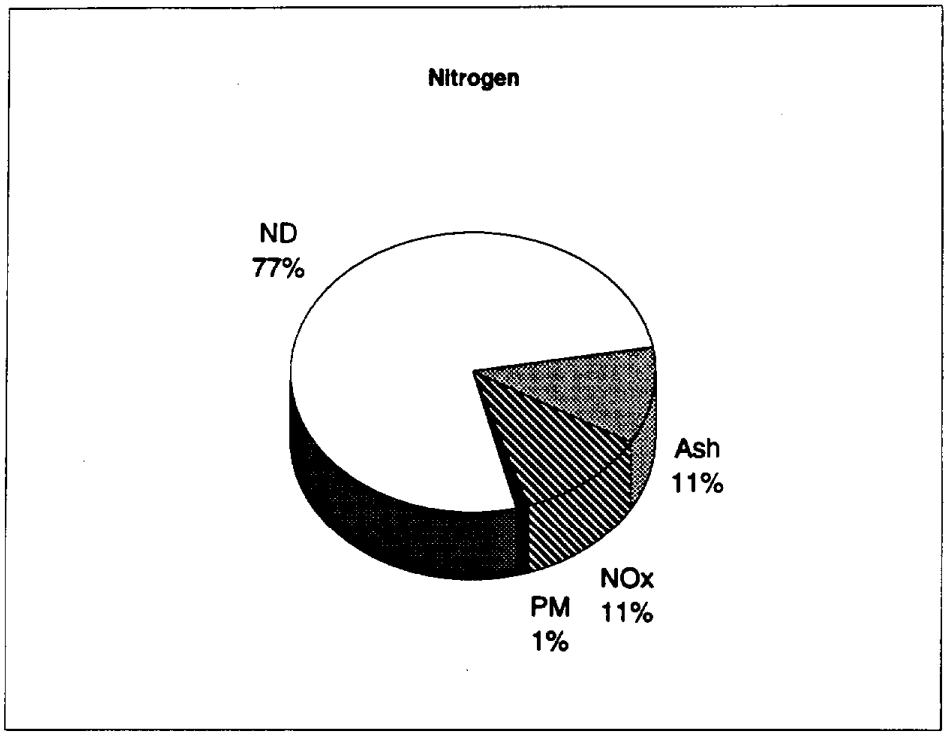


Figure 3.1.3.16. Sulfur balance.
Date of Test: 10-Jul-92
Fuel Rice Straw

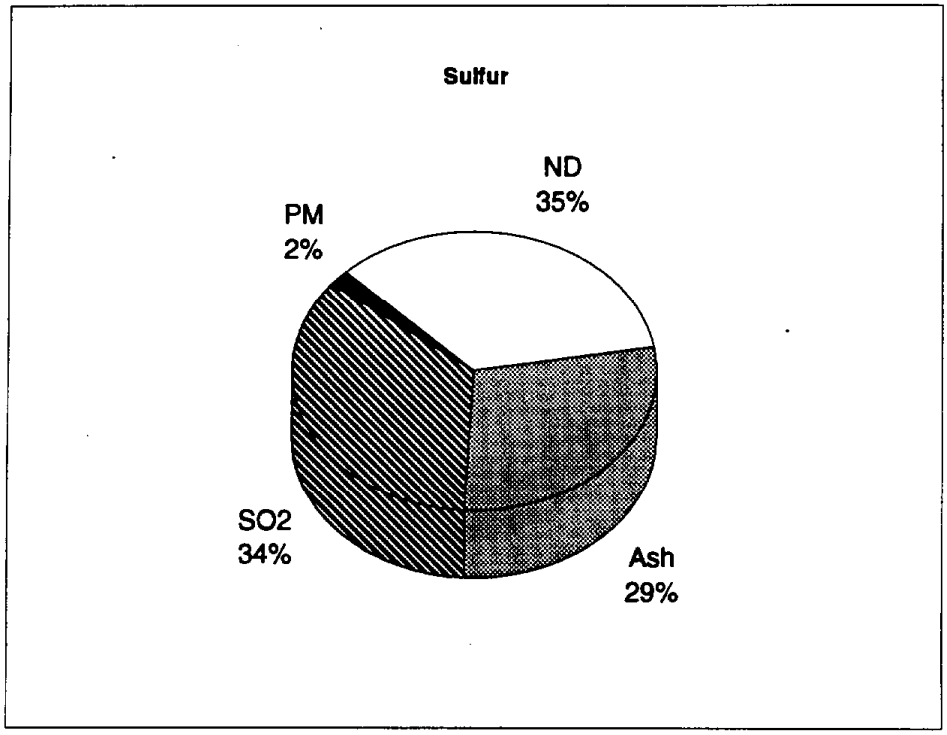


Figure 3.1.3.17. Relative abundance of major elements from DRUM impactor, Rice Straw, 10 July 92, (CEWF).

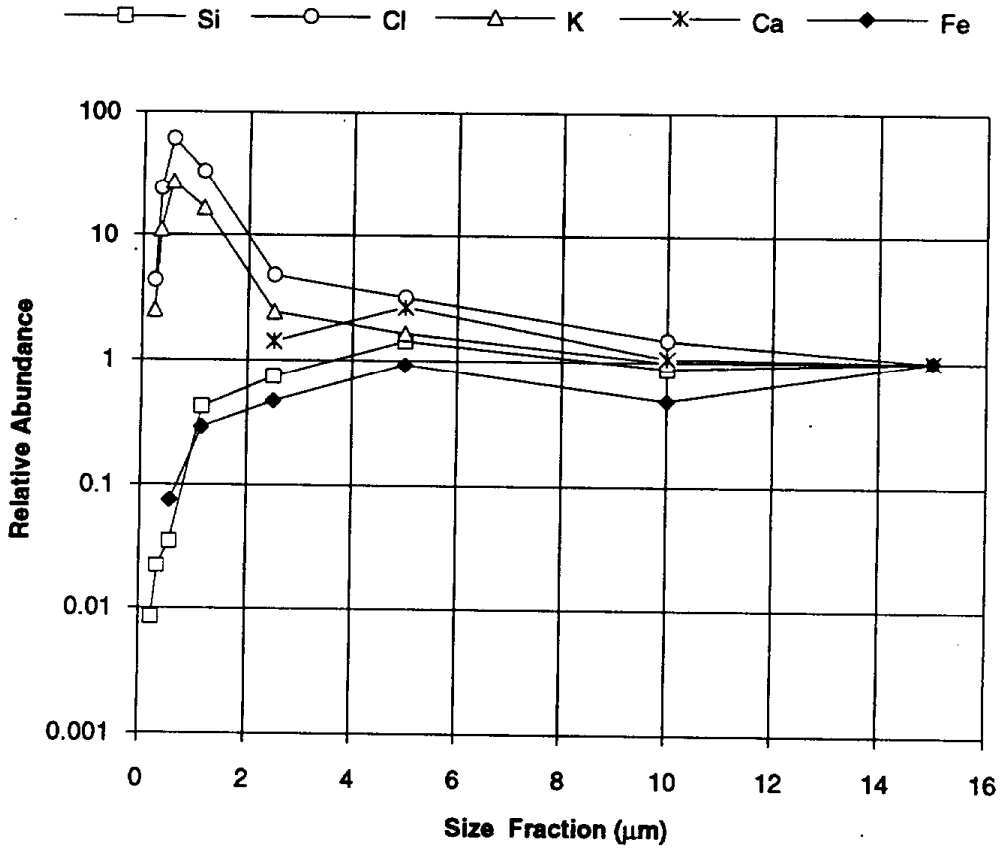


Figure 3.1.3.18. Mass fraction of PAH on primary filter samples, 10 July 1992, rice straw.

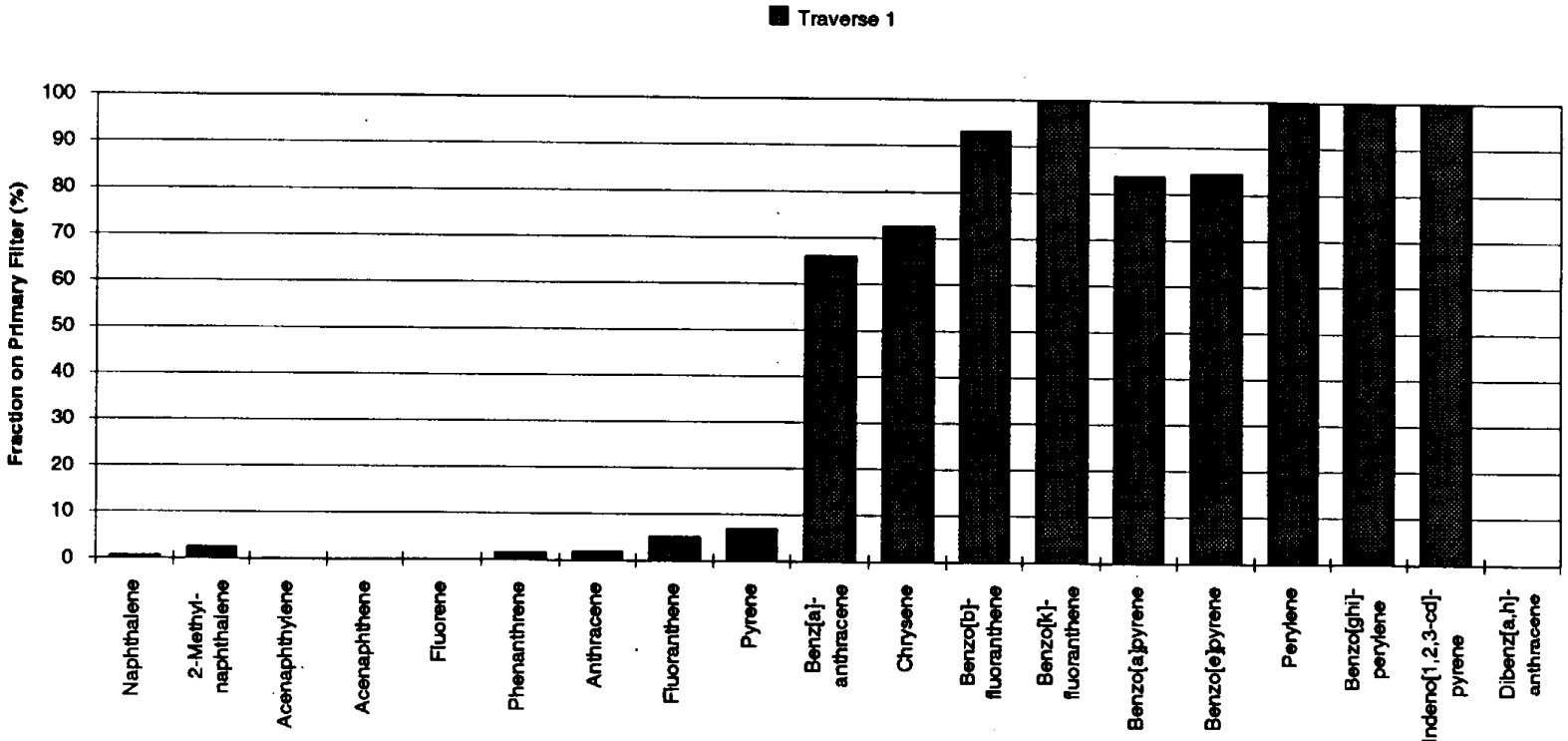


Table 3.1.4.1

Fuel and Ash Analyses

Run Date	14-Jul-92	14-Jul-92
Fuel Type	Rice Straw	Rice Straw
Sample Type	Fuel	Ash
Ultimate Analysis		
(% dry weight)		
C	37.99	9.12
H	5.27	0.62
N	0.59	0.15
Elemental Analysis		
(% by weight dry basis)		
N	0.70	0.64
P	0.06	0.25
K	0.82	2.85
Ca	0.27	1.27
Mg	0.16	0.70
Na	0.05	0.25
Cl	0.26	0.37
(mg/kg dry weight)		
S	720	650
B	7	16
Zn	27	87
Mn	884	3,900
Fe	209	565
Cu	7	12
Si		
Total (% dry weight)	45.77	16.59
Proximate Analysis		
(% dry weight)		
Ash	17.47	86.83
Volatiles	71.27	8.63
Fixed Carbon	11.26	4.54
Higher Heating Value		
(MJ/kg dry weight)	15.6532	2.9822

Table 3.1.4.2. Operating conditions and concentrations, rice straw 14 July 92.

Fuel:	Rice Straw	Date of Test:	14-Jul-92
		Configuration:	CRNF
Fuel Loading Rate (g/sq.m w.b.):	655		
Total Fuel Consumption (kg w.b.)	139.9		
Total Ash Recovered (kg w.b.)	26.7		
Ash Fraction (w.b.)	0.19		

	Traverse 1	Traverse 2	Traverse 3
Mean Values			
Air Temperature (°C)	27.71	31.20	33.41
Air Relative Humidity (%)	59.40	52.75	44.60
Inlet Air Temperature (°C)	30.89	34.40	36.30
Stack Temperature (°C)	51.40	58.44	61.84
Impinger Outlet Temperature (°C)	16.73	18.58	20.95
Fire Spreading Rate (m/min)	0.92	1.07	1.10
Stack Gas Velocity (m/s)	2.52	2.52	2.47
Gas and PM Concentrations (less background)			
CO (ppmv)	77.82	89.05	84.24
NO (ppmv)	4.07	5.07	5.07
NOx (ppmv)	4.65	5.76	5.83
SO2 (ppmv)	0.57	0.88	0.91
HC (ppmv as CH4 by GC)	1.24	2.17	1.25
CH4 (ppmv by GC)	0.82	1.29	0.86
NMHC (ppmv as CH4 by GC)	0.42	0.88	0.39
CO2 (ppmv by GC)	2,095	2,050	2,314
Total S (ppmv as SO2)	0.66	0.91	0.92
PM (mg/cu.m)	7.14	9.99	9.73
PM10 (mg/cu.m)	6.99	9.69	
PM2.5 (mg/cu.m)	6.42	8.75	

Table 3.1.4.3. Mass balance, rice straw, 14 July 92.

Fuel: Rice Straw | Date of Test: 14-Jul-92 | Configuration: CRNF

Mass Balance

	Traverse 1	Traverse 2	Traverse 3
Total Conveyor Travel (m)	45.23	52.37	53.74
Fuel Moisture Content (% w.b.)	9.1	7.8	8.1
Fuel Loading Rate (g/sq.m d.b.)	595	604	602
Total Fuel Consumption (g w.b.)	36,089	41,789	42,878
Total Fuel Consumption (g d.b.)	32,823	38,550	39,418
Residual Ash (g w.b.)	6,887	7,974	8,182
Fuel Vaporized (g w.b.)	29,202	33,814	34,696
Fuel Consumption Rate (g/s w.b.)	12.53	14.51	14.89
Fuel Consumption Rate (g/s d.b.)	11.40	13.39	13.69
Ash Generation Rate (g/s w.b.)	2.39	2.77	2.84
Fuel Vaporization Rate (g/s w.b.)	10.14	11.74	12.05
Stack Gas Density (kg/cu.m)	1.0890	1.0659	1.0551
Stack Gas Flow Rate (cu.m/s)	3.74	3.75	3.68
Stack Gas Mass Flow Rate (kg/s)	4.07	4.00	3.88
Inlet Air Mass Flow Rate (kg/s)	4.06	3.99	3.87
Overall Air-Fuel Ratio (w.b.)	324.06	274.65	259.85
Overall Air-Fuel Ratio (d.b.)	356.30	297.72	282.66

Table 3.1.4.4. Emission factors, rice straw, 14 July 92 (integrated basis)

Fuel: Rice Straw | Date of Test: 14-Jul-92 | Configuration: CRNF

Emission Factors (% of fuel dry weight)

Integrated Basis

	Traverse 1	Traverse 2	Traverse 3	Average
CO	2.797	2.623	2.360	2.593
NO	0.153	0.160	0.152	0.155
NOx (as NO2)	0.268	0.278	0.268	0.271
SO2	0.046	0.060	0.059	0.055
HC (as CH4 by GC)	0.024	0.036	0.019	0.027
CH4 (by GC)	0.016	0.021	0.013	0.017
NMHC (by GC)	0.008	0.015	0.006	0.010
CO2 (by GC)	113.538	92.875	99.549	101.987
Total S (as SO2)	0.053	0.061	0.059	0.058
SO2/Total S	0.87	0.98	0.99	0.95
PM	0.209	0.246	0.229	0.228
PM10	0.205	0.239		0.222
PM2.5	0.188	0.216		0.202
MMAD (μm)	0.082	0.105		0.093
σ	4.846	6.233		

Table 3.1.4.5. Emission factors, rice straw, 14 July 92 (average basis).

Fuel: Rice Straw

Date of Test: 14-Jul-92

Configuration: CRNF

Emission Factors (% of fuel dry weight)

Averge Basis

	Traverse 1	Traverse 2	Traverse 3	Average
CO	2.684	2.567	2.306	2.519
NO	0.151	0.157	0.149	0.152
NOx (as NO2)	0.263	0.273	0.262	0.266
SO2	0.045	0.058	0.057	0.053
HC (as CH4 by GC)	0.024	0.036	0.019	0.027
CH4 (by GC)	0.016	0.021	0.013	0.017
NMHC (by GC)	0.008	0.015	0.006	0.010
CO2 (by GC)	113.538	92.875	99.549	101.987
Total S (as SO2)	0.052	0.060	0.057	0.056
SO2/Total S	0.87	0.97	0.99	0.95
PM	0.209	0.246	0.229	0.228
PM10	0.205	0.239		0.222
PM2.5	0.188	0.216		0.202
MMAD (μm)	0.082	0.105		0.093
σ	4.846	6.233		

Table 3.1.4.6. Carbon balance.

Date of Test: Fuel	14-Jul-92 Rice Straw Traverse 1	14-Jul-92 Rice Straw Traverse 2	14-Jul-92 Rice Straw Traverse 3
Carbon Balance			
Dry Fuel Consumption Rate (g/s)	11.40	13.39	13.69
Ash Generation Rate (g/s)	2.39	2.77	2.84
Ash Fraction (% dry basis)	20.96	20.69	20.75
Fuel Carbon Concentration (%)	37.99	37.99	37.99
Residual Ash Carbon Concentration (%)	9.12	9.12	9.12
Carbon released to stack (g/s)	4.11	4.83	4.94
Maximum CO2 emission factor (%)	132.29	132.38	132.36
Stack Gas Density (kg/cubic meter)	1.09	1.07	1.06
Average CO2 concentration (ppmv)	2,095	2,050	2,314
Average CO concentration (ppmv)	77.82	89.05	84.24
Average THC concentration (ppmv as CH4)	1.24	2.17	1.25
PM Concentration (mg/cubic meter)	7.14	9.99	9.73
PM Carbon Concentration (%)	36.75	36.75	36.75
PM Carbon (mg/cubic meter)	2.62	3.67	3.58
Stack Gas Temperature (°C)	51.40	58.44	61.84
Impinger Temperature (°C)	16.73	18.58	20.95
PM molar concentration (ppm)	5.20	7.32	7.19
Estimated Average Stack Gas Velocity (m/s)	2.82	3.43	3.16
Emission Factors (% Average Basis):			
CO2	113.538	92.875	99.549
CO	2.684	2.567	2.306
HC (as CH4)	0.024	0.036	0.019
PM	0.209	0.246	0.229
Emission Factors (% Integrated Basis):			
CO2	113.538	92.875	99.549
CO	2.797	2.623	2.360
HC (as CH4)	0.024	0.036	0.019
PM	0.209	0.246	0.229
Closure (% Average Basis)	89	74	78
Closure (% Integrated Basis)	89	73	78

Table 3.1.4.7. Nitrogen balance

Date of Test: Fuel	14-Jul-92 Rice Straw Traverse 1	14-Jul-92 Rice Straw Traverse 2	14-Jul-92 Rice Straw Traverse 3
Nitrogen Balance			
Fuel Nitrogen Concentration (% dry weight)	0.70	0.70	0.70
Ash Nitrogen Concentration (% weight)	0.64	0.64	0.64
Emission Factors (% Average Basis):			
NOx (as NO2)	0.263	0.273	0.262
PM	0.209	0.246	0.229
Emission Factors (% Integrated Basis):			
NOx (as NO2)	0.268	0.278	0.268
NO3- Concentration of PM (% weight)	0.348	0.348	0.348
NH4+ Concentration of PM (% weight)	1.732	1.732	1.732
Nitrogen Concentration of PM (%)	1.426	1.426	1.426
Fuel Nitrogen (mg/s)	79.80	93.73	95.83
Ash Nitrogen (mg/s)	15.30	17.73	18.18
Nitrogen as NOx (mg/s Average Basis)	9.12	11.13	10.92
Nitrogen as NOx (mg/s Integrated Basis)	9.30	11.33	11.17
Nitrogen as PM (mg/s Average Basis)	0.34	0.47	0.45
Nitrogen as NOx+PM (mg/s Average Basis)	9.46	11.59	11.36
Nitrogen as NOx+PM (mg/s Integrated Basis)	9.64	11.80	11.61
NOx+PM Nitrogen/Fuel Nitrogen (Average)	0.119	0.124	0.119
NOx+PM Nitrogen/Fuel Nitrogen (Integrated)	0.121	0.126	0.121
Ash Nitrogen/Fuel Nitrogen	0.192	0.189	0.190
Ash+NOx+PM Nitrogen/Fuel Nitrogen (Average)	0.310	0.313	0.308
Ash+NOx+PM Nitrogen/Fuel Nitrogen (Integrated)	0.312	0.315	0.311

Table 3.1.4.8. Sulfur balance.

Date of Test:	14-Jul-92	14-Jul-92	14-Jul-92
Fuel	Rice Straw Traverse 1	Rice Straw Traverse 2	Rice Straw Traverse 3
Sulfur Balance			
Fuel Sulfur Concentration (mg/kg dry weight)	720	720	720
Ash Sulfur Concentration (mg/kg weight)	650	650	650
Emission Factors (% Average Basis)			
SO2	0.045	0.058	0.057
PM	0.209	0.246	0.229
Emission Factors (% Integrated Basis)			
SO2	0.046	0.060	0.059
Sulfur Concentration of PM (% weight)	1.409	1.409	1.409
Fuel Sulfur (mg/s)	8.21	9.64	9.86
Ash Sulfur (mg/s)	1.55	1.80	1.85
Sulfur as SO2 (mg/s Average Basis)	2.57	3.88	3.90
Sulfur as SO2 (mg/s Integrated Basis)	2.62	4.02	4.04
Sulfur as PM (mg/s Average Basis)	0.34	0.46	0.44
Sulfur as SO2+PM (mg/s Average Basis)	2.90	4.35	4.34
Sulfur as SO2+PM (mg/s Integrated Basis)	2.96	4.48	4.48
SO2+PM Sulfur/Fuel Sulfur (Average Basis)	0.353	0.451	0.441
SO2+PM Sulfur/Fuel Sulfur (Integrated Basis)	0.360	0.465	0.455
Ash Sulfur/Fuel Sulfur	0.189	0.187	0.187
Closure (% Average Basis)	54	64	63
Closure (% Integrated Basis)	55	65	64

Table 3.1.4.9. Water balance.

Estimated Stack Humidity

Fuel	Rice Straw
Configuration	CRNF
Date of Test	14-Jul-92

	Traverse 1	Traverse 2	Traverse 3
Ambient Air Temperature °C)	28	31	33
Ambient Air Relative Humidity (%)	59	53	45
Air Temperature (K)	301	304	307
Saturation Pressure (Pa)	3,719	4,547	5,151
Vapor Pressure (Pa)	2,209	2,399	2,298
Air Dew Point Temperature (°C)	19.1	20.4	19.7
Ambient Volume Fraction Water Vapor	0.0218	0.0237	0.0227
Ambient Mass Fraction Water Vapor	0.0135	0.0147	0.0141
Fuel Burning Rate (g/s wet basis)	12.53	14.51	14.89
Fuel Moisture Content (%)	9.1	7.8	8.1
Ash Fraction (wet basis)	0.19	0.19	0.19
Fuel Hydrogen Content (%)	5.27	5.27	5.27
Ash Hydrogen Content (%)	0.62	0.62	0.62
Moisture Evaporated (g/s)	1.14	1.13	1.21
Water of Combustion (g/s)	5.27	6.19	6.33
Total Fuel Water Added (g/s)	6.41	7.32	7.54
Inlet Air Mass Flowrate (g/s)	4,060	3,990	3,870
Inlet Air Water Vapor Flowrate (g/s)	55	59	54
Total Stack Water Vapor Flowrate (g/s)	61	66	62
Stack Gas Mass Flowrate (g/s)	4,070	4,002	3,882
Mass Fraction Water Vapor in Stack	0.0151	0.0165	0.0160
Volume Fraction Water Vapor in Stack	0.0243	0.0266	0.0257
Stack Vapor Pressure (Pa)	2,461	2,690	2,607
Stack Temperature (°C)	51	58	62
Stack Temperature (K)	325	332	335
Stack Saturation Pressure (Pa)	13,234	18,547	21,705
Stack Relative Humidity (%)	19	15	12
Stack Dew Point Temperature (°C)	20.8	22.3	21.8
Impinger Outlet Temperature (°C)	16.7	18.6	21.0
Volume Stack Gas Sampled for PM (L)	532	540	638
Estimated Impinger/Desiccant Weight Gain (g)	9.8	10.8	12.2

Totals:

	Estimated	Measured
Total Impinger/Desiccant Weight Gain (g)	32.8	30.7
Estimated/Measured Weight Gain	1.07	

Table 3.1.4.10. Power balance.

Date of Test: Fuel	14-Jul-92 Rice Straw Traverse 1	14-Jul-92 Rice Straw Traverse 2	14-Jul-92 Rice Straw Traverse 3
Power Balance			
Fuel Heating Value (MJ/kg dry weight)	15.6532	15.6532	15.6532
Ash Heating Value (MJ/kg dry weight)	2.9822	2.9822	2.9822
Average Energy Release Rate (kW)	171.3	201.3	205.8
Products of Incomplete Combustion (kW)			
CO	3.1	3.5	3.2
THC (as CH4)	0.2	0.3	0.1
PM	0.3	0.4	0.4
Heat Release Rate (kW)	167.8	197.2	202.1
Fireline Intensity (kW/m)	137.6	161.7	165.8
Stack Gas Flow (kg/s)	4.07	4.00	3.88
Stack Gas Temperature (°C)	51.40	58.44	61.84
Inlet Temperature (°C)	30.89	34.40	36.30
Sensible Power at Top of Stack (kW)	84.0	96.7	99.7
Tunnel Dissipation (kW)	83.8	100.5	102.4

Table 3.1.4.11. Mass concentrations (%) from DRI filter samples

Date		14-Jul-92		14-Jul-92	
Fuel		Rice Straw		Rice Straw	
		CRNF		CRNF	
Size Fraction	PM2.5		PM10		
Teflon Filter ID	ABTT018		ABTT019		
Quartz Filter ID	ABTQ018		ABTQ019		
Teflon Field Sample Flag					
Quartz field sample field					
Teflon mass sample flag			i1		
Quartz mass sample flag					
Anions sample flag					
Ammonium analysis flag					
Sodium ion analysis flag					
Magnesium ion analysis flag					
Potassium ion analysis flag					
Carbon analysis flag					
XRF analysis flag					
		±Uncertainty		±Uncertainty	
Teflon sample volume (m^3)	0.30	0.02	0.30	0.02	
Quartz sample volume (m^3)	0.30	0.01	0.30	0.02	
Teflon mass concentration (µg/m^3)	1,580	94	2,387	130	
	Concentration (%)	±Uncertainty	Concentration (%)	±Uncertainty	PM2.5/PM10
Cl-	21.9780	1.9578	14.8190	1.2671	1.48
NO3-	0.4923	0.1555	0.3478	0.1021	1.42
SO4=	5.9120	0.4889	3.9878	0.3140	1.48
NH4+	2.7173	0.2602	1.7319	0.1618	1.57
Na+	0.5539	0.0815	0.3718	0.0532	1.49
K+	15.9423	1.3095	10.4485	0.8178	1.53
C(org)	14.4816	2.4759	10.6782	1.6806	1.36
C(oht)	11.4595	2.5985	9.2842	1.9273	1.23
C(e)	39.1894	3.9294	26.0754	2.5345	1.50
C(eht)	1.7261	1.0869	2.6397	1.6276	0.65
C	53.6710		36.7536		1.46
Al	0.0000	0.1323	0.0000	0.1492	
Si	1.4404	0.1652	8.0722	0.6041	0.18
P	0.0000	0.2444	0.0000	0.1971	
S	1.9752	0.1851	1.4086	0.1333	1.40
Cl	21.8410	1.7080	17.9079	1.3285	1.22
K	25.5390	1.9931	18.8856	1.3987	1.35
Ca	0.2877	0.2985	1.1696	0.1149	0.25
Ti	0.0007	0.1024	0.0165	0.0683	0.04
V	0.0049	0.0449	0.0014	0.0300	3.50
Cr	0.0008	0.0120	0.0029	0.0085	0.28
Mn	0.0774	0.0091	0.3751	0.0285	0.21
Fe	0.0591	0.0251	0.3782	0.0328	0.16
Co	0.0000	0.0053	0.0000	0.0070	
Ni	0.0000	0.0058	0.0023	0.0041	0.00
Cu	0.0041	0.0062	0.0030	0.0042	1.37
Zn	0.1095	0.0099	0.0833	0.0070	1.31
Ga	0.0000	0.0109	0.0004	0.0074	0.00
As	0.0032	0.0132	0.0049	0.0088	0.65
Se	0.0048	0.0073	0.0019	0.0050	2.53
Br	0.1334	0.0117	0.1031	0.0084	1.29
Rb	0.0273	0.0050	0.0224	0.0035	1.22
Sr	0.0000	0.0065	0.0073	0.0031	0.00
Y	0.0000	0.0078	0.0018	0.0054	0.00
Zr	0.0024	0.0097	0.0027	0.0066	0.89
Mo	0.0000	0.0160	0.0011	0.0109	0.00
Pd	0.0000	0.0710	0.0000	0.0493	
Ag	0.0119	0.0823	0.0000	0.0579	
Cd	0.0520	0.0876	0.0000	0.0590	
In	0.0000	0.0955	0.0000	0.0651	
Sn	0.0345	0.1205	0.0343	0.0834	1.01
Sb	0.0348	0.1385	0.0000	0.0964	
Ba	0.0000	0.4890	0.0000	0.3291	
La	0.0000	0.6422	0.0536	0.4377	0.00
Au	0.0000	0.0186	0.0033	0.0129	0.00
Hg	0.0037	0.0151	0.0001	0.0102	37.00
Tl	0.0028	0.0140	0.0025	0.0095	1.12
Pb	0.0092	0.0187	0.0012	0.0125	7.67
U	0.0007	0.0149	0.0019	0.0103	0.37
Sum of measured species	109.0948	5.4329	87.7541	3.7153	1.24

Table 3.1.4.12. Element ratios from DRI filter samples.

Date	14-Jul-92	14-Jul-92	
Fuel	Rice Straw	Rice Straw	
Configuration	CRNF	CRNF	
Size Fraction	PM2.5	PM10	PM2.5/PM10
Teflon Filter ID	ABTT018	ABTT019	
Quartz Filter ID	ABTQ018	ABTQ019	
Cl-/Cl	1.01	0.83	1.22
K+/K	0.62	0.55	1.13
Sulfate S/Total S	1.00	0.94	1.06
C(org)/C	0.27	0.29	0.93
Cl/K	0.86	0.95	0.90
Cl-/K+	1.38	1.42	0.97
Cl-/Na+	39.68	39.86	1.00
S/K	0.08	0.07	1.04
S/Na+	3.57	3.79	0.94
Al/Si	0.00	0.00	

Table 3.1.4.13. Emission factors (mg/kg) from DRI filter samples.

Date		14-Jul-92		14-Jul-92	
Fuel		Rice Straw CRNF		Rice Straw CRNF	
Size Fraction	PM2.5		PM10		
Teflon Filter ID	ABTT018		ABTT019		
Quartz Filter ID	ABTQ018		ABTQ019		
Start Time	9:38				
Stop Time	10:08				
Start Time					
End Time					
Elapsed Time (minutes)	30				Traverse 1
PM (mg/m^3 by total filter)					7.140
PM10 (by total filter/impactor)					6.990
PM2.5 (by total filter/impactor)					6.420
PM emission factor (%)					0.209
PM10 emission factor (%)					0.205
PM2.5 emission factor (%)					0.188
		±Uncertainty		±Uncertainty	
Teflon sample volume (m^3)	0.30	0.02	0.30	0.02	
Quartz sample volume (m^3)	0.30	0.01	0.30	0.02	
Teflon mass concentration (mg/m^3)	1.580	0.094	2.387	0.130	
Teflon mass/Total mass	0.246		0.341		
	Emission (mg/kg)	±Uncertainty	Emission (mg/kg)	±Uncertainty	PM2.5/PM10
Cl-	378.7407	36.8066	346.1827	25.9756	1.09
NO3-	8.4837	2.9234	8.1249	2.0931	1.04
SO4=	101.8798	9.1913	93.1579	6.4370	1.09
NH4+	46.8265	4.8918	40.4585	3.3169	1.16
Na+	9.5452	1.5322	8.6855	1.0906	1.10
K+	274.7292	24.6186	244.0846	16.7649	1.13
C(org)	249.5573	46.5469	249.4506	34.4523	1.00
C(oht)	197.4783	48.8518	216.8857	39.5097	0.91
C(e)	675.3399	73.8727	609.1404	51.9573	1.11
C(eht)	29.7454	20.4337	61.6653	33.3658	0.48
C	924.8972	0.0000	858.5910	0.0000	1.08
Al	0.0000	2.4872	0.0000	3.0586	
Si	24.8220	3.1058	188.5725	12.3841	0.13
P	0.0000	4.5947	0.0000	4.0406	
S	34.0381	3.4799	32.9059	2.7327	1.03
Cl	376.3798	32.1104	418.3417	27.2343	0.90
K	440.1064	37.4703	441.1814	28.6734	1.00
Ca	4.9579	5.6118	27.3227	2.3555	0.18
Ti	0.0121	1.9251	0.3855	.1.4002	0.03
V	0.0844	0.8441	0.0327	0.6150	2.58
Cr	0.0138	0.2256	0.0677	0.1743	0.20
Mn	1.3338	0.1711	8.7626	0.5843	0.15
Fe	1.0185	0.4719	8.8350	0.6724	0.12
Co	0.0000	0.0996	0.0000	0.1435	
Ni	0.0000	0.1090	0.0537	0.0841	0.00
Cu	0.0707	0.1166	0.0701	0.0861	1.01
Zn	1.8870	0.1861	1.9459	0.1435	0.97
Ga	0.0000	0.2049	0.0093	0.1517	0.00
As	0.0551	0.2482	0.1145	0.1804	0.48
Se	0.0827	0.1372	0.0444	0.1025	1.86
Br	2.2988	0.2200	2.4085	0.1722	0.95
Rb	0.4705	0.0940	0.5233	0.0718	0.90
Sr	0.0000	0.1222	0.1705	0.0636	0.00
Y	0.0000	0.1466	0.0420	0.1107	0.00
Zr	0.0414	0.1824	0.0631	0.1353	0.66
Mo	0.0000	0.3008	0.0257	0.2235	0.00
Pd	0.0000	1.3348	0.0000	1.0107	
Ag	0.2051	1.5472	0.0000	1.1870	
Cd	0.8961	1.6469	0.0000	1.2095	
In	0.0000	1.7954	0.0000	1.3346	
Sn	0.5945	2.2654	0.8013	1.7097	0.74
Sb	0.5997	2.6038	0.0000	1.9762	
Ba	0.0000	9.1932	0.0000	6.7466	
La	0.0000	12.0734	1.2521	8.9729	0.00
Au	0.0000	0.3497	0.0771	0.2645	0.00
Hg	0.0638	0.2839	0.0023	0.2091	27.29
Tl	0.0483	0.2632	0.0584	0.1948	0.83
Pb	0.1585	0.3516	0.0280	0.2563	5.66
U	0.0121	0.2801	0.0444	0.2112	0.27
Sum of measured species	1,880	102	2,050	70	0.92

Table 3.1.4.14. Element concentrations (ng/m^3) from CNL filter samples.

Fuel:	Rice
Date:	14-Jul-92
Time:	10:16
Filter ID:	AG-28b

Element	Concentration	±Uncertainty
	ng/m^3	
H	34,070	5,100
Na		
Mg		
Al		
Si	320,940	16,800
P		
S		
Cl	1,263,110	63,800
K	1,267,190	63,800
Ca	43,230	10,100
Ti	550	300
V		
Cr	770	300
Mn	9,200	700
Fe	13,160	800
Ni	240	100
Cu	360	100
Zn	2,130	200
As	380	100
Pb		
Se		
Br	3,480	300
Rb	1,020	300
Sr		
Zr		

Table 3.1.4.15. Element emission factors (mg/kg) from CNL filter samples.

Fuel:	Rice
Date:	14-Jul-92
Time:	10:16
Filter ID:	AG-28b
Fuel rate (g/s)	11.40
Stack gas flow rate (m^3/s)	3.74
Stack Temperature (°C)	51.40
Ambient Temperature (°C)	27.71

Element	Emission factor (mg/kg)	±Uncertainty (mg/kg)
H	10.4	1.6
Na		
Mg		
Al		
Si	97.6	5.1
P		
S		
Cl	384.1	19.4
K	385.4	19.4
Ca	13.1	3.1
Ti	0.2	0.1
V		
Cr	0.2	0.1
Mn	2.8	0.2
Fe	4.0	0.2
Ni	0.1	0.0
Cu	0.1	0.0
Zn	0.6	0.1
As	0.1	0.0
Pb		
Se		
Br	1.1	0.1
Rb	0.3	0.1
Sr		
Zr		

Table 3.1.4.16. Element concentrations (ng/m^3) from CNL filter samples.

Fuel:	Rice
Date:	14-Jul-92
Time:	10:52
Filter ID:	AG-29b

Element	Concentration ng/m^3	±Uncertainty
H	27,190	3,500
Na		
Mg	5,580	3,300
Al		
Si	200,250	10,500
P		
S	38,440	2,600
Cl	603,870	30,600
K	640,620	32,300
Ca	31,300	5,600
Ti		
V		
Cr		
Mn	6,880	500
Fe	7,730	500
Ni	240	100
Cu		
Zn	1,680	100
As		
Pb		
Se		
Br	2,290	200
Rb	660	200
Sr		
Zr		

Table 3.1.4.17. Element emission factors (mg/kg) from CNL filter samples.

Fuel:	Rice
Date:	14-Jul-92
Time:	10:52
Filter ID:	AG-29b
Fuel rate (g/s)	13.39
Stack gas flow rate (m^3/s)	3.75
Stack Temperature (°C)	58.44
Ambient Temperature (°C)	31.20

Element	Emission factor (mg/kg)	±Uncertainty (mg/kg)
H	7.0	0.9
Na		
Mg	1.4	0.8
Al		
Si	51.5	2.7
P		
S	9.9	0.7
Cl	155.2	7.9
K	164.7	8.3
Ca	8.0	1.4
Ti		
V		
Cr		
Mn	1.8	0.1
Fe	2.0	0.1
Ni	0.1	0.0
Cu		
Zn	0.4	0.0
As		
Pb		
Se		
Br	0.6	0.1
Rb	0.2	0.1
Sr		
Zr		

Table 3.1.4.18. Relative element concentrations by stage from DRUM impactor.

Stage 1: 10 - 15 μm

	14-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H				
Na				
Mg				
Al				
Si	39,277.95	2,027.23	8.9797	1
S	365.22	65.85	0.0835	1
Cl	1,038.00	102.92	0.2373	1
K	4,374.08	288.62	1.0000	1
Ca	4,130.02	314.46	0.9442	1
Ti	233.51	60.77	0.0534	1
V				
Cr				
Mn	633.23	54.31	0.1448	1
Fe	4,523.14	256.77	1.0341	1
Ni				
Cu	1,039.57	76.00	0.2377	1
Zn	1,333.43	97.08	0.3048	1
As				
Se				
Br				
Rb				
Sr				
Pb	86.42	26.15	0.0198	1

Table 3.1.4.19. Relative element concentrations by stage from DRUM impactor.

Stage 2: 5 - 10 μm

	14-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H				
Na				
Mg				
Al				
Si	9,254.97	505.08	10.3257	0.2356
S	391.49	72.15	0.4368	1.0719
Cl	940.29	95.54	1.0491	0.9059
K	896.31	93.23	1.0000	0.2049
Ca	1,157.34	127.38	1.2912	0.2802
Ti				
V				
Cr				
Mn	271.94	27.54	0.3034	0.4294
Fe	2,291.12	139.69	2.5562	0.5065
Ni				
Cu				
Zn	56.03	11.85	0.0625	0.0420
As				
Se				
Br				
Rb				
Sr				
Pb				

Table 3.1.4.20. Relative element concentrations by stage from DRUM impactor.

Stage 3: 2.5 - 5 μm

	14-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H				
Na				
Mg				
Al				
Si	13,285.28	698.15	4.2298	0.3382
S				
Cl	2,823.09	185.85	0.8988	2.7197
K	3,140.86	203.38	1.0000	0.7181
Ca	1,877.60	160.31	0.5978	0.4546
Ti				
V				
Cr				
Mn	398.25	35.23	0.1268	0.6289
Fe	1,397.83	92.00	0.4450	0.3090
Ni				
Cu				
Zn				
As				
Se				
Br	23.43	7.54	0.0075	
Rb				
Sr				
Pb				

Table 3.1.4.21. Relative element concentrations by stage from DRUM impactor.

Stage 4: 1.15 - 2.5 μm

	14-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H				
Na				
Mg				
Al				
Si	1,297.37	92.92	0.3885	0.0330
S				
Cl	2,780.29	181.69	0.8326	2.6785
K	3,339.12	210.92	1.0000	0.7634
Ca				
Ti	39.46	22.15	0.0118	0.1690
V	77.35	21.69	0.0232	
Cr	46.42	19.54	0.0139	
Mn	113.00	28.00	0.0338	0.1784
Fe	221.86	35.38	0.0664	0.0491
Ni				
Cu				
Zn				
As				
Se				
Br				
Rb				
Sr				
Pb				

Table 3.1.4.22. Relative element concentrations by stage from DRUM impactor.

Stage 5: 0.56 - 1.15 μm

	14-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H	820.28	144.92	1.6859	
Na				
Mg	466.74	77.54	0.9593	
Al				
Si	190.75	41.85	0.3921	0.0049
S				
Cl	566.98	91.54	1.1653	0.5462
K	486.55	57.85	1.0000	0.1112
Ca				
Ti	79.34	29.54	0.1631	0.3398
V				
Cr				
Mn				
Fe	96.15	17.08	0.1976	0.0213
Ni				
Cu				
Zn				
As				
Se				
Br				
Rb				
Sr				
Pb				

Table 3.1.4.23. Relative element concentrations by stage from DRUM impactor.

Stage 6: 0.34 - 0.56 μm

	14-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H	2,211.49	208.77	0.2456	
Na				
Mg				
Al				
Si	489.20	58.15	0.0543	0.0125
S				
Cl	7,002.94	398.92	0.7776	6.7466
K	9,006.22	495.38	1.0000	2.0590
Ca				
Ti				
V				
Cr				
Mn				
Fe	86.77	18.62	0.0096	0.0192
Ni				
Cu				
Zn				
As				
Se				
Br				
Rb				
Sr	43.82	15.69	0.0049	
Pb				

Table 3.1.4.24. Relative element concentrations by stage from DRUM impactor.

Stage 7: 0.24 - 0.34 μm

	14-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H				
Na				
Mg	119.71	42.31	0.2992	
Al				
Si	109.46	30.92	0.2735	0.0028
S				
Cl	258.68	35.08	0.6464	0.2492
K	400.15	46.15	1.0000	0.0915
Ca				
Ti	73.85	21.38	0.1845	0.3162
V				
Cr				
Mn				
Fe				
Ni				
Cu				
Zn	21.71	6.00	0.0542	0.0163
As				
Se				
Br				
Rb				
Sr	22.80	9.85	0.0570	
Pb				

Table 3.1.4.25. Relative element concentrations by stage from DRUM impactor.

Stage 8: < 0.24 μm

	14-Jul-92 Concentration (relative)	±Uncertainty	Abundance Relative to Potassium (-)	Abundance Relative to Stage 1 (-)
H	2,313.55	355.23	0.2541	
Na				
Mg				
Al				
Si	280.92	49.38	0.0309	0.0072
S				
Cl	5,451.09	311.23	0.5987	5.2515
K	9,104.72	497.69	1.0000	2.0815
Ca				
Ti	88.65	37.54	0.0097	0.3796
V				
Cr				
Mn	36.20	16.46	0.0040	0.0572
Fe	137.35	22.15	0.0151	0.0304
Ni				
Cu	160.62	19.85	0.0176	0.1545
Zn	185.37	23.08	0.0204	0.1390
As				
Se				
Br	51.51	12.31	0.0057	
Rb				
Sr				
Pb				

Table 3.1.4.26
VOC Concentrations (ppbv)

Date	14-Jul-92	14-Jul-92	14-Jul-92
Fuel	Rice Straw	Rice Straw	Rice Straw
Traverse	Traverse 1	Traverse 2	Traverse 3
Acetic acid			
Propanone (acetone)			
Methyl ester acetic acid (methylacetate)			
Butane		19.8	16.7
Dimethyloxirane			
Pentene			
Methylbutanone (isopropylmethyl ketone)			
Furancarboxaldehyde (furfural)			
Benzene	20.5	29.9	30.7
Dimethylbutane			
Hexane			
Phenol			
Dimethylfuran			
2-methyl 2-cyclopenten-1-one			
2-chloro phenol			
Toluene	4.9	9.4	11.6
Benzonitrile			
Benzaldehyde	1.1	2.2	3.7
Methylphenol (hydroxy toluene)			
Styrene	1.5	3	2
Xylene	0.5	1.3	2
Trimethylpentane			
Benzofuran			
Methoxymethylphenol (creosol)			
Naphthalene	0.7	2.4	2.2
C10H12			
Alpha-pinene			
Camphene			
Δ3-Carene			
Limonene			
No match r.t. (6.7)			
No match r.t. (8.51)			
No match r.t. (8.71)			
No match r.t. (8.73)	13.8	7.6	12
No match r.t.(6.4)			
No match r.t.(8.5)			

Table 3.1.4.27
VOC Emission Factors (mg/kg)

Date	14-Jul-92	14-Jul-92	14-Jul-92
Fuel	Rice Straw	Rice Straw	Rice Straw
Traverse	Traverse 1	Traverse 2	Traverse 3
Fuel Consumption Rate (g/s d.b)	11.40	13.39	13.69
Stack Gas Mass Flow Rate (kg/s)	4.07	4.00	3.88
Acetic acid			
Propanone (acetone)			
Methyl ester acetic acid (methylacetate)			
Butane		12	9
Dimethyloxirane			
Pentene			
Methylbutanone (isopropylmethyl ketone)			
Furancarboxaldehyde (furfural)			
Benzene	20	24	23
Dimethylbutane			
Hexane			
Phenol			
Dimethylfuran			
2-methyl 2-cyclopenten-1-one			
2-chloro phenol			
Toluene	6	9	10
Benzonitrile			
Benzaldehyde	1	2	4
Methylphenol (hydroxy toluene)			
Styrene	2	3	2
Xylene	1	1	2
Trimethylpentane			
Benzofuran			
Methoxymethylphenol (creosol)			
Naphthalene	1	3	3
Unknown			
Alpha-pinene			
Camphene			
Δ3-Carene			
Limonene			

Table 3.1.4.28. PAH emission factors, rice straw, 14 July 1992 (zero indicates not detected).

	Traverse 1 Filter	Traverse 2 Filter	Trap/Tubing	Traverse 1 Sorbent	Traverse 2 Sorbent	Impinger Rinsate	Total Traverse 1	Total Traverse 2	Total Average
					µg/kg dry fuel				
Naphthalene	31.5	22.3	18.7	7,816.6	13,989.2	0.0	7,866.8	14,030.3	10,948.6
2-Methyl-naphthalene	12.4	7.1	0.0	494.8	429.9	0.0	507.1	437.0	472.1
Acenaphthylene	5.1	3.1	0.0	783.7	853.8	0.0	788.8	856.9	822.8
Acenaphthene	2.5	3.9	0.0	72.7	44.4	0.0	75.3	48.2	61.7
Fluorene	0.0	1.9	0.0	228.3	286.6	0.0	228.3	288.5	258.4
Phenanthrene	20.6	18.9	26.3	778.0	923.2	24.1	848.9	992.5	920.7
Anthracene	2.8	2.4	13.8	120.1	156.7	0.0	136.6	172.9	154.8
Fluoranthene	18.1	74.5	0.0	266.8	351.0	0.0	285.0	425.6	355.3
Pyrene	20.1	76.8	22.5	205.3	274.9	0.0	247.9	374.2	311.1
Benz[a]-anthracene	57.2	47.9	0.0	12.5	14.0	0.0	69.8	62.0	65.9
Chrysene	61.3	63.9	0.0	13.4	15.4	0.0	74.7	79.3	77.0
Benzo[b]-fluoranthene	120.5	126.5	0.0	5.6	2.4	0.0	126.1	128.9	127.5
Benzo[k]-fluoranthene	29.7	29.7	0.0	0.0	0.0	0.0	29.7	29.7	29.7
Benzo[a]pyrene	30.5	38.1	0.0	2.7	2.5	0.0	33.2	40.6	36.9
Benzo[e]pyrene	47.3	51.5	0.0	6.0	4.6	0.0	53.3	56.0	54.6
Perylene	9.7	12.8	0.0	0.0	4.1	0.0	9.7	16.9	13.3
Benzo[ghi]-perylene	32.3	52.4	0.0	0.0	0.0	0.0	32.3	52.4	42.4
Indeno[1,2,3-cd]-pyrene	38.6	43.8	0.0	0.0	0.0	0.0	38.6	43.8	41.2
Dibenz[a,h]-anthracene	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total	540.3	677.5	81.3	10,806.5	17,352.7	24.1	11,452.1	18,135.6	14,793.9

Figure 3.1.4.1. Ambient air conditions, 14 July 92.

Fuel Type: Rice Straw
Configuration: CRNF

Test Date 14-Jul-92

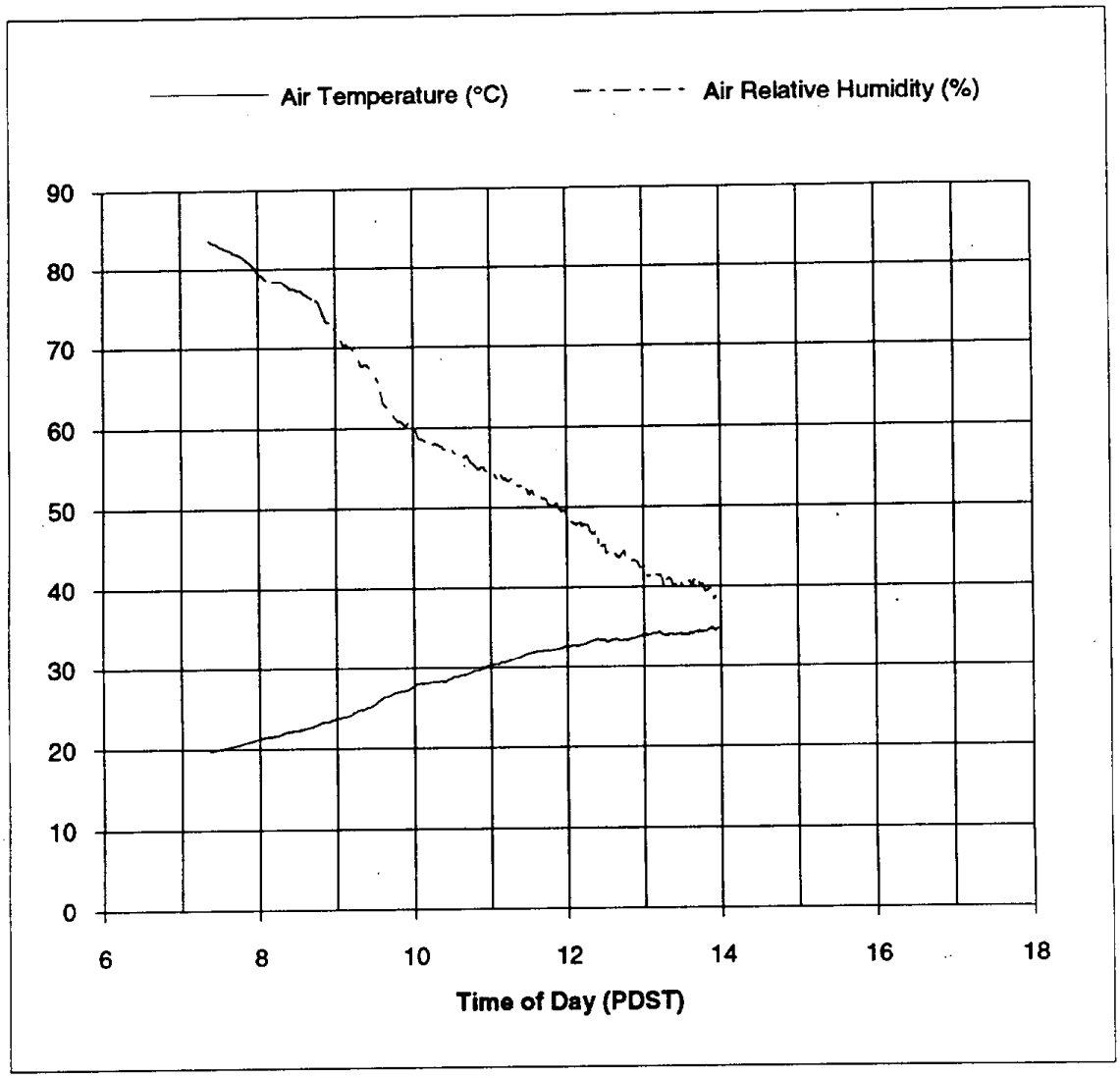


Figure 3.1.4.2. Air temperature and relative humidity from CIMIS station.

Fuel: Rice Straw Date of Test: 14-Jul-92

Configuration: CRNF

Hourly Average CIMIS Data for Davis, California

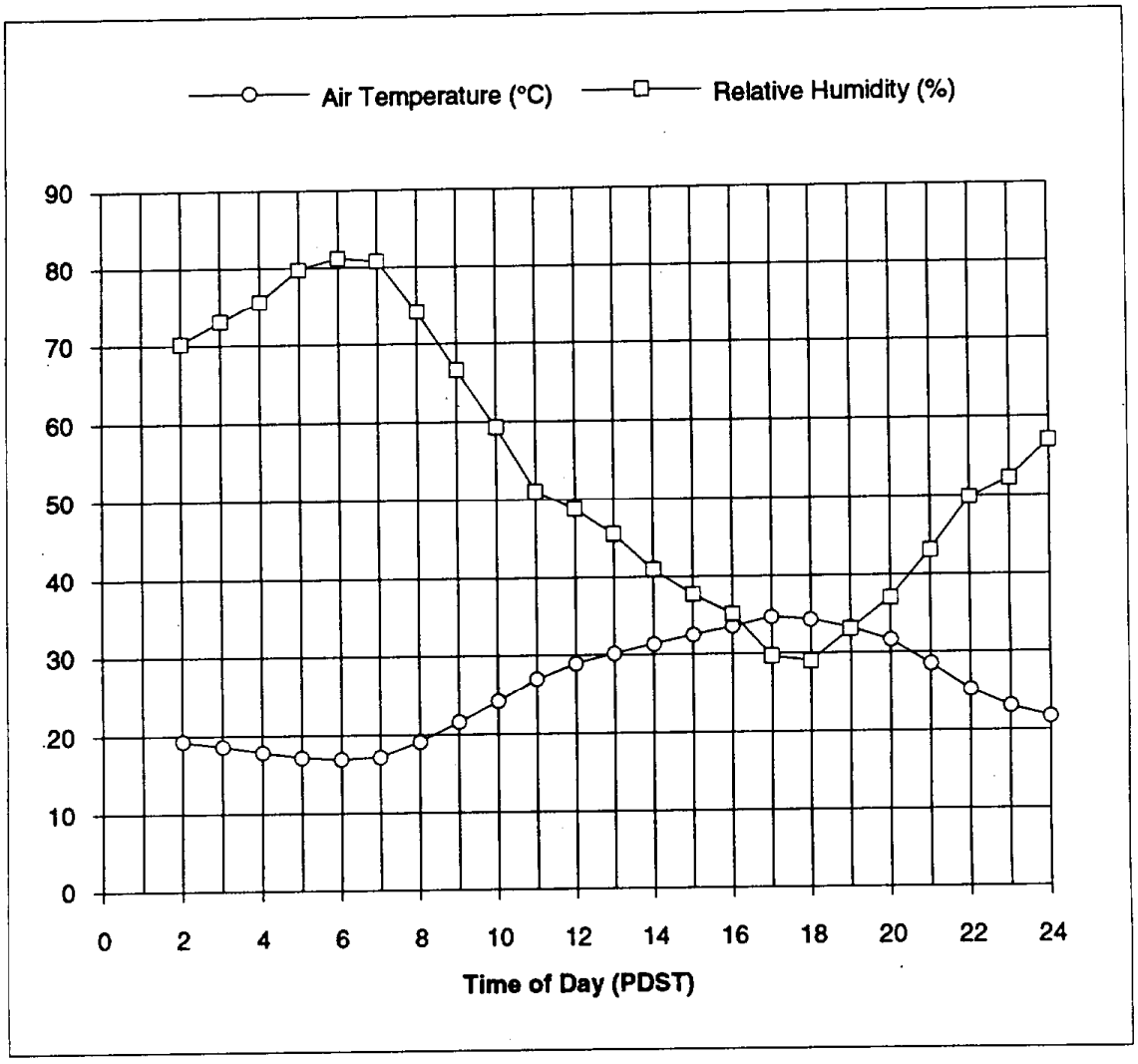


Figure 3.1.4.3. Wind speed from CIMIS station.

Fuel: Rice Straw Date of Test: 14-Jul-92

Configuration: CRNF

Hourly Average CIMIS Data for Davis, California

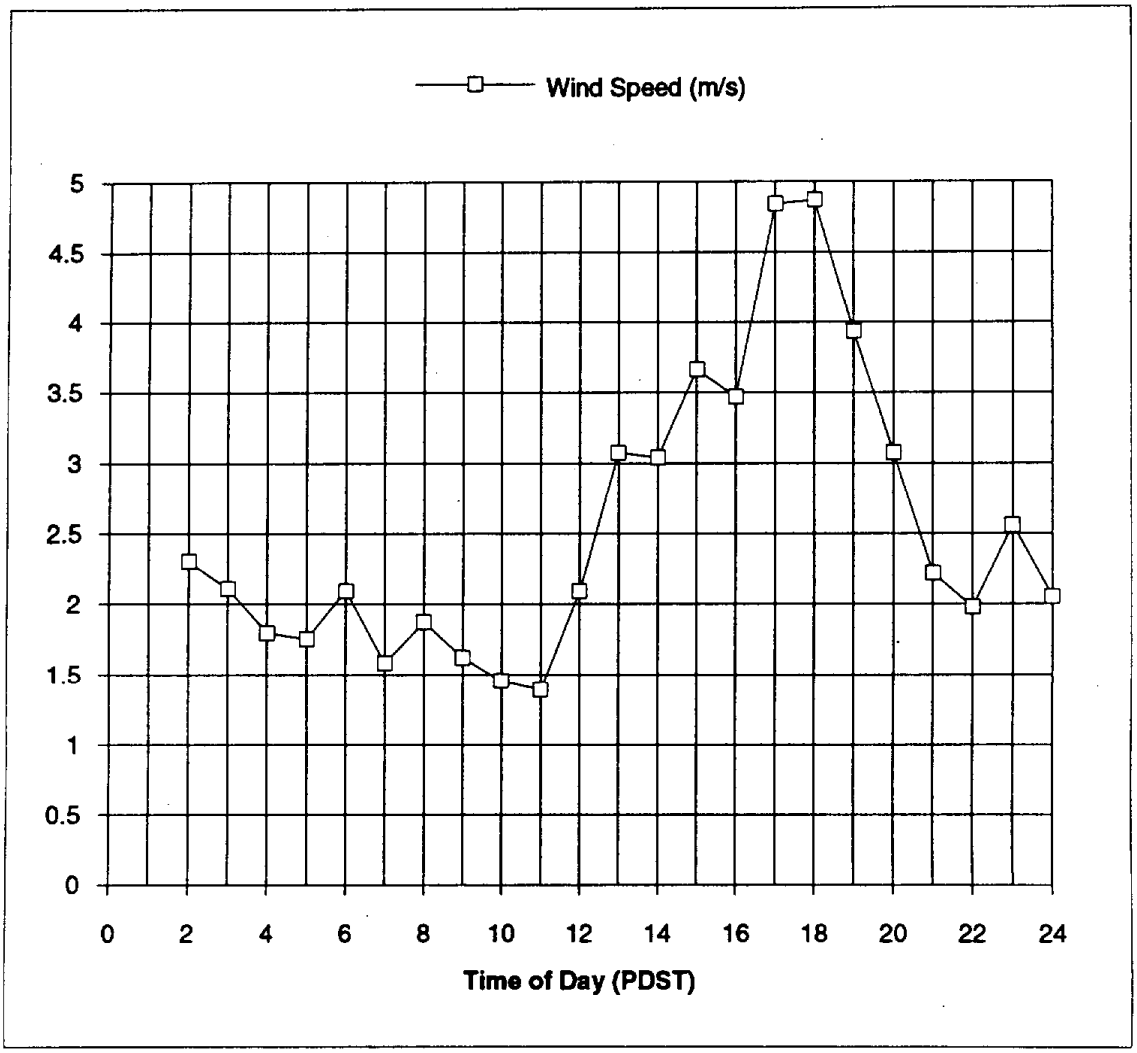


Figure 3.1.4.4. Wind direction and solar radiation from CIMIS station.

Fuel: Rice Straw Date of Test: 14-Jul-92

Configuration: CRNF

Hourly Average CIMIS Data for Davis, California

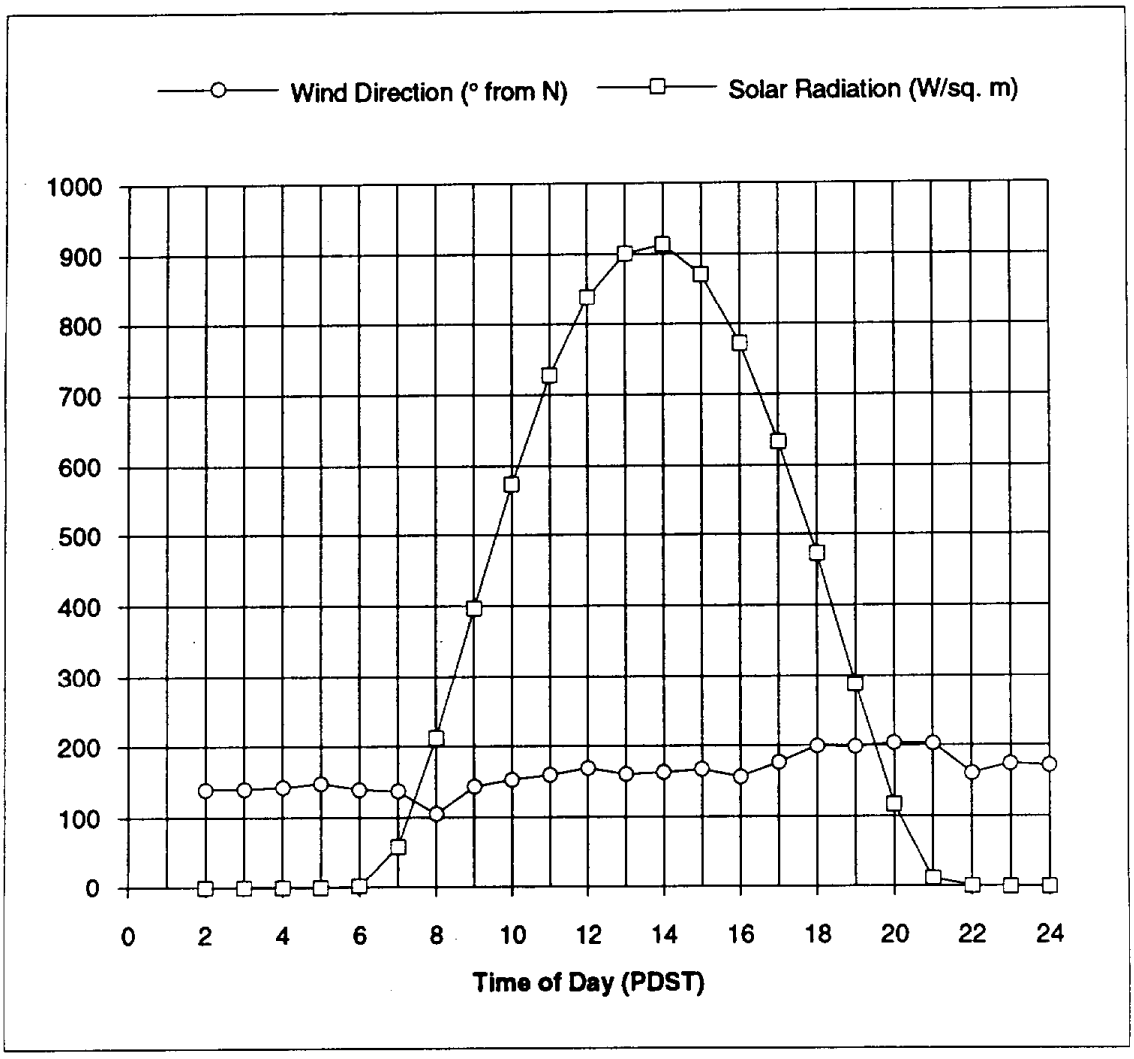


Figure 3.1.4.5. Inlet air, stack gas, and impinger outlet temperatures, 14 July 92.

Fuel Type:	Rice Straw	Test Date	14-Jul-92
Configuration:	CRNF		

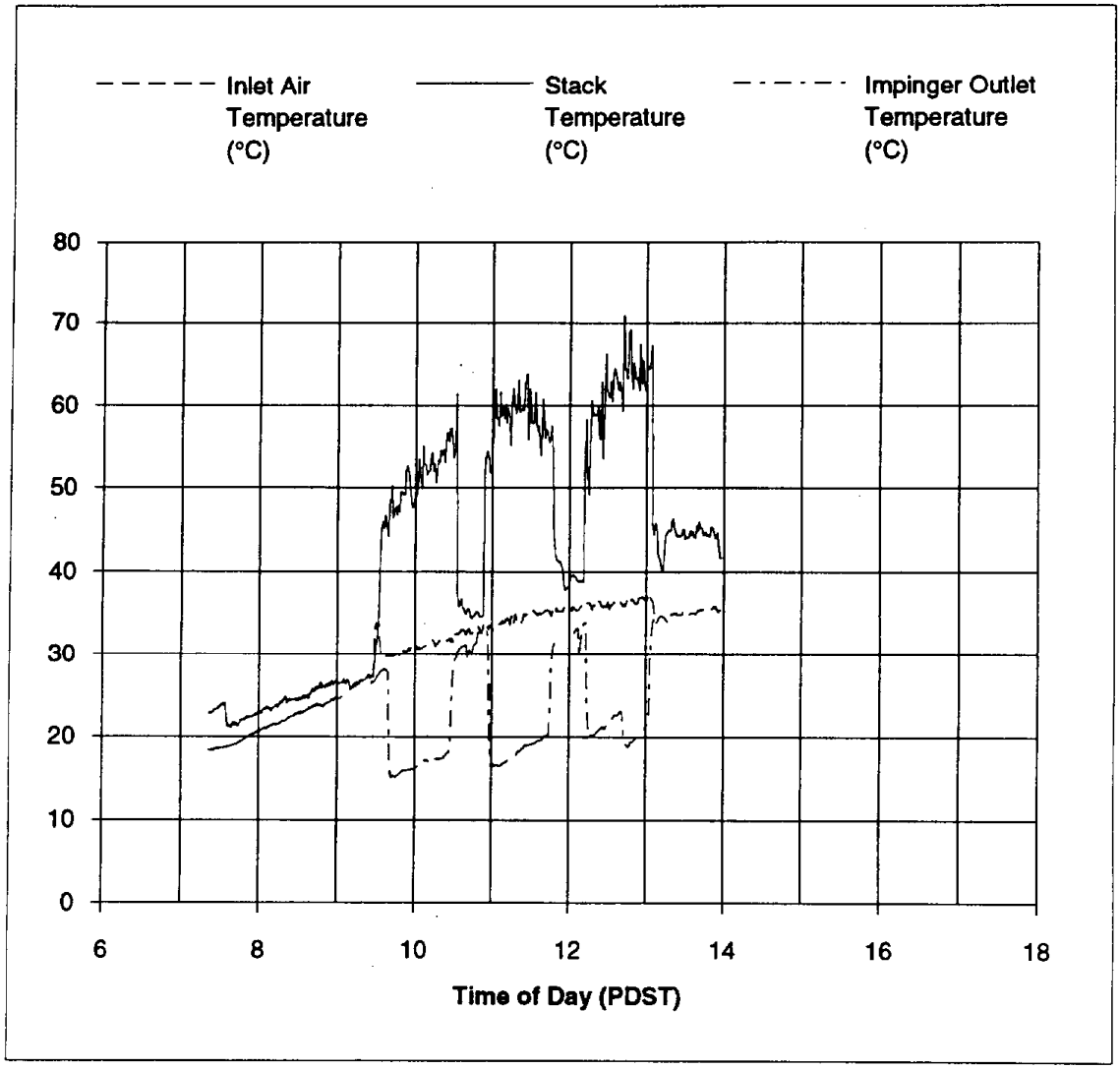


Figure 3.1.4.6. Conveyor speed and stack gas velocity, 14 July 92.

Fuel Type:	Rice Straw	Test Date	14-Jul-92
Configuration:	CRNF		

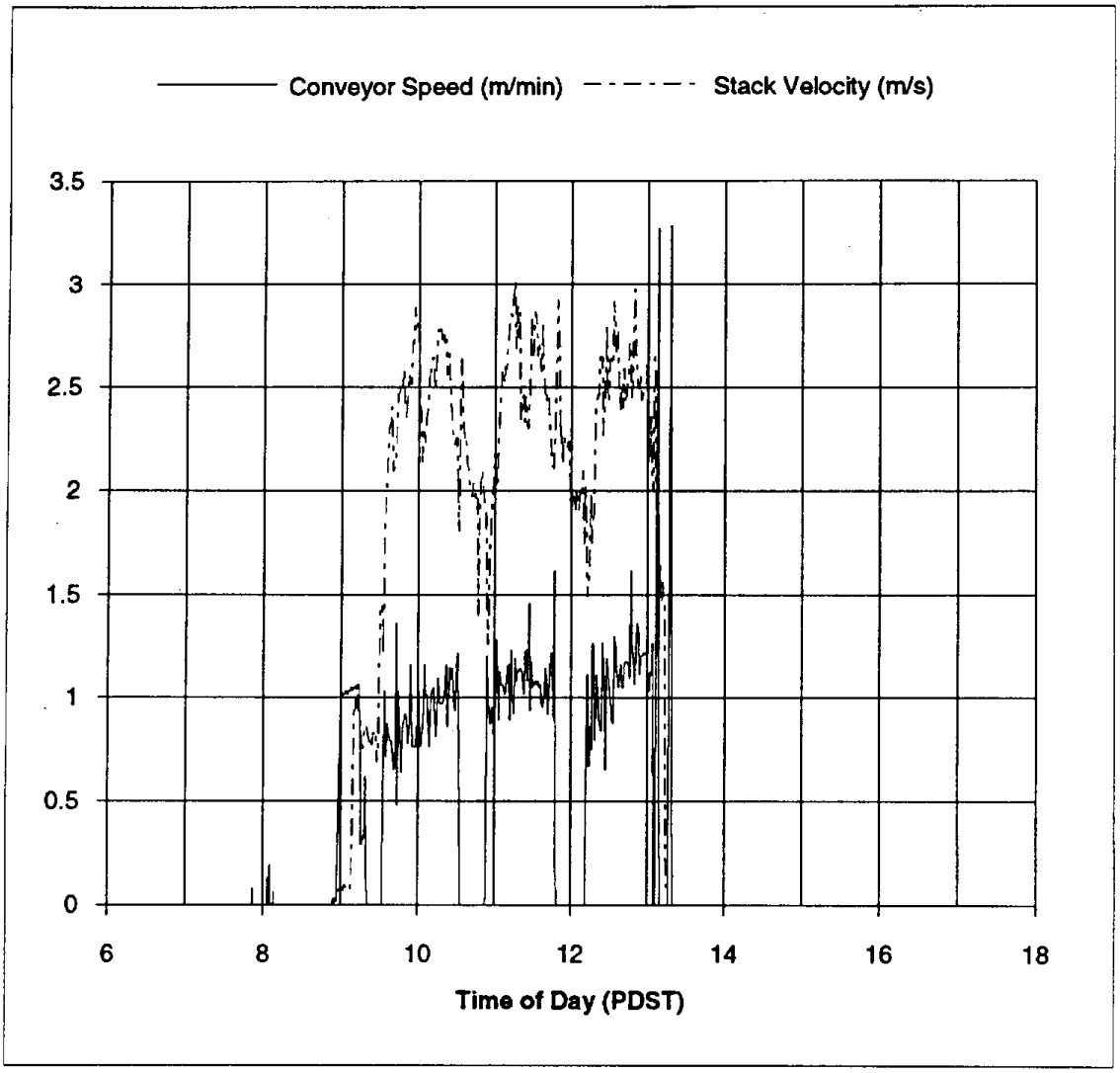


Figure 3.1.4.7. Conveyor travel with 10 min moving average, 14 July 92.

Fuel Type:	Rice Straw	Test Date	14-Jul-92
Configuration:	CRNF		

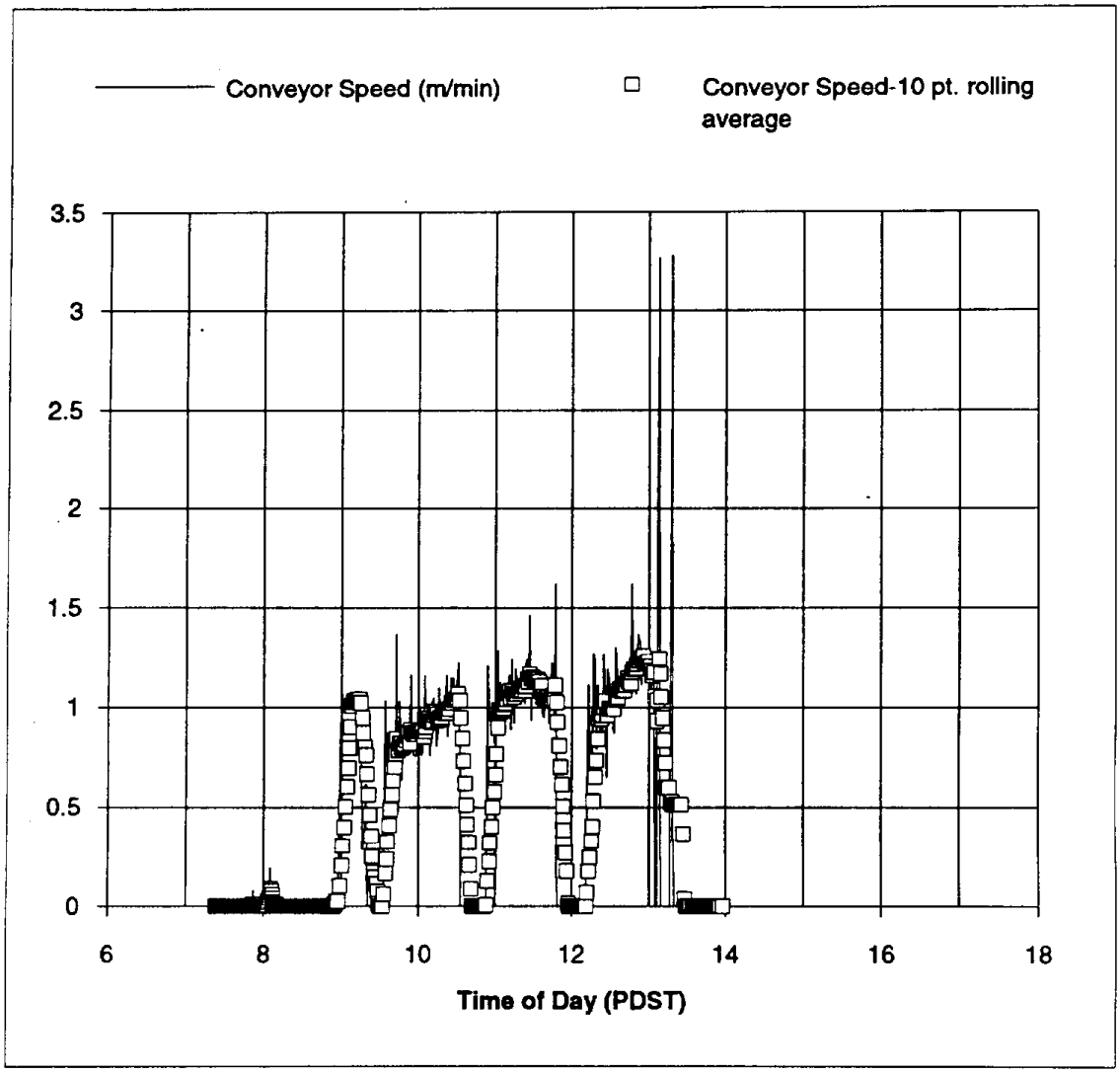


Figure 3.1.4.8. Conveyor travel, 14 July 92.

Fuel Type:	Rice Straw	Test Date	14-Jul-92
Configuration:	CRNF		

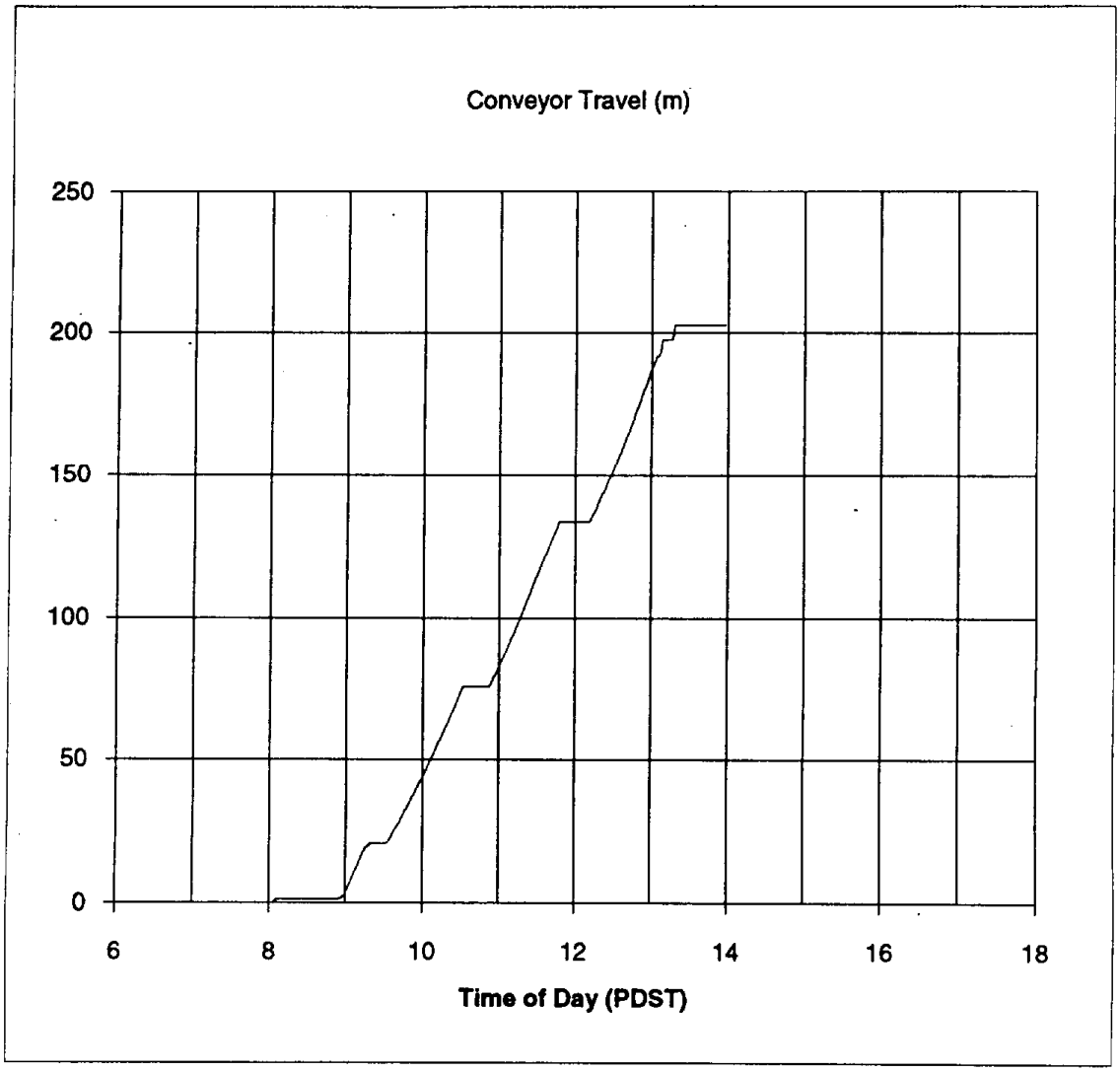


Figure 3.1.4.9. CO concentration in stack gas, 14 July 92.

Fuel Type:	Rice Straw	Test Date	14-Jul-92
Configuration:	CRNF		

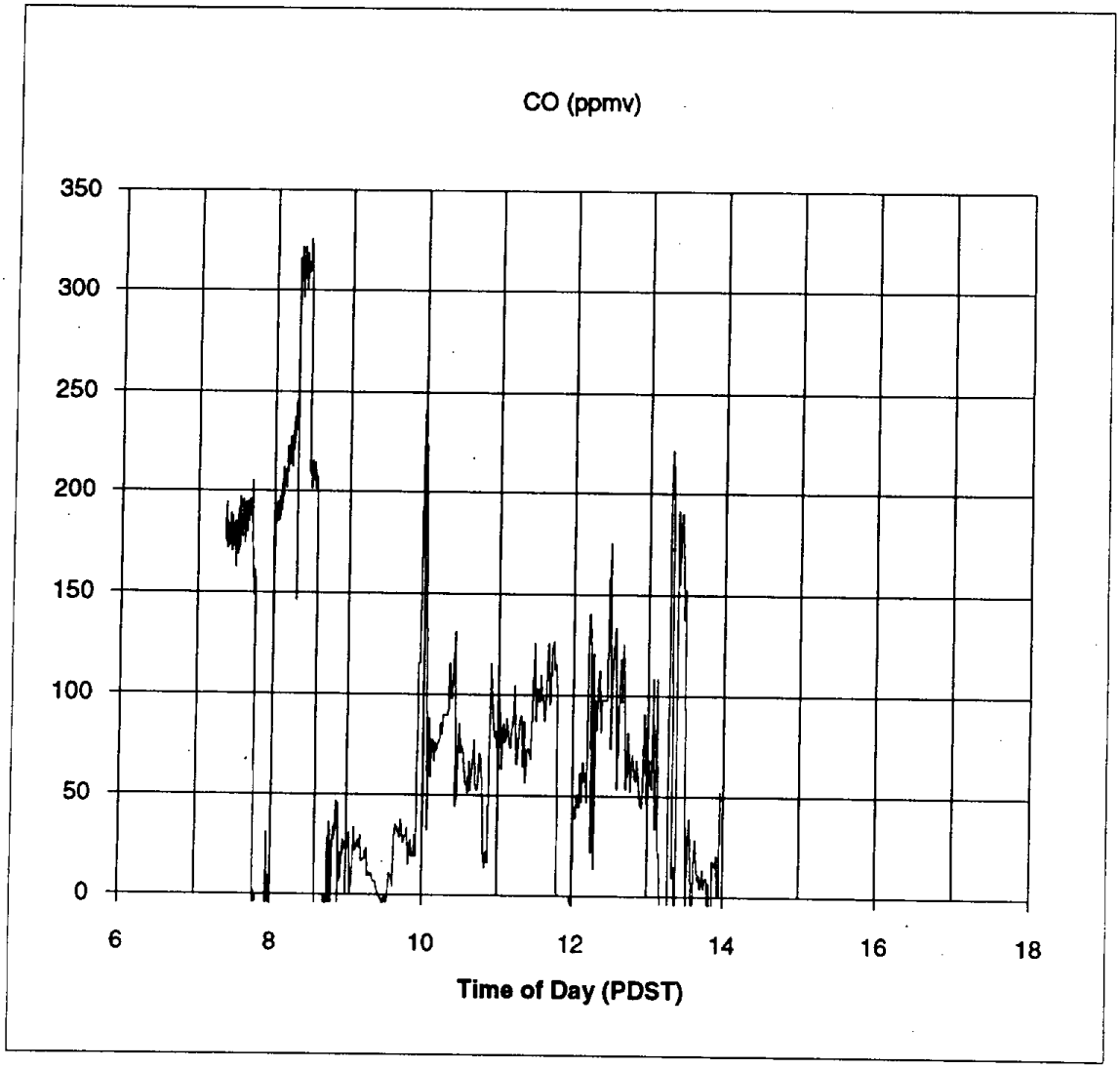


Figure 3.1.4.10. NO and NOx concentrations in stack gas, 14 July 92.

Fuel Type: Rice Straw
Configuration: CRNF
Test Date 14-Jul-92

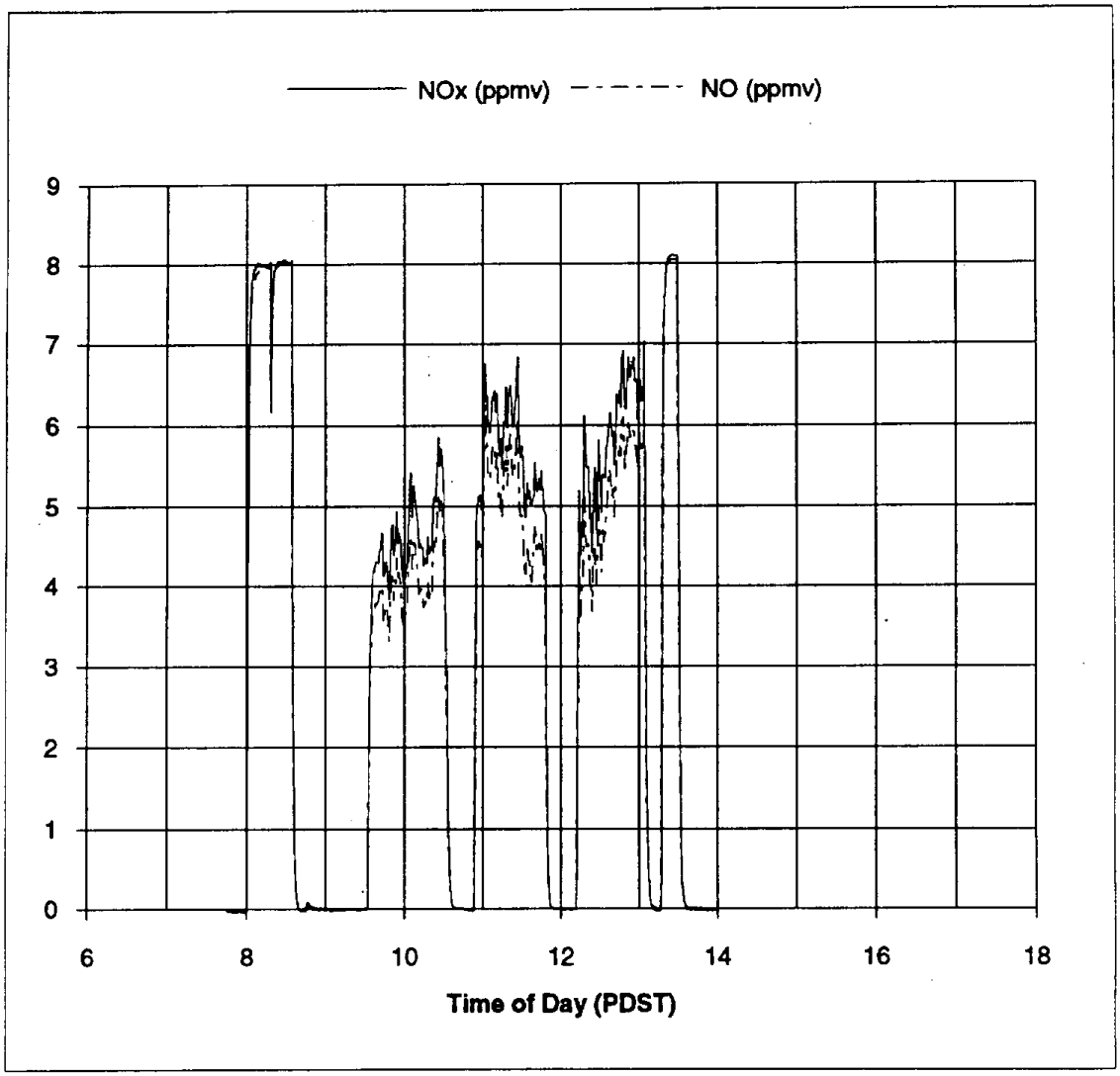


Figure 3.1.4.11. SO2 concentrations in stack gas, 14 July 92.

Fuel Type:	Rice Straw	Test Date	14-Jul-92
Configuration:	CRNF		

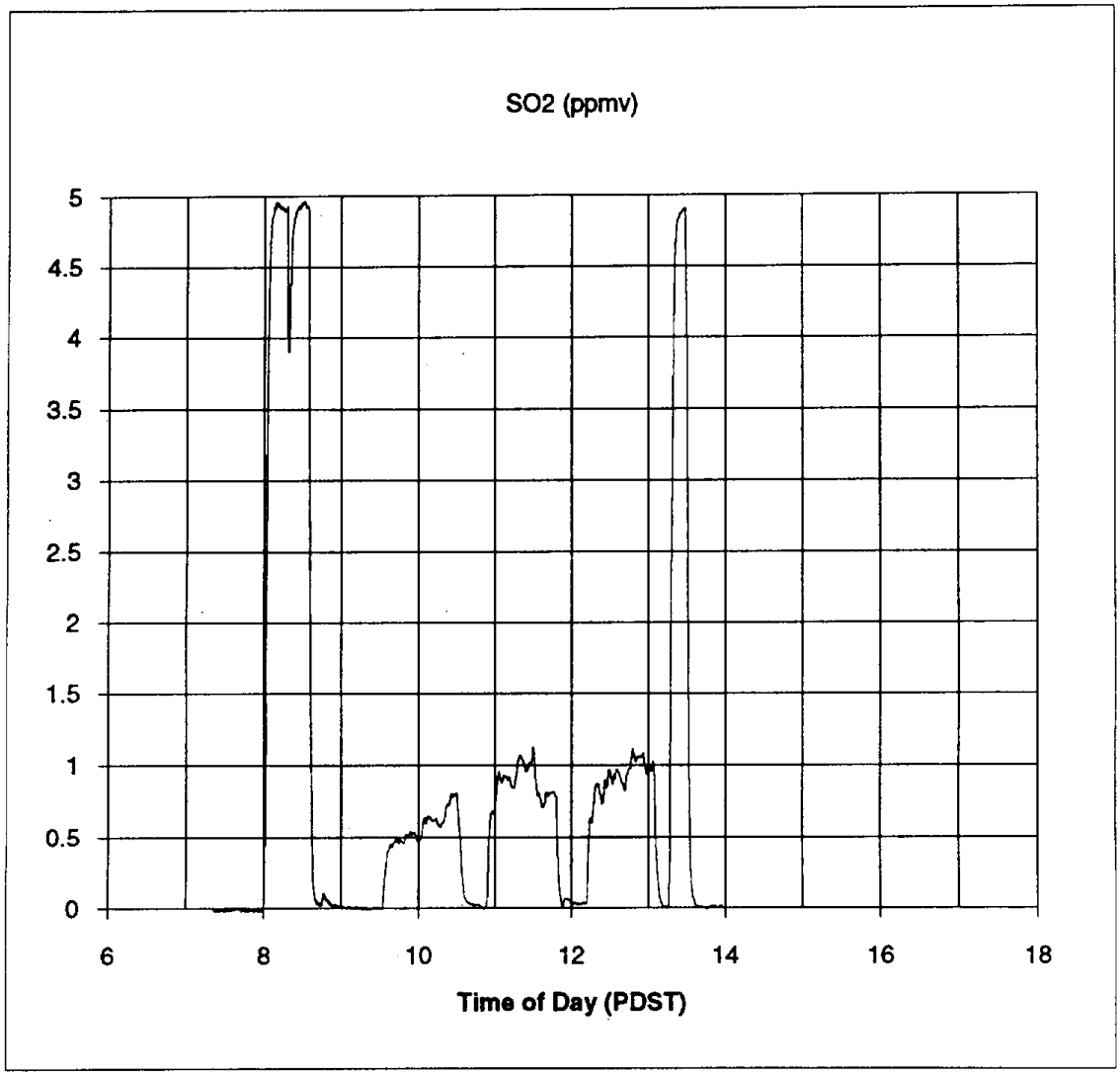


Figure 3.1.4.12. Total sulfur concentration in stack gas, 14 July 92.

Fuel Type:	Rice Straw	Test Date	14-Jul-92
Configuration:	CRNF		

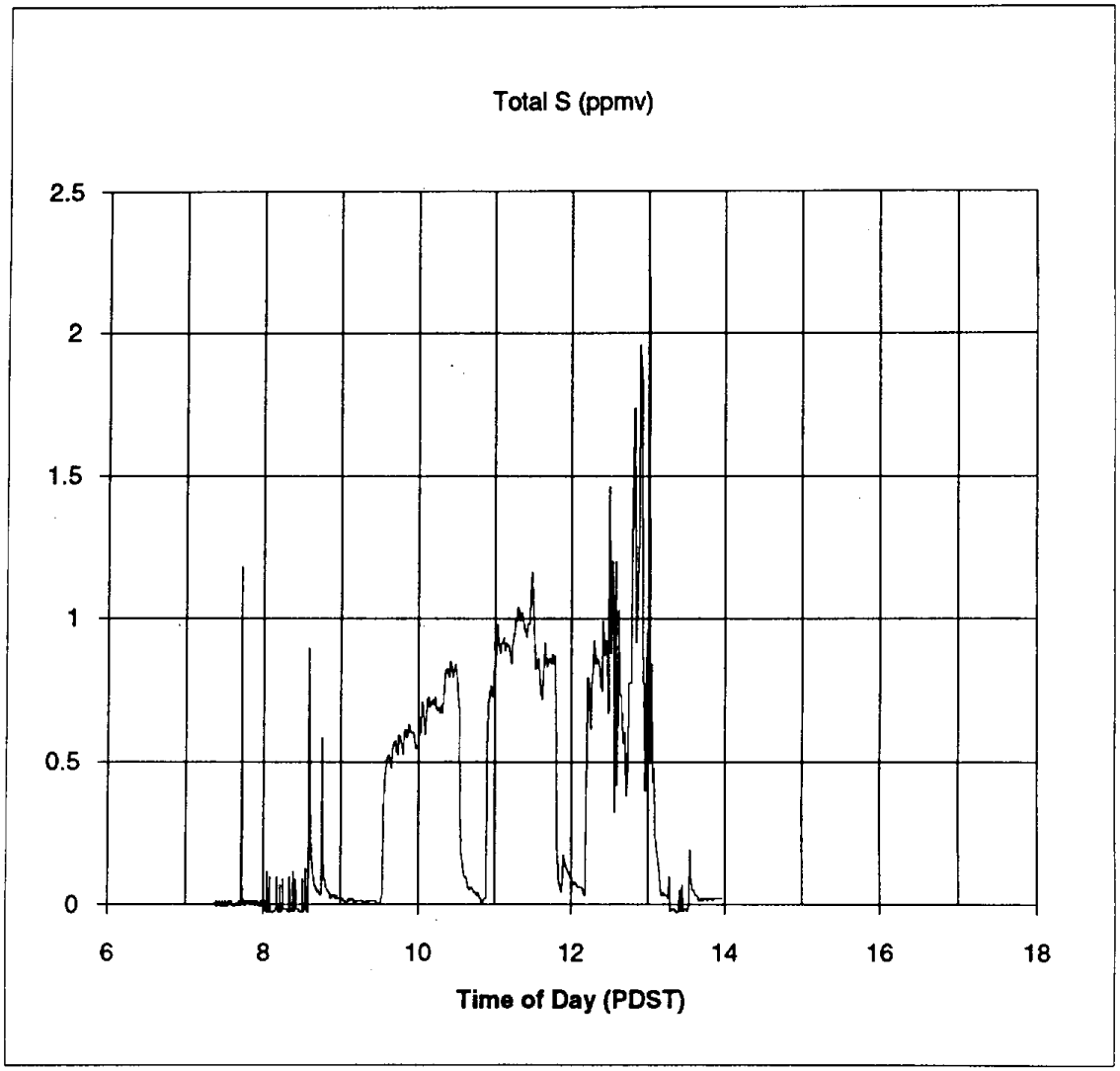


Figure 3.1.4.13. Particle size distribution, traverse 1, 14 July 92

Fuel: Rice Straw

Date of Test: 14-Jul-92

Configuration: CRNF

Particle Size Distribution
Traverse 1:

Stage	ECD (μm)	Weight (mg)	Cum. Wt (mg)	Cum. Fraction
1	13.70	0.1	3.8	1.000
2	7.67	0.2	3.7	0.974
3	4.09	0.1	3.5	0.921
4	2.16	0.2	3.4	0.895
5	1.25	0.1	3.2	0.842
6	0.73	0.2	3.1	0.816
7	0.38	0.2	2.9	0.763
filter	0.00	2.7	2.7	0.711

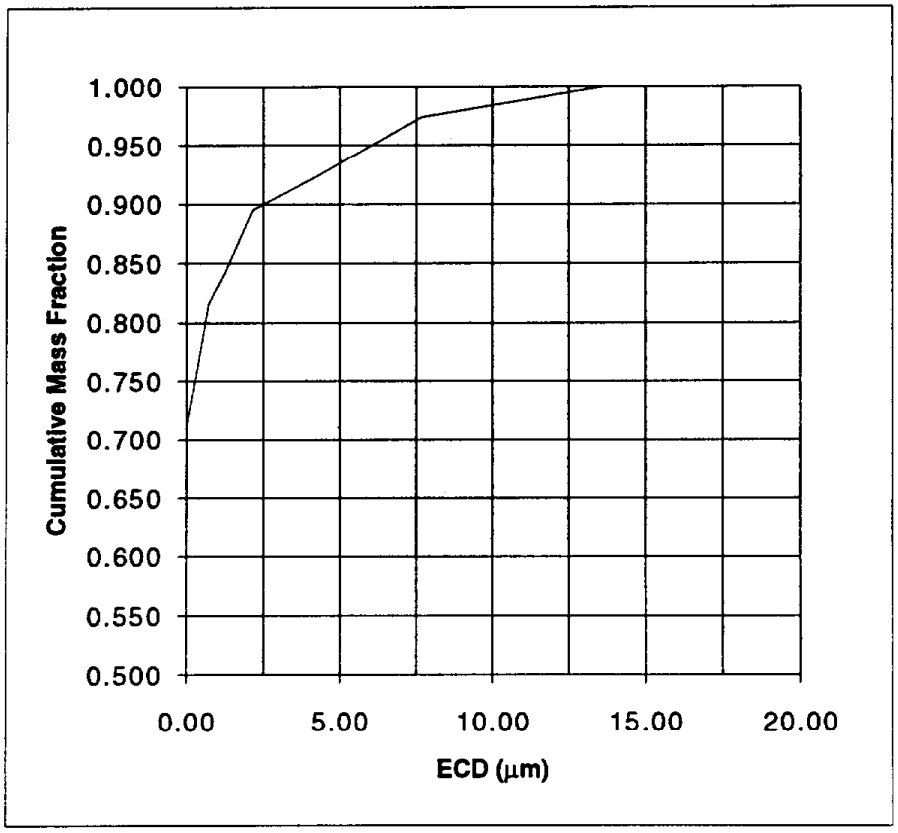


Figure 3.1.4.14. Particle size distribution, traverse 2, 14 July 92

Fuel: Rice Straw

Date of Test: 14-Jul-92

Configuration: CRNF

Particle Size Distribution
Traverse 2:

Stage	ECD (μm)	Weight (mg)	Cum. Wt (mg)	Cum. Fraction
1	13.85	0.3	6.2	1.000
2	7.76	0.3	5.9	0.952
3	4.14	0.2	5.6	0.903
4	2.19	0.3	5.4	0.871
5	1.26	0.3	5.1	0.823
6	0.74	0.3	4.8	0.774
7	0.39	0.4	4.5	0.726
filter	0.00	4.1	4.1	0.661

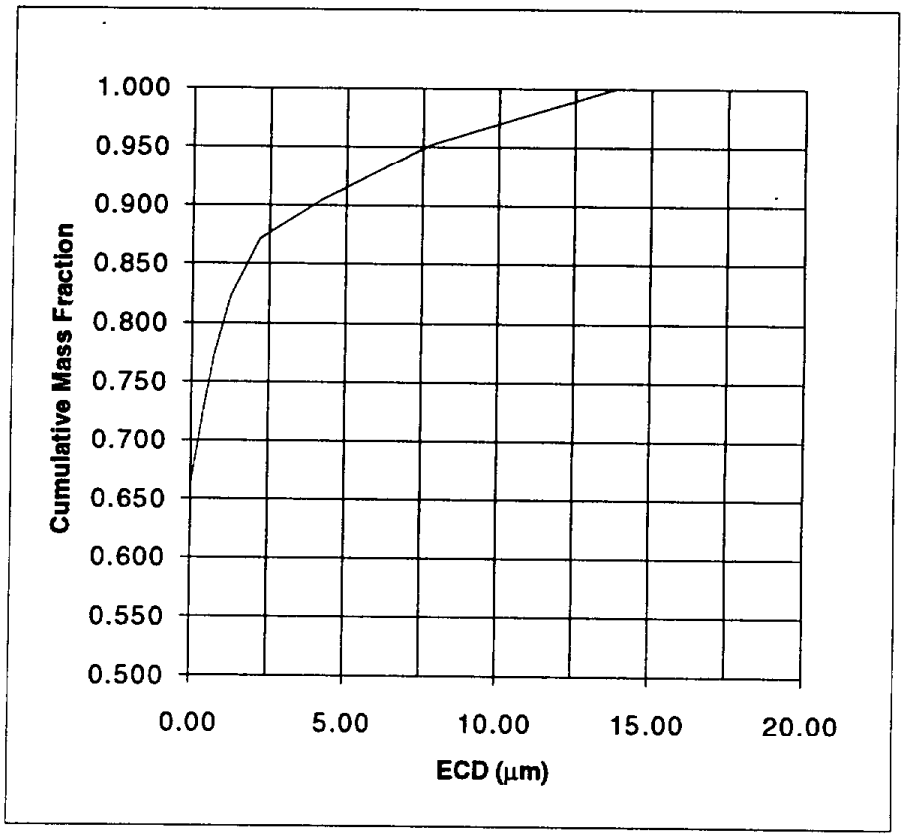


Figure 3.1.4.15. Nitrogen balance.
Date of Test: 14-Jul-92
Fuel Rice Straw

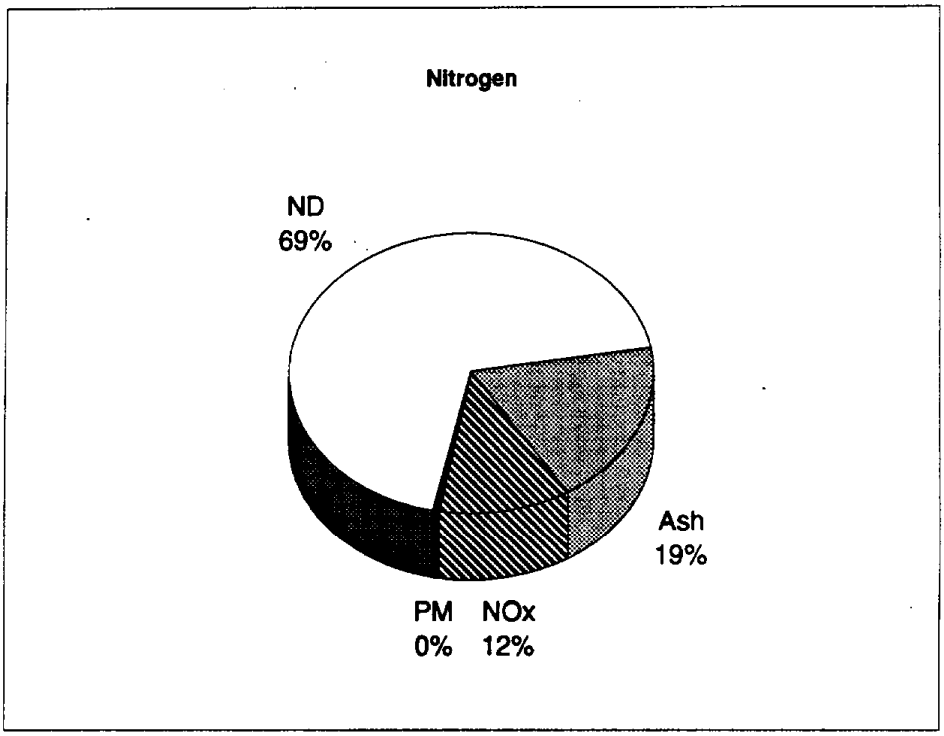


Figure 3.1.4.16. Sulfur balance.
Date of Test: 14-Jul-92
Fuel Rice Straw

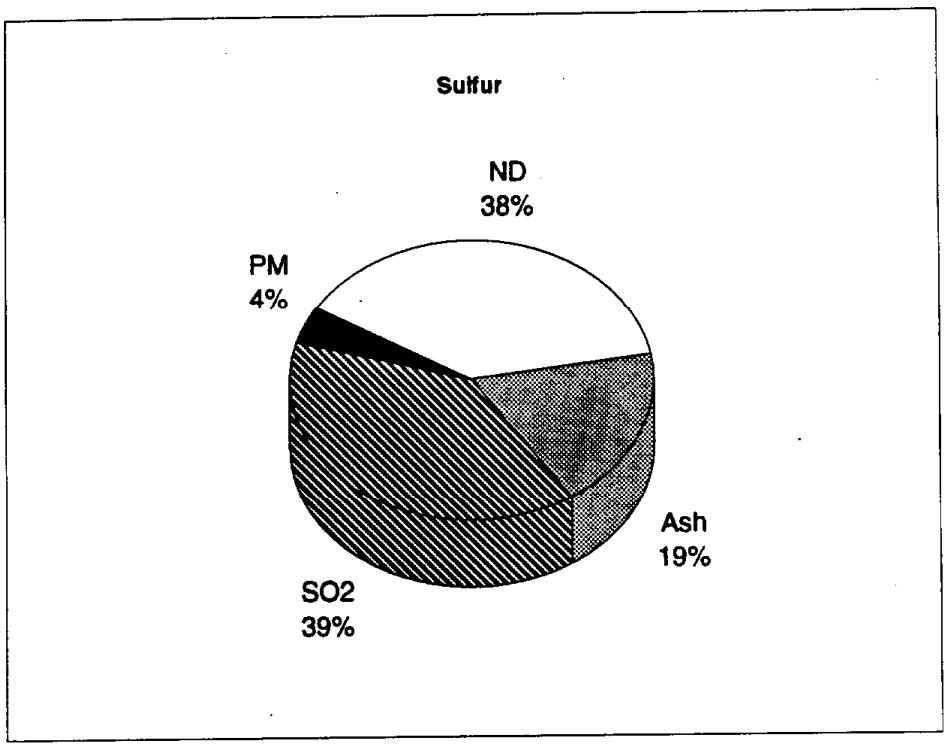


Figure 3.1.4.17. Relative abundance of major elements from DRUM impactor, Rice Straw, 14 July 92, (CRNF).

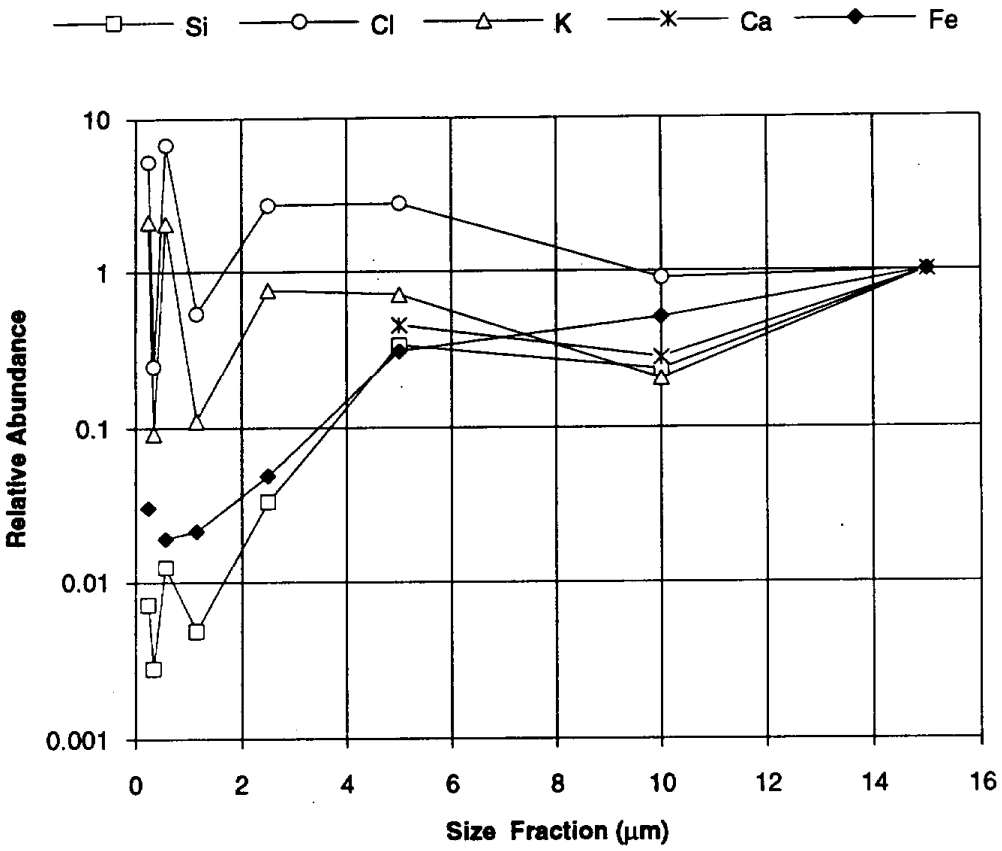


Figure 3.1.4.18. Mass fraction of PAH on primary filter samples, 14 July 1992, rice straw.

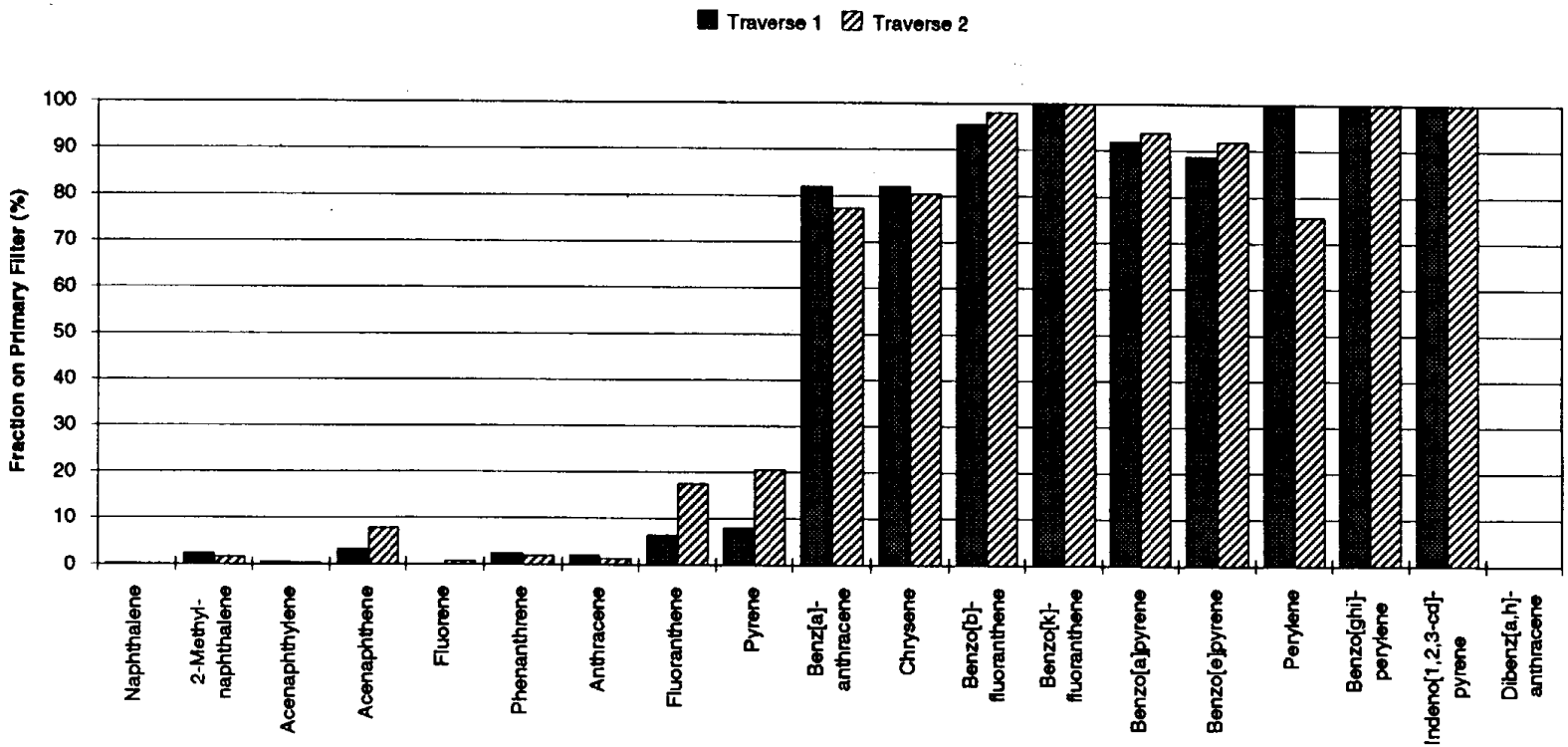


Table 3.1.5.1. Operating conditions and fire spreading rate, 25 August 92.

Fuel: Rice Straw Date of Test: 25-Aug-92

Configuration: CEWF

	Type 1	Type 2	Type 1
Fuel Loading Rate (g/sq.m w.b.):	680	680	680
Total Fuel Consumption (kg w.b.)	38.1	36.7	39.5
Fuel Moisture (% w.b.)	8.0	8.4	7.3
Mean Values			
Air Temperature (°C)	21.60	25.03	28.50
Air Relative Humidity (%)	53.69	43.07	31.55
Inlet Air Temperature (°C)	24.78	28.33	31.96
Stack Temperature (°C)	32.12	40.72	43.24
Fire Spreading Rate (m/min)	0.46	0.63	0.59
Stack Gas Velocity (m/s)	2.93	3.07	3.09

Figure 3.1.5.1. Ambient air conditions, 25 August 92.

Fuel Type:	Rice Straw	Test Date	25-Aug-92
Configuration:	CEWF		

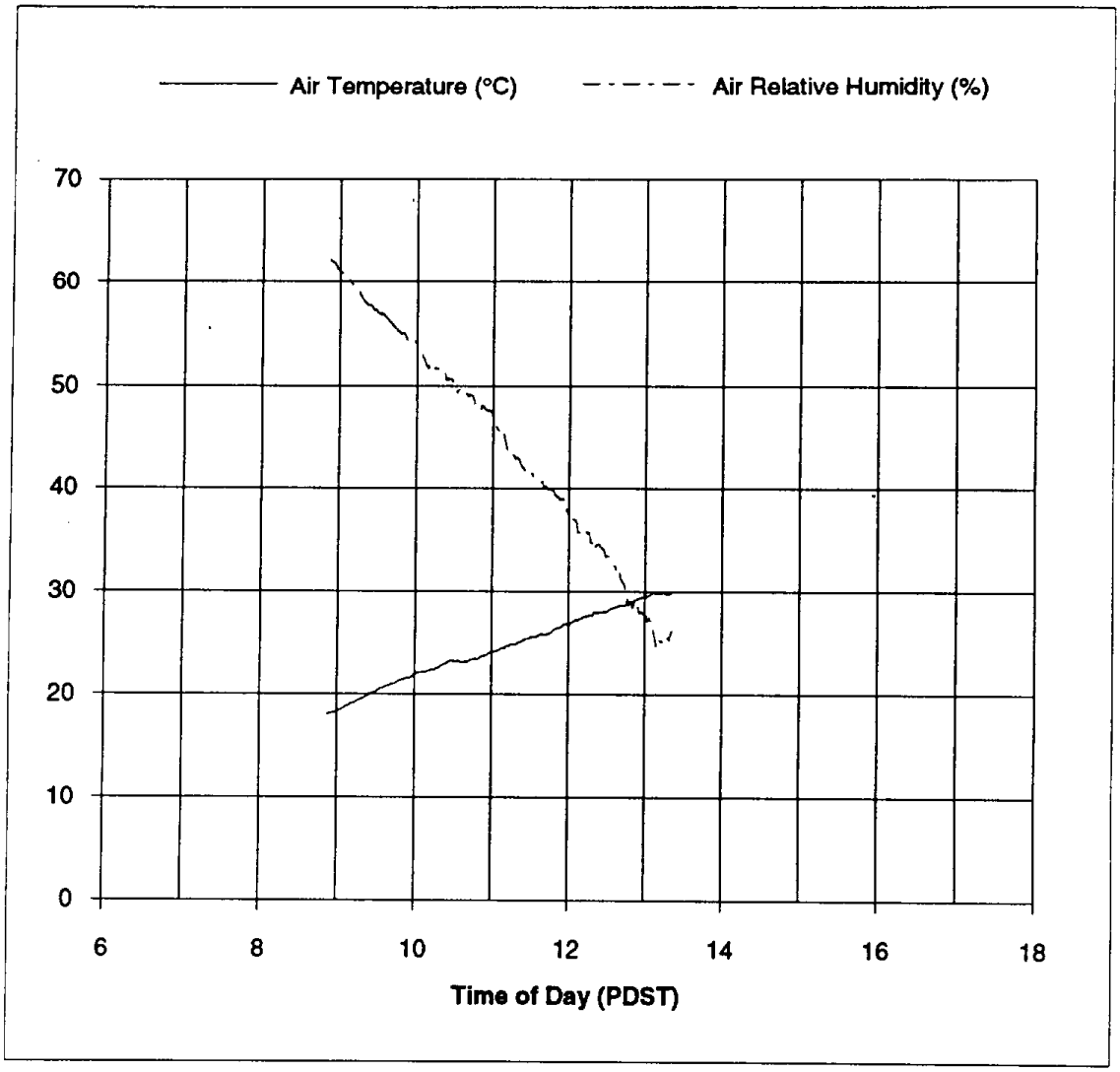


Figure 3.1.5.2. Air temperature and relative humidity from CIMIS station.

Fuel: Rice Straw Date of Test: 25-Aug-92

Configuration: CEWF

Hourly Average CIMIS Data for Davis, California

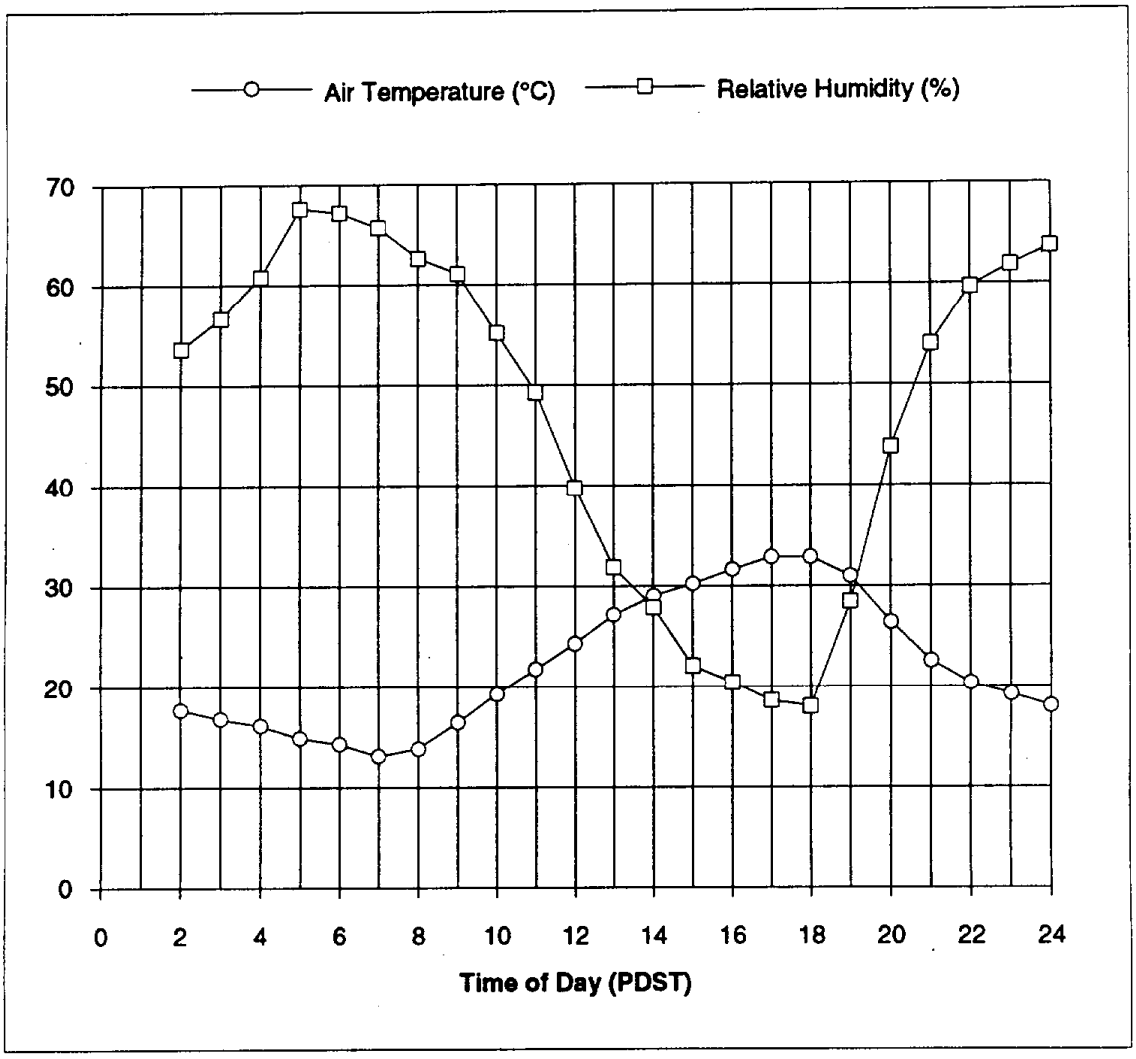
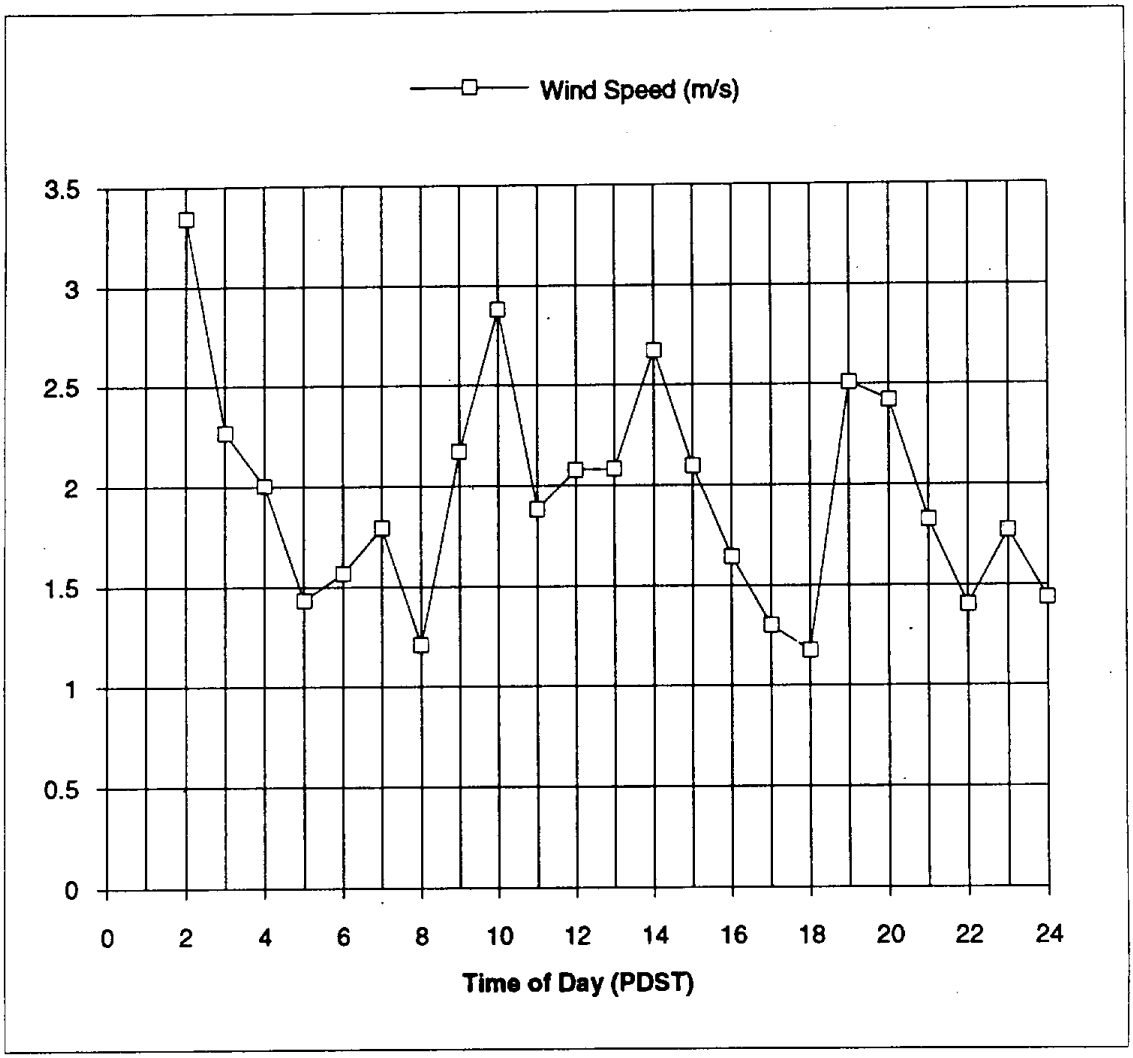


Figure 3.1.5.3. Wind speed from CIMIS station.

Fuel: Rice Straw Date of Test: 25-Aug-92

Configuration: CEWF

Hourly Average CIMIS Data for Davis, California