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KA 307-90-01

November 16, 1992

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Division of Air
Resources Management

Mr. C. H. Fancy
Bureau of Air Regulation
Florida Department of
Environmental Regulation
Twin Towers Office Building
2600 Blair Stone Road
Tallahassee, FL 32399-2400

Subject: Florida Crushed Stone Company
Minor Modification to Permits AC27-118674
(PSD-FL-091A) and A027-183509

Dear Mr. Fancy:

The purpose of this letter is to request a minor modification to the referenced air construction and air operating permits issued to the Florida Crushed Stone Company for the operation of a dry process Portland cement plant and related equipment. The minor modification will allow Florida Crushed Stone to use whole tire derived fuel (WTDF) to provide up to 15 percent of the heat input to the cement plant and will account for possible increases in total hydrocarbon emissions associated with the utilization of WTDF.

The referenced air permits limit the heat input to the cement kiln to 248.0 MMBTU per hour through the firing of coal with a maximum sulfur content of 0.75 percent. Florida Crushed Stone requests authorization to supplement 15 percent of this heat input, or up to 37.2 MMBTU per hour, with WTDF. This will be equivalent to feeding up to 1.33 tons per hour of WTDF to the cement kiln. The conditions associated with the use of the WTDF that were proposed by Hernando County on November 10, 1992, are acceptable to Florida Crushed Stone.

The other matter that must be addressed by the minor modification is the possible increase in total hydrocarbon emissions as a result of using WTDF. Measurements made at Florida Crushed Stone in November 1991 with only the cement plant operating and with coal being used to provide 100 percent of the heat input to the cement plant, indicated that total hydrocarbon emissions from the plant, as measured by EPA Method 25A, averaged 3.6 pounds per hour with a standard deviation of 0.26 pounds per hour. The 95th percentile total hydrocarbon emissions rate during this period of time would have been 4.1 pounds per hour. During the same period of time (November 1991), total hydrocarbon emissions were measured using EPA Method 25A while the cement plant only was operating and with WTDF providing 15 percent of the heat input to the kiln. The results of these measurements indicated total hydrocarbon emissions in the range of 1.2 pounds per hour.

In July 1992, total hydrocarbon emissions were measured at the CPL plant using Method 25A with the cement plant, power plant and lime plant operating. When coal was used to provide 100 percent of the heat input to the cement plant, the total hydrocarbon emissions averaged 2.5 pounds per hour. When WTDF was used to provide approximately 15 percent of the heat input to the cement plant, total hydrocarbon emissions averaged 3.7 pounds per hour. The July 1992 tests indicated there could be a 1.2 pound per hour increase in total hydrocarbon emissions as a result of using WTDF in the cement plant.

For purposes of this minor modification, Florida Crushed Stone proposes to establish baseline total hydrocarbon emissions from the cement plant only at 4.1 pounds per hour (the 95th percentile emission rate based on measurements made in November 1991) and 18.0 tons per year (based on 8,760 hours per year of operation as presently permitted). When WTDF is used to provide up to 15 percent of the heat input to the cement plant, the total hydrocarbon emissions from the cement plant only are proposed at 5.3 pounds per hour (baseline plus the possible 1.2 pound per hour increase measured in July 1992) and 22.9 tons per year (based on the cement plant operating 8,760 hours per year but only 8,300 hours per year with WTDF).

There are no other modifications or changes requested to the referenced air permits. Enclosed is a check in the amount of $250.00 payable to the Florida Department of Environmental Regulation for processing the requested minor modification.

We appreciate your consideration of this matter. If there are further questions regarding this matter, please do not hesitate to contact me.

Very truly yours,

KOOGLER & ASSOCIATES

John B. Koogler, Ph.D., P.E.

JBK:wa
Enc.

c: Mr. Bruce Mitchell, FDER
Mr. Tom Mountain, FCS
Mr. Randy Thompson, FCS
Mr. Larry Sellers

KOOGLER & ASSOCIATES

Department of Environmental Regulation

Routing and Transmittal Slip

To: (Name, Office, Location)

1. Bruce

2.

3.

4.

Remarks:

This has been logged in but file hasn't been set up or copies distributed. File # is AC27-222095

The attached is all I have received. If you should get another cash listing from F&A - with the original letter attached - just ignore it - I've already completed one

From: Patty

Date

Phone

Per your request, attached is a sealed copy of the letter to Mr. Fancy 11/19

due 11-24-92

Lets try to process quickly

PRELIMINARY REPORT

TIRE-DERIVED FUEL
TEST BURN
FLORIDA CRUSHED STONE
BROOKSVILLE, FLORIDA

Prepared For:

Hernando County Board of County Commissioners
20 North Main Street
Brooksville, Florida 34601

Prepared By:

KBN Engineering and Applied Sciences, Inc.
1034 NW 57th Street
Gainesville, Florida 32605

November 1992
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1.0 INTRODUCTION

The Florida Crushed Stone Company (FCS) has recently undergone a tire-derived fuel (TDF) test burn program at its Brooksville cement, power, and lime (CPL) plant. The purpose of the test burn was to determine conclusively if the firing of up to 15 percent TDF in the cement plant causes an increase in the emissions of any regulated air pollutant from the CPL plant. The test burn was conducted during July and August 1992.

The Hernando County Board of County Commissioners (HCBCC) has maintained a continuing interest in FCS's proposals to utilize waste tires as a supplemental fuel in the cement plant. In May 1992, HCBCC contracted with KBN Engineering and Applied Sciences, Inc. (KBN) to serve as a consultant to the county to evaluate the TDF test burn. The scope of services to be provided included: 1) review and approval of a test protocol for the test burn, which was to be developed by consultants to FCS, 2) witness all activities during the test burn period to determine if proper and adequate data are collected, 3) review of the data and results of the test burn to ascertain beyond a reasonable doubt that burning TDF can occur without an increase in allowable emissions, and 4) provide a final report to HCBCC concerning the adequacy of the test burn.

The report contained herein satisfies the last requirement of the contract, i.e., a final report which addresses the adequacy of the test burn to demonstrate if an increase in emissions of any regulated pollutant will occur under TDF firing conditions. An overview of the test program is presented in Section 2.0. Baseline testing is summarized in Section 3.0, and TDF firing results are presented in Section 4.0. A comparison of the baseline and TDF firing results is presented in Section 5.0. Results of an air quality impact analysis conducted for emissions from the CPL plant are discussed in Section 6.0. A summary and conclusions of the TDF test program are presented in Section 7.0.

2.0 OVERVIEW OF TEST PROGRAM

The overall test program to demonstrate the feasibility and acceptability of TDF firing in the cement kiln at FCS was conducted over an approximate 40-day period. The testing period is summarized in Table 2-1. Baseline testing, with no TDF being fired in the kiln, was conducted during the first 2 days of the test period, on July 21 and 22, 1992. TDF/coal firing in the cement kiln was initiated on July 23 and continued through July 30, at which time the cement kiln was shutdown due to full cement silos. Emission testing for TDF firing was conducted during this period, on July 28 and July 29.

The cement kiln was re-started on August 8, 1992, using 100 percent coal as fuel. TDF/coal firing in the kiln was begun on August 10 and continued through August 31, 1992. The kiln was shut down at this time due to high inventory levels.

The test period includes approximately 30 days of TDF/coal firing in the kiln, and 4 days of 100 percent coal firing in the kiln.

During the baseline and TDF/coal firing emission testing, the test methods set forth in the approved test protocol were utilized. All methods used were the U.S. Environmental Protection Agency (EPA) reference methods as specified in the Code of Federal Regulations (CFR), Title 40, Part 60. Manual stack testing was performed for the following during each test:

- Particulate matter (PM)
- Nitrogen oxides (NO_x)
- Carbon monoxide (CO)
- Total hydrocarbons (THC)
- Hydrogen chloride (HCl)
- Lead (Pb)
- Mercury (Hg)
- Arsenic (As)
- Chromium (Cr)
- Zinc (Zn)
- Volatile organic compounds:
  - Bromomethane
  - Acetone

Table 2-1. Summary of TDF Test Burn Operation

Period	Conditions
Prior to 07/21/92	100% coal firing in kiln
07/21/92 to 07/22/92	Baseline stack testing; 100% coal firing in kiln
07/23/92 to 07/27/92	TDF/coal firing in kiln
07/28/92 to 07/29/92	TDF/coal firing stack testing
07/30/92	TDF/coal firing in kiln; kiln shut down due to full silos
08/08/92 to 08/09/92	Kiln restarted; 100% coal firing in kiln
08/10/92 to 08/31/92	TDF/coal firing in kiln
08/31/92	Kiln shut down due to high inventory

Carbon disulfide

1,1,1-trichloroethane

Benzene

Toluene

Chlorobenzene

Ethylbenzene

Xylene

Styrene

Hexane

Pollutant measurements for NO_x, CO, and THC were performed continuously for two 12-hour periods (a total of approximately 24 hours) in each the baseline and TDF/coal firing emission test periods. All other pollutant measurements were obtained during a total of three runs in each the baseline and TDF/coal firing emission test periods. The duration of each run was approximately 2 hours.

All emission measurements were made at the main stack exhaust for the CPL plant. The cement, power and lime plants all exhaust through the main stack at FCS.

Several plant operating parameters were measured continuously throughout the entire 30-day test period. These included power plant, cement plant, and lime plant operating parameters. In addition, continuous stack measurements of NO_x, sulfur dioxide (SO_2), CO, and opacity are obtained by the plant using in-stack monitors.

Based upon the 30-day test period, Koogler & Associates (K&A) prepared emission test reports as well as a summary report comparing the baseline and TDF/coal firing results. The summary report concluded that the test data demonstrated that the use of up to 15 percent TDF in the cement kiln has no effect upon emissions from the CPL plant. An air quality screening analysis was also performed separately by K&A, which addressed the predicted ambient impacts of toxic pollutants from the CPL plant. This analysis concluded that impacts of all air toxics will be well below the Florida Department of Environmental Regulation's (FDER) established no-threat levels (NTLs).

3.0 BASELINE TESTING

3.1 PLANT OPERATING CONDITIONS

The baseline testing, utilizing 100 percent coal to fire the CPL plants, was conducted during the period 0810-1914 on July 21, 1992, and 0800-1900 on July 22, 1992. The CPL plants were all operating during the baseline testing. Prior to the baseline testing, the CPL plant had been operating with coal providing 100 percent of the heat input to the cement plant. This assured that all plant operating parameters and emission test results would be representative of 100 percent coal firing. Following the conclusion of baseline testing on July 22, 1992, firing of up to 15 percent TDF in the cement plant was begun, ending the baseline test period.

Based on review of the plant operating data, baseline testing was conducted with the CPL plants operating at or near their maximum operating rates. Plant operating data during the baseline testing are summarized in Table 3-1. The cement plant averaged 78.6 tons per hour (TPH) clinker production, which represents 105 percent of the maximum permitted production rate of 75 TPH. Kiln feed averaged 120.9 TPH, which is 109 percent of the maximum permitted feed rate of 110.6 TPH. Heat input to the kiln averaged 214 million British thermal units per hour (MMBtu/hr), which is 86 percent of the maximum heat input of 248 MMBtu/hr. Coal feed rate to the kiln averaged 8.5 TPH, compared to a maximum firing rate of 10.3 TPH.

The power plant electrical generating rate during the baseline test period averaged 114.0 megawatts (MW), and coal feed rate averaged 47.2 TPH. The maximum electric generating rate for the power plant is 125 MW.

The lime plant lime feed rate during the baseline test period averaged 16.4 TPH compared to a maximum permitted lime feed rate of 22 TPH. The coal feed rate to the lime plant averaged 8.8 TPH.

It is noted that FCS plant personnel were very cooperative in answering questions raised by KBN staff, in providing explanations to plant operations, conducting equipment inspections, and providing any other information requested by KBN staff during the baseline test period. Complete access to the plant control room was provided at all times, so that plant operations could be monitored. Hourly computer printouts of plant operating data were witnessed being generated in the control room, and later provided to KBN for inspection. The TDF feed system

Table 3-1. Summary of CPL Plant Operating Data During Emission Testing

Parameter	Permitted or Maximum Rate	Baseline Conditions (07/21/92 to 07/22/92) Test Average	Baseline Conditions (07/21/92 to 07/22/92) Percent of Maximum	TDF/Coal Firing (07/28/92 to 07/29/92) Test Average	TDF/Coal Firing (07/28/92 to 07/29/92) Percent of Maximum
Lime Plant					
Coal Feed (TPH)	—	8.8	—	12.9	—
Lime Feed (TPH)	22	16.4	75	20.8	95
Power Plant					
Coal Feed (TPH)	—	47.2	—	48.3	—
Gen. Rate (MW)	125	114.0	91	110.6	88
Cement Plant					
Coal Feed (TPH)	10.3/8.76 [a]	8.5	83	7.3	83
TDF Feed (TPH)	0/1.33 [a]	0	0	1.33	100
Heat Input (MMBtu/hr)	248	214	86	228	92
Kiln Feed (TPH)	110.6	120.9	109	117.6	106
Clinker Prod. (TPH)	75	78.6	105	76.4	102
Cement Plant Fan					
Temperature (°F)	—	754	—	762	—
Current (amp)	—	121	—	117	—
Damper (%)	—	53.1	—	54.8	—
Oxygen (%)	—	5.21	—	4.16	—
CO (ppm)	—	353	—	244	—
Preheater					
Exit Temperature (°F)	—	789	—	790	—
Internal Temperature (°F)	—	1,264	—	1,518	—
Meal Temperature (°F)	—	1,339	—	1,337	—
Kiln Inlet					
Temperature (°F)	—	1,601	—	1,616	—
Draft (inches H_2O)	—	0.78	—	0.72	—
Oxygen (%)	—	7.92	—	1.25	—
Combustibles (%)	—	-0.09	—	0.20	—
Bag House					
Inlet Temperature (°F)	—	403	—	400	—
Fan Speed (%)	—	74	—	71	—
Current (amp)	—	3,216	—	3,129	—
Pressure Drop (inches H_2O)	—	7.8	—	7.6	
Stack					
Oxygen (%)	—	6.6	—	6.3	—
NO_x (ppm)	—	150	—	165	—
Opacity (%)	—	4.0	—	3.6	—
Gas Flow (dscfm)	—	600,293	—	587,135	—

Note: NR = not reported on hourly basis.

[a] For 100 percent coal and 15 percent TDF/coal firing, respectively.

and monitoring equipment, lime feed and lime product systems, and coal feed systems were all inspected during the baseline testing.

Based on discussions with plant operating personnel, and a review of the plant operating data, the CPL plant was operating normally during the baseline test period.

3.2 STACK TEST PROCEDURES

Review of the stack test procedures employed by K&A indicate in general that proper procedures were followed during the stack testing. In a few instances, deviations from proper procedures were evidenced. These are discussed below:

1. The VOST sampling train used for stack sampling employed a digital flow meter to provide a constant sample flow rate. This rate was apparently multiplied by the sample duration to arrive at total sample volumes. However, the test method requires that a gas meter be used to record total sample volumes. Use of the flow meter as a sample volume totalizing device instead of a gas meter could introduce a test inaccuracy of up to 10 percent. Based on the VOC stack test results, as described below, this potential error is not considered to be significant (i.e., the conclusions of the testing would not change).
2. Review of the continuous monitoring strip chart data revealed several practices that are not in strict conformance with EPA Reference Methods 7E, 10, and 25A. The primary concern is with the frequent changing of analyzer ranges. A test range for each analyzer should be selected and the required linearity demonstrations made for that range. Other concerns are related to infrequent drift checks and in the failure to demonstrate NO_x bias checks.

While these inconsistencies might not be acceptable for compliance testing, the data is considered adequate for the purposes of demonstrating potential emission changes. There is adequate quality assurance demonstrated to ensure basic test accuracy.

3.3 BASELINE EMISSION TEST RESULTS

Baseline emission test results are summarized in Table 3-2. PM emissions averaged 47.7 lb/hr and were well below the allowable PM emission rate 86.5 lb/hr for the cement, power and lime plants all operating. NO_x emissions averaged 762 lb/hr, which is well below the allowable emission rate of 1,205 lb/hr when all three plants are operating.

Table 3-2. Summary of Emission Test Results for Baseline and TDF/Coal Firing Conditions, CPL Plant

	Baseline Conditions (100% Coal)		TDF/Coal Firing		
Pollutant Name	Number of Obs.	Average (lb/hr)	Number of Obs.	Average (lb/hr)	Test For Significant Change
Criteria Pollutants					
Particulate	3	47.7	3	62.7	Significant Change
Nitrogen Oxides	23	762.2	22	692.9	OK
Lead	3	0.0118	3	0.0146	OK
Mercury	3	0.0153	3	0.0099	OK
Carbon Monoxide	23	421.5	22	671.2	Significant Change
Total Hydrocarbons	23	2.5	22	3.7	a
Non-Criteria Pollutants					
Arsenic	3	0.0021	3	0.0018	OK
Chromium	3	0.0106	3	0.0096	OK
Zinc	3	8.92	3	6.20	OK
Hydrogen Chloride	3	71.62	3	65.93	OK
Volatile Organic Compounds:					
Bromomethane	3	b	3	0.001	OK
Acetone	3	0.141	3	0.137	OK
Carbon disulfide	3	0.068	3	0.101	OK
Benzene	3	0.417	3	0.200	OK
Trichloroethane	3	b	3	b	OK
Toluene	3	0.086	3	0.031	OK
1,1,1-Trichloroethane	3	b	3	b	OK
Chlorobenzene	3	0.024	3	0.023	OK
Ethylbenzene	3	0.011	3	0.007	OK
Xylene	3	0.043	3	0.023	OK
Styrene	3	0.032	3	0.021	OK
Hexane	3	b	3	b	OK

[a] Many observations below the detection limit; no calculation possible.
[b] Observations were all below the detection limit; no calculation possible.

There is no allowable emission rate for other pollutants from the CPL plant (except for sulfur dioxide, which was not measured during the emission testing). CO emissions averaged 421 lb/hr. In the case of THC emissions, nearly all of the measurements were below the minimum detectable limit (MDL) of the measurement method. Assuming a value of one-half the MDL for such measurements yields an average THC emission rate of 2.5 lb/hr for the baseline conditions.

Emissions of the other criteria pollutants, i.e., lead and mercury, were well below 0.1 lb/hr. Emissions of all non-criteria pollutants were also well below 0.5 lb/hr, except for HCl and zinc. HCl emissions averaged 71.6 lb/hr, while zinc emissions averaged 8.9 lb/hr.

Individual measurements for the baseline test runs can be found in the Appendix, Tables A-1 and A-2, or in the K&A test reports.

4.0 TIRE-DERIVED FUEL (TDF) TESTING

4.1 PLANT OPERATING CONDITIONS

The TDF/coal testing, utilizing up to 1.33 TPH TDF and 19 percent TDF on a heat input basis to fire the cement kiln, with remaining heat input supplied from coal, was conducted during the period 0715-1900 on July 28, 1992, and 0655-1817 on July 29, 1992. The power, cement and lime plants were all operating during the baseline testing. The power and lime plants were both operating utilizing 100 percent coal. Prior to the TDF testing, the cement kiln had been operating for approximately 5 days on TDF/coal, with TDF supplying approximately 15 percent of the heat input to the cement plant. This assured that all plant operating parameters and emission test results would be representative of TDF/coal firing.

Based on review of the plant operating data, TDF/coal firing testing was conducted with the CPL plants operating at or near their maximum operating rates. The cement plant averaged 76.4 TPH clinker production, which represents 102 percent of the maximum permitted production rate of 75 TPH. Kiln feed averaged 117.6 TPH, which is 106 percent of the maximum permitted feed rate of 110.6 TPH. Heat input to the kiln averaged 228 MMBtu/hr, which is 92 percent of the maximum heat input of 248 MMBtu/hr. Coal feed rate to the kiln averaged 7.3 TPH, compared to a maximum firing rate of 8.76 TPH when firing TDF/coal.

The TDF feed rate to the kiln averaged 1.33 TPH, which is the maximum permitted rate for TDF firing. It is noted that TDF firing is computer controlled, and by means of an automated weigh scale/feeder, the weight of TDF introduced to the kiln can be strictly controlled and monitored.

The power plant electrical generating rate during the baseline test period averaged 110.6 MW, and coal feed rate averaged 48.3 TPH. The maximum electric generating rate for the power plant is 125 MW.

The lime plant lime feed rate during the baseline test period averaged 20.8 TPH, and the coal feed rate averaged 12.9 TPH. The maximum permitted lime feed rate to the lime plant is 22 TPH.

As in the baseline testing, FCS plant personnel were very cooperative in answering questions raised by KBN staff and providing other information during the TDF/coal stack testing.

Plant operations were explained and demonstrated, operations were witnessed, and other information requested by KBN staff were provided. Complete access to the plant control room was provided at all times, so that plant operations could be monitored. Hourly computer printouts of plant operating data were witnessed being generated in the control room. These were later provided to KBN for review. The TDF feed system and monitoring equipment, lime feed and lime product systems, and coal feed systems were all inspected during the TDF/coal firing testing.

Based on discussions with plant operating personnel, and a review of the plant operating data, the CPL plant was operating normally during the TDF/coal test period.

4.2 STACK TEST PROCEDURES

The comments regarding the baseline stack test procedures, described above, also apply to the TDF/coal testing. The potential errors introduced from not strictly following all required test procedures are not considered to be significant (i.e., the conclusions of the testing would not change). While some procedures may not be acceptable for compliance testing purposes, the data is considered adequate for the purposes of demonstrating potential emission changes. There is adequate quality assurance demonstrated to ensure basic test accuracy.

4.3 TDF/COAL EMISSION TEST RESULTS

TDF/coal firing emission test results are summarized in Table 3-2. PM emissions averaged 62.7 lb/hr and were well below the allowable PM emission rate 86.5 lb/hr for the cement, power and lime plants all operating. NO_x emissions averaged 693 lb/hr, which is well below the allowable emission rate of 1,205 lb/hr when all three plants are operating.

There is no allowable emission rate for other pollutants from the CPL plant (except for sulfur dioxide, which was not measured during the emission testing). CO emissions averaged 671 lb/hr. In the case of THC emissions, about one-half of the measurements were below the minimum detectable limit (MDL) of the measurement method. Assuming a value of one-half the MDL for such measurements yields an average THC emission rate of 3.7 lb/hr for the TDF/coal firing conditions.

Emissions of the other criteria pollutants, i.e., lead and mercury, were well below 0.1 lb/hr. Emissions of all non-criteria pollutants were also well below 0.5 lb/hr, except for HCl and zinc. HCl emissions averaged 65.9 lb/hr, while zinc emissions averaged 6.2 lb/hr.

Individual measurements for the TDF/coal test runs can be found in the Appendix, Tables A-1 and A-2, and in the K&A test reports.

Two unannounced site visits to the FCS plant were conducted when TDF was being fired in the cement plant kiln. These visits were conducted on August 27, 1992, and September 22, 1992. In both cases, the lime plant was not operating. The power plant and cement plants were both operating normally. No operating problems with the CPL plant or TDF firing were indicated by the FCS operating personnel.

5.0 COMPARISON OF EMISSIONS DURING BASELINE AND TDF FIRING CONDITIONS

5.1 STACK TESTING

A comparison of baseline and TDF/coal firing emission test results is presented in Table 5-1. Statistical analysis were performed on the data, according to 40 CFR 60, Appendix C, Determination of Emission Rate Change. This method compares a "before" and "after" emission rate to determine if, based on a 95 percent confidence interval, an increase in emissions to the atmosphere has occurred. As indicated in Table 5-1, the average emission rate for PM, CO, and THC increased for TDF/coal firing as compared to the baseline emissions. Therefore, the Appendix C method was applied to PM and CO. The method was not applied to THC emissions due to many of the individual test values being below the MDL, therefore precluding a valid statistical analysis for this pollutant.

In the case of PM, the Appendix C method indicates that an increase in PM emissions has resulted due to TDF/coal firing. However, K&A has pointed out in the summary report that PM emissions from the CPL plant have shown variability based on historical test data. These test data are summarized in Table 5-2. PM emissions have been measured both under 100 percent coal firing and TDF/coal firing, and with and without the power plant operating. For all PM tests conducted when firing 100 percent coal in the CPL, PM emissions have averaged 52.1 lb/hr. PM emissions while firing TDF/coal in the cement plant, and coal in the power and lime plants, have averaged 57.4 lb/hr. Comparison of the 100 percent coal and the TDF/coal results show that a slight increase occurs when firing TDF in the kiln. However, analysis of the data based on the 40 CFR 60 Appendix C method shows no increase in emissions at the 95 percent confidence level. It is therefore concluded that TDF firing in the kiln has no significant effect upon PM emissions from the CPL plant.

In the case of CO, comparison of the baseline and TDF/coal firing emissions indicates a large increase in CO emissions when firing TDF. However, K&A presents arguments in their summary report that the CO emissions from the CPL plant are highly variable, and comparison of two sets of tests may not be indicative of overall emission levels. A discussion of these data is presented below:

1. During the August 1990 test burn, baseline CO emissions from the CPL plant ranged from 160 ppm to 430 ppm (test run averages) and from 444 lb/hr to 1,218 lb/hr, with the average 901 lb/hr. CO emissions from the CPL plant when firing TDF/coal

Table 5-1. Comparison of Emission Test Results for Baseline and TDF/Coal Firing Conditions, CPL Plant

Pollutant Name	Average Emission Rate (lb/hr) Baseline Conditions (100% Coal)	TDF/Coal Firing	Change (lb/hr)	Change Percent	Significant Change[c]
Criteria Pollutants					
Particulate	47.7	62.7	+15.0	+31	Yes
Nitrogen Oxides	762.2	692.9	-69.3	-9	No
Lead	0.0118	0.0146	+0.0028	+24	No
Mercury	0.0153	0.0099	-0.0054	-35	No
Carbon Monoxide	421.5	671.2	+249.7	+59	Yes
Total Hydrocarbons	2.5	3.7	+1.2	+48	a
Non-Criteria Pollutants					
Arsenic	0.0021	0.0018	-0.0003	-14	No
Chromium	0.0106	0.0096	-0.0010	-9	No
Zinc	8.92	6.20	-2.72	-30	No
Hydrogen Chloride	71.62	65.93	-5.69	-8	No
Volatile Organic Compounds:					
Bromomethane	b	0.001	+0.001	--	No
Acetone	0.141	0.137	-0.004	-3	No
Carbon disulfide	0.068	0.101	+0.033	+49	No
Benzene	0.417	0.200	-0.217	-52	No
Trichloroethane	b	b	--	--	No
Toluene	0.086	0.031	-0.055	-64	No
1,1,1-Trichloroethane	b	b	--	--	No
Chlorobenzene	0.024	0.023	-0.001	-4	No
Ethylbenzene	0.011	0.007	-0.004	-36	No
Xylene	0.043	0.023	-0.020	-47	No
Styrene	0.032	0.021	-0.011	-34	No
Hexane	b	b	--	--	No

[a] Many observations below the detection limit; no calculation possible.
[b] Observations were all below the detection limit; no calculation possible.
[c] Based on statistical analysis according to 40 CFR 60, Appendix C.

Table 5-2. PM Emission Test Results from CPL Plant

Date	Fuel	Run	Particulate Matter Emissions (lb/hr)
12/23/88	Coal	1	53.73
		2	48.89
		3	42.55
		4	55.33
09/18/90 to 09/20/90	Coal	1	62.21
		2	59.15
		3	49.05
02/28/91	Coal	1	50.12
		2	53.56
		3	59.84
07/21/92 to 07/22/92	Coal	1	54.38
		2	46.13
		3	42.64
			Average = 52.12
09/20/90 to 09/21/90	Coal/TDF	1	57.25
		2	33.55
		3	65.83
07/28/92 to 07/29/92	Coal/TDF	1	54.11
		2	60.42
		3	73.44
			Average = 57.43

Note: Cement, power, and lime plants were all operating during testing.

ranged from 60 ppm to 310 ppm (test run averages) and from 141 lb/hr to 859 lb/hr, and averaged 532 lb/hr. For these 1990 tests, baseline CO emissions were much higher than TDF/coal emissions. The 1990 baseline CO emissions are also higher than the TDF/coal firing emissions measured in the July 1992 tests.

2. CO emissions from the cement plant alone were measured during the November 1991 trial burn. CO emissions averaged 59 lb/hr under baseline conditions, and 80 lb/hr under TDF/coal firing conditions. This indicates that CO emissions from the cement plant alone are relatively small, and cannot account for the wider variation in CO emissions from the CPL plant.
3. CO concentrations at the kiln inlet were measured during the July 1992 test burn. During baseline conditions, the CO concentrations ranged from 121 ppm to 549 ppm, and averaged 280 ppm. During TDF/coal firing, the CO ranged from 139 ppm to 375 ppm, and averaged 244 ppm. This would indicate no increase in CO emissions from the cement plant due to TDF/coal firing.

An analysis of CO concentrations at the kiln inlet over the entire 30-day TDF test period is presented in Section 5.2. The CO data from this analysis also indicate that CO concentrations can normally fluctuate by a factor of two or more under either 100 percent coal firing or TDF/coal firing. It is therefore concluded that TDF firing in itself does not result in increased CO emissions from the cement plant or from the CPL plant.

The THC data do not lend itself to statistical analysis. However, analysis of the data indicate an average THC emission rate of 2.5 lb/hr for the baseline conditions, and of 3.7 lb/hr for the TDF/coal firing conditions. Since the TDF/coal firing emission rate is approximately 50 percent higher than the baseline emission rate, it is concluded that an increase in THC emissions occurs when burning TDF in the kiln.

The average emission rates for all other pollutants decreased under TDF/coal firing conditions, and therefore it is not necessary to apply the Appendix C method. These pollutants included NO_x, mercury, arsenic, chromium, zinc, and hydrogen chloride, as well as nearly all of the VOCs. For the VOCs tested, an increase in the average emission rate for only carbon disulfide occurred due to TDF firing. However, based on statistical analysis, no increase in carbon disulfide emissions is indicated at the 95 percent confidence level. It can, therefore, be concluded that emissions of these pollutants did not increase above the baseline emissions due to TDF/coal firing.

Another indication of the potential air emissions associated with TDF versus coal firing can be ascertained from fuel analysis data. Comparison of the coal and TDF fuel analysis data obtained during the baseline and TDF/coal testing shows TDF to be lower in concentrations of chloride, arsenic, mercury, lead, and chromium compared to coal (refer to Appendix A). Only zinc was higher in TDF compared to coal.

5.2 OPERATION DURING 30-DAY TEST PERIOD

Several plant operating parameters, including continuous emission monitoring data, were recorded for the CPL plant during the 30-day trail burn period. The 30-day period included approximately 4 days of baseline operating conditions, i.e., with the cement plant fired with 100 percent coal. Two of these days occurred during the baseline stack testing period (July 21-22, 1992), and the remaining two days occurred during the period August 8-9, 1992, when the cement plant was brought back on-line after approximately a week shutdown.

5.2.1 CLINKER QUALITY

A cement plant operating parameter of particular interest is that of clinker quality. The FCS cement plant tests for clinker quality as well as the finished cement quality approximately every two hours. The primary indicator of the quality of the clinker as well as the finished cement product is tricalcium silicate (C_3S). According to FCS plant personnel, a good clinker product would have a C_3S content generally between 60 and 70 percent. The finished cement product is generally maintained between 50 and 56 percent C_3S. FCS attempts to maintain clinker quality within these ranges on a daily (24-hr) average basis. Individual clinker or finished cement samples having C_3S values outside these ranges do not necessarily translate to a poor quality clinker or product. Blend silos within the finish mill allow off-specification material to be stored and blended with materials of higher or lower C_3S contents. However, a long-term trend of high or low C_3S values would indicate a potential problem.

The daily cement plant and finish mill C_3S values for the 30-day trail burn period are presented graphically in two figures (see Appendix B). These were obtained by averaging all the samples taken during each 24-hour period. The baseline and TDF/coal firing conditions are delineated by different symbols in the figures. Review of these figures indicates that clinker C_3S content was similar during both baseline conditions and TDF/coal firing conditions. The majority of values are in the 60 to 70 percent C_3S range, with only a few values lying below the target range. Values outside the acceptable range are accompanied by nearby values within the acceptable range. This indicates that acceptable clinker was being produced throughout the test period, including TDF/coal firing periods.

Finish mill cement product quality displays a similar trend in C_3S content. Finish mill values are more consistent than clinker, which is expected since blending can be used to maintain product quality. Two periods do occur when the daily average finish mill quality falls outside the acceptable range. This occurs during the TDF/coal firing period of July 25-28, and the baseline conditions of August 8-10. This latter period occurs just after cement kiln startup, and could be attributed to the startup process. However, the TDF/coal excursion period occurs during normal cement plant operations, a few days after TDF is introduced to the kiln. The cause of this excursion period is not known. This excursion period might be a cause for concern, except that the TDF/coal firing period of August 10-30 demonstrates that good quality cement can be produced on a continuing basis when TDF/coal is fired in the cement plant. During this period, all daily average C_3S values are within the acceptable range of 50 to 56 percent.

5.2.2 KILN INLET TEMPERATURE

The temperature at the cement kiln inlet is an indicator of cement kiln operation. The long-term trend of this parameter can be examined to determine if TDF/coal firing adversely affects kiln operation. The recorded values of this parameter for the 30-day test period are shown graphically in the appendix.

Kiln inlet temperature is shown to be vary between about 1,500°F and 1,800°F during the July test period. No significant difference between 100 percent coal firing and TDF/coal firing conditions are evident. During the August test period, kiln inlet temperature is more variable. Temperatures generally range between 1,500°F and 1,700°F for both 100 percent coal firing and TDF/coal firing. However, two periods exist during August when kiln inlet temperatures drop well below the normal range, and as low as 1,100°F. These all occur during TDF/coal burning. The reasons for this are not clear. This could represent normal operation. However, the baseline (100 percent coal firing) data may not reflect this due to the much shorter time period for which data is available.

5.2.3 KILN INLET CARBON MONOXIDE AND OXYGEN CONCENTRATION

The CO and O_2 concentrations at the cement kiln inlet are also indicators of cement kiln operation. The long-term trends of these parameters can be examined to ascertain if TDF/coal firing adversely affects kiln operation. The recorded values of these parameters for the 30-day test period are shown graphically in the appendix.

Kiln inlet CO concentrations are seen to be highly variable throughout the test period. During the July test period, concentrations are generally in the 0 to 700 ppm range. Some higher values, up to 1,000 ppm, occur during 100 percent coal firing conditions, and up to 2,500 ppm, occur during TDF/coal firing conditions. The highest values appear to be associated with a kiln upset condition on July 25.

During the August test period, CO concentrations generally range between 0 to 700 ppm as well. Higher values, up to 1,300 ppm, occur at the end of the August period and last for several days.

By far the highest CO values occurred during TDF/coal burning. The reasons for this are not clear; however, the variable nature of the CO levels in the kiln could represent normal operation. This theory has been espoused by FCS in the past, and there is scientific literature to support the theory.

Kiln inlet O_2 concentrations are also seen to be variable throughout the test period. During the July test period, concentrations are all in the range of approximately 3 to 7 percent. No significant differences between 100 percent coal firing and TDF/coal firing are indicated. No kiln upset conditions are evident from the O_2 data during this period, although the CO data indicated a possible upset condition on July 25.

During the August test period, O_2 concentrations also generally range between 4 and 8 percent. Concentrations are more variable than the July test period, but no upset conditions are evident. Coal firing conditions do not reflect significantly different concentrations than under TDF/coal firing conditions.

5.2.4 STACK NO_x EMISSIONS

NO_x emissions are recorded continuously from the CPL plant by means of an in-stack NO_x monitor. Hourly measurements from this monitor are available for the 30-day test period.

Emissions are reported in terms of both concentration (ppm) and lb/hr. The hourly measurements are presented graphically in the appendix.

During the July test period, NO_x stack emissions from the CPL plant averaged approximately 190 ppm and 550 lb/hr. No discernible difference is indicated between baseline and TDF/coal burning during this period.

During the August test period, after the cement plant was restarted after being shutdown, the NO_x levels are seen to increase to above the July levels. Average NO_x emissions are approximately 230 ppm and 650 lb/hr. However, the mass emissions are still well below the allowable NO_x emissions rate for the CPL plant of 1,205 lb/hr. The data further indicate that, during the August period, both baseline (100 percent coal being burned in the cement plant) and TDF/coal firing emissions are higher than during the July period. Further, the baseline emissions are in general higher than the TDF/coal burning emission levels. However, this could be a result of the kiln startup, wherein steady state levels or normal kiln operation may not have yet been reached.

6.0 AIR QUALITY MODELING ANALYSIS

K&A performed an air quality modeling analysis which evaluated the potential impacts of the CPL emissions. The emission rate for each pollutant used in the analysis was the higher of the average emission rate during baseline conditions or during TDF/coal firing emissions. Based on this analysis, it was demonstrated that the potential impacts of each pollutant were well below the respective FDER no-threat level (NTL). The maximum impacts for HCl and zinc were at least 10 times below their respective NTL. The maximum impacts for other pollutants were at least a factor of 1,000 below their respective NTL.

Emissions and potential impacts of hexavalent chromium (Cr^{+6}) were not specifically measured during the test burn and were not addressed in the K&A report. However, the potential impact of this very toxic air pollutant can be conservatively estimated by initially assuming that all the Cr emitted is of the Cr^{+6} type. Typically, the majority (i.e., 80 percent) of Cr emitted from combustion sources is of the chromium metal type, and the remainder is Cr^{+6}. Based on the Cr emissions used in the modeling analysis (0.01076 lb/hr), the maximum 1-hr impact is 0.00068 $\mu g/m^3$. Using the recommended USEPA averaging time factor of 0.1 to convert the 1-hr maximum to an annual average, the maximum annual average concentration is 6.8×10^{-5} $\mu g/m^3$. This annual impact is below the annual NTL for Cr^{+6} of 8.3×10^{-5} $\mu g/m^3$. As a result, impacts of Cr^{+6} are predicted to be below the FDER NTL and would not pose a threat to the public.

KBN has reviewed the K&A report and finds that the modeling analysis was preformed in an appropriate manner, and has verified the results of the analysis.

7.0 SUMMARY AND CONCLUSIONS

FCS has conducted a test burn program utilizing TDF to provide up to 15 percent of the heat input to the cement kiln located within the CPL plant. The program was witnessed and evaluated by KBN, acting on behalf of the HCBCC. The FDER also witnessed the testing by sending staff representatives from the Tallahassee and Tampa offices. Based on the review of all available data, the major aspects of the TDF test burn are summarized below:

1. The test protocol developed for the test burn was adequate to demonstrate whether any increases in emissions of regulated air pollutants will occur due to TDF firing in the cement kiln;
2. USEPA reference methods were used to measure stack emissions from the CPL plant. In general, proper stack test procedures were followed during the stack testing. In a few instances, deviations from proper procedures were evidenced, but these deviations are not considered significant to the conclusions reached.
3. FCS plant personnel were completely cooperative throughout the test period. No indication was received of any intent to conceal or falsify any plant operating or test data. Two unannounced visits were conducted to verify proper operation when firing TDF.
4. Both baseline and TDF/coal testing were conducted with the CPL plants operating at or near their maximum operating rates.
5. PM and NO_x emissions from the CPL plant were well below the allowable emission rate during both baseline and TDF/coal firing conditions.
6 Emissions of all pollutants, except THC, do not increase as a result of TDF firing in the cement kiln. Based on the available data, it is concluded that THC emissions increased for TDF/coal firing as compared to the baseline emissions. However, the THC emissions are low (less than 4 lb/hr average), and do not represent a concern from an emission or air quality impact standpoint.
7. The data indicate that acceptable clinker was being produced on a continuous basis throughout the test period, including TDF/coal firing periods.
8. There is no apparent difference in cement kiln inlet temperatures when firing 100 percent coal and when firing TDF/coal in the cement kiln. However, two periods exist during TDF/coal burning in August when kiln inlet temperatures drop well below the normal range. The reasons for this are not clear, but are not of major concern since clinker quality was demonstrated throughout the test period.

9. The analysis of coal and TDF demonstrate that TDF is overall a cleaner fuel than coal. Concentrations of nearly all trace elements measured in the TDF are significantly lower than the concentrations in coal.
10. The modeling analysis demonstrates that the potential impacts of each air toxic pollutant are well below the respective FDER no-threat level (NTL). Maximum impacts of Cr^{+6} are also predicted to be below the FDER NTL and would not pose a threat to the public health.

In conclusion, the test burn satisfies beyond all reasonable doubts that TDF firing in the cement kiln at FCS can occur without an increase in allowable emissions. Further, reasonable assurance has been provided that TDF firing can occur without an increase in actual emissions of any regulated pollutant measured during the test period, except for THC. The small increase in THC emissions, and the small magnitude of THC emissions, does not pose any threat to the public health. It is cautioned, however, that these conclusions are valid only for the range of conditions experienced during the test burn.

It is concluded that TDF firing at FCS, <u>if conducted properly</u>, can occur in an environmentally safe manner, and that the health and safety of the residents of Hernando County will not be jeopardized.

This conclusion is supported in part by the large number of cement kilns in the U.S. which have or are currently burning waste tires as a permitted supplemental fuel. Test data available from some of the dry process cement kilns in the United States that were burning TDF indicate emissions are not adversely affected and, in many cases, improve. For example, at Ash Grove Cement in Durkee, Oregon, emissions of PM, CO, SO_2, eight metals, chlorides and aliphatic compounds were all found to either remain the same or decrease with 10 percent TDF firing as compared to 100 percent coal firing. The long residence times, high operating temperatures, and scrubbing action of cement kilns provide an ideal environment to burn tires as a supplemental fuel. Organics are efficiently destroyed, and many trace elements are incorporated into the clinker product. Refer to additional related information contained in Appendix C.

In order to provide reasonable assurance that FCS conducts TDF burning in an environmentally acceptable manner, the following conditions are recommended to be included in any air permit issued for TDF firing in the cement kiln at FCS. Some of these recommended conditions were contained in DER's May 29, 1992, proposed performance test authorization which included a draft amendment to FCS's air permits.

Specific Conditions:

1. The cement kiln's maximum utilization/firing rate of whole tires shall not exceed 15.0 percent of the total Btu heat input, or 1.33 tons per hour.
2. The utilization/firing rate of whole tires shall be quantified (weighed) continuously and recorded and the records shall be kept on file for a minimum of two years.
3. The quantity of all deliveries of whole tires shall be documented and kept on record/file for a minimum of two years.
4. Tire-derived fuel (TDF) may be introduced into the cement kiln only at a point at the base of the preheater (i.e., at the kiln inlet).
5. TDF firing in the cement kiln shall not commence or be conducted unless the cement kiln has reached an operating temperature of at least 1,400°F for one hour. The operating temperature shall be measured at the cement kiln inlet.
6. TDF firing in the cement kiln shall not commence or be conducted unless the oxygen level in the kiln is at least 3 percent, as measured at the base of the preheater.
7. A sonic-type flow meter or equivalent shall be installed in the CPL main plant stack to continuously measure the stack gas flow rate. The meter shall be periodically calibrated to insure adequate data. The stack gas flow rate shall be recorded on an hourly basis and used in the determination of NO_x stack emissions.

Recommendations to HCBCC

Based on the test burn results, which indicate an increase in THC emissions due to TDF firing, an air construction permit should be required of FCS prior to being authorized to burn TDF on a continuous basis.

It is recommended that if the above recommended conditions are incorporated into the construction permit, the HCBCC should not challenge the issuance of the construction permit. If such conditions are not incorporated into the construction permit, reasonable assurance will not be provided that TDF fuel will be utilized in an environmentally acceptable manner, and the HCBCC should challenge the construction permit in an administrative hearing.

APPENDIX A

STATISTICAL ANALYSIS OF EMISSION TEST RESULTS

Table A-1. Summary of Emission Test Results for Baseline and TDF Firing Conditions, CPL Plant, FCS

	BASELINE CONDITIONS (100% COAL)						TDF/COAL FIRING						TEST FOR SIGNIFICANT CHANGE					
Pollutant Name	Run 1 (lb/hr)	Run 2 (lb/hr)	Run 3 (lb/hr)	N	Average (lb/hr)	Standard Deviation	Run 1 (lb/hr)	Run 2 (lb/hr)	Run 3 (lb/hr)	N	Average (lb/hr)	Standard Deviation	Is Test Applicable[a]	Sp	tcalc	Degrees of Freedom	tTABLE	TDF Emission Test
<u>Criteria Pollutants</u>																		
Particulate	54.38	46.13	42.64	3	47.72	6.03	54.11	60.42	73.44	3	62.66	9.86	YES	8.170	2.24	4	2.13	Significant Change
Nitrogen Oxides	b	b	b	23	762.22	95.27	b	b	b	22	692.85	103.98	NO	99.619	N/A	43	1.68	OK
Lead	0.0118	0.0177	0.0059	3	0.0118	0.0059	0.0225	0.0111	0.0102	3	0.0146	0.0069	YES	0.006	0.54	4	2.13	OK
Mercury	0.0120	0.0131	0.0207	3	0.0153	0.0047	0.0075	0.0096	0.0127	3	0.0099	0.0026	NO	0.004	N/A	4	2.13	OK
Carbon Monoxide	b	b	b	23	421.48	142.93	b	b	b	22	671.24	300.02	YES	233.261	3.59	43	1.68	Significant Change
Total Hydrocarbons	b	b	b	23	--	--	b	b	b	22	c	c	NO	N/A	N/A	N/A	N/A	N/A
<u>Non-Criteria Pollutants</u>																		
Arsenic	0.00211	0.00213	0.00193	3	0.0021	0.00011	0.00150	0.00179	0.00224	3	0.0018	0.00037	NO	0.0003	N/A	4	2.13	OK
Chromium	0.01044	0.00896	0.01240	3	0.0106	0.00173	0.00988	0.00945	0.00947	3	0.0096	0.00024	NO					OK
Zinc	13.74	6.42	6.60	3	8.92	4.18	6.96	6.40	5.24	3	6.20	0.88	NO	3.0179	N/A	4	2.13	OK
Hydrogen Chloride	62.88	80.84	71.14	3	71.62	8.99	84.97	63.82	48.99	3	65.93	18.08	NO	14.28	N/A	4	2.13	OK
Volatile Organic Compounds:																		
Bromomethane	d	d	d	3	c	c	0.001	d	d	3	0.001	0.0006	NO	0.0004	N/A	4	2.13	OK
Acetone	0.151	0.158	0.114	3	0.1412	0.0235	0.242	0.095	0.074	3	0.137	0.0912	NO	0.0666	N/A	4	2.13	OK
Carbon disulfide	0.064	0.107	0.031	3	0.0676	0.0380	0.209	0.047	0.046	3	0.101	0.0939	YES	0.0717	0.57	4	2.13	OK
Benzene	0.449	0.405	0.396	3	0.4167	0.0281	0.227	0.183	0.191	3	0.200	0.0235	NO	0.0259	N/A	4	2.13	OK
Trichloroethane	d	d	d	3	c	c	d	d	d	3	c	c	NO					OK
Toluene	0.084	0.083	0.089	3	0.0855	0.0030	0.034	0.029	0.029	3	0.031	0.0029	NO	0.0029	N/A	4	2.13	OK
1,1,1-Trichloroethane	d	d	d	3	c	c	d	d	d	3	c	c	NO					OK
Chlorobenzene	0.010	0.029	0.032	3	0.0239	0.0120	0.024	0.022	0.023	3	0.023	0.0011	NO					OK
Ethylbenzene	0.006	0.015	0.011	3	0.0106	0.0045	0.006	0.007	0.007	3	0.007	0.0002	NO	0.0032	N/A	4	2.13	OK
Xylene	0.023	0.050	0.057	3	0.0430	0.0179	0.020	0.025	0.023	3	0.023	0.0024	NO					OK
Styrene	0.013	0.043	0.038	3	0.0316	0.0161	0.022	0.020	0.022	3	0.021	0.0014	NO	0.0114	N/A	4	2.13	OK
Hexane	d	d	d	3	c	c	d	d	d	3	c	c	NO	0.0000	N/A	4	2.13	OK

[a] Test is only applicable when average TDF/Coal firing emissions are greater than baseline emissions.
[b] See Table A-2.
[c] Observations were all below the detection limit; no calculation possible.
[d] Value below detectable limit.

Table A-2. Continuous Emission Test Data, Baseline and TDF Firing

	Baseline Conditions (100% Coal)			TDF/Coal Firing		
	CO (lb/hr)	THC (lb/hr)	NOx (lb/hr)	CO (lb/hr)	THC (lb/hr)	NOx (lb/hr)
	621	11.6	674	565	8.2	539
	489	4.1 *	843	1012	8.2	517
	376	4.1 *	687	1319	8.2	573
	426	4.1 *	597	1400	6.5	616
	321	4.1 *	687	1051	7.4	628
	342	4.1 *	636	880	4.1	718
	474	4.1 *	692	802	4.1	752
	547	4.1 *	752	429	4.1 *	975
	582	4.1 *	605	612	4.1 *	654
	568	4.1 *	770	455	4.1 *	573
	534	4.1 *	744	448	4.1 *	590
	403	4.1 *	839	489	4.1 *	778
	584	4.1 *	981	779	4.0 *	771
	644	4.1 *	831	342	4.0 *	663
	469	4.1 *	754	734	4.0 *	708
	519	4.1 *	758	681	4.0 *	696
	279	4.1 *	848	409	4.0 *	742
	245	4.1 *	818	401	4.0 *	787
	323	4.1 *	720	499	4.0 *	717
	162	4.1 *	887	409	4.4	746
	180	4.1 *	870	464	4.8	717
	253	4.1 *	805	588	4.0	783
	352	4.1 *	733		4.1 *	
	----	----	----	----	----	----
N=	23		23	22		22
Avg.=	421	2.5	762	671	3.7	693

* Value was below detectable limit. Value equal to one-half the detectable limit was used for calculating averages.

Summary of PM and CO Emission Rates, All Past Data

	Baseline Conditions PM (lb/hr)	Baseline Conditions CO (lb/hr)	TDF Conditions PM (lb/hr)	TDF Conditions CO (lb/hr)
	53.73	1043	57.25	859
	48.89	1218	33.55	597
	42.55	444	65.83	141
	55.33		54.11	
	62.21		60.42	
	59.15		73.44	
	49.05			
	50.12			
	53.56			
	59.84			
	54.38			
	46.13			
	42.64			
Average	52.1	901.7	57.4	532.3
Standard Deviation S	6.272	405.9	13.543	363.3
N	13	3	6	3

Table 2. Test for Significant Change of PM Emissions, FCS

	Baseline Conditions			TDF Conditions			TEST FOR SIGNIFICANT CHANGE					
Pollutant Name	N	Average (lbs/hr)	Standard Deviation	N	Average (lbs/hr)	Standard Deviation	Is Test Applicabl	Sp	tcalc	Degrees of Freedom	tTABLE	Post Emission Test
Criteria Pollutants												
Particulate	13	52.12	6.27	6	57.43	13.54	YES	9.040	1.19	17	2.13	OK
Carbon Monoxide	3	901.7	405.9	3	532.3	363.3	NO	385.206	N/A	4		OK

Note: Test is only applicable if there is any increase in average TDF emissions over the average basline emissions.

TABLE 6
SUMMARY OF COAL ANALYSES

TDF CONDITIONS

FLORIDA CRUSHED STONE COMPANY
CPL PLANT
BROOKSVILLE, FLORIDA

Sample Date	Moisture (%)	Carbon (%)	Hydrogen (%)	Nitrogen (%)	Sulfur (%)	Ash (%)	Oxygen (%)	Chloride (%)
Coal								
7-28-92	6.26	71.53	4.79	1.43	0.74	8.85	6.40	0.09
7-28-92	6.76	71.86	4.73	1.43	0.77	8.27	6.18	0.11
7-29-92	7.09	69.20	4.66	1.46	0.69	9.61	7.29	0.09
7-29-92	5.90	71.32	4.81	1.44	0.69	8.80	7.04	0.09
Average	6.50	70.98	4.75	1.44	0.72	8.88	6.73	0.10
TDF								
7-28-92	1.07	66.42	6.70	0.66	0.98	19.73	4.44	0.06
7-29-92	0.76	65.51	6.17	0.51	1.23	24.18	1.64	0.03
Average	0.92	65.95	6.44	0.58	1.10	21.95	3.04	0.05

Sample Date	Arsenic (μg/g)	Mercury (μg/g)	Lead (μg/g)	Chromium (μg/g)	Zinc (μg/g)
Coal					
7-28-92	3	0.05	86	82	87
7-28-92	3	0.18	92	78	95
7-29-92	1	0.10	98	72	102
7-29-92	1	0.08	88	70	84
Average	2	0.10	91	75	92
TDF					
7-28-92	1	0.03	10	2.0	319
7-29-92	<1	0.04	17	4.0	712
Average	1	0.04	14	3.0	515

TABLE 6
SUMMARY OF COAL ANALYSES

BASELINE CONDITIONS

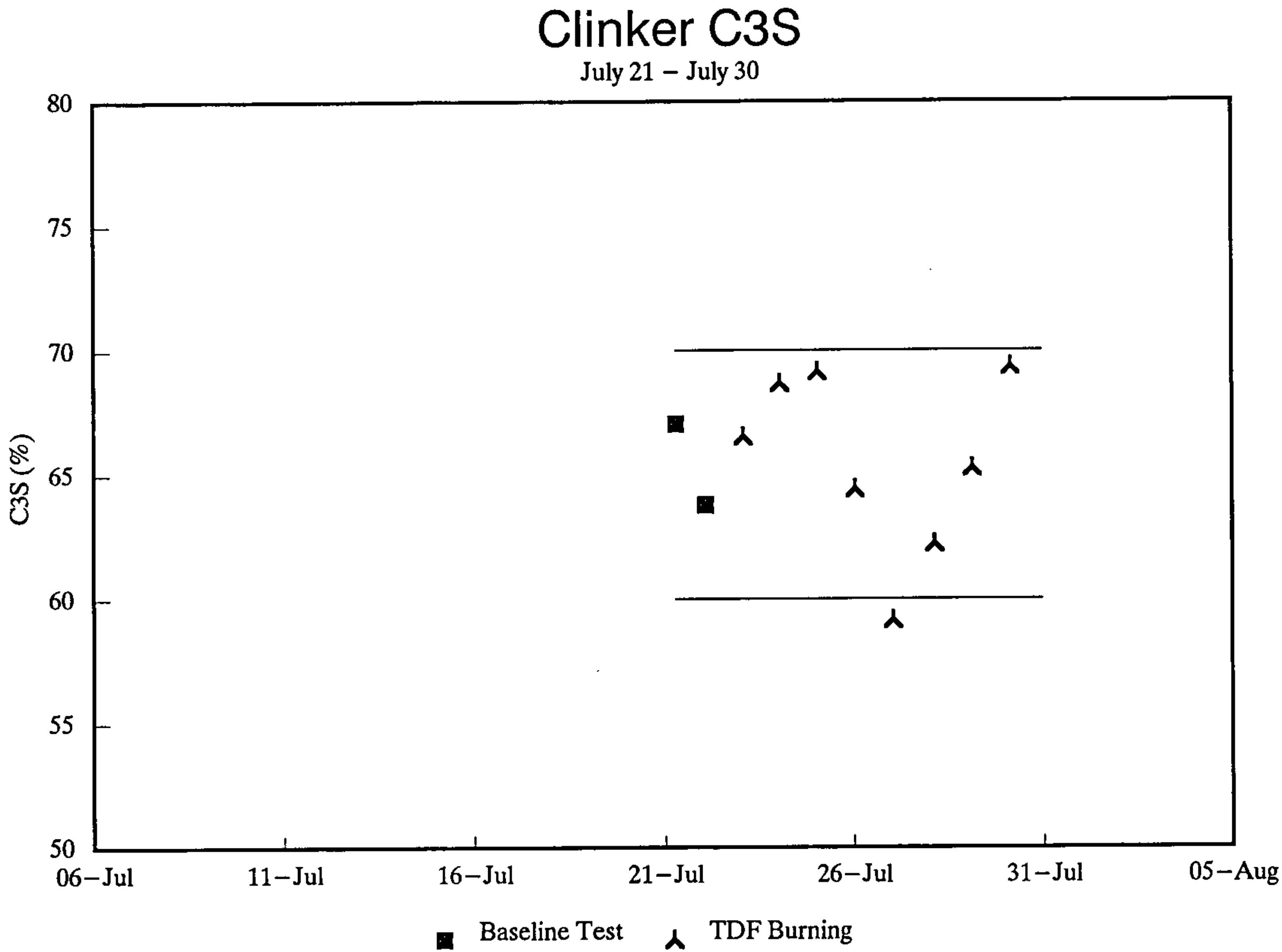
FLORIDA CRUSHED STONE COMPANY
CPL PLANT
BROOKSVILLE, FLORIDA

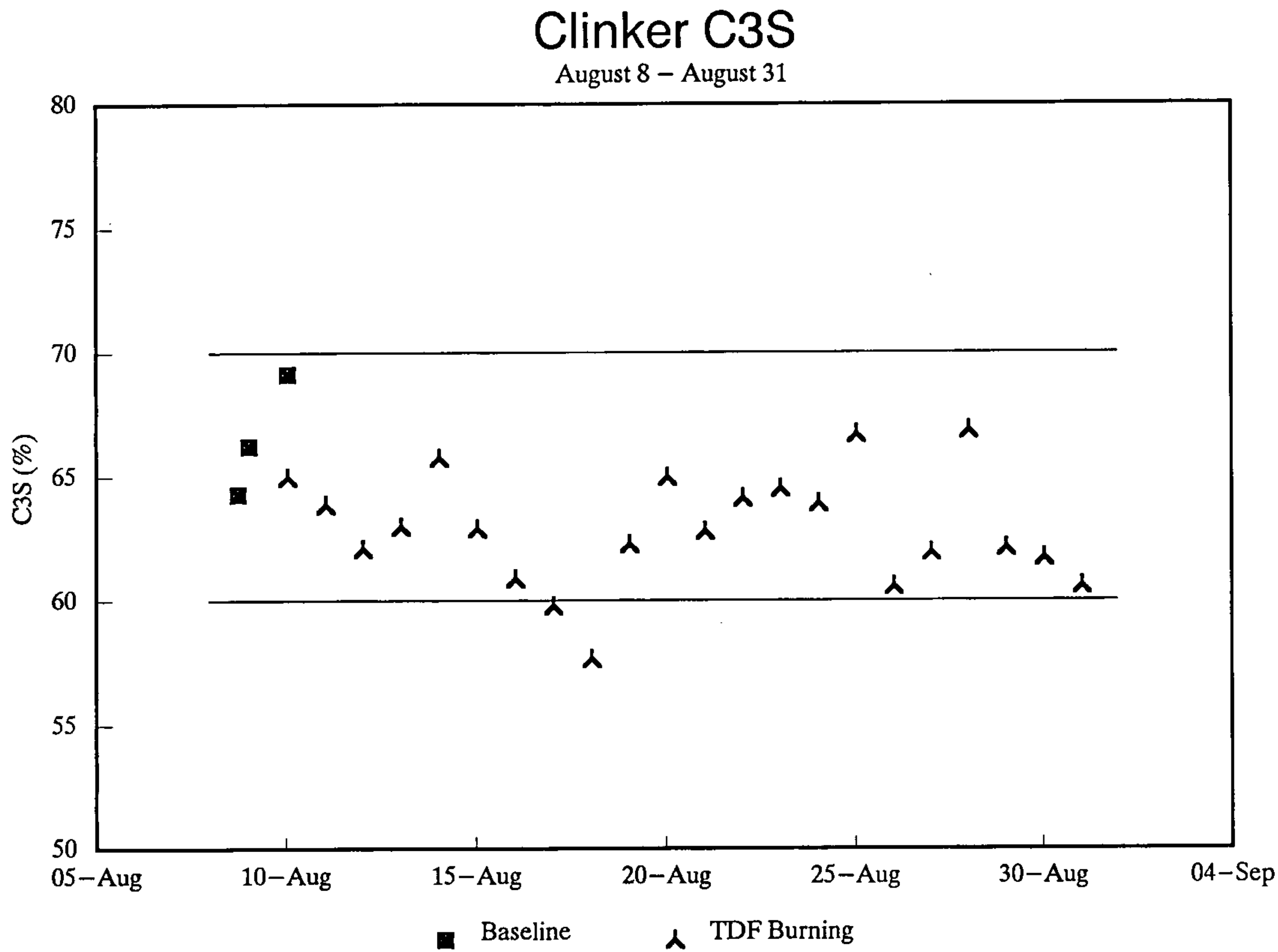
Sample Date	Moisture (%)	Carbon (%)	Hydrogen (%)	Nitrogen (%)	Sulfur (%)	Ash (%)	Oxygen (%)	Chloride (%)
7-21-92	7.89	69.95	4.74	1.45	0.69	8.73	6.55	0.10
7-21-92	4.01	74.38	5.06	1.55	0.69	7.41	6.90	0.11
7-22-92	7.79	69.98	4.71	1.43	0.70	8.54	6.85	0.09
7-22-92	5.25	73.00	4.84	1.42	0.64	7.85	7.00	0.09
Average	6.24	71.83	4.84	1.46	0.68	8.13	6.82	0.10

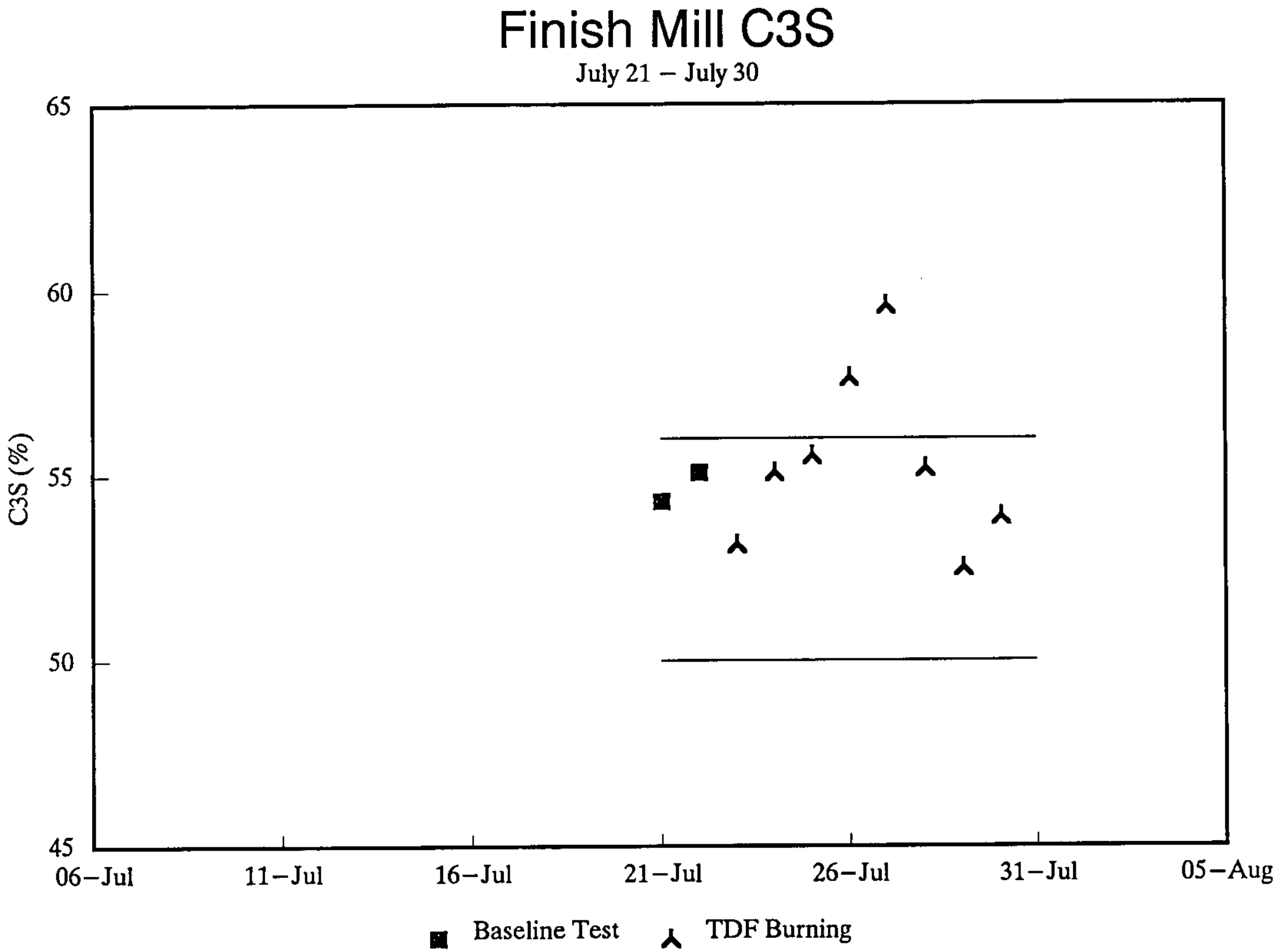
Sample Date	Arsenic (µg/g)	Mercury (µg/g)	Lead (µg/g)	Chromium (µg/g)	Zinc (µg/g)
7-21-92	1	0.10	93	73	115
7-21-92	<1	0.05	96	85	98
7-22-92	2	0.05	94	72	116
7-22-92	<1	0.03	94	82	105
Average	<1.2	0.06	94	78	108

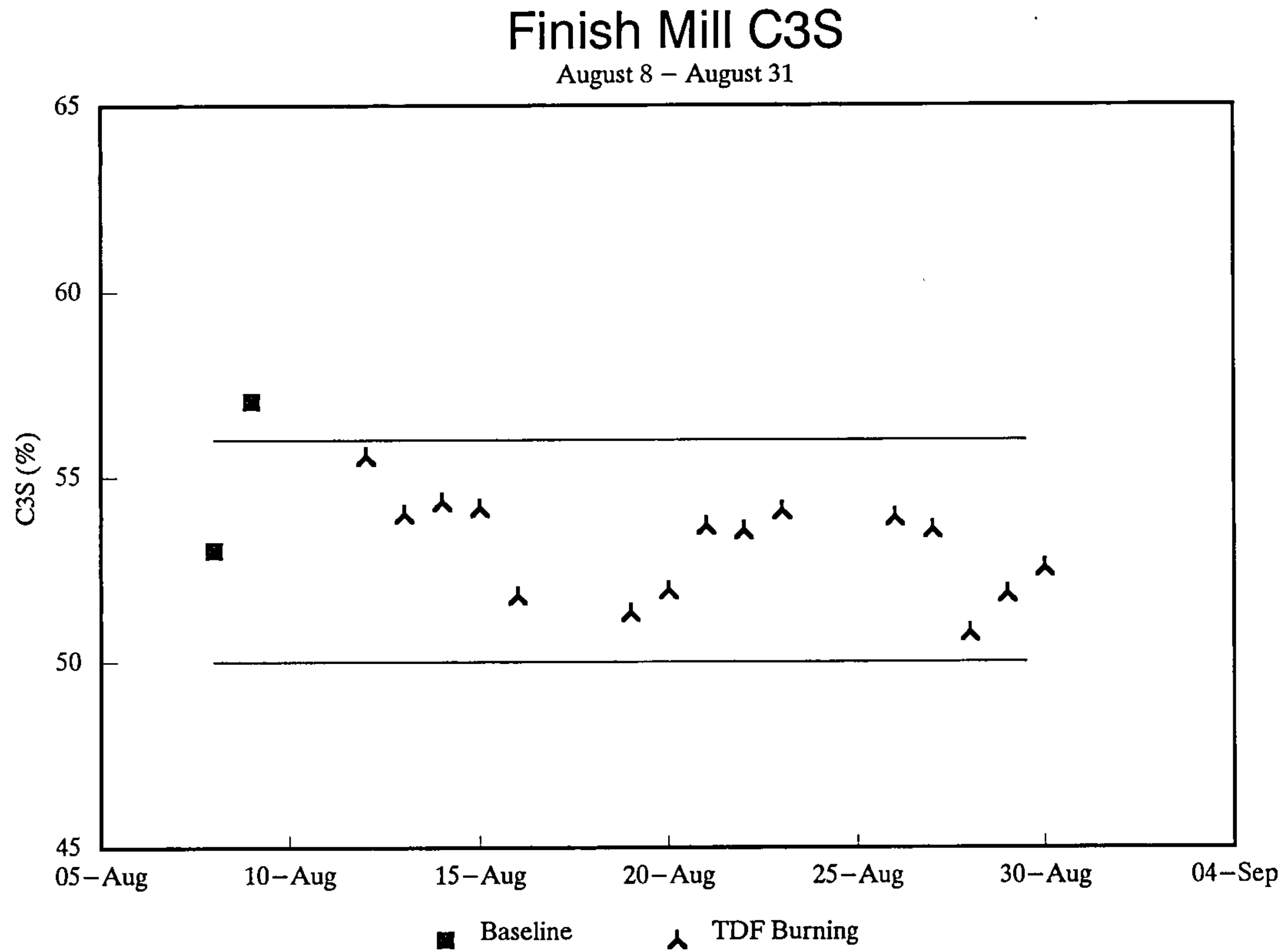
APPENDIX B

GRAPHICAL DISPLAY OF TEST PARAMETERS DURING 30-DAY TEST PERIOD


Clinker C3S
July 21 – July 30
C3S (%)
80
75
70
65
60
55
50
06–Jul
11–Jul
16–Jul
21–Jul
26–Jul
31–Jul
05–Aug
Baseline Test
TDF Burning


Clinker C3S
August 8 – August 31
80
75
70
65
60
55
50
C3S (%)
05–Aug
10–Aug
15–Aug
20–Aug
25–Aug
30–Aug
04–Sep
Baseline
TDF Burning

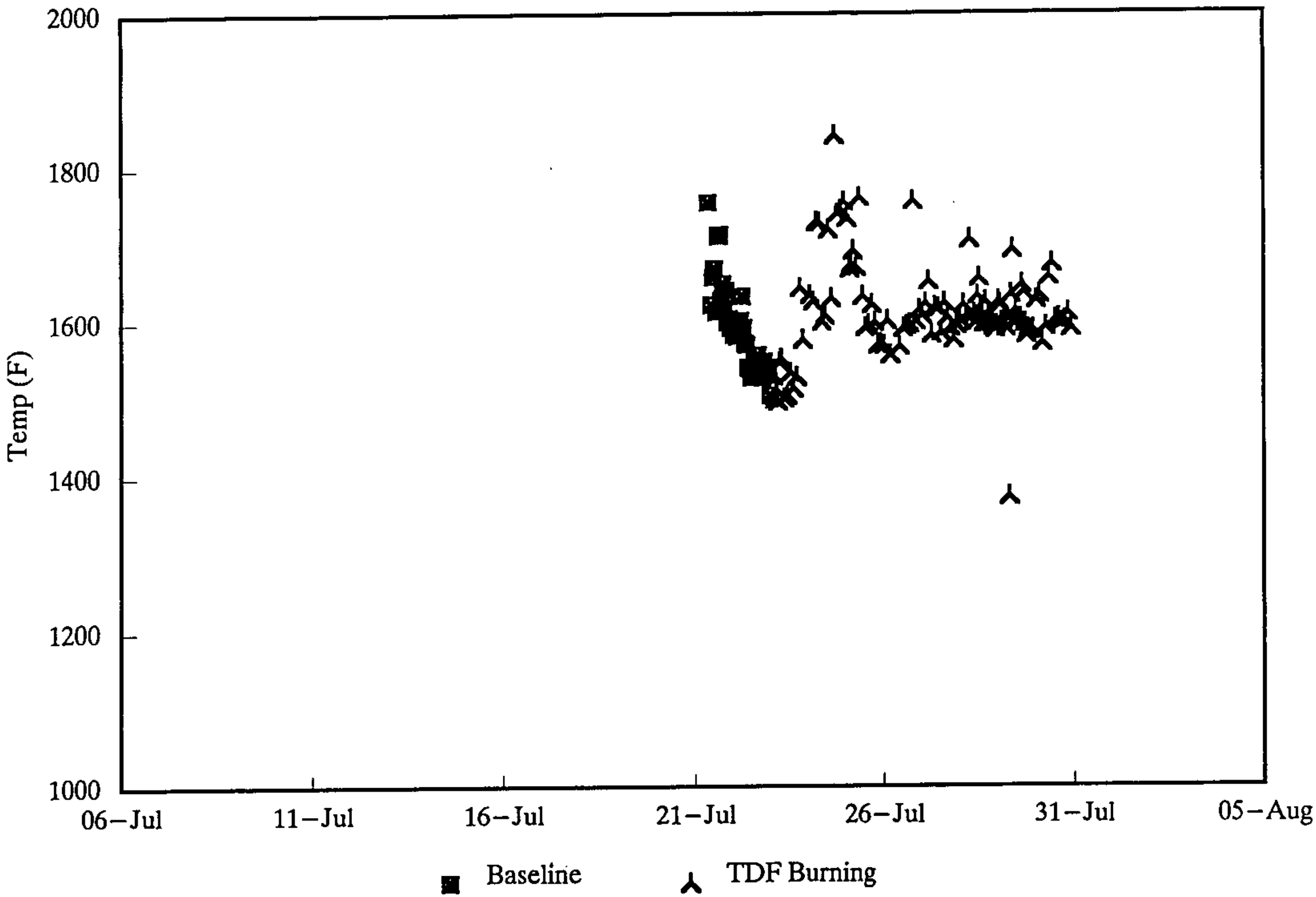

Finish Mill C3S
July 21 – July 30
65
60
55
50
45
C3S (%)
06–Jul
11–Jul
16–Jul
21–Jul
26–Jul
31–Jul
05–Aug
Baseline Test
TDF Burning

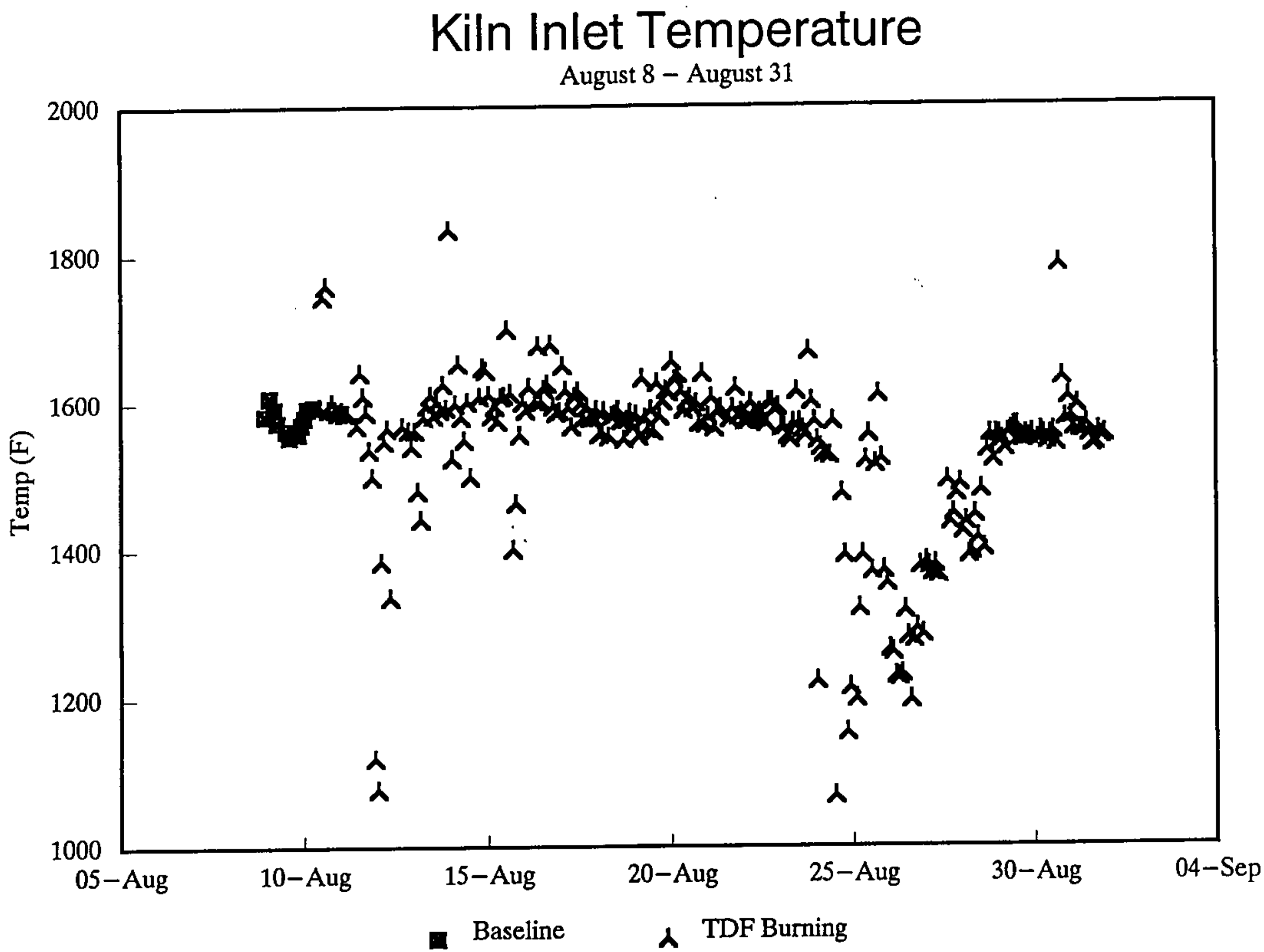


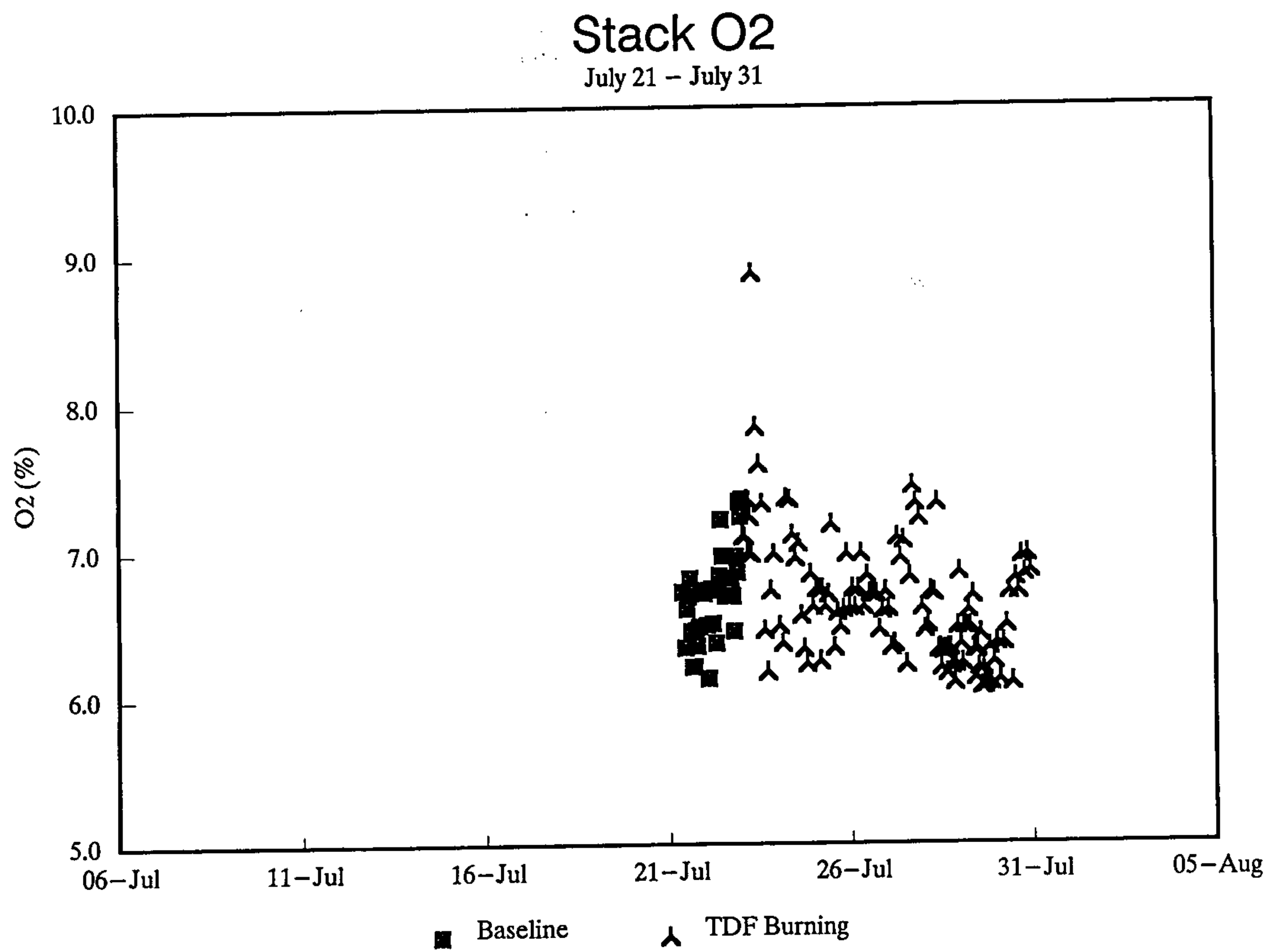
Finish Mill C3S
August 8 – August 31
65
60
55
50
45
C3S (%)
05–Aug
10–Aug
15–Aug
20–Aug
25–Aug
30–Aug
04–Sep
Baseline
TDF Burning

Kiln Inlet Temperature

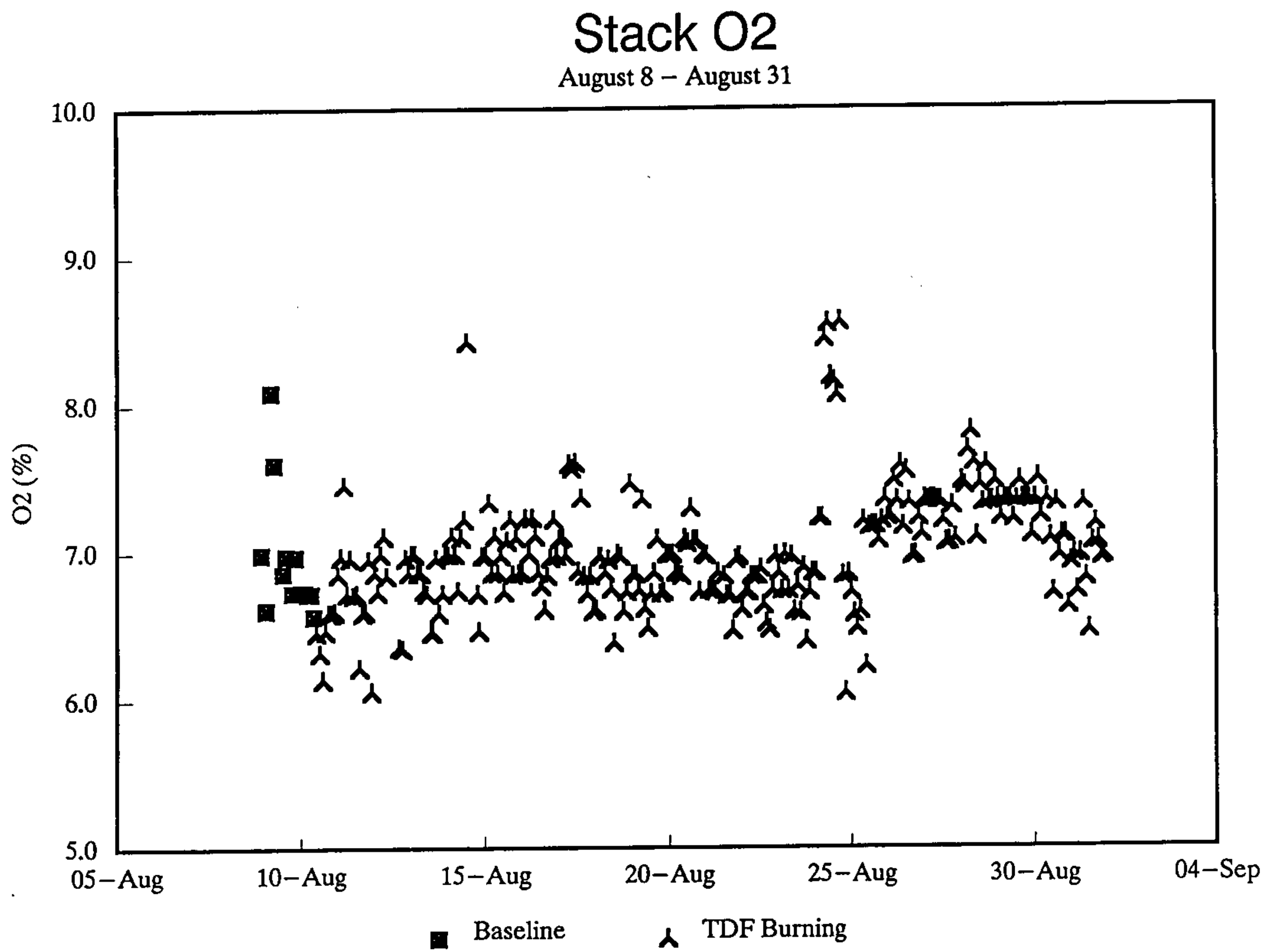
July 21 – July 30

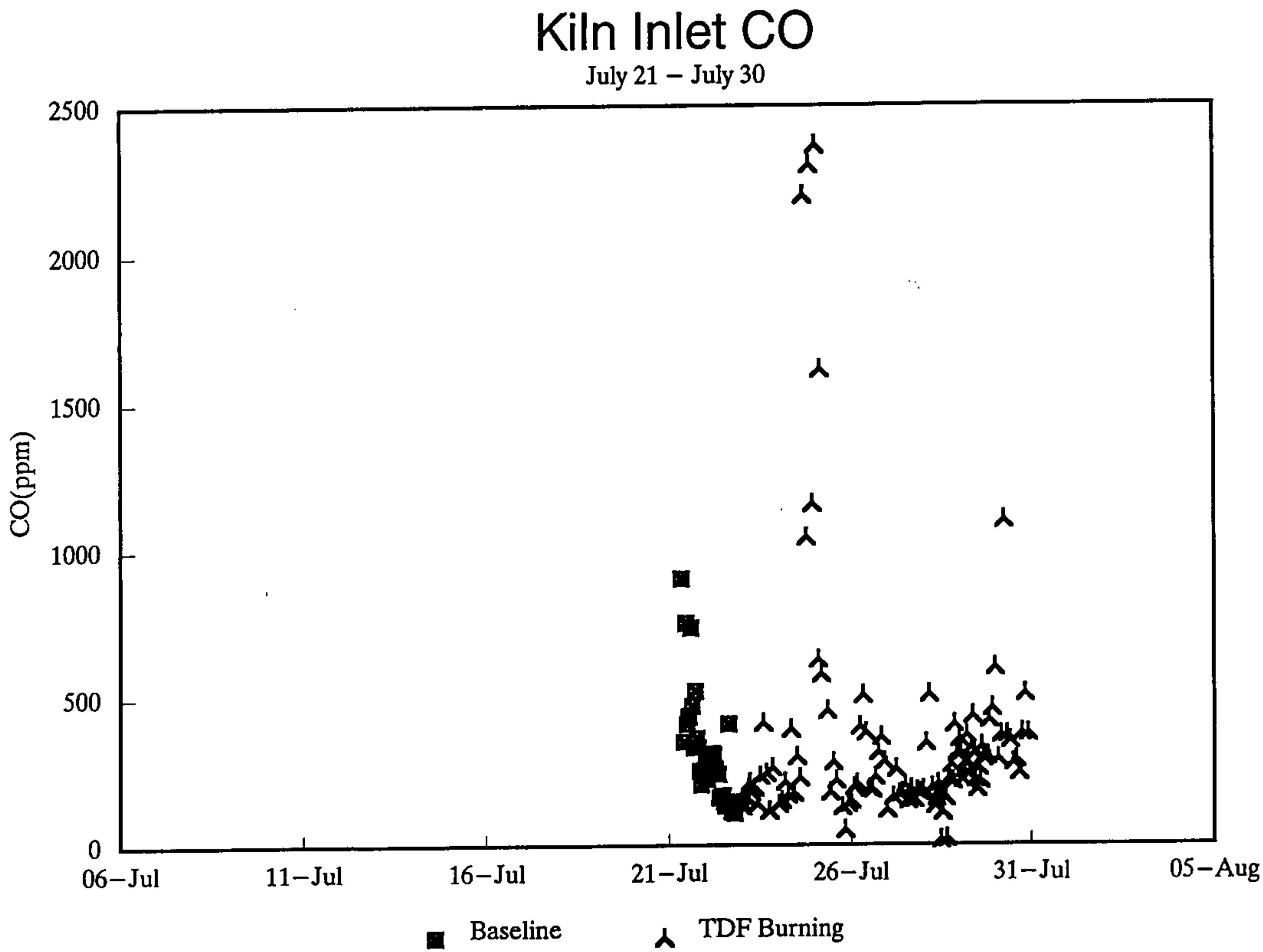



Kiln Inlet Temperature
August 8 – August 31
2000
1800
1600
1400
1200
1000
Temp (F)
05–Aug
10–Aug
15–Aug
20–Aug
25–Aug
30–Aug
04–Sep
Baseline
TDF Burning

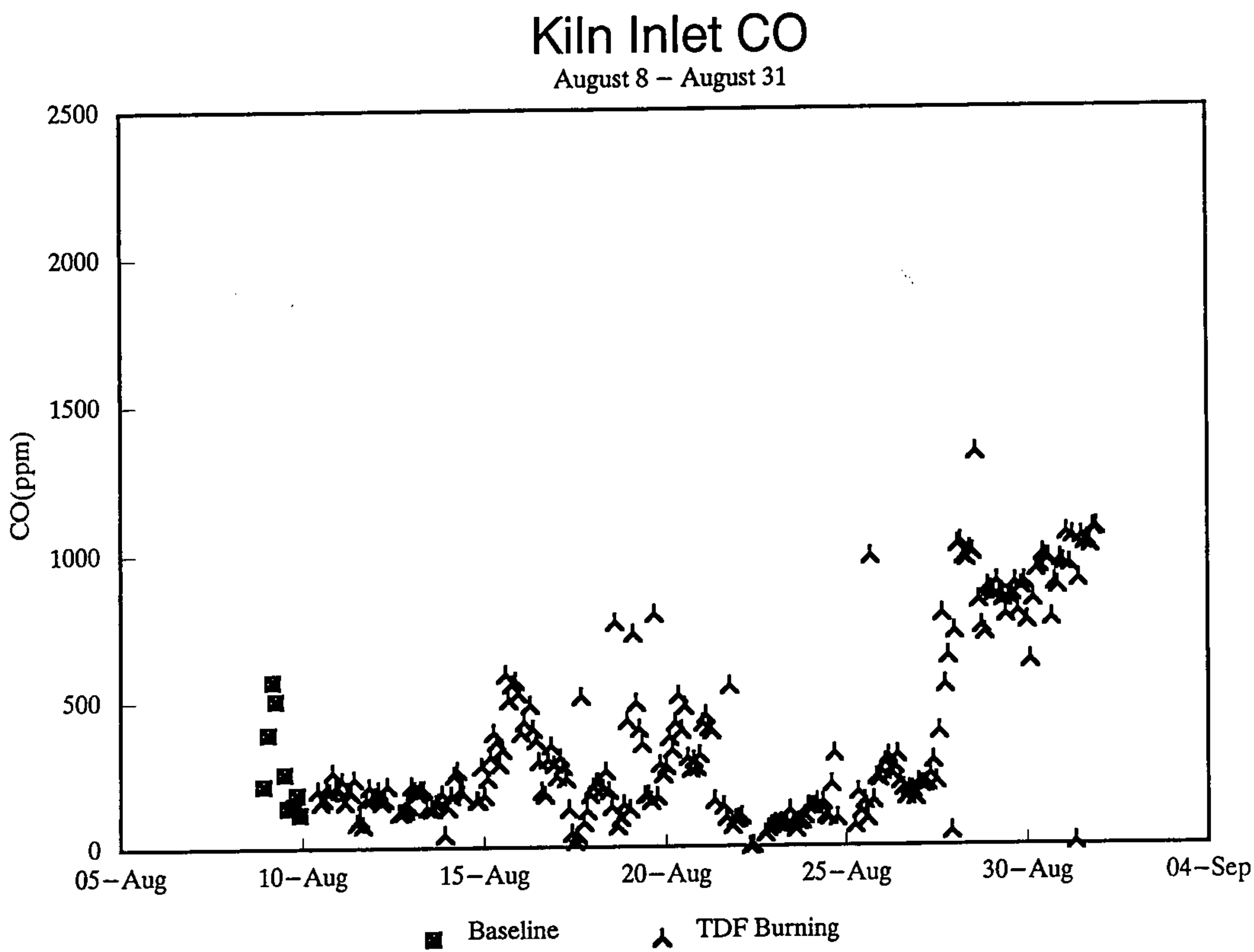


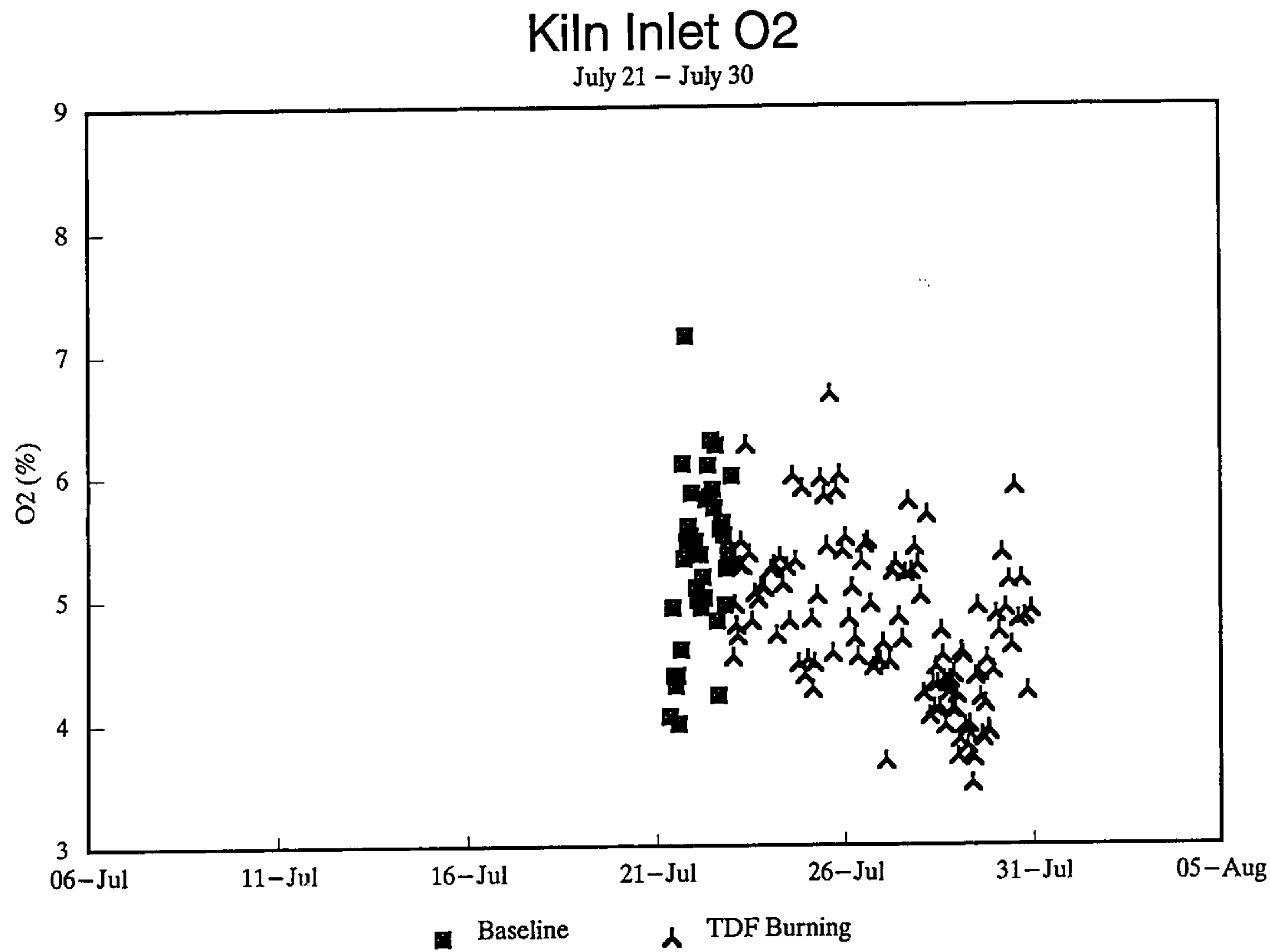
Stack O2
July 21 – July 31
O2 (%)
10.0
9.0
8.0
7.0
6.0
5.0
06–Jul
11–Jul
16–Jul
21–Jul
26–Jul
31–Jul
05–Aug
Baseline
TDF Burning


Stack O2
August 8 – August 31
10.0
9.0
8.0
7.0
6.0
5.0
O2 (%)
05–Aug
10–Aug
15–Aug
20–Aug
25–Aug
30–Aug
04–Sep
Baseline
TDF Burning

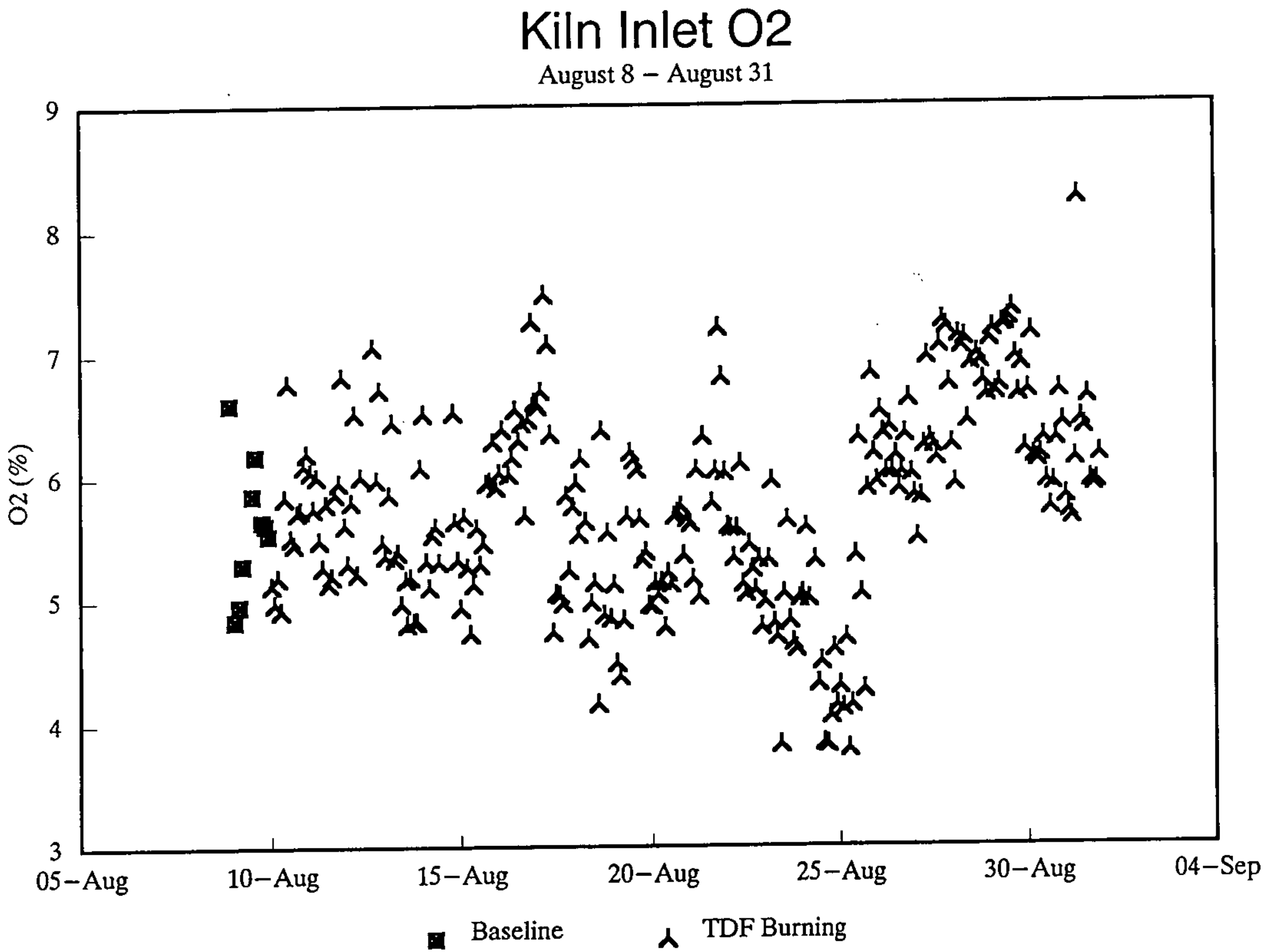


Kiln Inlet CO
July 21 – July 30
CO(ppm)
2500
2000
1500
1000
500
0
06–Jul
11–Jul
16–Jul
21–Jul
26–Jul
31–Jul
05–Aug
Baseline
TDF Burning

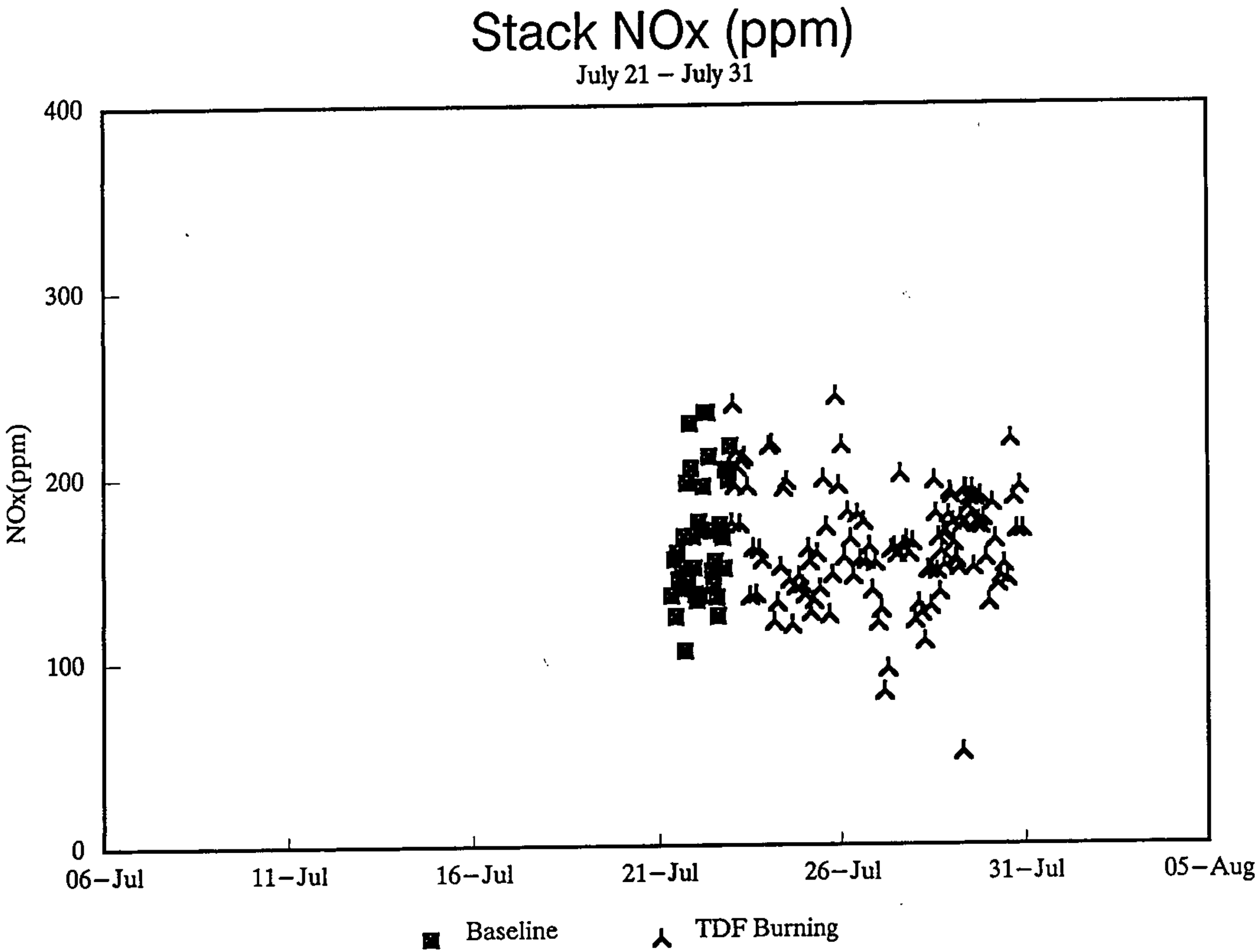

Kiln Inlet CO
August 8 – August 31
CO(ppm)
2500
2000
1500
1000
500
0
05–Aug
10–Aug
15–Aug
20–Aug
25–Aug
30–Aug
04–Sep
Baseline
TDF Burning

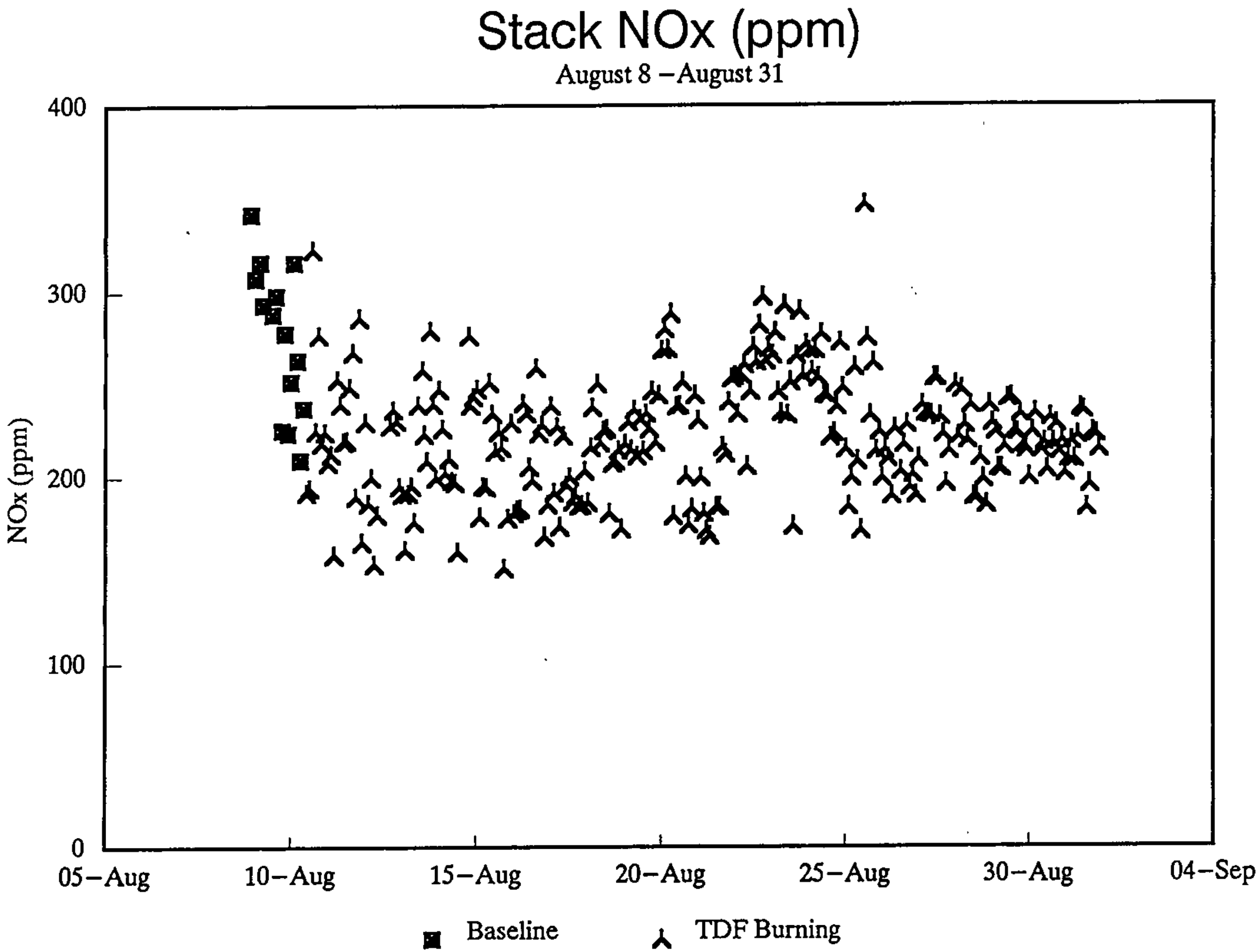


Kiln Inlet O2
July 21 – July 30
O2 (%)
9
8
7
6
5
4
3
06–Jul
11–Jul
16–Jul
21–Jul
26–Jul
31–Jul
05–Aug
Baseline
TDF Burning

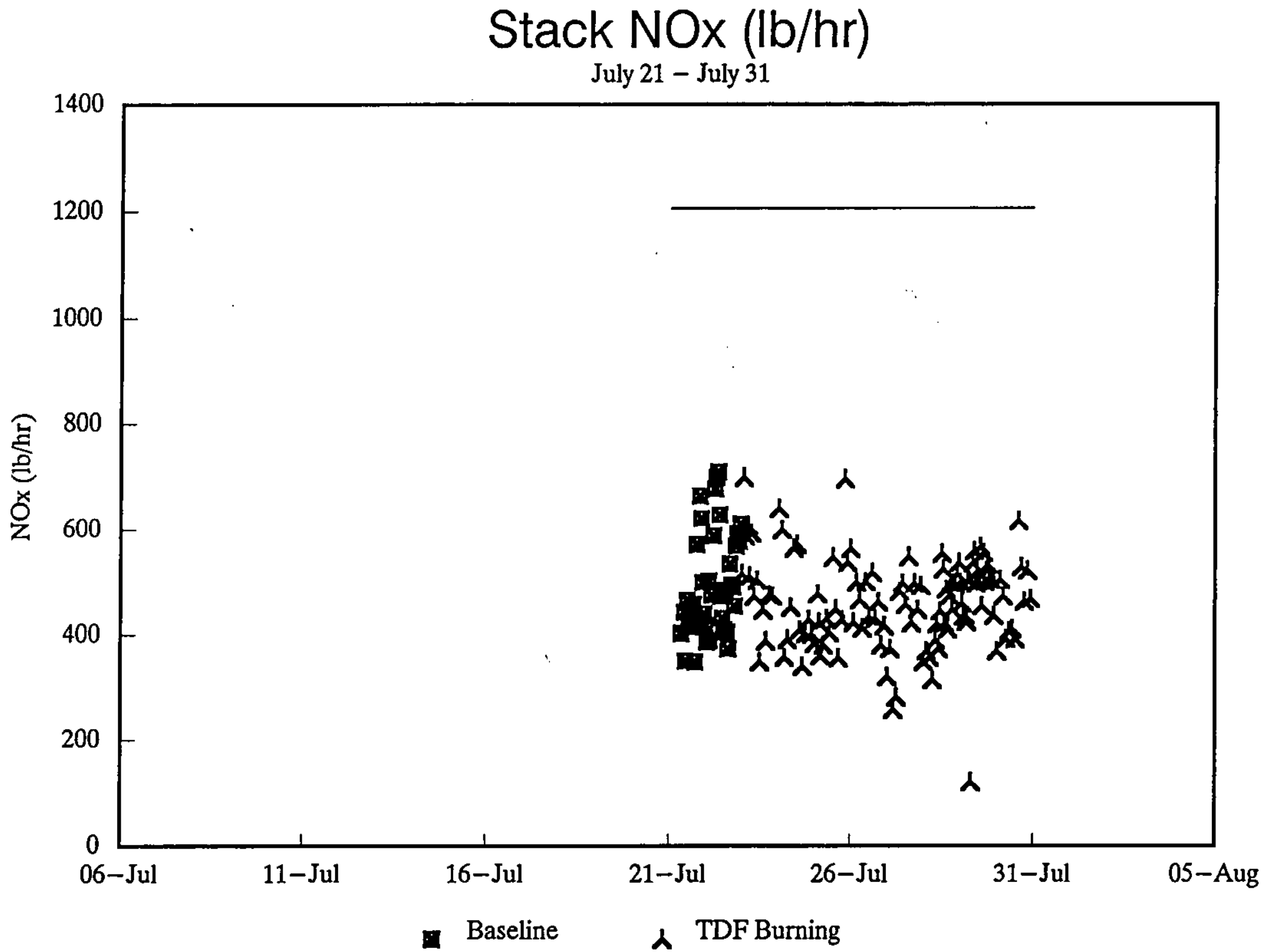


Kiln Inlet O2
August 8 – August 31
9
8
7
6
5
4
3
O2 (%)
05–Aug
10–Aug
15–Aug
20–Aug
25–Aug
30–Aug
04–Sep
Baseline
TDF Burning

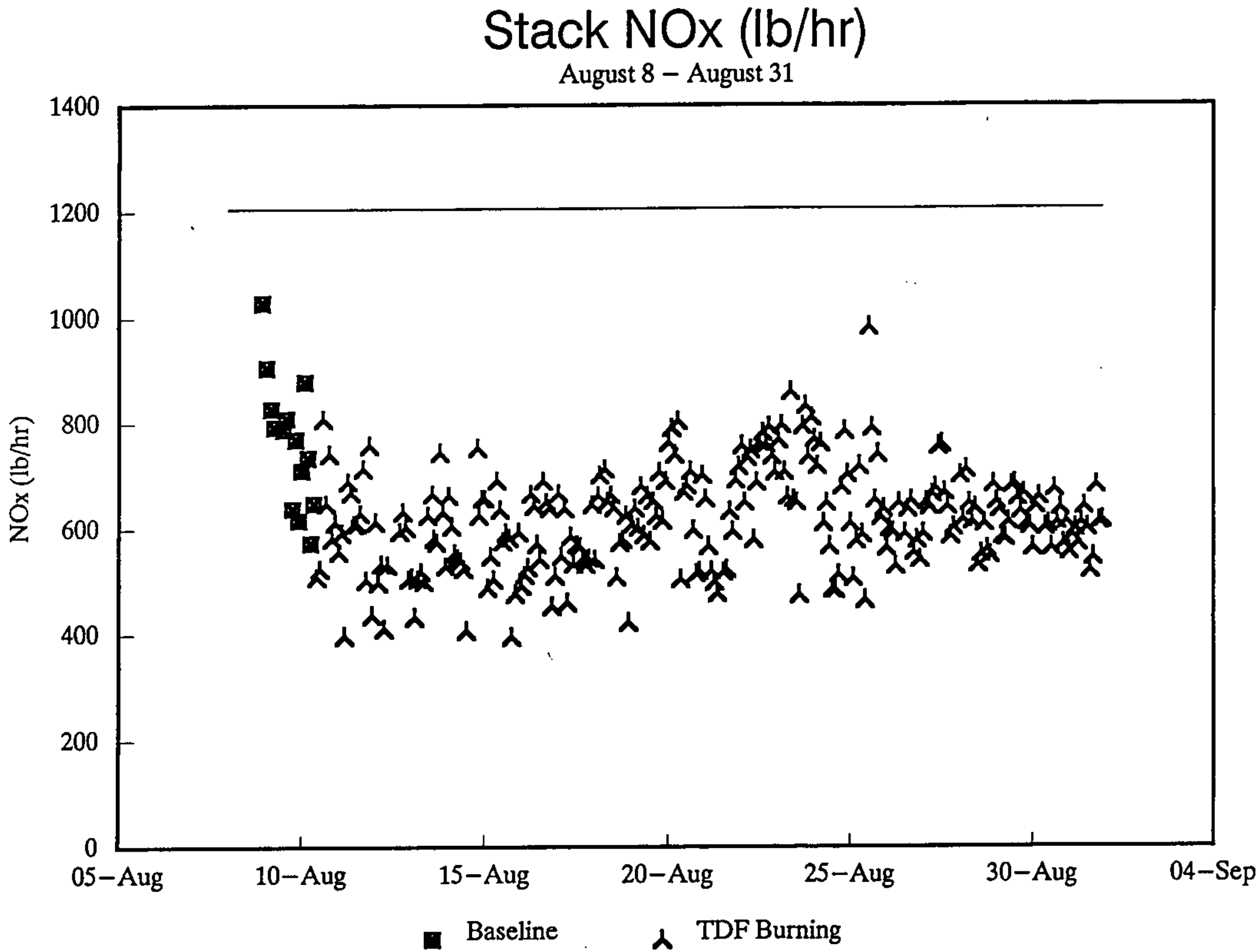

Stack NOx (ppm)
July 21 – July 31
NOx(ppm)
400
300
200
100
0
06–Jul
11–Jul
16–Jul
21–Jul
26–Jul
31–Jul
05–Aug
Baseline
TDF Burning



Stack NOx (ppm)
August 8 – August 31
400
300
200
100
0
NOx (ppm)
05–Aug
10–Aug
15–Aug
20–Aug
25–Aug
30–Aug
04–Sep
Baseline
TDF Burning



Stack NOx (lb/hr)
July 21 – July 31
NOx (lb/hr)
1400
1200
1000
800
600
400
200
0
06–Jul
11–Jul
16–Jul
21–Jul
26–Jul
31–Jul
05–Aug
Baseline
TDF Burning



Stack NOx (lb/hr)
August 8 – August 31
NOx (lb/hr)
1400
1200
1000
800
600
400
200
0
05–Aug
10–Aug
15–Aug
20–Aug
25–Aug
30–Aug
04–Sep
Baseline
TDF Burning

APPENDIX C

PUBLISHED LITERATURE CONCERNING WASTE TIRE BURNING IN CEMENT KILNS

United States
Environmental Protection
Agency

Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

EPA-450/3-91-024
December 1991

PB92-145358

Air

EPA

Burning Tires for Fuel and Tire Pyrolysis: Air Implications

control technology center

ctc

4. TIRE AND TDF USE IN PORTLAND CEMENT KILNS

The portland cement production process is extremely energy intensive (from 4 to 6 million Btu's (MMBtu's) are required to make a ton of product); therefore, alternative and cost-effective fuel options are of great interest. Waste tires have been tried as a supplemental fuel in well over 30 cement kilns and in at least one rotary lime manufacturing kiln. Currently, tires are in use, either on a trial or permanent basis, in 11 cement kilns and one lime kiln.

A cement kiln provides an environment conducive to the use of many fuel substances, such as tires, not normally included in the fuel mix. Specifically, the very hot, long, inclined rotary kiln provides temperatures up to 2700°F, long residence time, and a scrubbing action on kiln materials that allows a kiln to accommodate and destroy many problem organic substances. Also, the rock-like "clinker" formed in the kiln can often incorporate the resulting ash residue with no decrease in product quality. Tires are a compact fuel, with very low moisture. Tires have some iron and zinc content, both desirable materials in the raw material mix for cement manufacturing. Further, the materials handling operations already in place at many cement plants require only minimal modification to accommodate TDF feed. For these reasons, cement kilns are one of the most common methods by which energy in waste tires is recovered.

Cement plants attract favorable power rates because the process is so energy intensive; TDF cost per Btu is thus less of a savings. Second, cement kilns can accommodate many alternate fuels,[1] such that regional availability and price for these may affect the marginal savings of TDF. For example, on the Southeast Gulf coast, petroleum coke is

Table 4-1. Portland Cement Facilities that have been, or are, Burning TDF or Whole Tires

COMPANY AND LOCATION	KILNS DESCRIPTION[a]	TDF OR TIRE EXPERIENCE	AIR EMISSIONS TEST DATA	COMMENTS/REFERENCES
Allentown Cement (LeHigh Portland Cement Co.) Allentown, PA	2 dry kilns; coal/coke fired			References 2 and 5
Ash Grove Cement Co. West Plant Durkee, OR	Dry/1980; PH; ESP; natural gas/oil co-fire; one four-stage preheater; 500,000 tpy.	Current use; burned since 6/90, 2"x2"; fed pneumatically into feed end of kiln; permitted to burn up to 10% TDF; currently running 8%	Extensive testing for PM, SO_x, metals, HC; showed no significant increase	References 2, 6, and 7
Blue Circle, Inc. Atlanta, GA	2 dry kilns; coal/coke fired	Past use		References 2 and 5
Box Crow Cement Co., Box Crow Plant Midlothian, TX	1 dry kiln; PH/PC; coal-fired; baghouse; 310,000 tpy	Past use; 2"x6" TDF; 10-12% TDF	CEMS only; test burn planned soon	References 2, 5, and 7
Calaveras Cement Co. Redding, CA	1 kiln; PH/PC; FF; coal fired, 650,000 tpy	Current use; burned since 1985, 2"x2" TDF, wire-free now; whole by mid-1991; about 20% Btu; 65 tons TDF per day (6,000 tires); TDF into riser duct just above kiln feed housing	Yes; emission not significantly different than burning coal	Use permit modification from local agency. References 1, 2, 7, and 8
California Portland Cement (Arizona Portland) Rillito, AZ	4-dry kilns; 1 with PH/PC; coal-fired; 2 kilns inactive in 1990.	Past use; 2"x2" 10% of energy from TDF; TDF since 1986	No	References 1 and 2
California Portland Cement Mojave, CA	1 dry kiln; PH/PC; FF; coal-fired; 3,250 tpd	2.5"x 2.5"; 30% TDF of total fuel	No	References 2 , 5, and 7
Centex Illinois Cement Co. LaSalle, IL	1 dry kiln; PH; FF; coal fired.	Test use; anticipate 4/91 test burn	Applied for test burn permit; plant 4/91 test burn.	Completed permit application; plans April 1991 test burn. References 2 and 9
Essroc Materials, Inc. Nazareth, PA	1 planned dry kiln; PC; to be completed 1991		Test burn in November	References 2, 5, and 7

Table 4-1. (Continued)

COMPANY AND LOCATION	KILNS DESCRIPTION[a]	TDF OR TIRE EXPERIENCE	AIR EMISSIONS TEST DATA	COMMENTS/REFERENCES
Florida Crushed Stone Co. Brookville, FL	1 dry kiln; PH; FF; ; coal fired	Past use; fed TDF into preheater; stopped because of preheater plugging problems; installing whole tire feeder; Test data (10/90) not valid, but tested for PM, SO_2, VOCs, furans, dioxins, metals.	Incomplete	References 2 and 10
Giant Resource Recovery Harleyville, SC	4 wet Kilns; ESP; coal fired			References 2 and 5
Gifford Hill Cement Co. Harleyville, SC (now Blue Circle)	1 dry kiln; PH; FF; coal fired	Past use; whole tires; 20% of energy from TDF during testing; in process of making modifications to install feed equipment.	No	References 2 and 11
Holnam/Ideal Cement Dundee, MI	2 wet kilns; coal/coke-fired	2"x2"		References 2 and 5
Holnam/Ideal Cement Seattle, WA	1 wet kiln; ESP; coal/coke fired	Current use; 2" wire-free; test permit is for up to 25%; first used TDF in 1986; discontinued because TDF not price competitive with coal; reinstated TDF use in 1990; 20% of energy is from TDF.	Yes; using 0%, 11%, and 14% TDF; complete data for PM, SO_2, NO_x, heavy metals, PNA's, and VOC's.	References 2, 5, 12, and 13
Kosmos Cement Co. Kosmosdale, KY	1 dry kiln; PH; FF; coal fired, 2,160 tpd	Past use; shredded TDF	Yes (PM, SO_2, CO, HC, HCl)	References 2, 5, and 7
La Farge Corp., Balcones Plant New Braunfels, TX	1 dry kiln; PH/PC	Current test use; 2" wire-free. Used TDF experimentally for 2 yrs; completed trials for emission testing; permit being issued to limit TDF to 25% of energy used; planning to test VOC, PAH's, PCDD/PCDR.	planned	Investigating tire burning on corporate level. References 2, 5, and 7

Table 4-1. (Continued)

COMPANY AND LOCATION	KILNS DESCRIPTION[a]	TDF OR TIRE EXPERIENCE	AIR EMISSIONS TEST DATA	COMMENTS/REFERENCES
Lone Star Cement, Cape Girardeu, MO			Test burn soon	Reference 7
Medusa Concrete Clinchfield, GA	1 Wet Kiln inactive in 1990; 1 dry kiln w/PH; FF; coal fired.			References 2 and 5
Medusa Cement Charlevoix, MI	1 dry kiln; PH/PC; coal-fired			References 2 and 5
Monarch Cement Co. Humboldt, KS	3 dry kilns; 2 with PH; FF; coal/coke			References 2 and 5
River Cement Co., Selma Plant Festus, MO	2 dry kilns; FF; coal fired.			References 2 and 5
RMC Lone Star Davenport, CA	1 dry kiln; PH/PC; ESP; coal fired	Current use		References 2 and 14
Roanoke Cement Co. Cloverdale Plant Roanoke, VA	5 dry kilns; 1 with PH; coal fired; TDF planned in kiln with PH	Test use; planning use of whole tires, beginning with 4% and increasing to 20% tires; tires from retailers and maybe from dumps.	Yes, winter 1991; tires at 20%	Have spent $320,000 for equipment and testing; will be paid a disposal fee for taking tires, and perhaps a state subsidy based on $0.50 tax on new tires; currently permitting. References 2 and 15
Southdown, Inc. Southwestern Portland Cement Co. Victorville, CA	2 dry kilns, 1 with PH/PC; FF; coal fired.	Current use; test permit; use not continuous; whole and shredded; TDF added at precalciner; whole added into feed end of kiln by double gate method.	CEMS; new test data	Test permit; final permit pending CEMS data analysis. Whole into kiln feed end; TDF into preheater at precalciner. References 2, 7, and 16
Southdown, Inc. Southwestern Portland Cement Co. Fairborn, OH	1 dry kiln; PH FF; coal fired.	Past permitted use; Whole 36"; 10-15%; use was successful and are renewing alternate fuels permit; tires were slid, not rolled, into feed end of kiln.	CEMS; new emissions tests have been done	Tire burning stopped until renew permit to burn whole tires; public opposition to solvent-derived fuels; working their copy through the permit process References 2, 7, 16, and 17

Table 4-1. (Continued)

COMPANY AND LOCATION	KILNS DESCRIPTION[a]	TDF OR TIRE EXPERIENCE	AIR EMISSIONS TEST DATA	COMMENTS/REFERENCES
Southdown, Inc. (Southwestern) Lyons, CO	1 dry kiln; PH/PC; FF; gas, coal, waste oil; 1,400 tpd	Current use; 3"x3" TDF; dropped on to feed shelf by screw conveyor; 1/2 ton/hr @ 5%; some feeding problems; plugging of rubber shreds to hopper if shreds have belts and beads.		References 2, 5, 7, and 16
St. Mary's Peerless Cement Detroit, MI	1 wet kiln; coal-fired			References 2 and 5
<u>Lime Manufacture</u>				
Boise Cascade Wallula, WA	1 rotary lime kiln; freed by gas, oil, and tires; venturi scrubber controlled.	TDF up to 15%	Yes; 5/86; baseline gas fired; TDF 15% with gas; measured PAH's and metals	Lime manufacturing rotary kiln. Reference 18

[a] PH = Preheater, PC = Precalciner, ESP = electrostatic precipitator, FF = fabric filter

4.2.5 Tires as Fuel in the Kiln

Tires or TDF can be used to supplement the kiln fuel and/or the precalciner fuel. When TDF is added to the kiln fuel mix, it is often added at the burner (lower) end of the kiln, near, but not mixed with, the coal feed. At one plant (Holnam/Ideal), TDF is fed in above the coal flame.[19] This arrangement permits the chips to be blown further into the kiln and causes the chips to fall through the coal flame to produce much better combustion. In most cases, TDF is added at the feed end (high end) of the kiln. Several kilns have added whole tires at the feed end of the kiln so that burning occurs as the tires move down the kiln; this method is common in Europe.[4] However, many kilns in the U.S., particularly wet process kilns, have chains hanging down in the feed end of the kiln to enhance heat exchange. Such equipment forms a barrier to everything but finely ground materials, and precludes use of whole tires at the feed end. Kilns with preheaters provide the best environment for adding TDF or tires at the feed end, because significant preheating of the dry feed has occurred before the feed contacts the tire chips.

Tires have occasionally been used to supplement the primary precalciner fuel (usually coal), with mixed results. Florida Crushed Stone in Brookville, Florida, was feeding TDF into the preheater, but had to discontinue use because of plugging of the preheater (most likely due to oil condensate from the incomplete combustion of the tire chips). The company is in the process of installing a whole tire feeder with weight-belt, computer, variable rate belt, and triple gate chute to feed tires into the kiln.[10]

Southwestern Portland Cement in Victorville, California, not only adds TDF successfully to the preheater, but concurrently supplements the primary kiln fuel by mixing whole tires in the kiln feed.[16] Tire chips are added in the preheater, at the pyroclone (precalciner) unit, right after the tertiary air duct that brings hot air from the clinker cooler.[16] The chips burn quickly and go up the air stream into the preheater. Concurrently, whole tires are introduced into the feed end of the kiln with a double gate method. First, the tire is fed upright into a downward chute that slopes 30 to 40 degrees, so that it rolls down and stops at the second gate. The first gate closes and the second gate opens. The tire then rolls across the feed shelf and into the kiln. The double gate method reduces excess air introduction to and heat loss from the kiln.[16] Using both kinds of tires concurrently helps maximize the percent of fuel provided by tires. Whole tire use reduces coal used at the firing end of the kiln, but too many whole tires would provide too much heat in the kiln feed end. The TDF replaces coal used in the precalciner, but would not be used in the kiln, because they are more expensive than the whole tires.[16]

4.3 EMISSIONS, CONTROL TECHNIQUES AND THEIR EFFECTIVENESS

Testing results from three cement facilities and one lime kiln were evaluated for this report. The four facilities are: Ash Grove Cement, Durkee, Oregon; Holnam/Ideal Cement, Seattle, Washington; Calaveras Cement, Redding, California; and Boise Cascade Lime, Wallula, Washington.

Testing performed at Ash Grove Cement in Durkee, Oregon, on October 18 to 20, 1989, evaluated criteria pollutants, aliphatic and aromatic compounds, metals, and specifically examined chloride emissions to assess the possibility of dioxin formation.[20] Ash Grove's normal fuel is a mixture of gas and coal. As seen in Table 4-2, emissions of chloride were lower burning some TDF than with normal kiln firing, and; therefore, the Oregon Department of Environmental

Table 4-2. Effect of Burning 9 to 10 percent TDF in a Gas and Oil Co-fired Dry Process, Rotary Cement Kiln Controlled by an ESP[20]
Ash Grove Cement, Durkee, Oregon

Pollutant	Baseline, 0% TDF	9-10% TDF	Percent Change
Particulate, lb/MMBtu	0.969	0.888	-8
SO_2, lb/MMBtu	0.276	0.221	-20
CO, ppm	0.049	0.036	-27
Aliphatic compounds, lb/MMBtu	0.0011	0.0009	-18
Nickel, μg	30	DL[a]	NA[b]
Cadmium, μg	3.0	2.0	-33
Chromium, μg	30	DL[a]	NA[b]
Lead, μg	DL[a]	DL[a]	NA[b]
Zinc, μg	35	35	0
Arsenic, μg	0.2	0.2	0
Chloride, lb/hr	0.268	0.197	-26
Copper, μg	37	13	-65
Iron, μg	400	200	-50

[a] Below detection limit (DL).
[b] NA = not applicable.

4.6 CONCLUSIONS

The long residence time and high operating temperatures of cement kilns provide an ideal environment to burn tires as supplemental fuel. Results of several tests conducted on cement kilns while burning tires or TDF indicate the emissions are not adversely affected, but in many cases improve when burning tire.

Costs associated with modifying feed equipment to burn TDF in cement kilns is minor in most cases. Cost savings in fuel cost can be 70 to 90 percent of the cost of the primary fuel, depending on location and governmental incentives.

Overall, burning tires or TDF in cement kilns appear to be an economically satisfactory and environmentally sound way of not only disposing scrap tires, but also reclaiming their fuel value.

Dave Buff

SCRAP TIRE MANAGEMENT COUNCIL

Scrap Tire Use/Disposal Study

Final Report

A.T. Kearney

September 11, 1990

2.1 USE AS FUEL IN CEMENT KILNS

Abstract. Either whole tires or tire-derived fuel (TDF) can be used as supplemental fuel in cement kilns, depending on kiln size and technology. The technology is proven. At least two U.S. kilns are currently burning tires or TDF on an operating basis, with at least five additional kilns burning whole tires or TDF on an experimental basis. Burning scrap tires or TDF in kilns does not adversely effect environmental performance or product quality.

Kilns currently burning TDF have volume capacities in the 0.5 - 3 million tire per year range. At an average burning rate of 1.5 million tires per year, we estimate that cement kilns could use approximately 60 million tires per year as auxiliary fuel by 1995. This assumes switchover of about 40 kilns with optimal scrap tire burning configurations (kilns with preheaters/precalciners), out of a total kiln population of about 240.

Principal barriers to further scrap tire use in this industry are:

- Marginal cost advantage of TDF over typical kiln fuels (coal, petroleum coke); whole tires have a greater advantage, but can only be used in larger kilns with preheaters
- Air permit modification requirements for testing, and delays in issuing modifications
- Reliability of tire/TDF supply (risk to recovering capital investment)
- Certain kiln designs require costly feed system design modifications

2.1.1 Technology Description

Cement is manufactured by controlled heating of a mixture of finely ground calcareous material (e.g., limestone), argillaceous material (e.g, clay or shale), and siliceous material (e.g., sand) to about 1500-1600°C in a rotary kiln. These materials provide the basic elements required in cement: calcium, silicon, aluminum, and iron. The high temperatures in the kiln cause decarbonation of lime and subsequent reaction with silica to form calcium silicates. The calcium silicate "clinker" is ground with gypsum to produce cement.

Rotary kilns are long, inclined, cylindrical furnaces through which the cement ingredients move in approximately one to four hours. Due to their unusually high operating temperature and long exhaust gas residence times in the burning zone, cement kilns have the capacity to safely use a wide variety of fuels, including tires or tire-derived fuel (TDF). Whole tires or TDF are a good auxiliary fuel for coal or oil burning cement kilns because their:

- BTU value is comparable to or higher than typical coal used in making cement
- Nitrogen, sulfur, and ash content is lower than typical values for coal
- Steel content provides supplemental iron for the cement.

The high operating temperature in the kiln allows for complete combustion of tires and oxidation of steel beads or belts without adversely affecting kiln operation. Therefore, steel reinforcement does not need to be removed prior to tire use as fuel. In fact, because iron is a basic ingredient in cement, and the temperature in cement kilns is high enough for complete combustion of steel to iron oxide, burning whole tires or TDF with steel content reduces raw material costs for supplemental iron for some kilns.

Cement manufacture is energy intensive, requiring about 160 kwh of energy per ton of clinker produced. Typical energy costs are about $6.00 per ton of clinker.

The form in which tires can be used as an auxiliary fuel, either whole or as tire-derived fuel, is dependent upon the configuration of the kiln. Kilns with preheaters can utilize whole tires as fuel; kilns without preheaters can only use tire-derived fuel, typically in 2 inch x 2 inch to 4 inch x 4 inch size.

In either case, kilns must be equipped with separate fuel feed systems to utilize tires. Whole tires are fed to kilns using a mechanical feed system designed for tire charging. TDF may be fed using either mechanical or pneumatic systems. Mechanical feed systems have been successful in feeding TDF to cement kilns without any problems. Three of the cement kilns using TDF on an experimental basis used pneumatic blowers to feed TDF but experienced problems with feed line plugging caused by wire. Subsequently, one of these kilns has switched over to a mechanical feed system for TDF.

Typical feed rates in the cement kilns using TDF in U.S. vary from 2-3 tons per hour, with about 10-25% of the BTU value of the fuel being provided by the tires. Average annual tire consumption at a typical facility is about 2-3 million tires.

Two cement kilns in the U.S. use TDF as an auxiliary fuel, and another five use TDF on an experimental basis with intentions to install permanent systems. Tires have been widely used in Europe and Japan as an auxiliary fuel in cement kilns for several years.

U.S. Facilities

- Calaveras Cement, Redding, CA:
  - Annual consumption: 2 million tires
  - 25% of BTU value of fuel is provided by tires
  - Has used TDF as supplemental fuel for 5 years

- Arizona Portland Cement:
  - Approximate annual consumption: 3 million tires
  - Uses 2" x 2" TDF at a rate of 2T/hour, expected to rise to 4T/hour
  - About 10% of BTU value of the fuel is provided by tires

- Southwest Portland Cement Co., Fairborn, OH
  - Approximate annual consumption: 1.0 million tires
  - Whole tires used
  - About 6-8% of BTU value provided by tires
  - Modified air emissions permit

- Ashgrove Cement, Durkee, Oregon
  - Has used TDF on an experimental basis for the last two years
  - Expected approximate annual consumption: 0.4 million tires
  - Completed trial burns for emissions testing for modified permit
  - Public hearings for permit scheduled for October
  - Pneumatic blower used to feed TDF
  - Use 2" relatively wire free TDF

- Ideal Cement, Seattle, WA
  - Has used TDF on an experimental basis for the last six months
  - Expected approximate annual consumption: 1.4 million tires
  - Pneumatic blower used to feed TDF
  - 20% of BTU value of fuel provided by tires

- Use 2" relatively wire free TDF

- La-Farge Cement, Texas

  - Has used TDF on an experimental basis for two years
  - Expected approximate annual consumption: 1.3 million tires
  - Completed trial burns for emissions testing; permit issuance in process
  - Modified permit will place restraint only on percentage of tires allowed to be burnt (25% of the fuel)
  - 9-10% of BTU value of fuel provided by tires
  - Auger feed system
  - Use 2" relatively wire free TDF

- Gifford Hill Cement Co., Harleyville, S.C.

  - Experimental use of whole tires
  - Test burn in May 1990
  - Expected approximate annual consumption: 1.2 to 1.5 million tires per year
  - 20% of BTU value of fuel to be provided by tires
  - Joint venture with Oxford Energy and Radian Corp.

<u>Foreign Facilities</u>

- Heidelberger Cement Plant, W. Germany:

  - Total of 50,000 MT of tires burnt per year in 6 of its cement plants
  - Tires fed whole into the kilns
  - Percent of tires in the fuel feed varies from 10-20%

- Blue Circle Dry Process Cement Works, Hope, Sheffield, England

  - Annual consumption of tires: 4,700 tons (expected to increase to about 8,000 tons)
  - Whole tires used
  - 17% of fuel substituted by tires

- Sumitomo Cement Co., Japan

- Onada Cement Co., Japan

- Chichibu Cement Co., Japan

- Osaka Cement Co., Japan

In Japan, over 69,000 tons of tires are used per year as fuel in cement kilns. Typically, tires are used whole in Japanese kilns.

2.1.2 Environmental, Economic, and Volume Characteristics

Environmental Characteristics

- TDF use reduces NO_x emissions by 10%. No changes observed in SO_2 particulates and CO (as total C) emissions.
- No waste residues produced from TDF use.
- No formation of furans from TDF use due to extremely high temperatures in the kiln.

Use of tires as fuel in cement kilns typically reduces production of nitrogen oxides and does not adversely affect other components of kiln air emissions. This is due to the relative characteristics of waste tire materials compared to typical coals used in cement manufacture.

The average sulfur content of TDF is about 1.23% by weight, as compared to 1.59% for coal. The nitrogen content of TDF is also lower than that for coal, 0.24% by weight as compared to 1.76%. The ash content of TDF is about 4.7% by weight as compared to 6.23% by weight for coal. Sulfur in the TDF becomes incorporated into the calcining lime as $CaSO_4$, which is a raw material in the manufacture of cement. All of the ash gets absorbed in the clinker, so there are no residues from the use of TDF in cement kilns. No adverse effects on the quality of cement have been observed due to the use of TDF in cement kilns.

The Bavarian State Institute for Environmental Protection (W. Germany) concluded that the best process of disposing of waste tires is to use them as a fuel in cement kilns.

Tests on kilns in the U.S. demonstrate that existing emission controls on kilns should be sufficient to enable them to use TDF as an auxiliary fuel, while meeting the emission standards as long as the percentage of TDF used is no more than 20% of the heat value of the total fuel used in the kilns.

Economic Characteristics

- Estimated break even procurement cost = $30.00 - 45.00/ton