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OF A
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FOR
IOWA FLY ASH

FINAL REPORT
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IOWA DOT PROJECT HR-286
ERI PROJECT 1847

Sponsored by the Highway Division of the
Iowa Department of Transportation and the
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ENGINEERING RESEARCH INSTITUTE

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ABSTRACT

Iowa coal fired power plants currently produce over 350,000 tons of high calcium (ASTM Class C) fly ash each year. Most of the plants are of modern design and burn low-sulfur, sub-bituminous coal from the Powder River Basin near Gillette, Wyoming. The ashes produced from these plants are self-cementitious and exhibit 28-day paste compressive strengths ranging from 500 to 7000 psi. Past research had indicated that the paste strength of ash from a given power plant was highly variable over time. Standard ASTM test data of these same ashes, however, did not indicate any obvious differences in the ash being produced. This research project was conducted in an attempt to determine the cause of the paste strength variability and to develop test methods to more adequately reflect fly ash physical and chemical characteristics.

An extensive 3 year sampling and testing program was developed and initiated which incorporated fly ash from several Iowa power plants. Power plant design and operating data were collected. Results of ASTM physical and chemical testing show little variation with time, irrespective of fly ash source. Part of the reason for this is directly attributable to the ASTM composite method of sampling which tends to mask actual variability. The ASTM available alkali test underestimates the amount of alkalis that can be released from Iowa high-calcium fly ashes. Fly ash paste strength and other physical properties can change dramatically within short periods of time. This variability is directly linked to power plant maintenance schedules and to sodium carbonate coal pretreatment. Fly ash physical and chemical properties can change drastically immediately before and after a maintenance outage. The concentrations of sulfate bearing minerals in the fly ash increases sharply during shutdown. Chemical, mineralogical, and physical testing indicated that the sodium, sulfate bearing minerals, lime and tricalcium aluminate contents of the fly ashes play important roles in the development of hydration reaction products in fly ash pastes. The weak pastes always contained ettringite as the major reaction product. The strong pastes contained straetlingite and monosulfoaluminate as the major reaction products along with minor amounts of ettringite. Recommendations for testing procedure changes and suggested interim test methods are presented in the report.

INTRODUCTION

Iowa coal fired power plants currently produce over 350,000 tons of high-calcium (ASTM Class C) fly ash each year. These fly ashes tend to be highly reactive with water, and hence, they are often referred to as self-cementitious fly ashes. The potential for utilization of these fly ashes has been severely hampered by a lack of knowledge concerning their chemical and physical properties. To date, nearly all of the high-calcium fly ash used in Iowa has been utilized as a mineral admixture in portland cement concrete. However, production of such fly ash greatly exceeds its utilization and thus, much of the fly ash must be disposed of in landfills. The goal of this research project has been to actively pursue the characterization of these high-calcium fly ashes in the hope that increased knowledge of their physical and chemical properties will lead to increased utilization. We sincerely believe that fly ashes are a resource that should be recycled rather than a by-product that must be disposed of.

RESEARCH APPROACH

Background

Research conducted under project HR-225 lead to the knowledge that the elemental composition of Iowa fly ashes remained relatively consistent over time [1]. These results verified the findings of an earlier in-house Iowa Department of Transportation (IDOT) research project on fly ash variability [2]. However, the in-house IDOT research project also indicated that the compressive strength of fly ash mortar cube specimens exhibited extreme variability as a function of sampling date. Isenberger suggested that further work should be done to confirm the observations because the experimental methodology was subject to "a significant amount of operator variability" [2]. Hence, IDOT personnel continued molding water-sand-fly ash mortar cubes in accordance to Iowa Test Method No. 212, and they continued to observe erratic strength behavior. Results of IDOT tests performed on fly ash from Ottumwa generating station are shown in Figure 1. Preliminary work at the Materials Analysis and Research Laboratory (MARL) had also indicated a significant amount of variability in the compressive strength of Class C fly ash pastes. Thus a testing program was initiated to monitor the physical and chemical characteristics of these Class C fly ashes as a function of time.

Iowa Fly Ash Production and Sampling

Iowa power plants

The general locations of the power plants studied during this investigation are shown in Figure 2. Technical and operating details are summarized in Tables I and II, respectively. General information sheets for these power plants plus several additional (smaller) generating stations can be found in Appendix A.

In general, all of the power plants studied were of modern design and they all burned low-sulfur, sub-bituminous coal from the Powder River Basin near Gillette, Wyoming. Three of the power plants routinely added sodium carbonate to the raw coal feed to enhance the performance of their electrostatic precipitators.

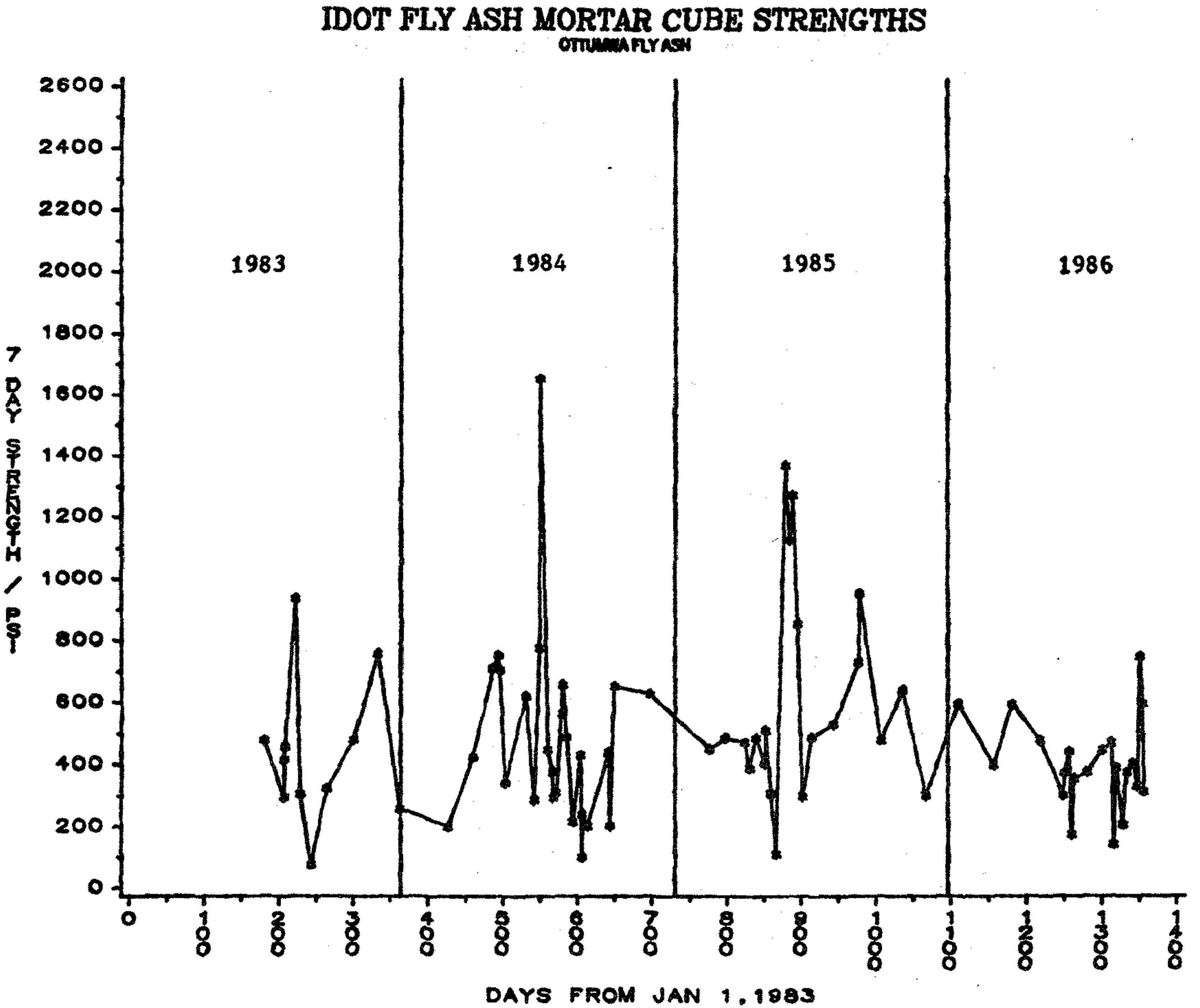

Figure 1. IDOT seven day mortar cube strengths for Ottumwa fly ash.

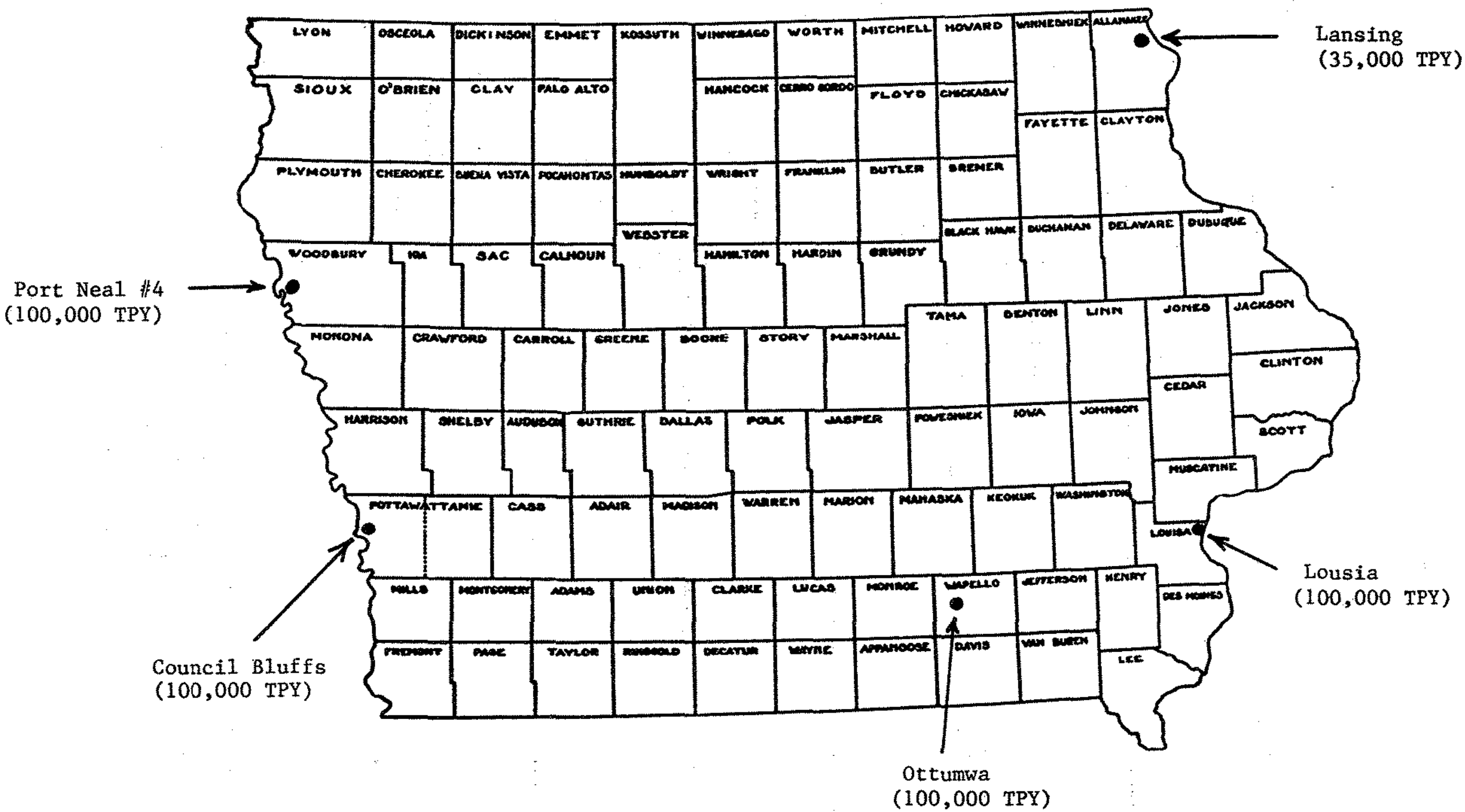

Figure 2. General Locations and ash production rates for the power plants studied in this project.

TABLE I
Power plant technical details

Power Plant--------------->

	Council Bluffs #3	**Lansing #4**	**Louisa**	**Ottumwa**	**Port Neal #4**
Boiler Type	Babcock-Wilcox	Riley Stoker	Babcock-Wilcox	Combustion Engineering	Foster Wheeler
Maximum Generating Capacity (net MW)	700	260	650	675	600
Year on Line	1978	1977	1983	1981	1979
Fly Ash Silo Storage Capacity (tons)	4000	300	3500	3500	5000
Precipitator type	Hot-ESP	Hot-ESP	Hot-ESP	Hot-ESP	Currently being changed to cold ESP
Additive used to enhance ESP performance (lbs/ton of coal)	Sodium Carbonate (1 lb/ton)	NONE	NONE	Sodium Carbonate (1 - 3 lbs/ton)	Sodium Carbonate prior to 12/1/88 Future use uncertain

Hot-ESP = hot side electrostatic precipitator

TABLE II
Power plant operating details

Power Plant-------------->

	Council Bluffs #3	Lansing #4	Louisa	Ottumwa	Port Neal #4
Coal Source (mine)	PRB, Wyoming (Eagle Butte - Bell Ayr)	PRB, Wyoming (Eagle Butte - Bell Ayr)	PRB, Wyoming (Cordero)	PRB, Wyoming (Cordero)	PRB, Wyoming (Caballo) (Rawhide prior to 1987)
Date when current coal contract expires	Dec. 31, 1997	Approx. 1996	Dec. 31, 2002	Approx. 2000	Dec. 31, 1998
Annual ash prod. (tons/yr)	100,000	25,000	72,000 (for 1986)	83,000 (for 1987)	100,200 (for 1987)
Approx. percent ash sold	16	40	100 (for 1986)	43 (for 1987)	36 (for 1987)
Typical Maintenance Cycle (tentative, 1988)	September for 4 weeks	Feb 28-Mar 5 May 29-Jun 11 Aug 28-Sep 3 Nov 27-Dec 10	Mid-Sept. thru Oct.	4/1 - 4/22/88 also 2 weeks in October	June 3 thru Jun 10 Sep 4 thru Nov 25
Start-up fuel	Fuel oil	Fuel oil	Natural gas or fuel oil	Fuel oil	Fuel oil

PRB = Powder River Basin

Fly ash sampling scheme

Fly ashes from Council Bluffs, Lansing, Ottumwa and Neal 4 power plants were selected to represent the range of Class C fly ashes available in Iowa. Samples of these ashes, for testing and use on the project, were supplied through the cooperation of Mr. Lon Zimmerman of Midwest Fly Ash and Materials, Inc., Sioux City, IA.

The sampling procedure that was used is described in ASTM C 311 [3]. Briefly, grab samples were taken from each ash truck (approximately 20 tons) exiting the plant. After 20 grab samples were obtained, they were combined to form a composite sample representing 400 tons of fly ash. This sample was then tightly sealed in a clean one gallon paint can and mailed to the MARL.

Each sample, which represented a 400 ton lot of fly ash, was subjected to physical testing as per ASTM C 311. After five such samples were received, a chemical - physical test sample was made. The chemical - physical test sample was made by combining equal portions from each of the 400 ton lot samples, and hence, represented 2000 tons of fly ash. These chemical - physical test samples are referred to as "composite" samples by the ASTM.

After the first year of this project, it was observed that a power plant's operating conditions and maintenance cycle could significantly influence the chemical and physical properties of its fly ash. Hence, two very similar power plants (Ottumwa and Louisa) were chosen to study in detail. Grab samples of each fly ash were taken about three or four times per week for a duration of about four months. None of the samples were composited. Again, all of the samples were tightly sealed in metal paint cans and stored until they were collected from the power plants by MARL personnel. A total of about 100 samples were obtained from the two power plants.

Fly Ash Testing Scheme

Two fly ash testing schemes were utilized in this study. The first method utilized methods similar to those described in ASTM C 311-77 [3]. The second testing scheme was developed to monitor the self-cementing properties of fly ash pastes. A diagram of the overall (physical) testing scheme is shown in Fig. 3.

The two major differences between the testing methods used in this study and those specified in ASTM C311-77 were: (1) a portland cement-fly ash mortar cube test was used in place of the lime-fly ash mortar test to access the 7-day pozzolanic activity of the samples; (2) quick chemical methods (x-ray techniques) were used instead of the gravimetric and/or volumetric methods specified by the ASTM. The lime pozzolan test was replaced with a cement pozzolan test because we have found that the lime pozzolan test appears to be biased against Class C fly ashes [4]. Others have also noted this fact [5]. The change from classical (ASTM) chemical methods to x-ray methods was made to allow a throughput of a large number of samples. The analytical details of the chemical methods used in this study will be described later in this report.

The fly ash paste testing scheme developed during this research program was used to study the compressive strength, volume stability, setting time and heat evolution characteristics of fly ash-water mixtures. The repeatability of the fly ash testing scheme was studied in detail. A multi-day, multi-operator test program indicated that the procedures, as

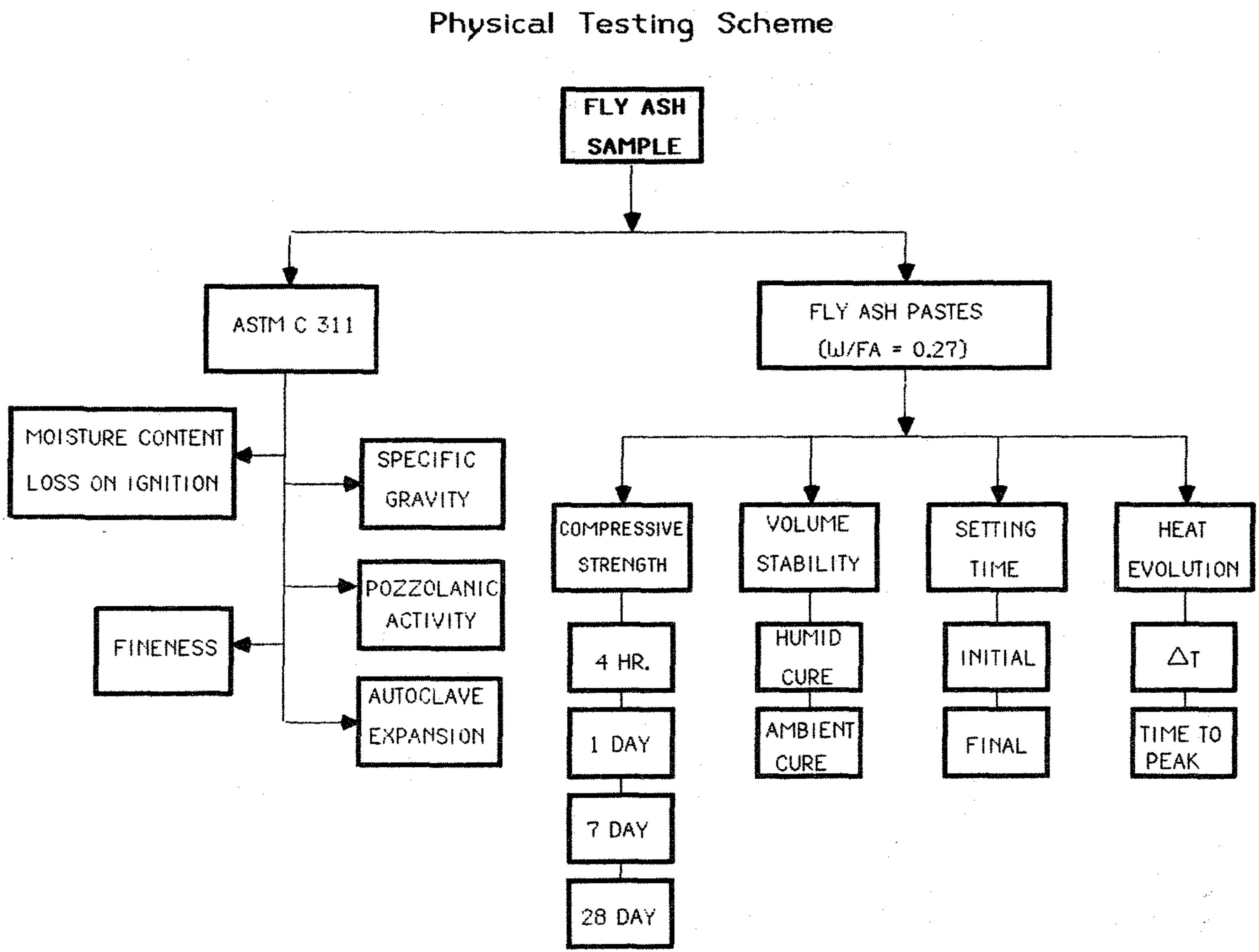

Figure 3. Diagram of the physical testing scheme.

defined below, were adequate for monitoring the physical characteristics of the fly ash pastes. The results obtained from the repeatability test program are summarized in Appendix B.

All of the fly ash paste mixes (except for the heat evolution test) were prepared at a water/fly ash ratio of 0.27. A typical batch consisted of 2000 grams of fly ash and 540 grams of deionized water. Hobart laboratory size mixers were used throughout the study. The paste mixing procedure consisted of: (1) adding water to the fly ash; (2) mixing at low speed for 30 seconds; (3) quickly scraping down the residue on the sides of the mixing bowl; (4) mixing at medium speed for 30 seconds. This mixing procedure produced a fluid paste that could be poured into the various molds for the different tests. A small vibration table was used to eliminate air voids from the fluid compressive strength and volume stability specimens.

The general details of the physical tests used during this project can be summarized as follows:

1. Compressive strengths were measured on one inch cube specimens tested after four hours, and 1, 7 and 28 days of moist curing. Three cubes were broken for each curing period. The cubes were loaded at a rate of 4000 pounds per minute until failure.

2. Volume stability characteristics were measured on 1 x 1 x 11 inch prisms (i.e., normal autoclave bar molds with gage studs positioned to maintain an effective gage length of 10 $\pm$ 0.1 inch). Two specimens were cast from each mix. One specimen was moist cured, the other was cured under ambient room conditions. Length measurements were taken periodically in accordance with ASTM C 490 [3].

3. Setting properties were evaluated using a soil pocket penetrometer. Test specimen container size was about 4.5 inches in diameter by 1 inch in depth. Penetrometer readings, in tons per square foot, were taken as a function of time. Most of the fly ash pastes set so quickly that readings needed to be taken at about 1 to 2 minute intervals for the first 15 minutes of the test. Hence, the specimens were not stored in a humid cabinet between readings. Initial set was defined as the first discontinuity in the pressure versus time curve. Final set was arbitrarily defined as 4.5 tons per square foot penetrometer bearing pressure.

4. Heat evolution of fly ash-water mixtures was monitored using a conduction calorimeter. Test specimens consisted of 28.5 grams of fly ash and 10.0 grams of deionized water. The specimens were briefly mixed by hand before being inserted into the calorimeter. The calorimeter temperature was displayed directly on a chart recorder so a continuous record of temperature versus time was obtained for each specimen.

Other Analytical Techniques

X-ray fluorescence

X-ray fluorescence spectrometry (XRF) was used to identify and quantify the major and minor elements present in the fly ash samples. A Siemens SRS 200 sequential x-ray spectrometer was used throughout this study. The spectrometer was fully computer controlled via an LC 200 interface and a PDP 11/03 microcomputer. The technical details of the quantitative routines that have been utilized at the Materials Analysis and Research Laboratory have been described elsewhere [6,7]. Briefly, the XRF method is a comparative analytical technique. Samples of known elemental composition (i.e., standards) are used to calibrate the spectrometer for the elements of interest (Si, Al, Fe, Mg, Ca, K, Na, P, S and Ti in this instance).

After calibration, specimens of unknown composition are analyzed and elemental concentrations are estimated. Existing software allows for the correction of interelement effects via multiple regression techniques and correction for x-ray tube drift [8]. The absolute accuracy of the method was not tremendous because of lack of good standard reference materials for calibration. We estimate that the relative error of our fly ash analyses was about 3 to 5% of the amount reported for major elements (reported as oxides), and about 5 to 10% for minor elements. However, the overall precision of the method (i.e., repeatability of sample preparation and analysis) was very good. Typically, assays of duplicate samples were repeatable to 0.2% (absolute concentration) for major elements and 0.05% (absolute) for minor elements.

X-ray diffraction

X-ray diffraction (XRD) was used to determine the crystalline compounds present in the various fly ash specimens. A Siemens D500 diffractometer was used throughout this study. The diffractometer was fully computer controlled via an LC 500 interface and a PDP 11/23 microcomputer. A copper x-ray tube was used for all analyses. Monochromatic radiation was obtained via a diffracted beam monochromater and electronic discrimination (pulse height analysis/discrimination). The diffractometer was equipped with medium resolution slits and it was operated in step scan mode.

Thermal methods

Thermal analysis methods, such as differential thermal analysis (DTA) and thermogravimetric analysis (TGA), were also used to characterize specific fly ash samples. Typically, since fly ash is the by-product of a combustion process, the information obtained from DTA-TGA is of limited use for studying raw (as-received) fly ashes. However, the method is excellent for studying fly ash paste hydration products. The method has also been a useful tool in the study of the different particle size fractions of fly ash.

Miscellaneous methods

Two additional methods were used during this study to enhance the characterization of Class C fly ashes. The first method employed was the Blaine fineness test. The second method consisted of separating fly ash into specific size fractions by sonic sifting.

The Blaine permeability method is most commonly used to measure the specific surface of portland cement [9]. The method has also been applied to fly ashes [10] and other pozzolanic type admixtures [11] by making proper modifications. Actually, the Blaine permeability method was routinely used to estimate the specific surface of fly ash samples until 1973 [12]. The method was dropped from the routine testing program because the carbon content significantly influenced the results of the test [10,12]. However, the residual carbon content (loss on ignition) of the Class C fly ashes investigated in this study was very low when compared to a typical Class F fly ash; hence, we expect little bias from the carbon content of our Class C fly ashes. The Blaine fineness tests were conducted in accordance to ASTM C 204-84 [13]. Specific surface of a fly ash sample was obtained from equation 7 of ASTM C 204; the coefficient *b* of the equation was determined as specified in the Appendix of C 204. The density of the fly ash specimen was determined as specified in ASTM C 311 [3].

Several fly ashes were subjected to particle size separation by using an Allen-Bradley Sonic sifter (model L3P). The apparatus uses waves of sonic frequency to agitate particles on the sieves and thus, produces relatively quick and accurate size separation. Electroformed nickel metal sieves with nominal sizes of 45, 20 and 10 microns were used throughout this study. The fly ash particles passing through all of the sieves were also collected for subsequent analysis. Hence, four particle size fractions were obtained from the sonic sifter: 1) particles greater than 45 microns (denoted as >45); 2) particles smaller than 45 but larger than 20 microns (denoted as >20); 3) particles smaller than 20 but greater than 10 microns (denoted as >10); 4) particles smaller than 10 microns in diameter (denoted as <10).

RESULTS AND DISCUSSION

Results of ASTM Physical and Chemical Testing

The results of chemical and physical testing (also referred to as "total analysis") and of physical testing (also referred to as "routine analysis") of fly ashes obtained from Council Bluffs (CBF), Lansing (LAN), Ottumwa (OTT or OGS) and Neal 4 (NE4) power plants are summarized in Tables III and IV, respectively. Each table lists the mean, $\overline{X}$, standard deviation, S, the maximum observed value, MAX, the minimum observed value, MIN, and the number of samples, n. Data from each power plant has been analyzed separately and it represents fly ash obtained from 1983 through 1987.

A year by year statistical analysis of the total analysis samples (mostly composite samples) is summarized in Table I (Appendix C). Similar information concerning the physical test samples (routine tests) is summarized in Table II (Appendix C). Raw data is listed in a reduced format in Table III (Appendix C). Plots of the results of both the physical and chemical testing programs are shown in Figures 1 through 64 (Appendix C). The plots illustrate the uniformity of the test results obtained during the 5 year monitoring period. It is pertinent to mention that the results of both the pozzolanic activity test (7 and 28 day cement pozz.) and the autoclave expansion test are strongly influenced by the cement used when performing the tests. Hence, the physical and chemical properties of cements used during this study are summarized in Table IV (Appendix C).

All of the fly ash samples tested during this phase of the study (189 total analysis samples and 685 physical test samples, taken over a 5

TABLE III

Summary of results of chemical-physical testing of fly ashes from 1983 through 1987.

Power plant→ Test	Council Bluffs (n=37) $\bar{X}$	S	MAX	MIN	Lansing (n=31) $\bar{X}$	S	MAX	MIN	ASTM Specifications
Moisture content	0.07	0.05	0.21	0.00	0.04	0.03	0.14	0.00	3.0 max.
Loss on ignition	0.40	0.14	0.76	0.19	0.45	0.19	0.77	0.20	6.0 max.
Fineness	11.5	2.3	19.1	7.7	11.8	2.3	16.8	6.6	34 max.
7 day Pozzolan	89	5	99	80	89	4	99	80	
Autoclave Exp.	0.11	0.03	0.15	0.05	0.10	0.03	0.17	0.04	0.8 max.
Specific Gravity	2.70	0.04	2.76	2.60	2.78	0.02	2.82	2.72	
28 day Pozzolan	93	8	117	81	90	7	103	75	75 min.
H2O required	90	2	96	86	91	3	100	88	105 max.
SiO_2	31.2	1.9	35.3	27.6	31.9	2.6	41.2	29.2	sum
Al_2O_3	16.6	0.7	18.0	15.1	16.2	0.7	17.6	14.7	≥ 50
Fe_2O_3	5.6	0.7	7.1	4.7	5.9	0.4	6.7	5.2	≤ 70
SO_3	3.25	0.50	4.37	2.22	3.91	0.51	4.88	2.84	5.0 max.
CaO	28.6	1.6	32.4	25.7	28.3	1.4	30.4	25.3	
MgO	5.92	0.61	6.82	4.90	5.97	0.55	7.30	5.13	
P_2O_5	1.04	0.29	1.71	0.60	0.92	0.18	1.33	0.61	
K_2O	0.28	0.06	0.38	0.18	0.29	0.08	0.54	0.2	
Na_2O	1.82	0.20	2.29	1.45	1.89	0.26	2.33	1.14	
Avail. Alkali	1.29	0.14	1.62	1.02	1.38	0.18	1.70	0.88	1.5 max.

TABLE III (cont.)

Summary of results of chemical-physical testing of fly ashes from 1983 through 1987.

Power plant→ Test	Neal 4 (n=46) $\bar{X}$	S	MAX	MIN	Ottumwa (n=75) $\bar{X}$	S	MAX	MIN	ASTM Specifications
Moisture content	0.04	0.02	0.08	0.00	0.03	0.03	0.09	0.00	3.0 max.
Loss on ignition	0.29	0.07	0.50	0.16	0.27	0.06	0.42	0.17	6.0 max.
Fineness	11.5	2.1	15.9	4.9	10.1	0.8	13.1	8.3	34 max.
7-day Pozzolan	91	6	104	79	92	5	104	76	
Autoclave Exp.	0.07	0.02	0.11	0.02	0.05	0.03	0.10	-0.01	0.8 max.
Specific Gravity	2.61	0.08	2.74	2.42	2.64	0.04	2.72	2.54	
28-day Pozzolan	96	7	113	82	97	8	112	78	75 min.
H2O required	90	2	100	86	89	2	96	83	105 max.
SiO_2	34.5	2.3	41.1	30.0	33.0	2.2	38.2	29.5	sum
Al_2O_3	16.5	1.1	18.5	14.9	18.6	0.7	20.5	17.3	≥ 50
Fe_2O_3	5.8	0.4	6.3	4.5	5.5	0.4	6.4	4.8	≤ 70
SO_3	3.02	0.79	4.57	1.84	2.38	0.50	3.68	1.37	5.0 max.
CaO	25.4	1.6	28.1	22.1	24.9	1.0	27.3	22.3	
MgO	5.39	0.62	6.32	4.35	4.72	0.23	5.28	4.28	
P_2O_5	1.04	0.29	2.09	0.72	1.62	0.31	2.31	0.90	
K_2O	0.33	0.08	0.64	0.21	0.38	0.04	0.48	0.27	
Na_2O	2.25	0.24	2.84	1.78	2.27	0.46	3.28	1.33	
Avail. Alkali	1.44	0.31	1.84	0.80	1.55	0.37	2.62	0.84	1.5 max.

TABLE IV

Summary of results of physical testing of fly ashes from 1983 through 1987.

Power plant→	Council Bluffs (n=112)				Neal 4 (n=153)				ASTM
Test	$\bar{X}$	S	MAX	MIN	$\bar{X}$	S	MAX	MIN	Specifications
Moisture content	0.09	0.12	0.85	0.01	0.04	0.03	0.17	0.00	3.0 max.
Loss on ignition	0.43	0.20	1.58	0.17	0.30	0.06	0.47	0.16	6.0 max.
Fineness	11.3	1.9	18.3	7.6	12.1	1.9	17.5	8.0	34 max.
7 day Pozzolan	89	6	103	74	91	6	107	77	
Autoclave Exp.	0.10	0.03	0.15	0.03	0.07	0.02	0.13	0.02	0.8 max.
Specific Gravity	2.70	0.04	2.78	2.54	2.59	0.09	2.73	2.36	

Power plant→	Lansing (n=61)				Ottumwa (n=359)				ASTM C 618
Test	$\bar{X}$	S	MAX	MIN	$\bar{X}$	S	MAX	MIN	Specifications
Moisture content	0.04	0.03	0.15	0.00	0.03	0.02	0.13	0.00	3.0 max.
Loss on ignition	0.44	0.18	0.96	0.13	0.26	0.07	0.54	0.10	6.0 max.
Fineness	11.1	2.1	15.8	7.1	10.1	1.1	14.5	7.4	34 max.
7 day Pozzolan	87	5	98	74	93	7	129	74	
Autoclave Exp.	0.09	0.03	0.17	0.04	0.05	0.03	0.11	-0.01	0.8 max.
Specific Gravity	2.78	0.02	2.82	2.72	2.64	0.05	2.75	2.47	

year interval) passed the specifications listed in ASTM C 618 [3,14]. In fact, few of the samples even approached the specification limits (see the MIN and MAX columns in Tables III and IV). Hence, one may assert that we are currently "overtesting" our fly ash sources. This may be so. However, we believe that the existing ASTM fly ash tests and sampling scheme may not adequately identify "bad" fly ash, especially if a power plant is approaching a maintenance shutdown. The major problem with the current ASTM methods is that they were created for Class F fly ashes. Class C ashes, which are enriched with alkaline earth elements (i.e., Ca, Mg, Sr and Ba), are drastically different from Class F ashes. The major items of the current ASTM fly ash tests that we are concerned about are: (1) the composite sampling scheme, (2) the available alkali test, (3) the pozzolanic activity test, and (4) the wet-sieved fineness test.

The composite sampling scheme was described earlier in this report. A composite sample represents 2000 tons of fly ash and it consists of a linear combination of five physical test samples (each representing 400 tons). Our test results indicate that the compositing process tends to smooth out (or eliminate) extreme values. Both the physical test samples and the composite samples were subjected to the same basic tests (i.e., moisture content, loss on ignition, fineness, specific gravity, 7-day pozzolanic activity and soundness). Hence, by comparing the coefficient of variation and the range variation statistics for these tests, one observes that the compositing scheme tends to reduce the variation in the test results. This trend is illustrated in Figures 4 and 5. The line of equality depicted in these figures simply indicates the trend that one would expect if both series of tests produced exactly the same results. The mean values (average test result) were the same for both series of tests. This

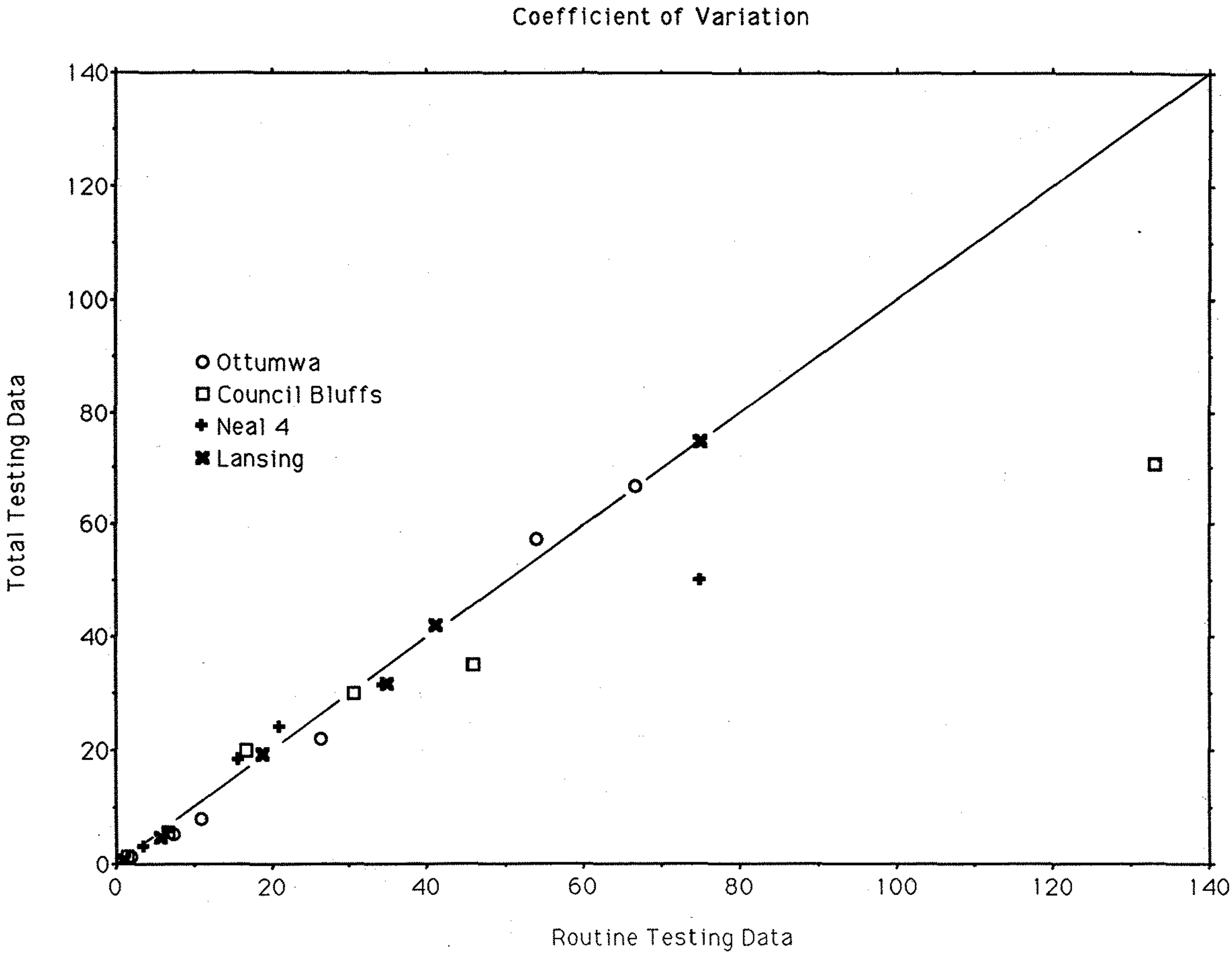

Figure 4. **Coefficient of variation of chemical-physical test data (composite samples) versus physical test data.**

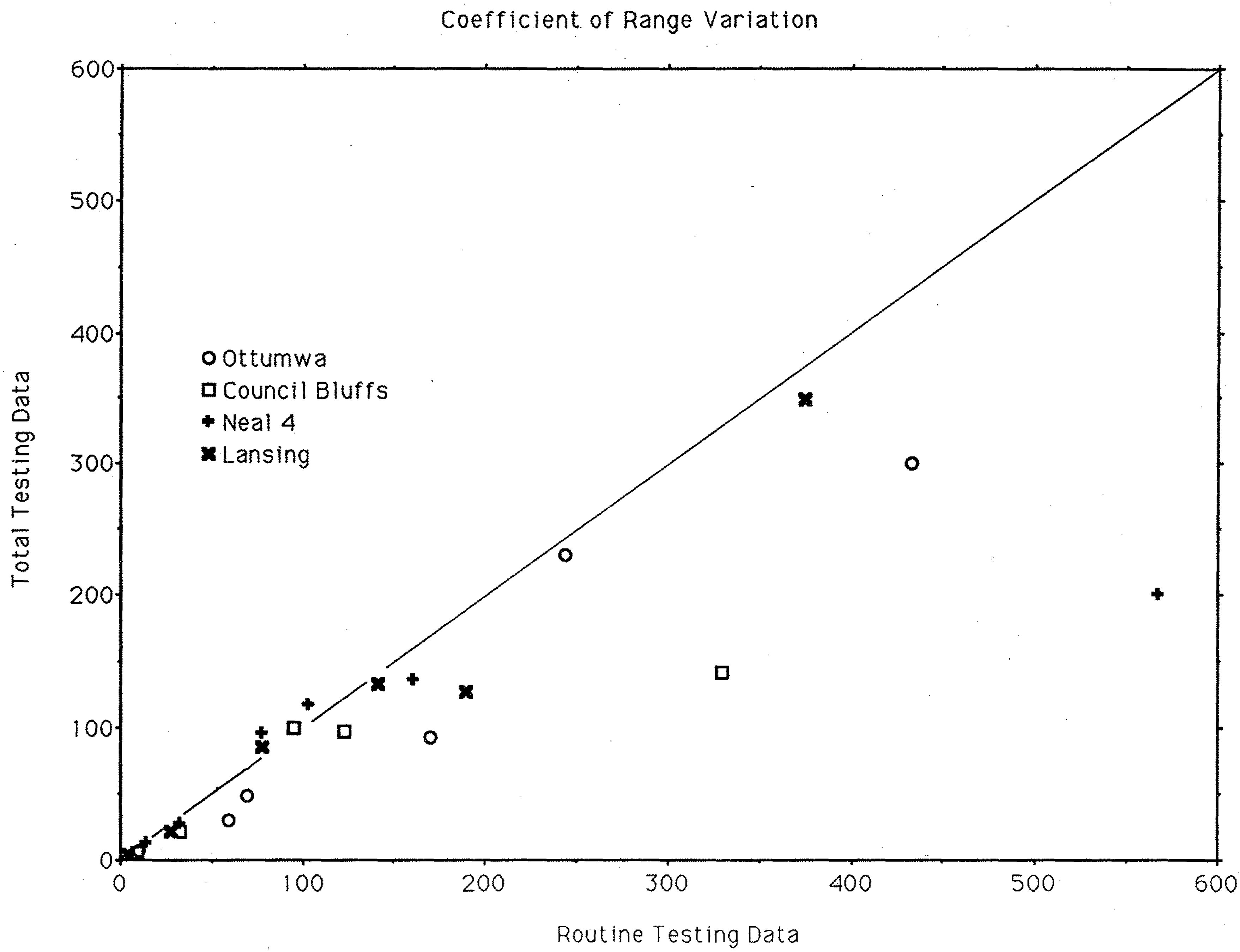

Figure 5. Coefficient of range variation of chemical-physical test (composite samples) versus physical test data.

smoothing process is not totally bad because it also indicates that the composite samples should quickly produce a good estimate of the properties of an "average" fly ash sample. However, the penalty paid for this information is rather severe because the compositing step makes it difficult to predict the true variability present in a given source of fly ash. Hence, one must conclude that the chemical information presented in Table III is biased. The mean test results are reasonable but the standard deviation and range statistics are at best a lower bound to the true variation that exists in the various power plants. This observation is in agreement with our earlier work on fly ash variability [1].

The alkali content of fly ash from several of the power plants is of great concern to us. The concern stems from the potential problems that may occur when using the fly ashes in portland cement concrete, however, we have also observed poor performance in paste specimens because of excessive alkali content. Cement alkalis normally have a potential to adversely influence the long term strength of concrete [15], cause physical disruption by reacting with alkali sensitive aggregates [16] or to cause unsightly efflorescence on the surfaces of finished products. Fly ash alkalis may (or may not) lead to similar problems; more research is definitely needed in this area. Whatever the case, we first must adopt a new test for measuring the alkali content of Iowa fly ashes because the current test, the available alkali test, is not adequate [17].

The major problem with the available alkali test is that it underestimates the amount of alkali that may be leached into solution [17]. The test results (see Figure 6) clearly indicate that the 28 day curing period simply is not long enough to extract all the alkalis into solution. This same observation was made in 1956 by Brink and Halstead [18],

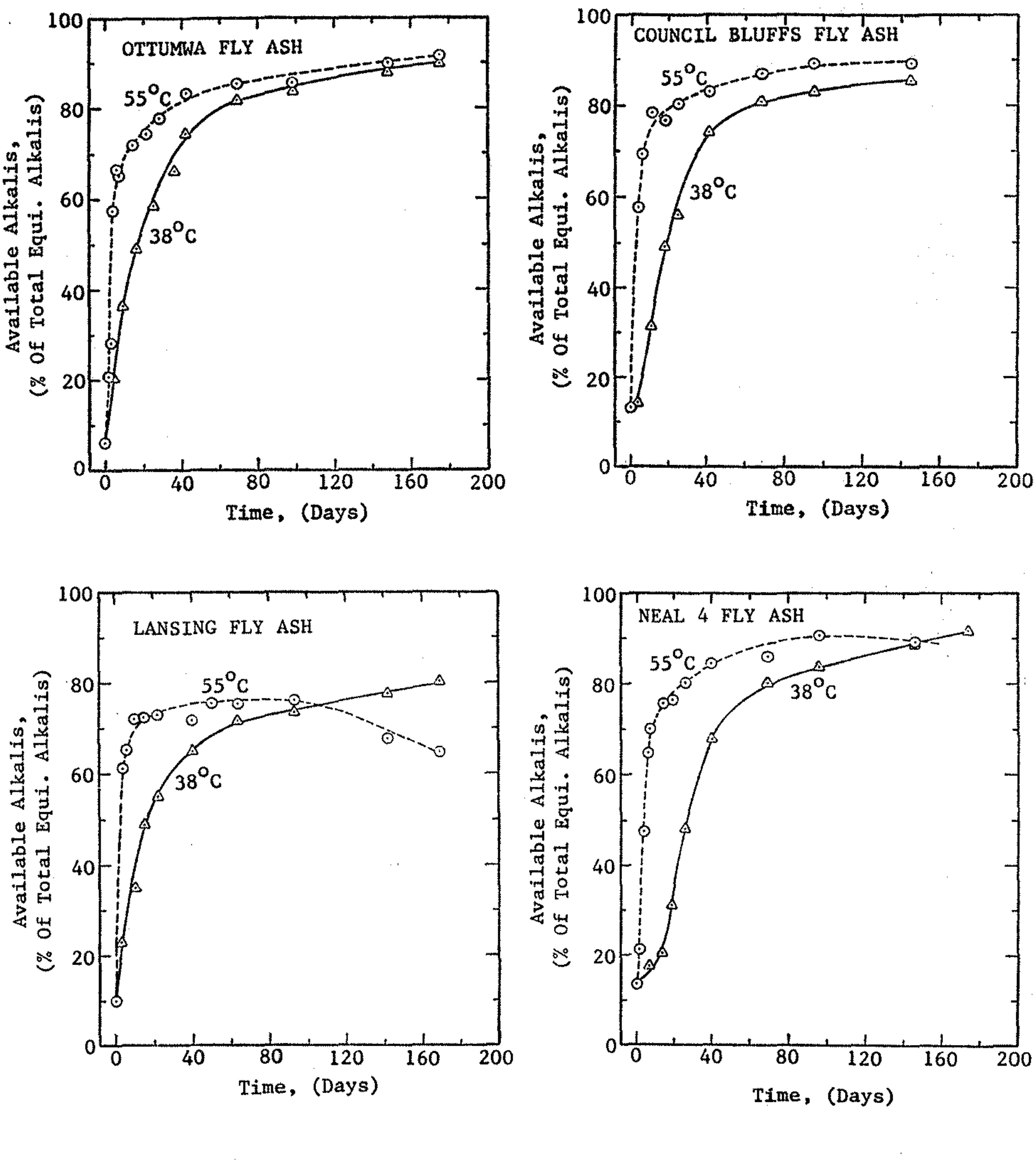

Figure 6. Effect of temperature and time on the mobilization of available alkalis for four Iowa fly ashes.

although their work pertained only to Class F fly ashes. Such discrepancies may help to explain why researchers typically find a poor correlation between available alkali test results and the alkali induced expansion observed in laboratory test specimens [19]. We suggest the measurement of the total alkali content of fly ash in place of the available alkali test.

The ASTM no longer requires a pozzolanic activity test for the physical test samples (i.e., 400 ton lots) of Class C fly ashes [14]. Only the chemical-physical test samples are subjected to a 28 day cement pozzolan test. Class F fly ashes are still required to be tested for pozzolanic activity (lime pozzolan test) on a sample by sample basis. The exact rationale behind this change is not clear; however, our test results (see Tables III and IV) indicate that the change should have little influence on the process of accepting or rejecting a given lot of fly ash. All of the Class C fly ashes tested at the MARL between 1983 and 1987, behaved satisfactorily in the cement pozzolanic activity test. However, as we alluded to earlier, testing only composite samples (i.e., 2000 ton lots) may severely hinder the process of identifying if a power plant is producing subpar fly ash, especially if one must wait 28 days for test results.

The wet-sieved fineness test is another example of a test that may not be directly applicable to the analysis of Iowa Class C fly ashes. These Class C fly ashes contain a significant portion of water soluble compounds which may simply be washed into solution and through the sieve. Class C fly ashes contain very little residual carbon, so the test really only measures the coarse quartz particles in the fly ash. The determination of a particle size distribution curve would perhaps correlate better to the observed physical behavior of fly ash pastes or to the pozzolanic activity of fly ash-cement mortars and concretes.

Results of Fly Ash Paste Testing

A statistical summary of the results obtained from the fly ash paste testing program is given in Table V. Raw data, results of correlation studies and additional plots of the various fly ash properties versus sampling date can be found in Appendix D.

The results of compressive strength tests of 7-day old paste specimens made from Ottumwa, Council Bluffs and Lansing fly ashes are shown in Figures 7, 8 and 9, respectively. All of these figures illustrate that the paste specimens had large variations in compressive strength as a function of sampling date. Paste specimens that were moist cured for other periods of time also exhibited nearly identical trends (see Appendix D). These test results are in agreement with those reported by IDOT personnel. Hence, one must conclude that the unexplained test variability reported by Isenberger [2] was due to changes in fly ash properties rather than simply poor test procedures. Also, both IDOT and MARL test results indicate how quickly the compressive strength of fly ash paste (or mortar) specimens can change as a function of sampling date. The variations in the compressive strength of pastes made from Ottumwa fly ash appear to be cyclical in nature (see Figure 7) and this trend will be discussed in detail later in this report. Figure 10 illustrates the influence of moist curing time on the compressive strength of several fly ash paste specimens; it also illustrates the tremendous range in compressive strengths that was observed during this project. Many of the fly ash samples studied during this project behaved similar to hydraulic cements.

Typical results obtained from the volume stability testing are shown in Figure 11. In general, most of the fly ash paste specimens

TABLE V

A summary of fly ash paste statistics

Test	Council Bluffs (n=50)				Lansing (n=43)				Ottumwa (n=153)			
	$\bar{X}$	S	MAX	MIN	$\bar{X}$	S	MAX	MIN	$\bar{X}$	S	MAX	MIN
Compressive Strength (psi)												
4 hour	1127	365	2057	475	1955	524	2824	78	314	116	613	33
1 day	1483	454	2624	580	2847	1061	5074	316	549	366	2467	112
7 day	2409	1068	5669	820	4041	1443	6869	792	1084	887	4721	132
14 day*	3033	1355	5325	1011	4499	1622	8196	772	1198	995	5221	173
28 day	3769	1625	6681	921	5187	1729	8180	787	1393	1198	6038	148
56 day*	4807	996	6933	3402	6070	2113	9335	3024				
% Expansion @ 28 Days												
Air cured	-0.05	0.02	0.01	-0.10	-0.09	0.04	-0.02	-0.17	-0.04	0.03	0.12	-0.14
Humid cured	0.04	0.06	0.31	-0.03	0.04	0.04	0.16	-0.01	0.00	0.03	broke	-0.04
Setting time (minutes)												
Initial set	11	4	19	4	8	3	17	2	21	12	97	8
Final set	14	5	26	7	12	7	50	4	33	22	198	12
Heat Evolution												
Time to peak (min)	29	11	58	13	26	9	56	15	40	14	82	11
ΔT (°C)	11	2.6	18	8	14	3.0	19	4	5	1.5	8	0.3

* n was less than the value denoted above for these tests, see the raw data.

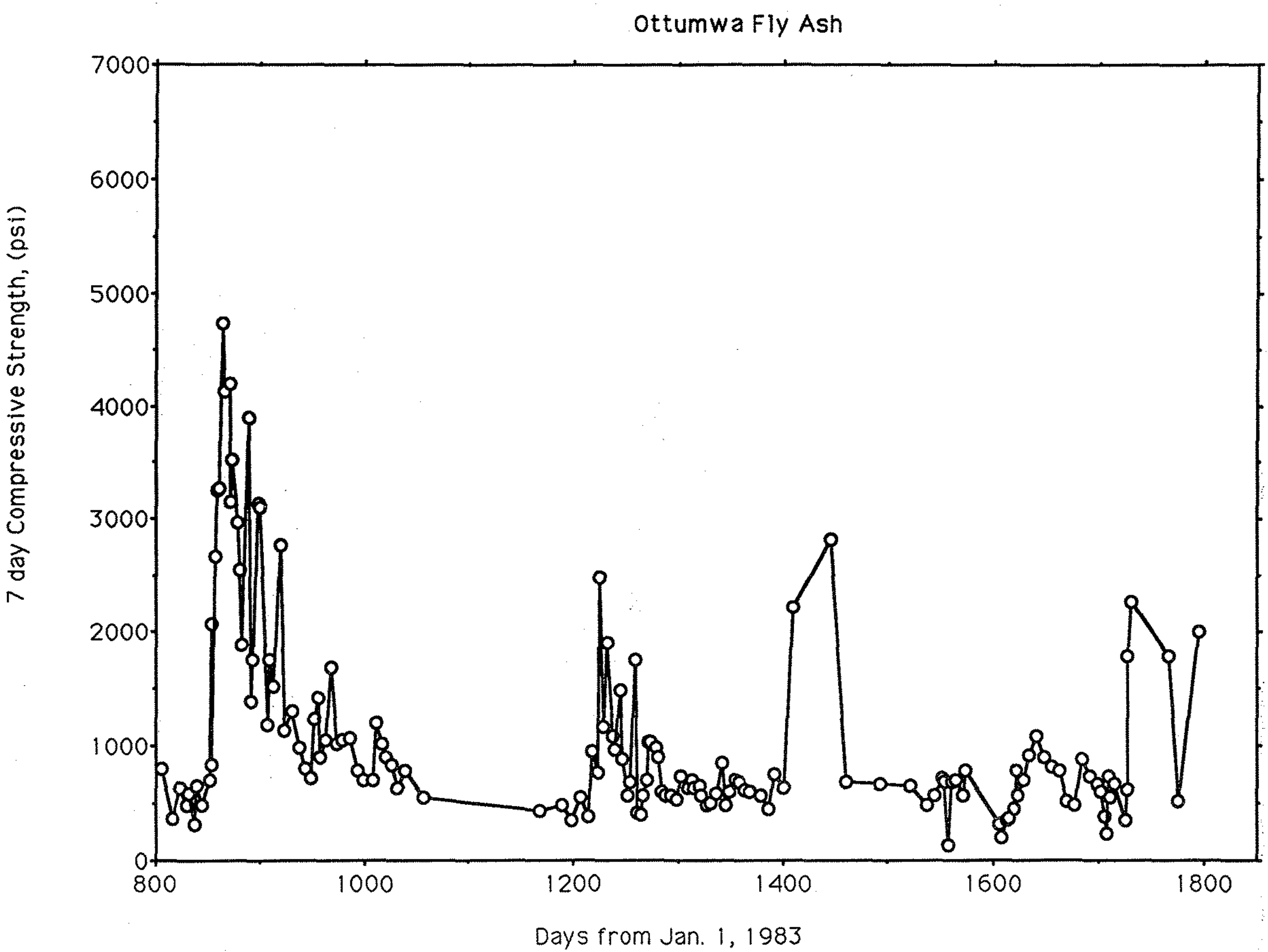

Figure 7. Seven day compressive strength of Ottumwa fly ash pastes versus sampling date.

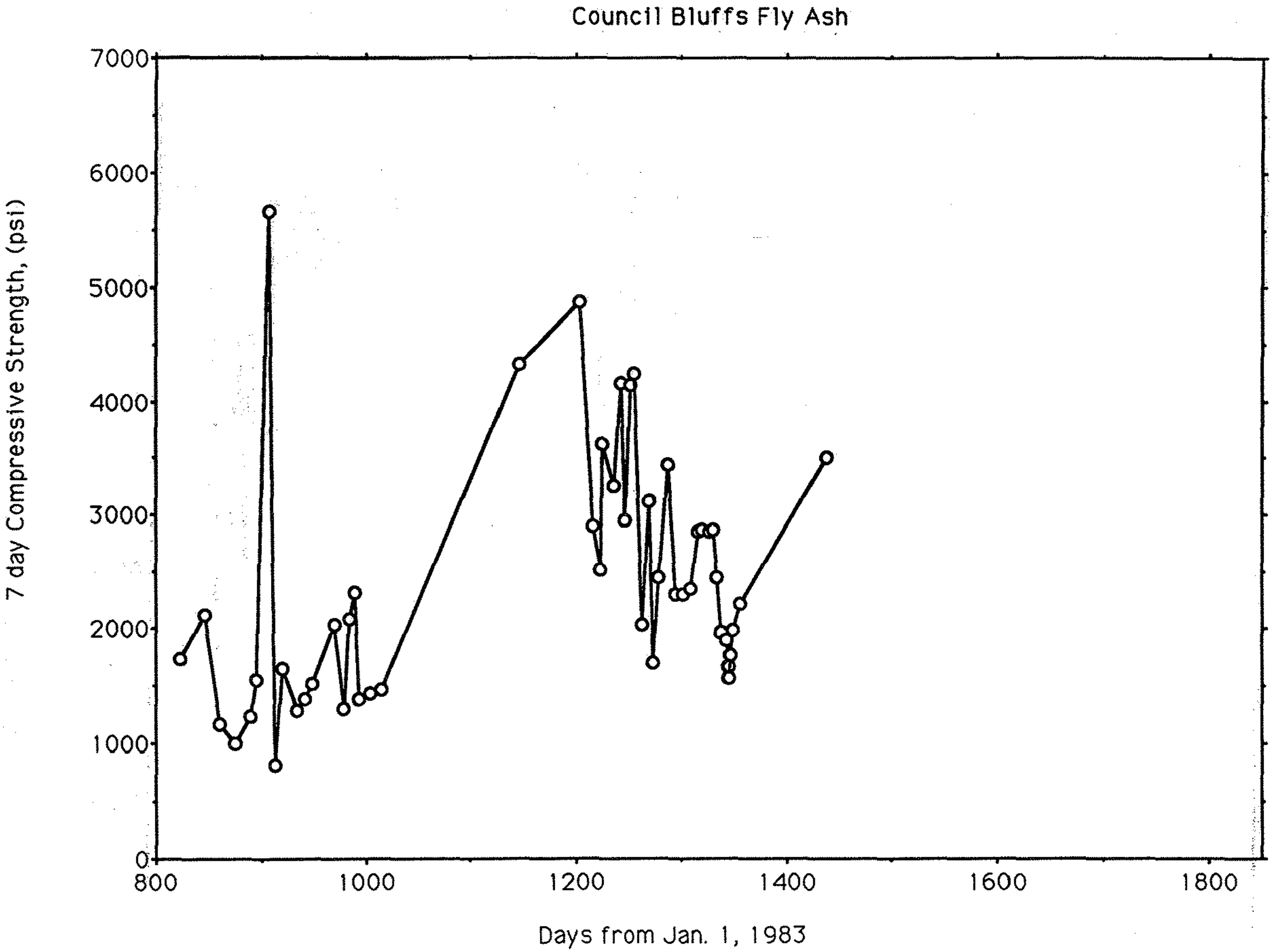

Figure 8. **Seven day compressive strength of Council Bluffs fly ash pastes versus sampling date.**

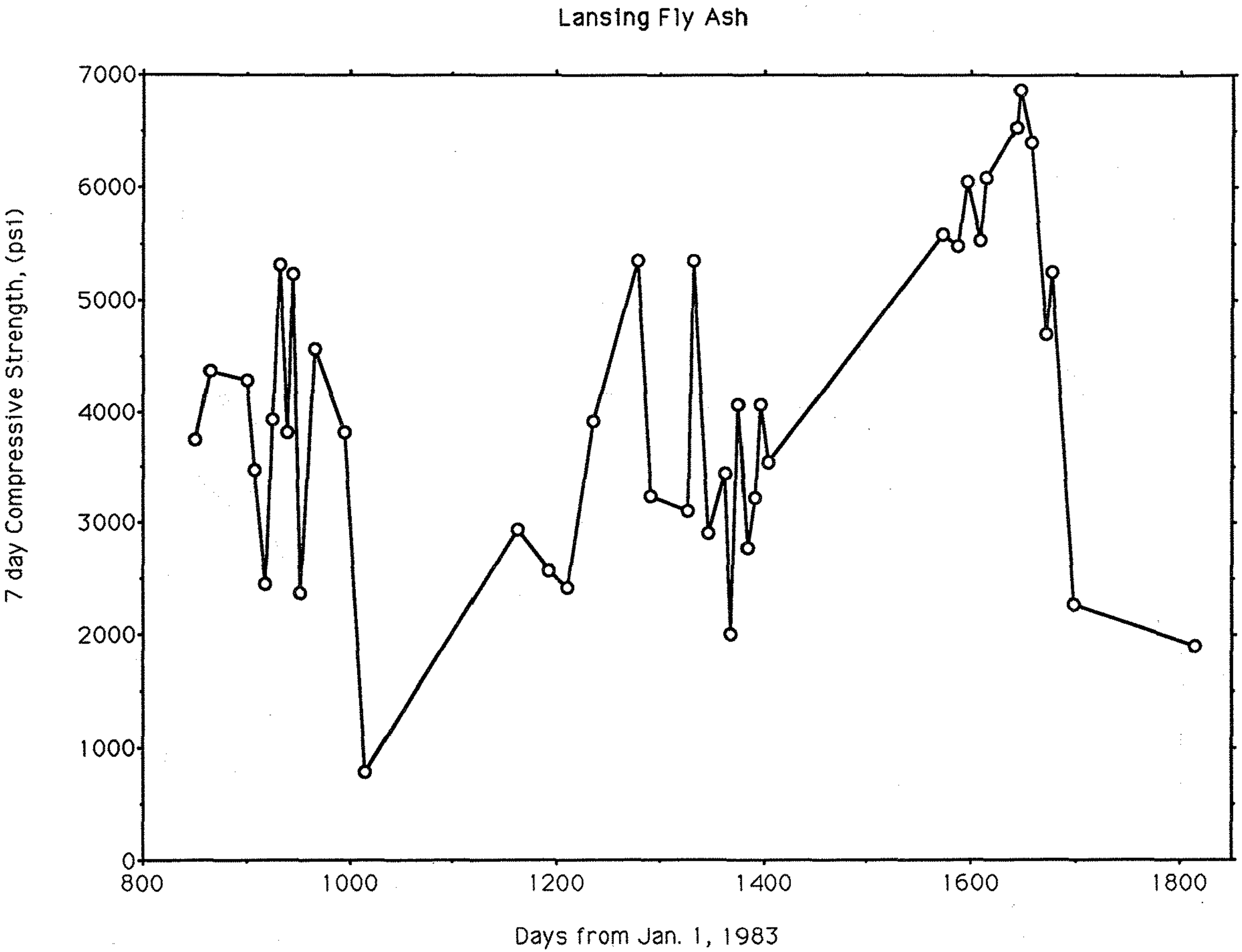

Figure 9. Seven day compressive strength of Lansing fly ash pastes versus sampling date.

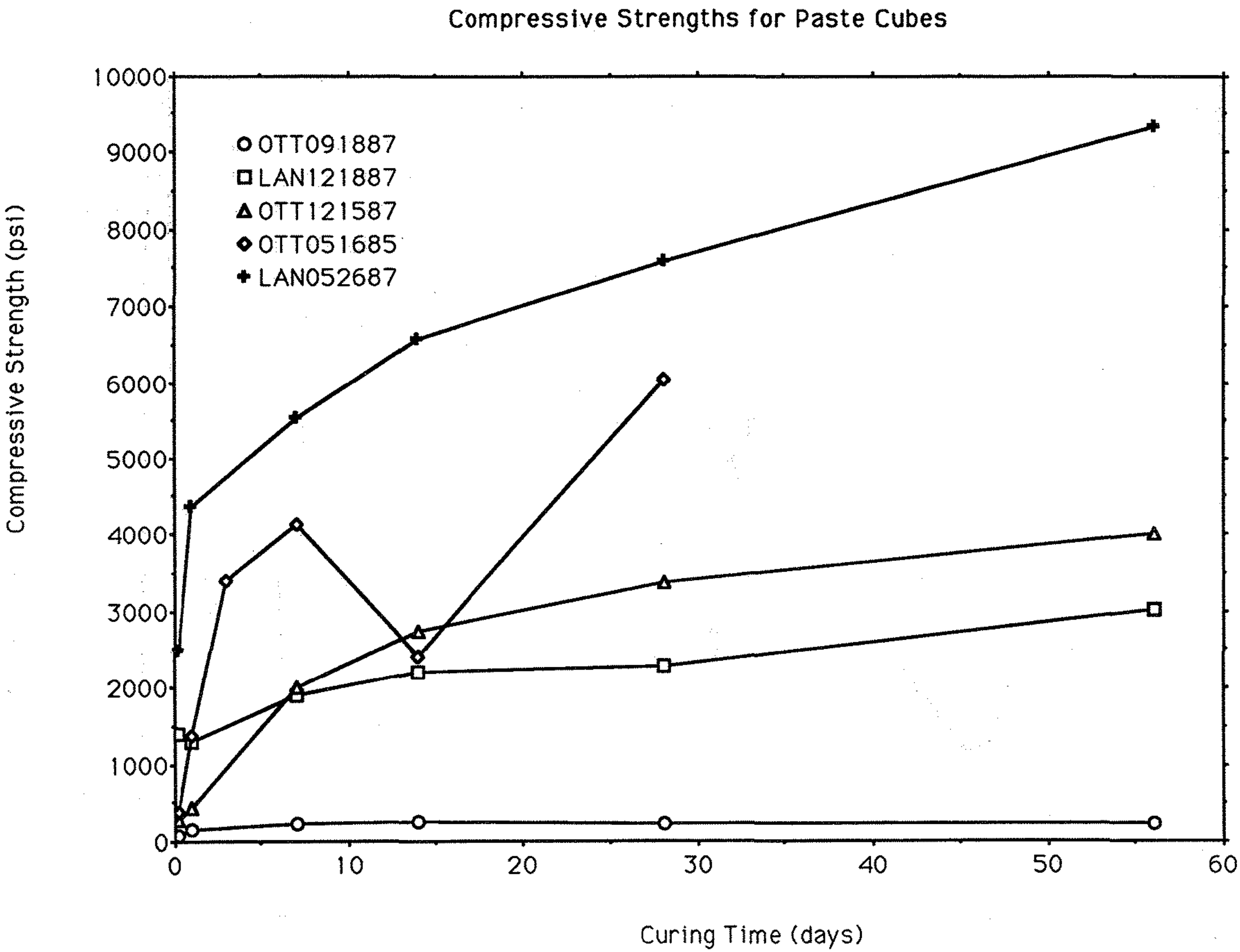

Figure 10. Compressive strength of fly ash pastes versus moist curing time.

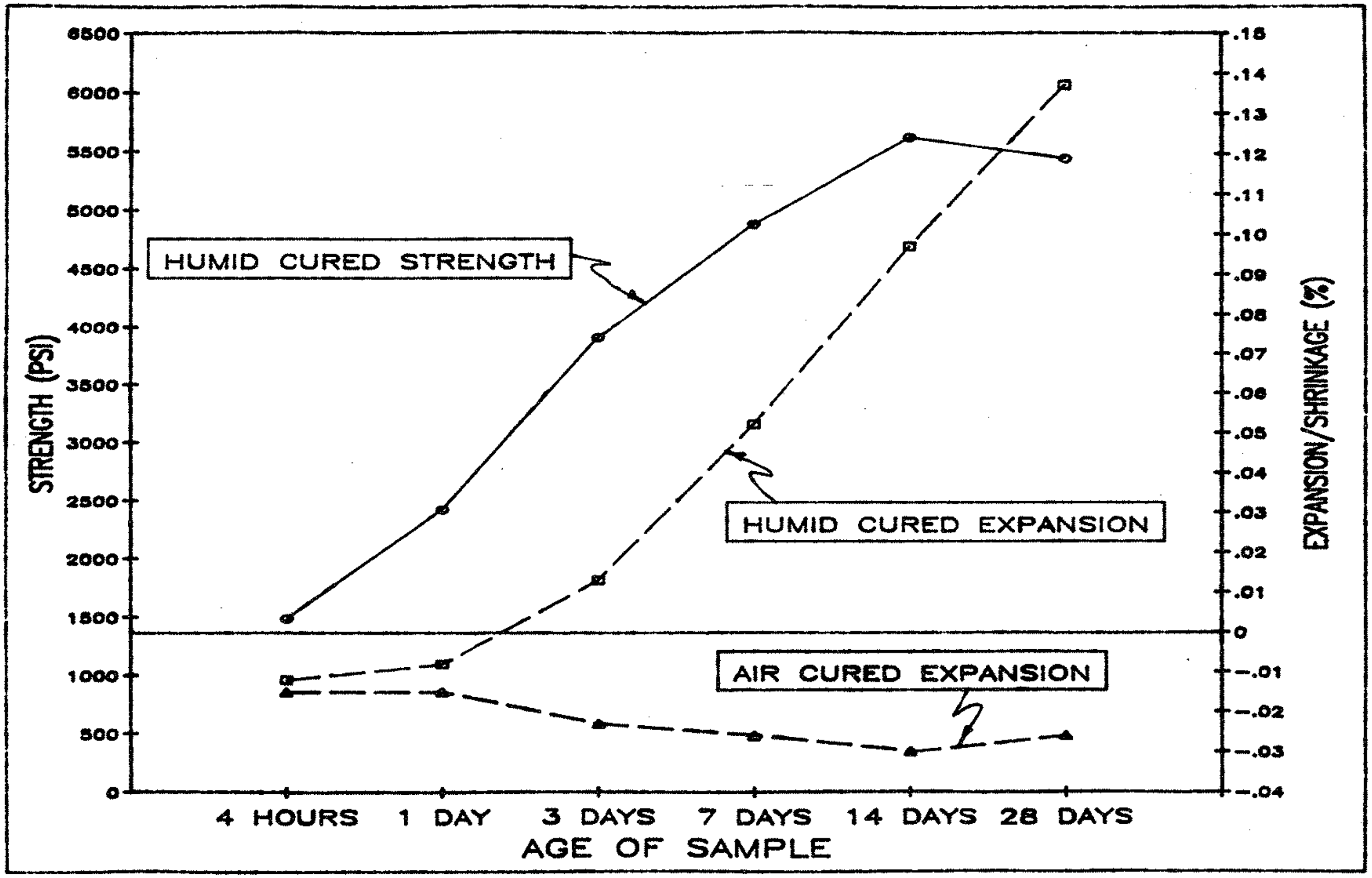

Figure 11. Volume stability of fly ash pastes versus type of curing and time in days.

expanded slightly during moist curing and shrank slightly during air curing. However, several of the fly ash samples from Ottumwa power plant exhibited severe expansive properties. In fact, such specimens generally fell apart (disintegrated) during the first few days of either moist or air curing. It was difficult to accurately measure the lengths of such specimens because their rates of expansion were very large immediately after removing them from the molds. More will be said about these samples later in this report. The large majority of the specimens studied in this project did not exhibit problematic expansive behavior.

Typical results obtained from the set time tests are shown in Figure 12. Figure 12 illustrates the definitions of initial and final set that were used in this study. Generally, the fly ash paste specimens had initial set times of about 10 minutes and final set times of about 15 minutes. Hence, some field applications, such as soil stabilization or void filling, may be tricky unless proper retarders are found. Portland cement appears to be a reasonably good retarder for most of these fly ashes.

Typical results obtained from the heat evolution test are shown in Figure 13. Again, the various samples obtained from a single power plant exhibit drastically different behaviors as a function of sampling date. Fly ash from the Lansing power plant was generally the most reactive with water (i.e., highest ΔT), followed by the Council Bluffs fly ash and then the Ottumwa fly ash.

Correlation studies were performed in an attempt to define relationships between the various paste properties studied in this research project. The results of a correlation study utilizing all of the fly ash paste samples from 1985 and 1986 is summarized in Table VI. The result obtained by performing a correlation analysis on each individual power

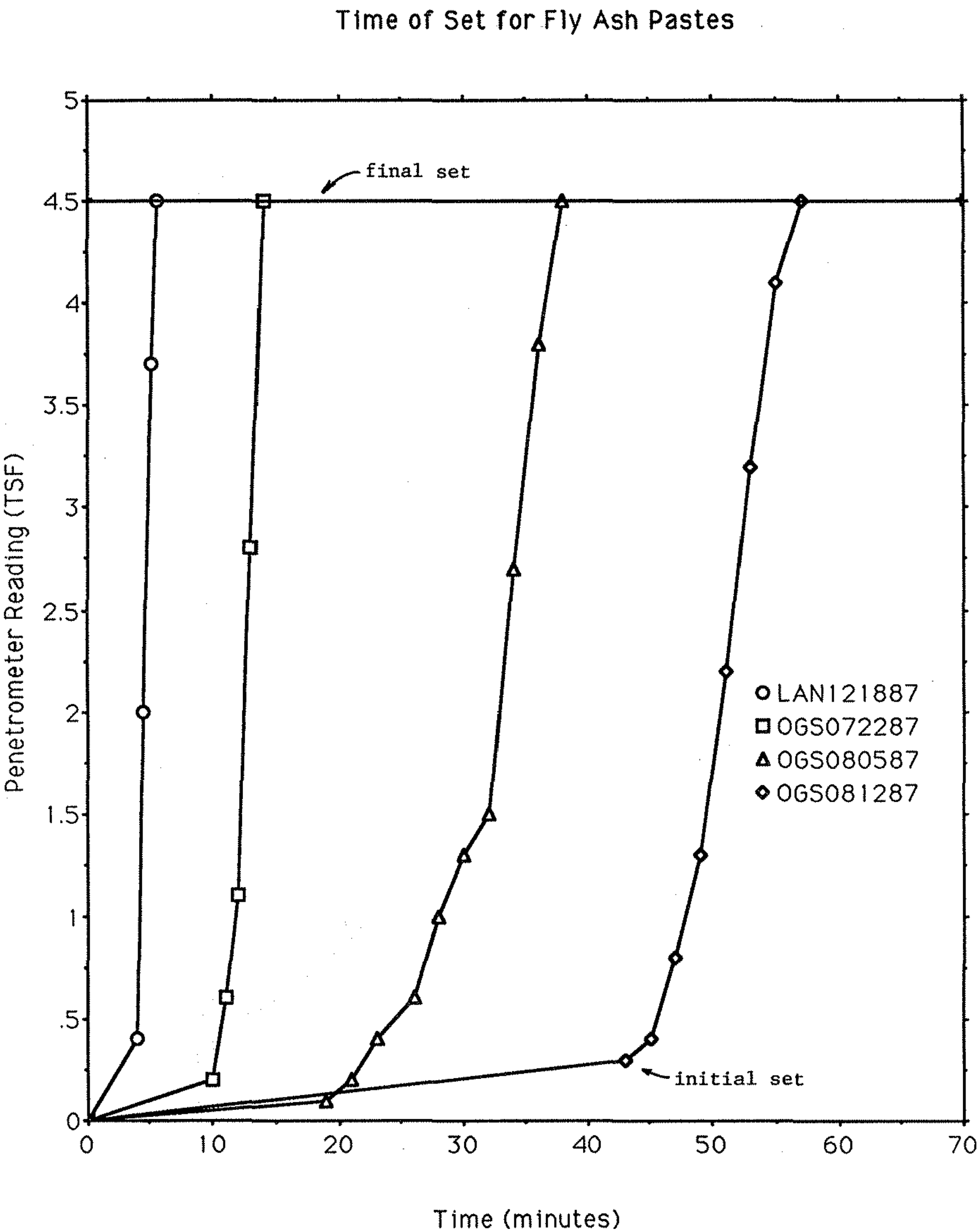

Figure 12. Results of set time testing of several Iowa fly ash pastes.

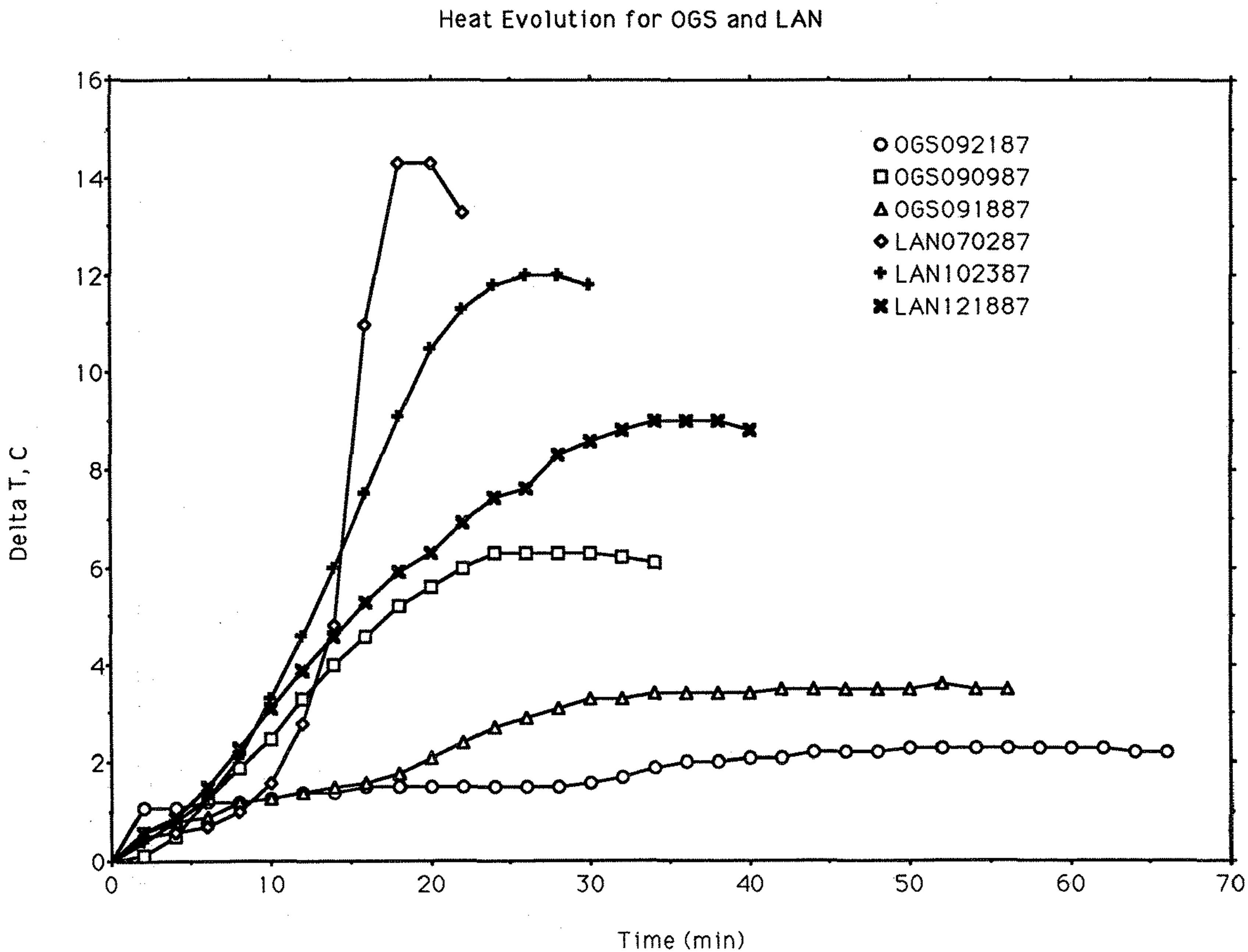

Figure 13. Heat evolution test results for several Iowa fly ash pastes.

Table VI

1985-86 TOTAL FLYASH CORRELATION MATRIX

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	H4	D1	D7	D14	D28	D56	ACE	HCE	IS	FS	PKT	TIM	DT
H4	1.00000 0.0000 167	0.91727 0.0001 159	0.71059 0.0001 167	0.75057 0.0001 164	0.73012 0.0001 163	0.49975 0.0080 27	-0.41706 0.0001 150	0.47374 0.0001 153	-0.59629 0.0001 155	-0.63082 0.0001 156	0.89996 0.0001 153	-0.45463 0.0001 153	0.90818 0.0001 153
D1	0.91727 0.0001 159	1.00000 0.0000 180	0.84500 0.0001 178	0.83695 0.0001 174	0.83464 0.0001 177	0.34844 0.0811 26	-0.48421 0.0001 159	0.48498 0.0001 166	-0.53595 0.0001 168	-0.59473 0.0001 169	0.80989 0.0001 163	-0.48595 0.0001 163	0.82929 0.0001 163
D7	0.71059 0.0001 167	0.84500 0.0001 178	1.00000 0.0000 187	0.92216 0.0001 182	0.93464 0.0001 183	0.32845 0.0944 27	-0.44758 0.0001 165	0.60735 0.0001 172	-0.46826 0.0001 175	-0.57205 0.0001 176	0.63390 0.0001 169	-0.51918 0.0001 169	0.65541 0.0001 169
D14	0.75057 0.0001 164	0.83695 0.0001 174	0.92216 0.0001 182	1.00000 0.0000 183	0.94781 0.0001 179	0.54260 0.0051 25	-0.47774 0.0001 162	0.66914 0.0001 168	-0.48895 0.0001 171	-0.58297 0.0001 172	0.71536 0.0001 166	-0.54283 0.0001 166	0.71687 0.0001 166
D28	0.73012 0.0001 163	0.83464 0.0001 177	0.93464 0.0001 183	0.94781 0.0001 179	1.00000 0.0000 186	0.67899 0.0001 27	-0.51497 0.0001 167	0.66343 0.0001 174	-0.47144 0.0001 175	-0.58763 0.0001 176	0.70475 0.0001 169	-0.54653 0.0001 169	0.70547 0.0001 169
D56	0.49975 0.0080 27	0.34844 0.0811 26	0.32845 0.0944 27	0.54260 0.0051 25	0.67899 0.0001 27	1.00000 0.0000 27	0.09331 0.6645 24	0.34160 0.1023 24	0.39023 0.0487 26	0.42780 0.0260 27	0.52134 0.0053 27	-0.05477 0.7862 27	0.33864 0.0840 27
ACE	-0.41706 0.0001 150	-0.48421 0.0001 159	-0.44758 0.0001 165	-0.47774 0.0001 162	-0.51497 0.0001 167	0.09331 0.6645 24	1.00000 0.0000 168	-0.18533 0.0172 165	0.12399 0.1218 157	0.23772 0.0026 158	-0.35368 0.0001 153	0.12482 0.1242 153	-0.32537 0.0001 153
HCE	0.47374 0.0001 153	0.48498 0.0001 166	0.60735 0.0001 172	0.66914 0.0001 168	0.66343 0.0001 174	0.34160 0.1023 24	-0.18533 0.0172 165	1.00000 0.0000 175	-0.32003 0.0001 164	-0.43748 0.0001 165	0.54712 0.0001 159	-0.50430 0.0001 159	0.50876 0.0001 159
IS	-0.59629 0.0001 155	-0.53595 0.0001 168	-0.46826 0.0001 175	-0.48895 0.0001 171	-0.47144 0.0001 175	0.39023 0.0487 26	0.12399 0.1218 157	-0.32003 0.0001 164	1.00000 0.0000 178	0.83813 0.0001 178	-0.57485 0.0001 165	0.62440 0.0001 165	-0.60555 0.0001 165
FS	-0.63082 0.0001 156	-0.59473 0.0001 169	-0.57205 0.0001 176	-0.58297 0.0001 172	-0.58763 0.0001 176	0.42780 0.0260 27	0.23772 0.0026 158	-0.43748 0.0001 165	0.83813 0.0001 178	1.00000 0.0000 179	-0.63854 0.0001 166	0.74224 0.0001 166	-0.65154 0.0001 166
PKT	0.89996 0.0001 153	0.80989 0.0001 163	0.63390 0.0001 169	0.71536 0.0001 166	0.70475 0.0001 169	0.52134 0.0053 27	-0.35368 0.0001 153	0.54712 0.0001 159	-0.57485 0.0001 165	-0.63854 0.0001 166	1.00000 0.0000 172	-0.54389 0.0001 172	0.92984 0.0001 172
TIM	-0.45463 0.0001 153	-0.48595 0.0001 163	-0.51918 0.0001 169	-0.54283 0.0001 166	-0.54653 0.0001 169	-0.05477 0.7862 27	0.12482 0.1242 153	-0.50430 0.0001 159	0.62440 0.0001 165	0.74224 0.0001 166	-0.54389 0.0001 172	1.00000 0.0000 172	-0.53143 0.0001 172
DT	0.90818 0.0001 153	0.82929 0.0001 163	0.65541 0.0001 169	0.71687 0.0001 166	0.70547 0.0001 169	0.33864 0.0840 27	-0.32537 0.0001 153	0.50876 0.0001 159	-0.60555 0.0001 165	-0.65154 0.0001 166	0.92984 0.0001 172	-0.53143 0.0001 172	1.00000 0.0000 172

plant can be found in Table II (Appendix D); the trends indicated by each analysis were reasonably consistent. Abbreviations for the different variables were as follows:

H4	=	4 hour compressive strength
D1	=	1 day compressive strength
D7	=	7 day compressive strength
D14	=	14 day compressive strength
D28	=	28 day compressive strength
D56	=	56 day compressive strength
ACE	=	air cured expansion @ 28 days
HCE	=	humid cured expansion @ 28 days
IS	=	initial set time
FS	=	final set time
PKT	=	peak temperature
TIM	=	time required to reach peak temperature
DT	=	temperature rise (peak temp. - initial temp.)

Linear correlation coefficients (Pearson) were generated using a standard statistical package. The tables also list the significance probability of the correlation and the number of observations that were used when calculating the statistics. For example, in Table VI, the Pearson correlation coefficient, r, between the four hour compressive strength (H4) and the one day compressive strength (D1) was 0.91727. The number directly below the correlation coefficient, 0.0001 in this instance, is the significance probability of the correlation. This value indicates that the linear correlation between H4 and D1 was significant (i.e., we can reject the null hypothesis that no linear correlation ($r = 0$) exists between H4 and D1). We have arbitrarily adopted a 99% confidence interval for accepting or rejecting potential correlations; this corresponds to a significance probability value of 0.005 or less. The integer directly below the significance probability of the correlation value denotes the number of samples used in the statistical calculations (159 observations in this instance). Please note that all correlation matrices are symmetric about their main diagonals.

Strong correlations were observed between several of the paste variables studied in this project. Correlation coefficients greater than 0.7 have been circled in Table VI. The most obvious correlations were between compressive strengths measured at different curing times, between compressive strength and temperature rise, between initial set and final set, and between final set and the time required to reach the peak temperature.

Several of the more interesting trends are shown in Figures 14, 15 and 16. Figure 14 illustrates the relationship between the 7-day and 28-day compressive strengths of the fly ash pastes. Linear regression of the data yielded the equation listed in Figure 14. Figure 15 illustrates the relationship between initial set and final set. Again, linear regression of the data yielded the equation listed in Figure 15. Figure 16 illustrates the relationship between the four hour compressive strength and the temperature rise (line estimated using linear regression).

Results of Additional Chemical Tests

The purpose of this phase of the research project was to conduct a detailed investigation of the chemical constitution of the Iowa high-calcium fly ashes. The samples used in this analysis were all physical test samples, each representing 400 tons of fly ash. This was done to avoid the "smoothing" problems (as described earlier) that appear to be associated with the composite samples.

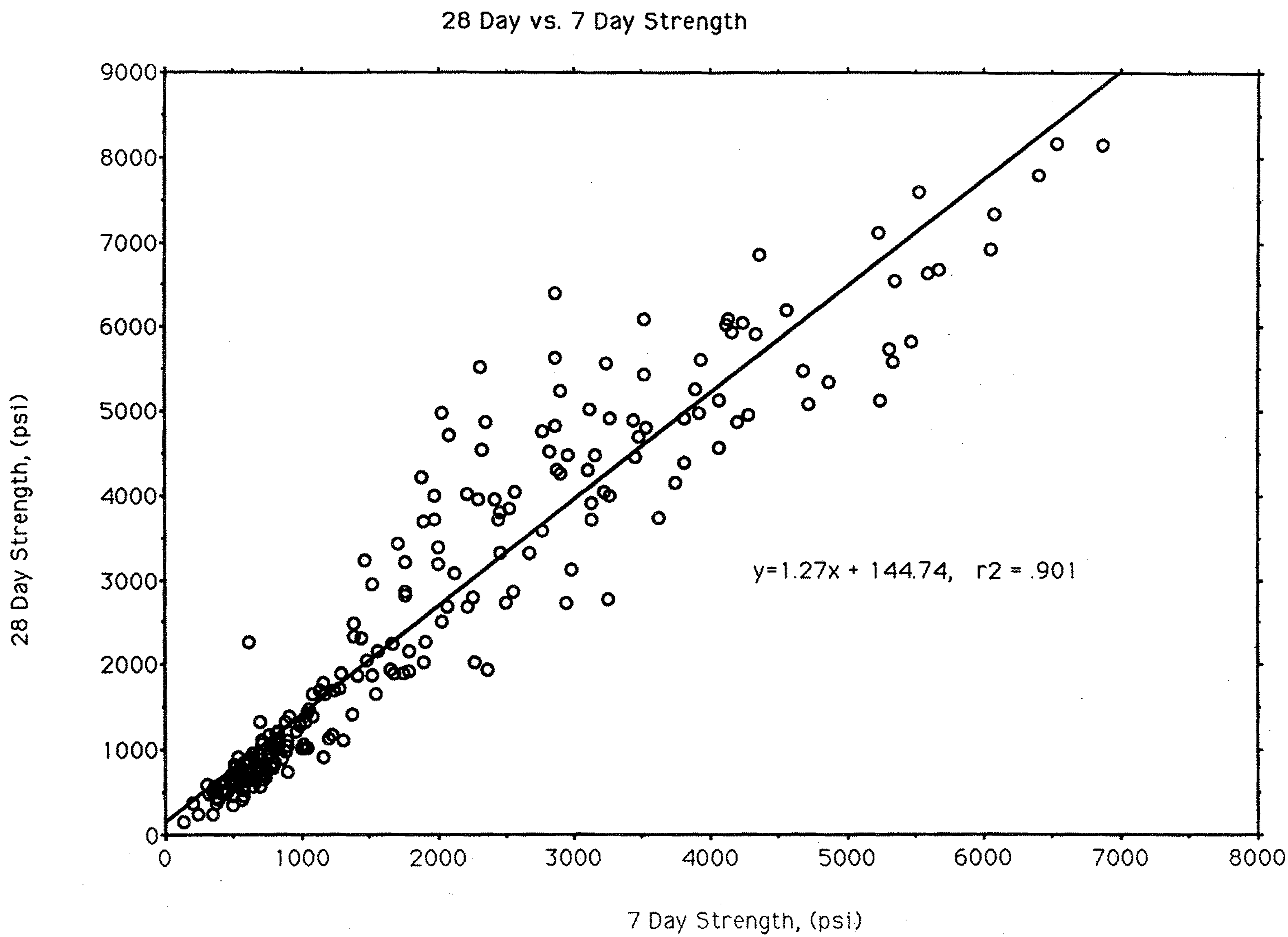

Figure 14. **Relationship between seven day and twenty-eight day compressive strengths of Iowa fly ash pastes.**

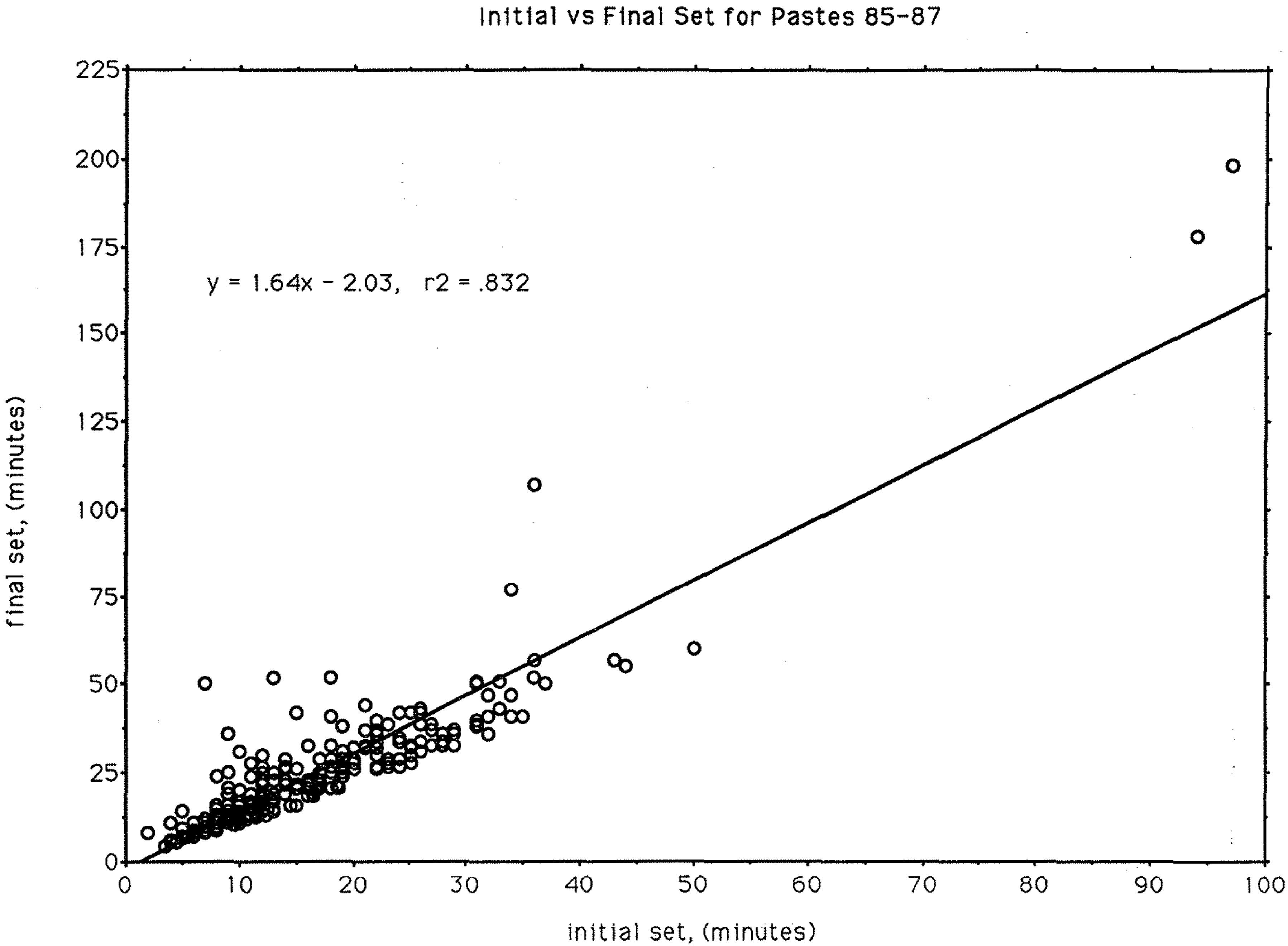

Figure 15. Relationship between initial set and final set for temperature rise for Iowa fly ash pastes.

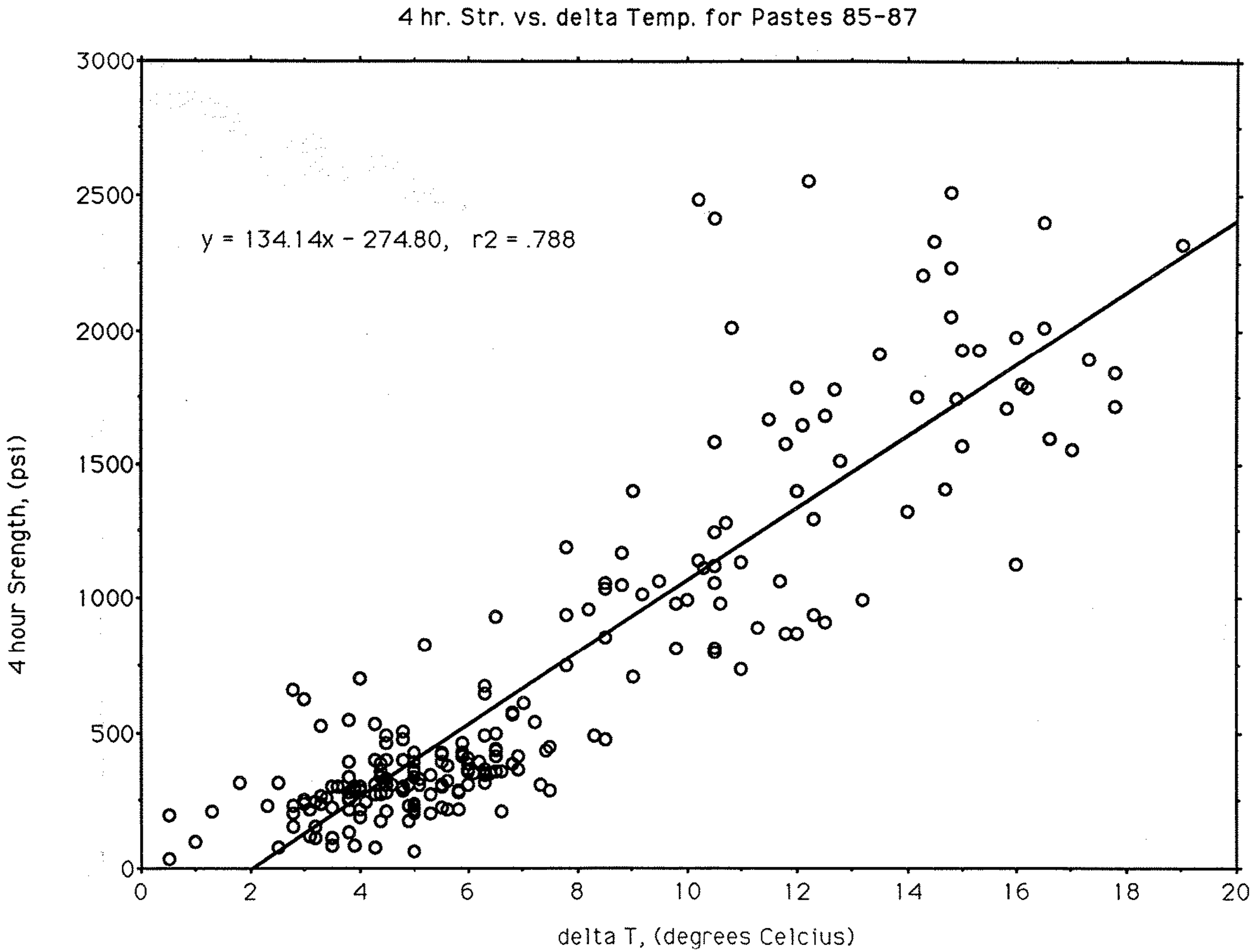

Figure 16. Relationship between four hour compressive strength and temperature rise for Iowa fly ash pastes.

Bulk mineralogy

Typical diffractograms of raw (as-received) fly ashes from the various power plants are shown in Figure 17. All of the fly ashes exhibited very similar bulk mineralogies. Each of the fly ashes contained alpha-quartz, lime, periclase, anhydrite, tricalcium aluminate (or an altered mineral similar in structure and reactivity to tricalcium aluminate) and often a mineral similar to tetracalcium trialuminate sulfate. Also, a diffraction peak was often found at about 3.9 Å in many of the fly ash samples; this peak has not yet been assigned to a specific compound (although we suspect that it may be a weak reflection from anhydrite or possibly sodium sulfate). Each of the fly ashes exhibited a glass halo that reached a maximum intensity above 30 degrees 2-theta (Cu K-alpha radiation). This scattering halo has been attributed to the presence of a calcium aluminate or a calcium aluminum silicate glass by other researchers [20, 21].

Table VII summarizes the results of elemental analysis on the 3 fly ashes. In general, all of the fly ashes contained more than about 25% CaO. All of the fly ashes met the general requirements specified by the ASTM for Class C fly ash.

To obtain additional information about the glass phases and minor components present in the various fly ash samples, the raw fly ashes were digested in hot acid (HCl) as described in ASTM C 114, section 17.1.7.1 [13]. Flame photometry was used to estimate the concentrations of Na, K and Ca in the acid soluble fraction of the fly ash. The portion of the fly ash that was insoluble in the hot acid was washed, dried and then subjected to x-ray diffraction analysis.

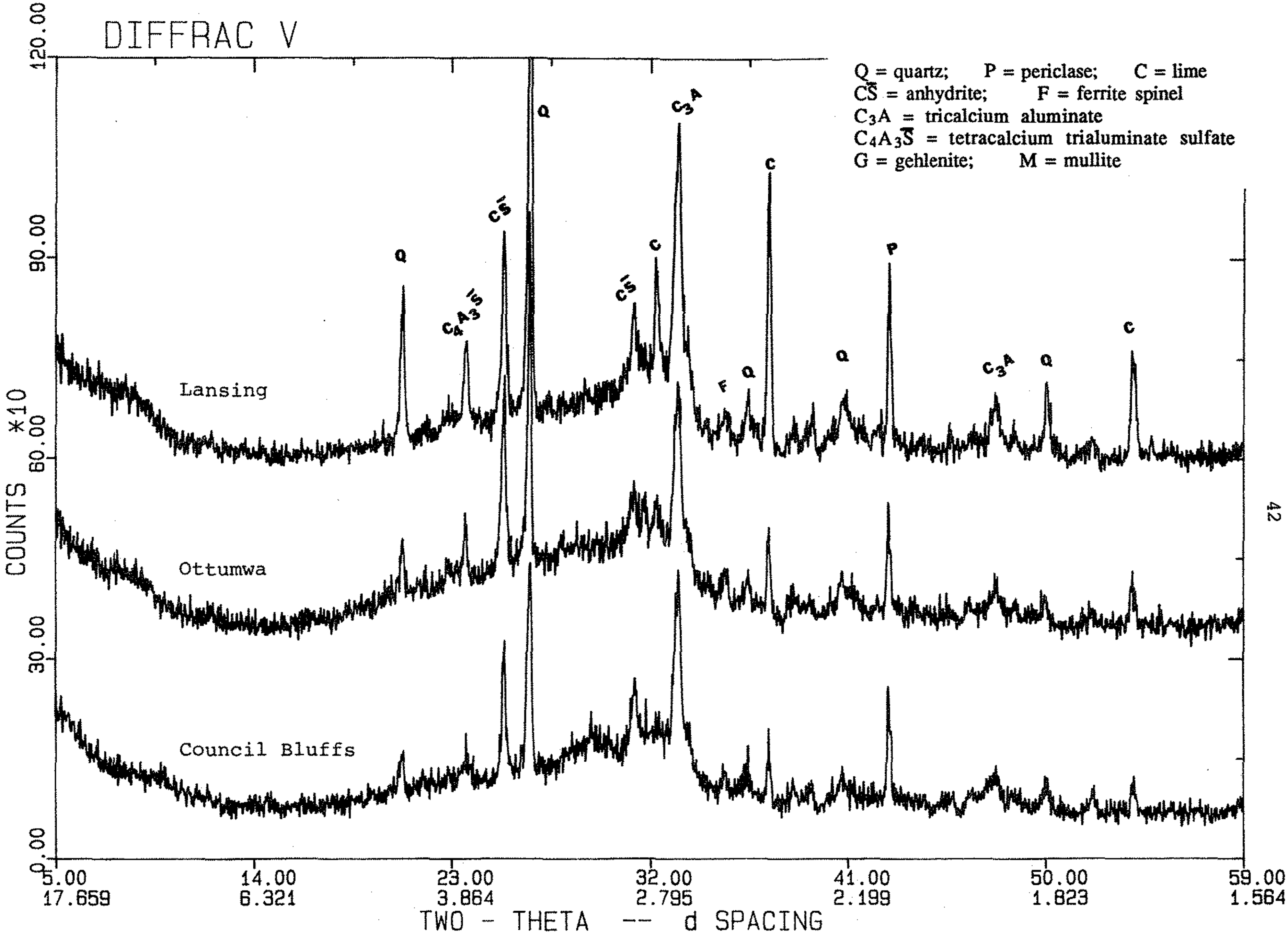

Figure 17. X-ray diffractogram of fly ashes from 3 different Iowa power plants.

TABLE VII
Bulk compositions of the fly ashes used in this study (all values in weight percent).

Oxide	Council Bluffs	Lansing	Ottumwa
SiO_2	30.6	31.1	34.6
Al_2O_3	15.3	15.9	18.5
Fe_2O_3	5.5	5.3	4.8
Sum	51.4	52.3	57.9
SO_3	3.3	3.9	3.7
CaO	28.8	28.1	24.9
MgO	5.8	5.7	5.3
Na_2O	2.0	1.6	3.3
K_2O	0.3	0.3	0.4
P_2O_5	0.9	1.2	1.1
TiO_2	1.0	1.4	1.4
SrO	0.4	0.4	0.5
BaO	0.7	0.6	0.8
%Acid Soluble	74	67	73

Figure 18 shows the results of XRD analysis of the acid insoluble residue obtained from the three fly ashes. The acid digestion process removed many of the minerals present in the raw fly ashes, it also appeared to remove the majority of the glass that exhibited a scattering halo above 30 degrees 2-theta (i.e., the calcium aluminate or calcium aluminum silicate glass). In fact, all three of the fly ashes were quite soluble in hot HCl (about 70% soluble, see Table VII), when compared to the results obtained using Class F (low-calcium, <10% CaO) fly ashes. Results at our laboratory indicate that most low-calcium fly ashes are less than 10 to 20% soluble in hot HCl. The major minerals identified in the XRD patterns were alpha-quartz, mullite and magnetite (? some hematite). At least one minor mineral remains unidentified in the diffractograms.

The glass remaining after the HCl digestion appears to be high in silica. Detailed elemental analysis is currently being performed on the acid insoluble residue. However, it is apparent that the glass scattering halos (see Figure 18) have shifted back to about 23 degrees 2-theta (Cu K-alpha

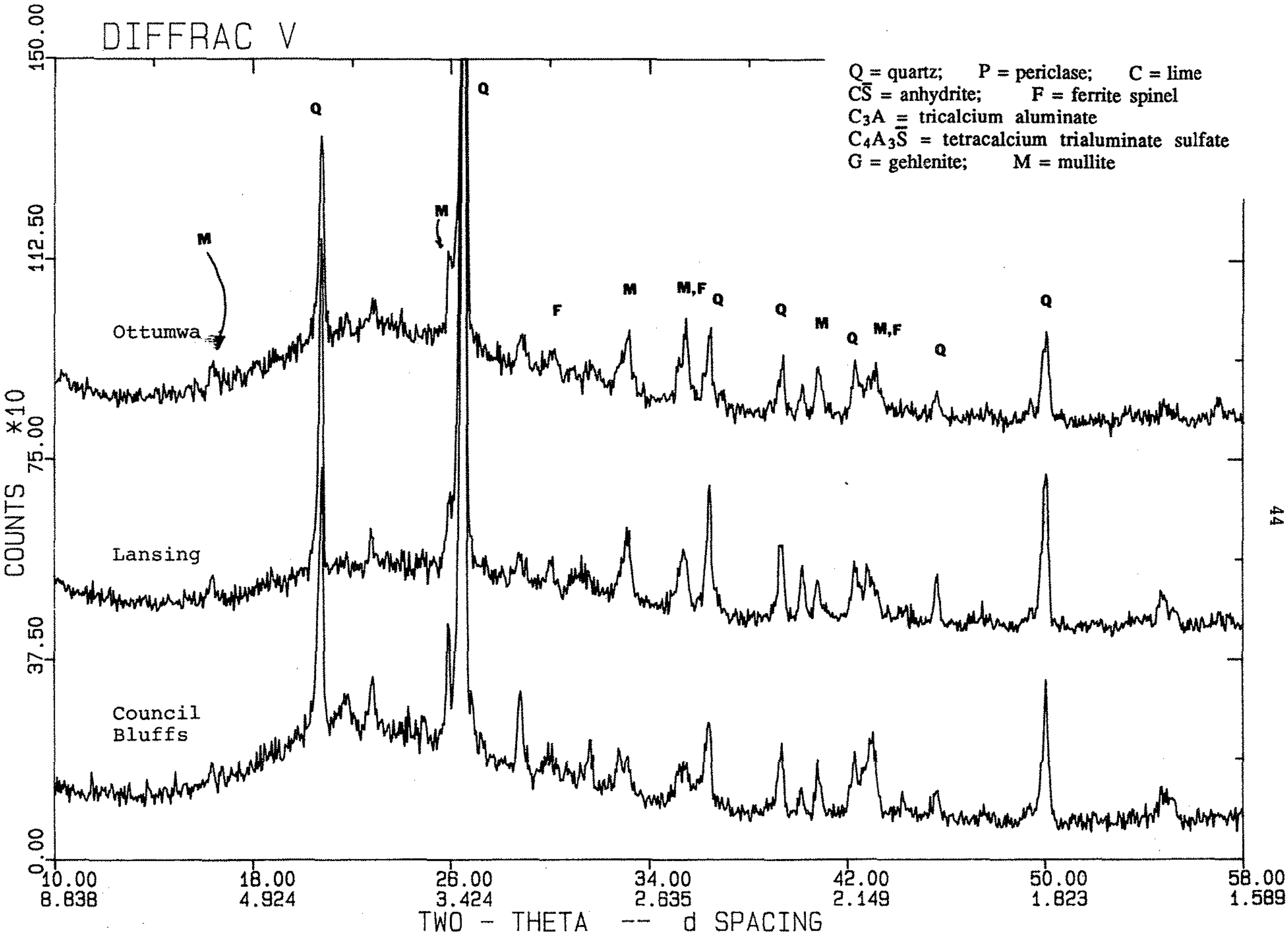

Figure 18. X-ray diffractogram of the acid insoluble fraction of Iowa fly ashes.

radiation) for all of the fly ashes. This scattering halo is more indicative of a Class F (low-calcium) fly ash [20, 21]. Hence, we appear to have made Class F fly ashes out of the three Class C fly ashes by a simple acid extraction.

Flame photometry analysis of the acid soluble portion of the fly ashes indicated that about 60% of the Na, 50% of the K and 50% of the Ca had been extracted from a given bulk fly ash. These numbers should be regarded as only qualitative at this time because of possible (unexpected) interferences in the flame photometry method.

Particle size separation (via a sonic sifter) was also very helpful in enhancing our ability to identify the minor crystalline compounds and different glasses present in the bulk fly ashes. Diffractograms of the various particle size fractions of fly ashes from Lansing and Council Bluffs power plants are shown in Figures 19 and 20, respectively. The fly ash from Ottumwa power plant exhibited particle size-mineralogy trends similar to the other two and, for brevity, will not be presented here.

The fly ash obtained from Lansing power plant showed minor changes in mineralogy when comparing the coarse fraction (>45 microns) to the smaller size fractions. One apparent trend indicated that alpha-quartz tended to accumulate in the larger (i.e., >45 and >20 micron) particle size fractions. The remaining two size fractions investigated (i.e., the >10 and <10 micron fractions) appeared to become enriched in lime, periclase and both calcium aluminates and sulfates. The glass scattering halos in these two size fractions appeared different from the halos observed in the larger size fractions. All of these observations are, of course, only qualitative.

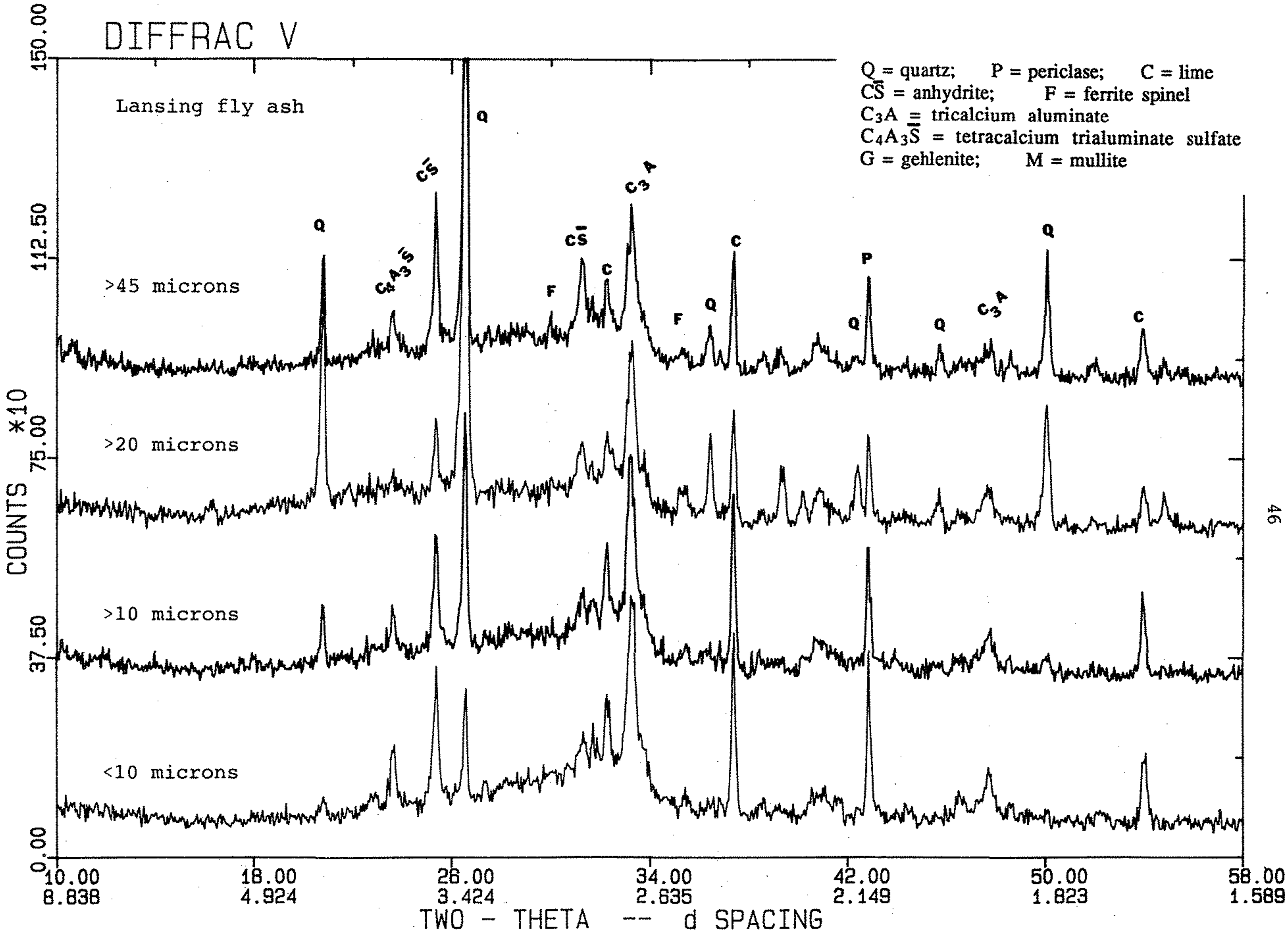

Figure 19. X-ray diffractogram of various particle size fractions of Lansing fly ash.

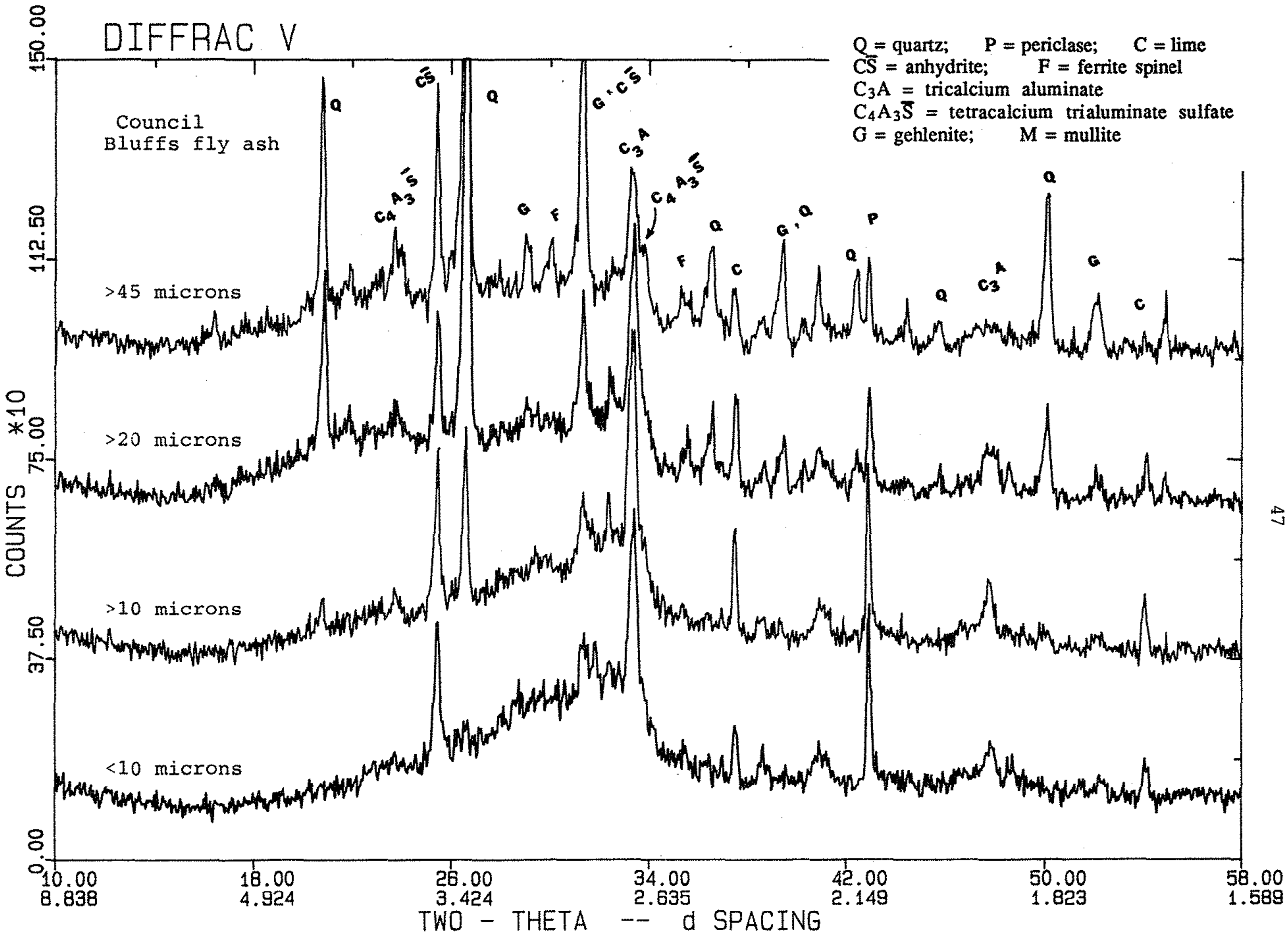

Figure 20. X-ray diffractogram of various particle size fractions of Council Bluffs fly ash.

The fly ash obtained from the Council Bluffs power plant shows a rather distinct mineralogy for each of the different size fractions. Again, the mineralogy of the coarse size fractions (i.e., >45 and >20 micron sizes) tended to be dominated by silicate type minerals such as alpha-quartz, a mineral similar to gehlenite (a melilite structural group) and a small amount of mullite. The major peaks for tricalcium aluminate, anhydrite, periclase and lime were still evident in the diffractograms but were of low intensity. The glass scattering halos for the >45 and >20 micron size fractions were distinctly different from two smaller size fractions. The mineralogy of the smallest size fraction (<10 micron particles) was especially interesting because it did not contain alpha-quartz. The major minerals in the <10 micron size fraction were anhydrite, lime, periclase and a mineral similar to tricalcium aluminate.

Table VIII summarizes the results of chemical analysis of the various particle size fractions of the Council Bluffs fly ash. The analyses were performed using XRF and a loose powder technique described elsewhere [7]. We consider the values as semi-quantitative at this time, because both mineralogical and particle size effects were ignored during the analyses (however, interelement corrections were performed). Trends were, however, quite distinct and did tend to agree with both the XRD results and with results reported by other researchers [22]. We acknowledge that Hemmings and Berry [22] did not find distinct differences in mineralogy between the various size fractions of the fly ash that they studied but they did find a relationship between mineralogy and density fraction. This discrepancy could be due to the rather low concentration of calcium present in their fly ash (i.e., 10% CaO versus >25% for this study). In general, the chemical analyses of the various particle size fractions of the Council Bluffs fly ash (see Table VIII) indicated that the alkaline earth elements (Mg, Ca, Sr, Ba) tended to accumulate in the smaller size fractions at the expense of Si.

The glass halo present in the <10 micron particle size fraction, strongly indicated the presence of a calcium aluminum silicate glass (as previously hypothesized by Diamond and Mehta [20, 21]). Since no silicate bearing minerals were identified in the diffractogram of the <10 micron size fraction, we must conclude that the glass contains about 20% SiO_2.

TABLE VIII
Composition of various particle size fractions of Council Bluffs fly ash (all values in weight percent).

	Decreasing particle size→			
Oxide	>45	>20	>10	<10
SiO_2	39	41	25	21
Al_2O_3	16	14	17	19
Fe_2O_3	5.3	5.3	5.9	6.4
Sum	60	60	48	46
SO_3	3.2	2.6	3.7	4.2
CaO	22	25	32	36
MgO	5.2	5.5	7.5	8.5
Na_2O	2.0	2.8	2.7	2.5
K_2O	0.4	0.3	0.2	0.2
P_2O_5	0.8	0.8	1.2	1.4
TiO_2	0.9	0.9	1.0	1.0
BaO	0.5	0.5	0.7	0.9
SrO	0.4	0.4	0.5	0.5

Quantitative estimates were made of several of the crystalline compounds present in fly ash from Ottumwa power plant. Ottumwa fly ash was chosen for analysis because it had the largest variability in physical (paste) properties of all the power plants studied. Hence, these analyses were conducted in an attempt to help explain the high variability in physical properties of the pastes.

Quantitative x-ray diffraction (QXRD) analysis of fly ash is a complex problem due to (1) small amounts of the compounds present, (2) numerous compounds in the ash with overlapping peaks, (3) the presence of the glassy phase, and (4) isomorphous substitution. As of this writing quantitative evaluation of the amounts of compounds present are, at best, estimates only; nevertheless, it is necessary to define the cause(s) of the paste variations and to provide input to a rational characterization method. Table IX summarizes the results of QXRD on 10 raw Ottumwa fly ash samples; again, traversing the low to high strength paste region shown on Figure 7. The values shown on Table IX are expressed relative to the concentrations of the various compounds present in the OTT051685 sample. From this data, it is noted that the variation in relative amount of tricalcium aluminate (C_3A) roughly corresponds to variation in paste compressive strength shown on Figure 7. Obviously the cause of the variation in paste properties is more complicated than simply C_3A content. However, the Ottumwa fly ash does not normally contain much free lime or tetracalcium trialuminate sulfate, so one may speculate that a tricalcium aluminate-anhydrite reaction should control the early setting and hardening relationships in these fly ash pastes. If this is so, then the early pore solution chemistry may be dominating the formation of hydration products, and hence, the physical properties of Ottumwa fly ash pastes.

TABLE IX
QXRD results for Ottumwa fly ash

Concentrations (wt%) relative to OTT051686

Sample	Day from 1/1/83	SiO_2	$CaSO_4$	CaO	MgO	C_3A*
OTT011385	743	1.23	1.10	0.71	0.75	0.49
OTT022085	781	0.58	1.19	1.39	0.95	0.57
OTT031585	804	0.75	1.13	1.40	0.81	0.71
OTT032685	815	0.79	1.01	0.82	0.79	0.58
OTT050785	857	0.85	1.05	1.17	0.83	0.91
OTT051685	866	1.00	1.00	1.00	1.00	1.00
OTT061085	891	0.85	0.83	0.86	1.01	0.71
OTT071985	930	0.95	1.32	1.31	1.03	0.66
OTT072685	937	1.18	1.12	0.94	0.94	0.69
OTT080185	943	0.86	0.88		0.89	0.88
OTT051685**	866	7.0%	1.0%	1.0%	2.3%	4.6%

* ratios based on peak height only
** actual composition determined by QXRD before normalization

Fly ash hydration products

Iowa high-calcium fly ashes are very reactive with water, this fact has been emphasized in both an earlier report [1] and also in the paste section of this report. The major hydration reactions appear to occur between tricalcium aluminate and the sulfate bearing compounds (anhydrite and tetracalcium trialuminate sulfate) present in a fly ash. Also, one must consider the minor components such as lime, periclase (although this compound may be hard-burnt) and the alkalis (sodium and potassium) present in the fly ash. Obviously, composition and microstructure of the hydration products will influence the physical properties of the fly ash pastes.

microstructure of the hydration products will influence the physical properties of the fly ash pastes.

In our previous progress report [23], we proposed the relationship between fly ash hydration products and compressive strength that is shown in Figure 21. However, we were premature in making this proposition, the actual relationship appears to be more complex. The diffractograms shown in Figure 22 clearly indicate that we oversimplified the relationship between hydration products and compressive strength. The major hydration products shown in the diffractograms are ettringite, monosulfoaluminate and straetlingite. Thermal analysis methods (DTA and TGA) were used to confirm the results of x-ray diffraction analysis. Hence, a more accurate model describing the physical properties of Class C fly ash must include the relative amounts of these three compounds plus some type of factor to account for the potential substitution of various cations or anions into their crystal structures. Such a model is still well beyond our grasp.

The long-term stability of these three hydrates in fly ash pastes appears to be reasonably good. X-ray analysis of paste specimens that had been cured in sealed plastic vials for the past three years indicated that all major phases were still present. Some of the ettringite appeared to have decomposed into monosulfoaluminate during the three year time period but other changes were minimal.

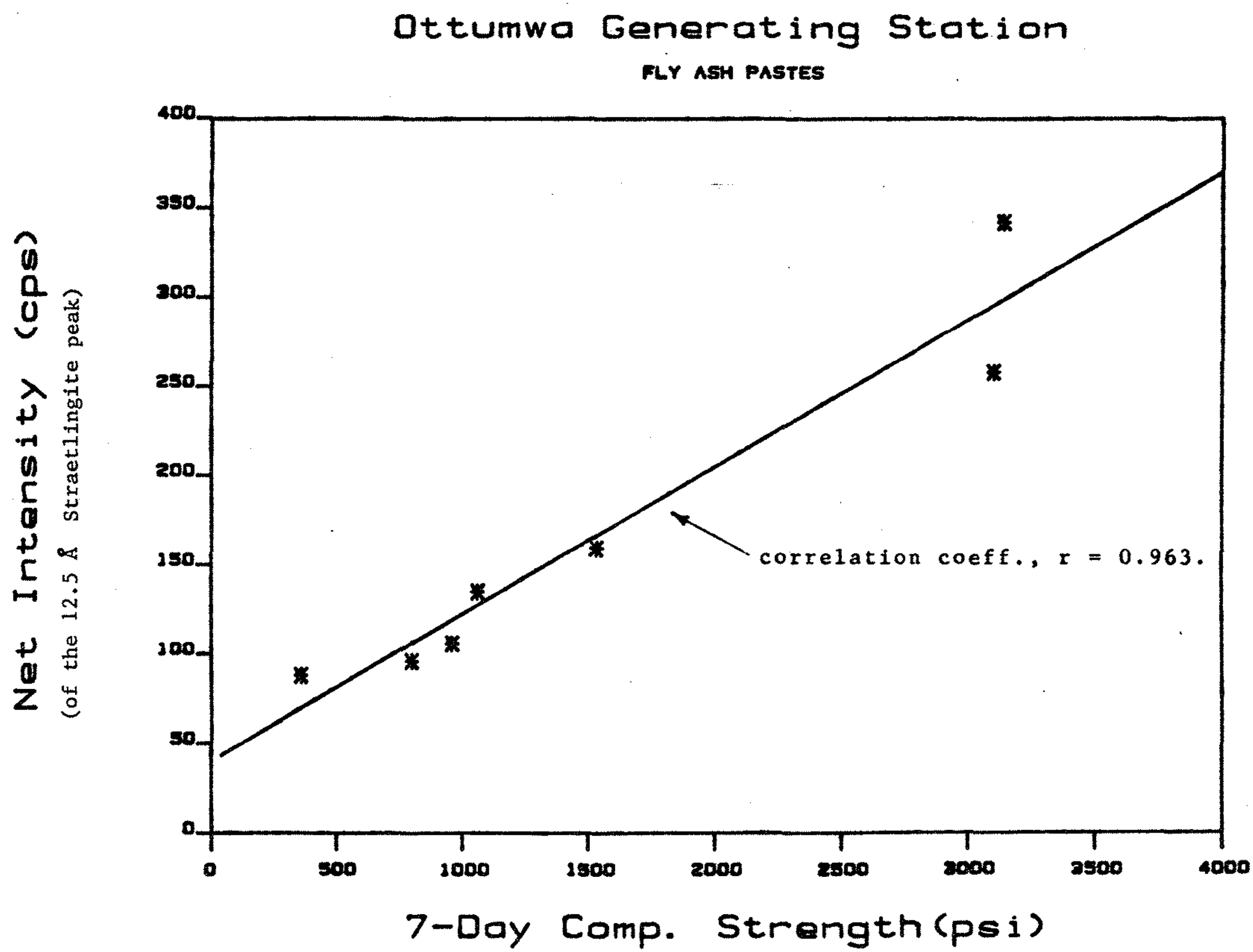

Figure 21. Previously proposed relationship between hydration products and compressive strength.

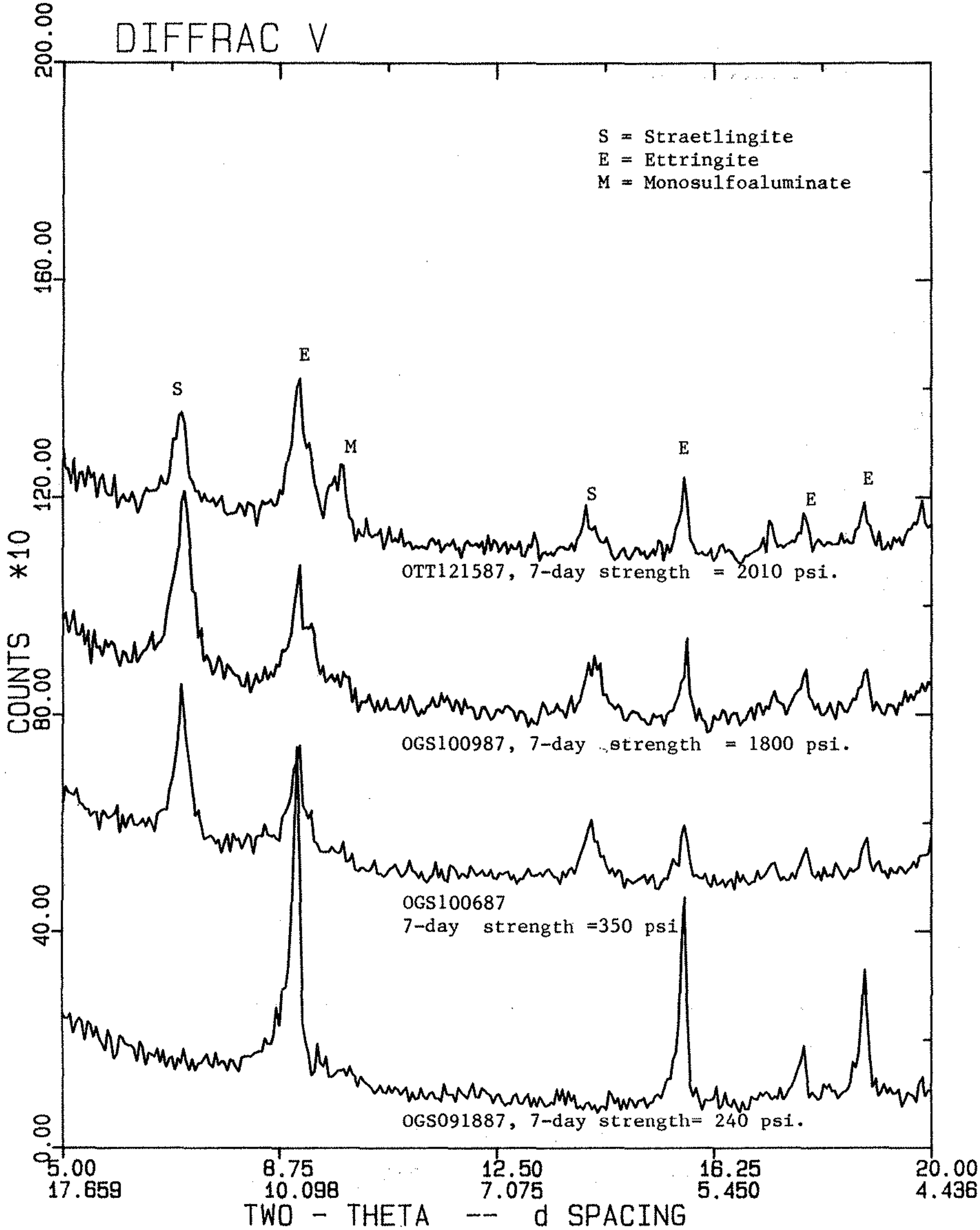

Figure 22. X-ray diffractogram of Iowa fly ash paste hydration products.

A Case Study of Ottumwa and Louisa Power Plants

The purpose of this section of the report is to compare fly ash sampled from two very similar power plants before and after a routine maintenance shutdown. Louisa and Ottumwa generating stations (LGS and OGS, respectively) were chosen for this phase of the study because they burn coal from the same mine, they are similar in size, and they were built and came on line in the early 1980's (see Tables I and II for additional details). The major difference between the two power plants is that OGS dopes its coal with sodium carbonate while LGS does not (although LGS may have to begin sodium carbonate doping to avoid EPA fines). Hence, we can directly compare fly ash produced from Cordero mine coal with and without sodium carbonate treatment.

The sampling and testing schemes used in this study were described earlier. However, it is pertinent to add that LGS samples were obtained from an autosampler. The LGS autosampler is located between the electrostatic precipitator ash hoppers and the fly ash silo. It samples the ash stream at specific time intervals and produces a composite sample daily. OGS ash samples were taken from ash trucks while loading from a 3000 ton capacity silo. Hence, one must consider the possibility of silo mixing in the OGS fly ash samples. The OGS fly ash silo was completely emptied during the maintenance outage so fly ash samples taken immediately after start up should reflect transient conditions at the power plant.

Background

The bulk of the Materials Analysis and Research Laboratory fly ash data base consists of information about samples obtained from

Ottumwa Generating Station (OGS). Also, OGS personnel have been very receptive to providing power plant operating conditions and maintenance schedules to Iowa State researchers. Hence, the current state of knowledge about the fly ash produced at OGS is well ahead of the other Iowa power plants.

OGS produces about 80,000 tons per year of high-calcium fly ash having a nominal analytical CaO content of about 25%. The power plant burns low sulfur, sub-bituminous coal from the Powder River Basin near Gillette, Wyoming. Sodium carbonate is routinely added to the raw coal feed to enhance the performance of the power plants hot-side electrostatic precipitators.

As mentioned earlier, the compressive strength of Ottumwa fly ash pastes change drastically as a function of sampling date. A plot of the 7-day compressive strength of OGS fly ash pastes versus sampling date is shown in Figure 23. It is evident that the major fluctuations in compressive strength occur during the late spring or late fall months of the calendar year. These fluctuations in compressive strength correspond roughly to the OGS maintenance schedule (note the bars near the x-axis). The lower half of Figure 23 shows the sodium carbonate feed rate, expressed in pounds per ton of coal, that was added to the raw coal to enhance the performance of the electrostatic precipitators. It is apparent that the power plant operating parameters (both sodium carbonate feed rate and routine maintenance periods) influence the strength properties of the OGS fly ash pastes. It must be mentioned that the maintenance cycle is not independent of the sodium carbonate feed rate. In fact, the two are directly related because the sodium carbonate doping is utilized to increase the length of time that the power plant can operate within EPA air quality

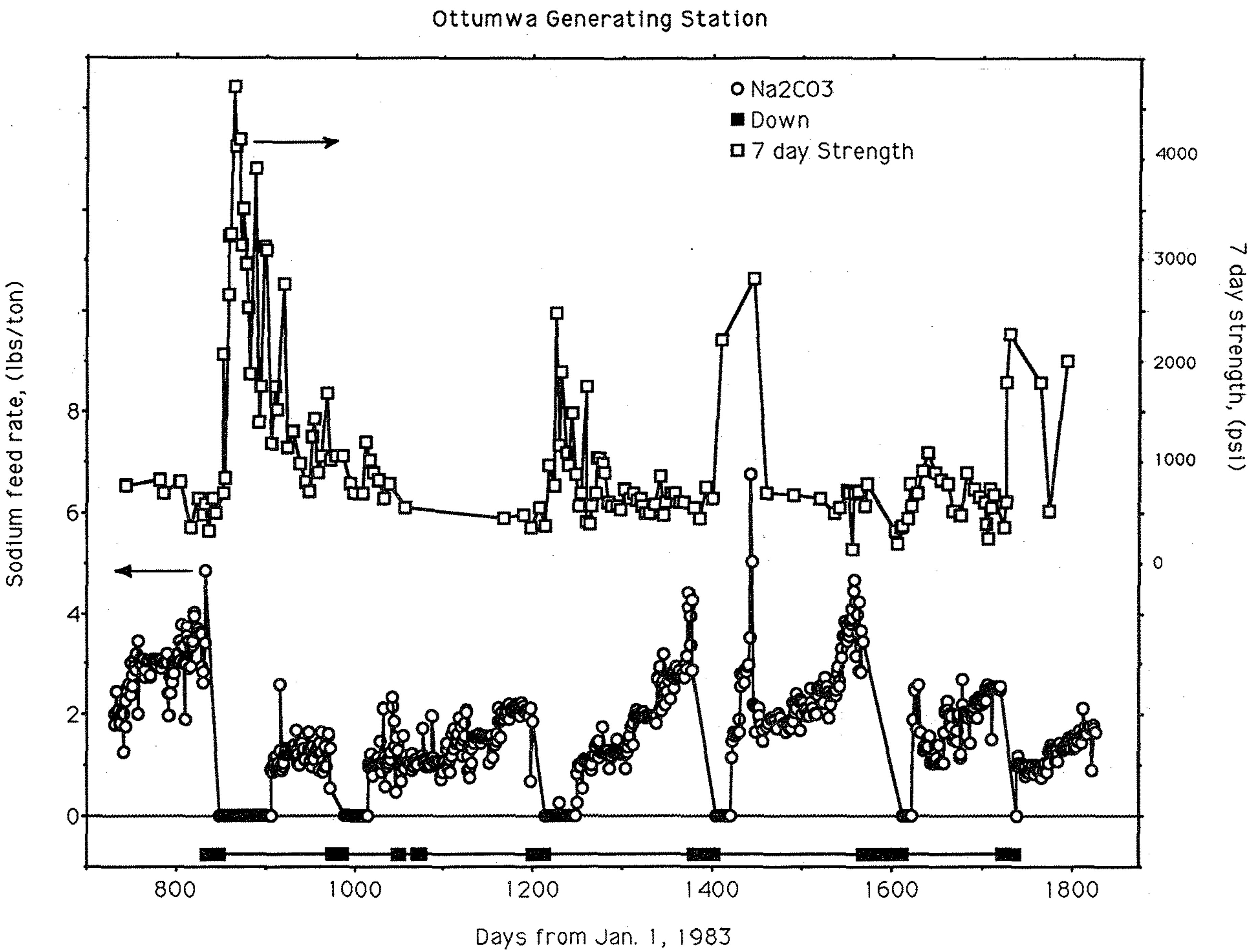

Figure 23. Overlay of 7-day compressive strength and OGS sodium carbonate feedrate versus sampling date.

specifications. Hence, the sodium carbonate feed rate is normally cycled during the generating year. After a maintenance shutdown, during which the electrostatic precipitators are washed out, the power plant needs little (or no) sodium carbonate doping to meet EPA specifications. However, when the power plant is approaching a maintenance shutdown, a high sodium carbonate feed rate is normally needed to stay within EPA guidelines. When the sodium carbonate feed rate gets large enough to cause excessive boiler slagging (typically between 3 and 4 pounds of sodium carbonate per ton of raw coal) the power plant will shutdown for cleaning. A plot of the bulk fly ash sodium oxide content versus sampling time is shown in the top portion of Figure 24. The sodium carbonate feed rate is shown in the lower half of Figure 24. As one would expect, the sodium carbonate feed rate used at the power plant directly influences the amount of sodium oxide present in the fly ash. The sulfur trioxide content of the fly ash also exhibited a similar trend, however, it did not correspond to the sodium carbonate feed rate as well as sodium oxide did. The remaining elements monitored in this study (Si, Al, Fe, Mg, Ca, P and Ti) did not indicate any consistent trends with power plant operating conditions. Figure 25 shows the net output factor (monthly average values) of OGS versus time from January 1, 1985. The power plant shows a trend of slowly increasing net output factor which may help explain the slow rise in the sodium oxide content of the Ottumwa fly ash over the past several years.

OGS versus LGS

Both OGS and LGS fly ashes were sampled about 3 to 4 times per week from early July, 1987 until their scheduled fall maintenance

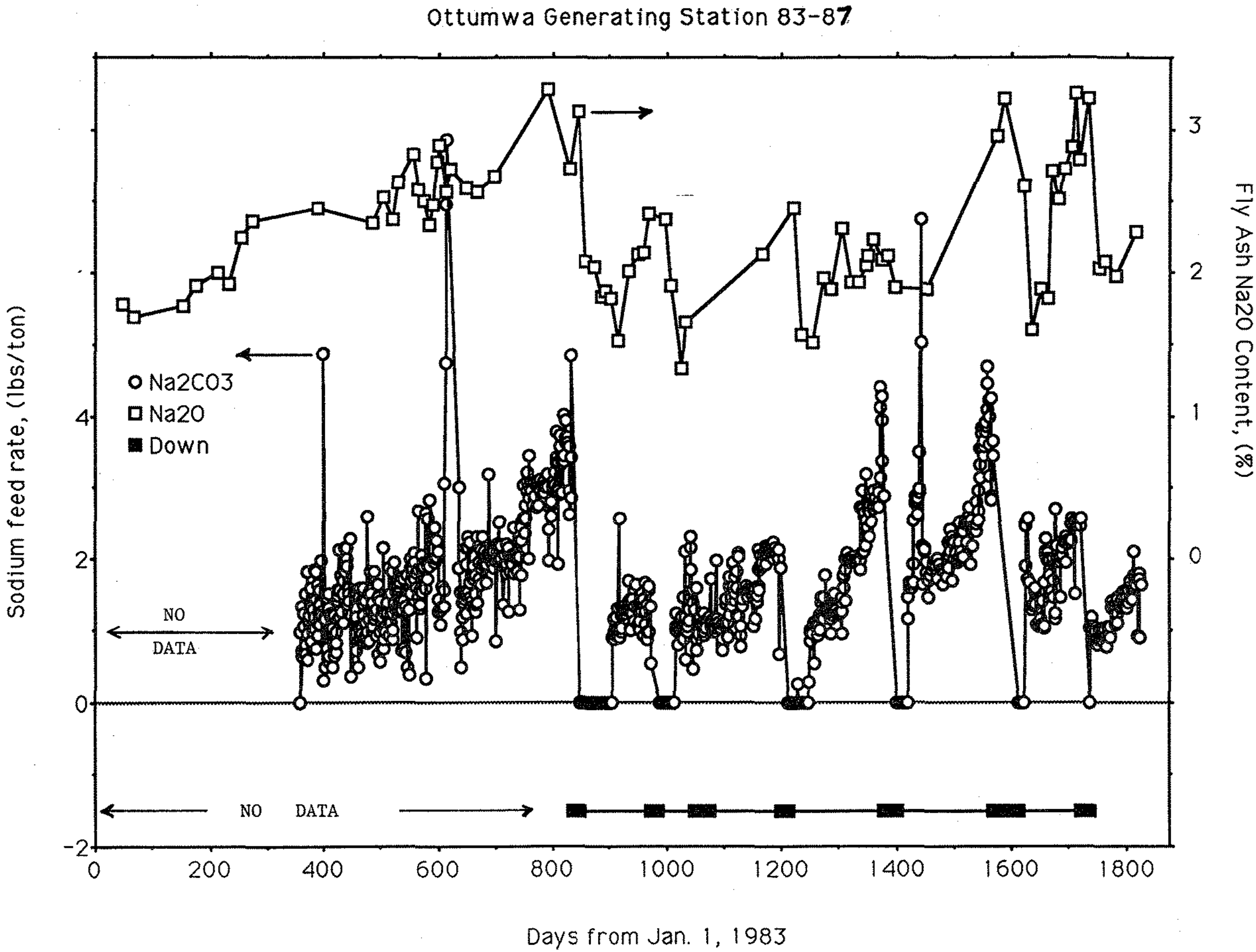

Figure 24. Overlay of fly ash sodium oxide content and OGS sodium carbonate feedrate versus sampling date.

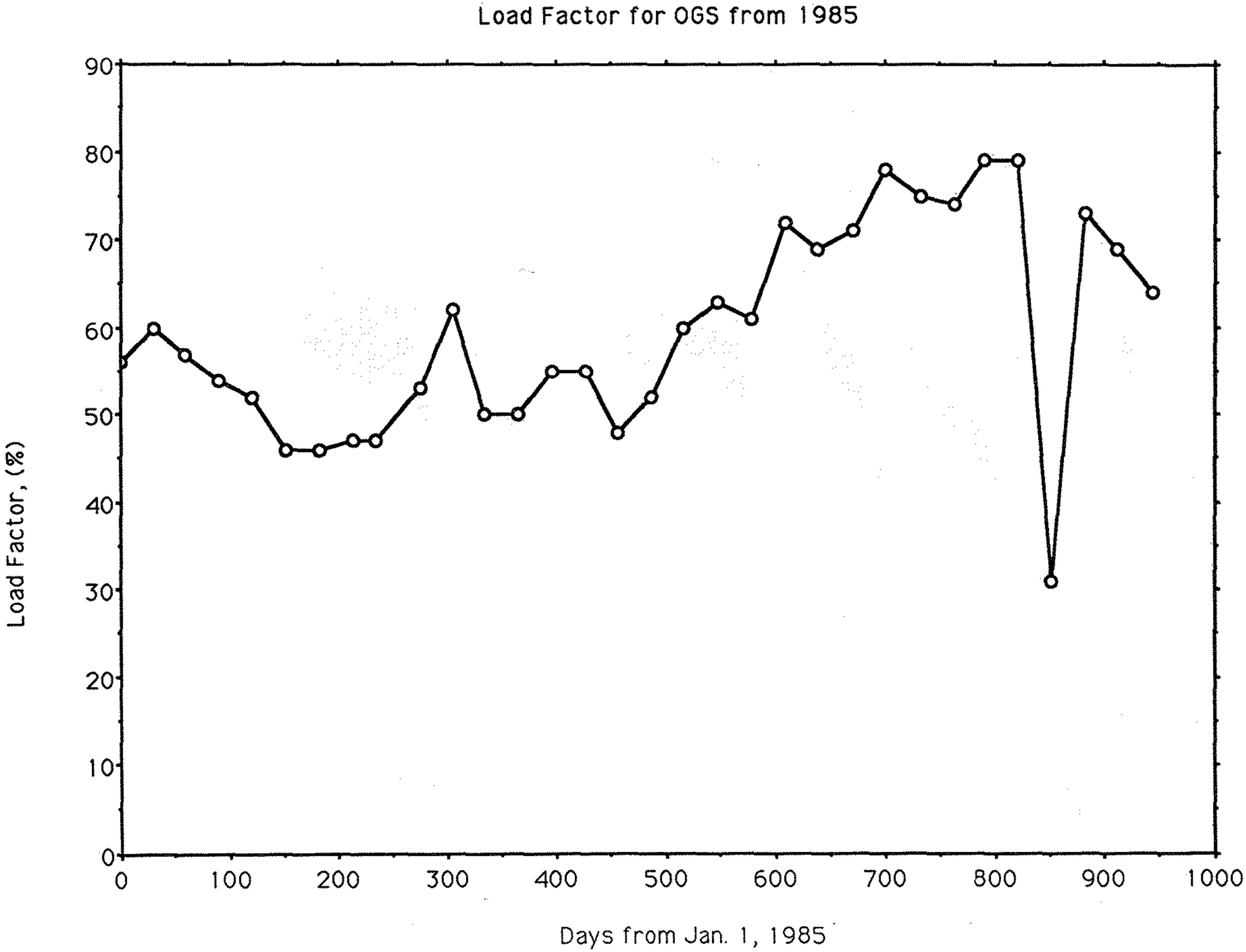

Figure 25. **OGS net output factor versus time.**

shutdown (actual outages were 9/18/87 through 10/2/87 for OGS, and 9/27/87 through 10/25/87 for LGS). While OGS was off line, samples of fly ash were obtained 3 times per week until the fly ash silo was empty. No ash samples were available while LGS was off line because its autosampler does not function during a shutdown. After start up, ash samples were again obtained from both power plants about 3 or 4 times per week for about 2 weeks. All of the ash samples taken immediately before and after a maintenance shutdown were subjected to chemical analysis, x-ray diffraction analysis and the paste testing scheme. Many of these specimens were also subjected to Blaine fineness testing to monitor the specific surface of the fly ash samples. A sub-group of samples were selected from the remaining ash samples to represent the "background" level of fly ash characteristics that existed before the maintenance shutdown. This sub-group of samples was subjected to the same testing scheme that was described above.

The results of the paste testing program are summarized in Table X. In general, the LGS specimens consistently performed better than the OGS specimens in the paste tests. A plot of compressive strength (7-day) versus sampling date is shown in Figure 26. It is interesting to note that the OGS compressive strength tends to increase immediately after start up, this is consistent with the trend reported earlier in this report (see Figures 7 and 23). The LGS specimens showed no clear trend, although the compressive strength values were down slightly after start up. Blaine fineness tests indicated only a relatively small change (less than ± 6% from the mean value) in the specific surface of ash samples taken from either power plant. Hence, the fineness of the fly ash does not

TABLE X
Results of the OGS - LGS paste tests

Test	OGS (n=21) $\bar{X}$	OGS S	OGS MAX	OGS MIN	LGS (n=18) $\bar{X}$	LGS S	LGS MAX	LGS MIN
Compressive Strength (psi)								
4-hour	307	144	566	33	527	238	936	230
1-day	454	170	793	158	1123	413	1796	368
7-day	799	477	2273	238	2836	743	3893	1267
14-day	940	570	2508	258	3302	949	4499	1593
28-day	1004	584	2277	236	3514	578	4701	2241
56-day	1282	835	3342	229	3754	628	4832	2364
Volume Stability (% Expansion @ 28 Days)*								
Air cured	-0.05	0.02	-0.03	-0.08	-0.12	0.05	-0.06	-0.19
Humid cured	0.00	0.01	0.01	-0.02	0.07	0.04	0.15	0.00
Setting time (minutes)								
Initial set	26	25	97	9	8	2	12	4
Final set	43	50	198	14	11.5	3	19	6
Heat Evolution								
Time to peak (min)	32	13	56	12	29	9	47	18
ΔT (°C)	4	2	7	0.3	4	2	8	2

*This statistical summary does not include data from OGS091887 or OGS091687.

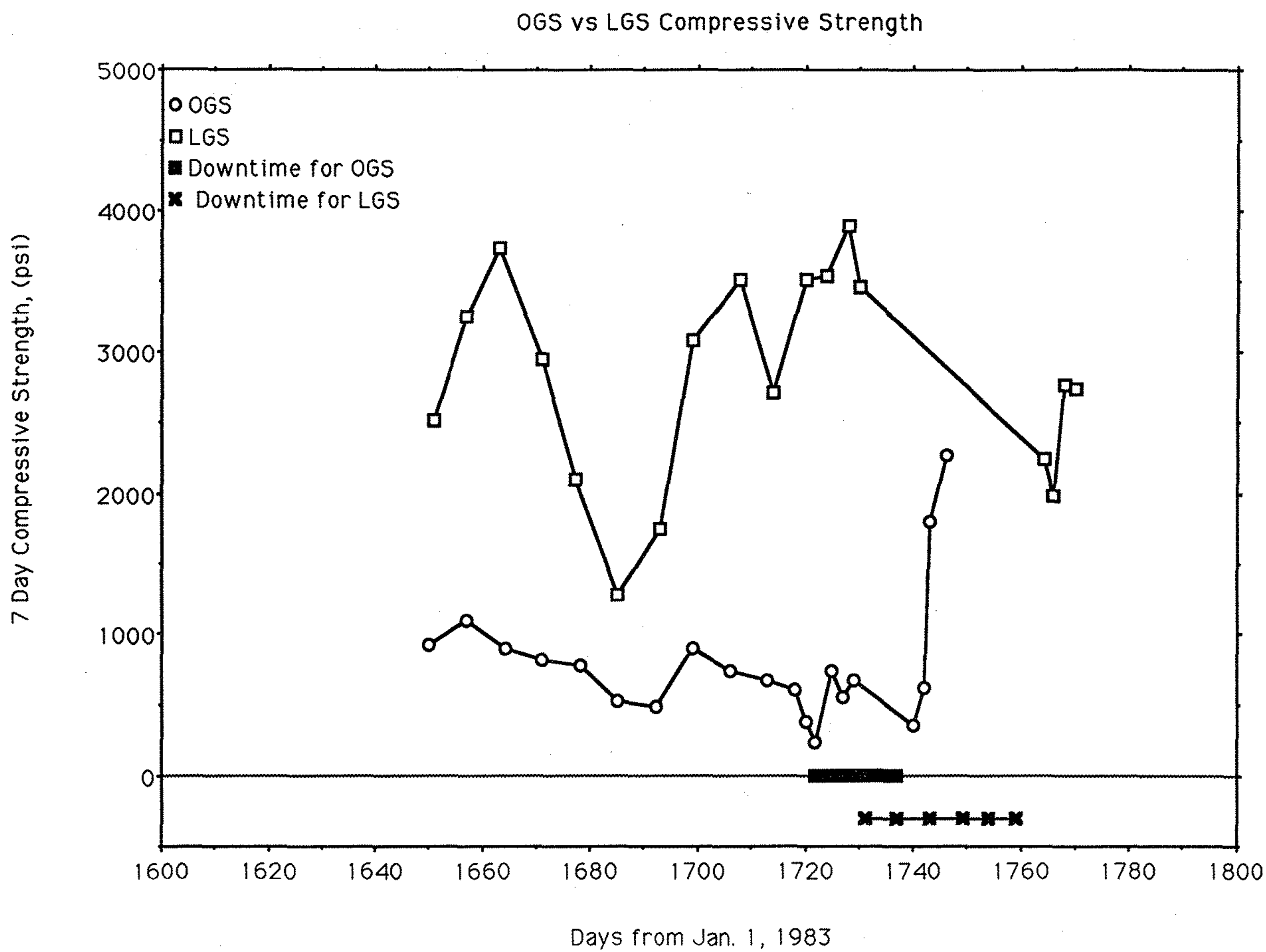

Figure 26. OGS and LGS 7-day paste strengths versus sampling date.

appear to be playing a major role in determining the bulk physical properties of these fly ash pastes.

Several OGS samples obtained immediately before shutdown and after start up exhibited very anomalous physical properties. None of these samples failed to meet the chemical specifications listed in ASTM C 618. Two of the samples obtained before shutdown (OTT091687 and OTT091887), had severe expansive tendencies when they were removed from the autoclave bar molds. The expansive properties of OGS091687 are illustrated in Figure 27. Please note that the time axis represents the time after the specimen was removed from the mold. The specimen was 1 hour old when it was removed from the mold. The OGS091887 specimen had similar tendencies although they were not as severe (about 0.7% expansion in 4 hours). Both samples had rather high SO_3 contents (4.5% and 3.6% for OGS091687 and OGS091887, respectively) and mineralogical studies indicated that the SO_3 appeared to be present in the fly ash as anhydrite ($CaSO_4$), only small concentrations of tetracalcium trialuminate sulfate were observed. In fact, these two specimens had the highest concentrations of anhydrite that were observed in the OGS samples during this study. Also, the first two specimens obtained after start up (OGS100687 and OGS100787), had very odd setting and hardening characteristics. Both specimens had final set times of about 3 hours and had a negligible temperature rise in the conduction calorimeter test. Chemical analysis indicated that the two samples were deficient in analytical CaO and enriched in P_2O_5 (both samples had over 2.2% (by weight) of P_2O_5). Mineralogical studies were in agreement with the chemical studies. XRD indicated that both OGS100687 and OGS100787

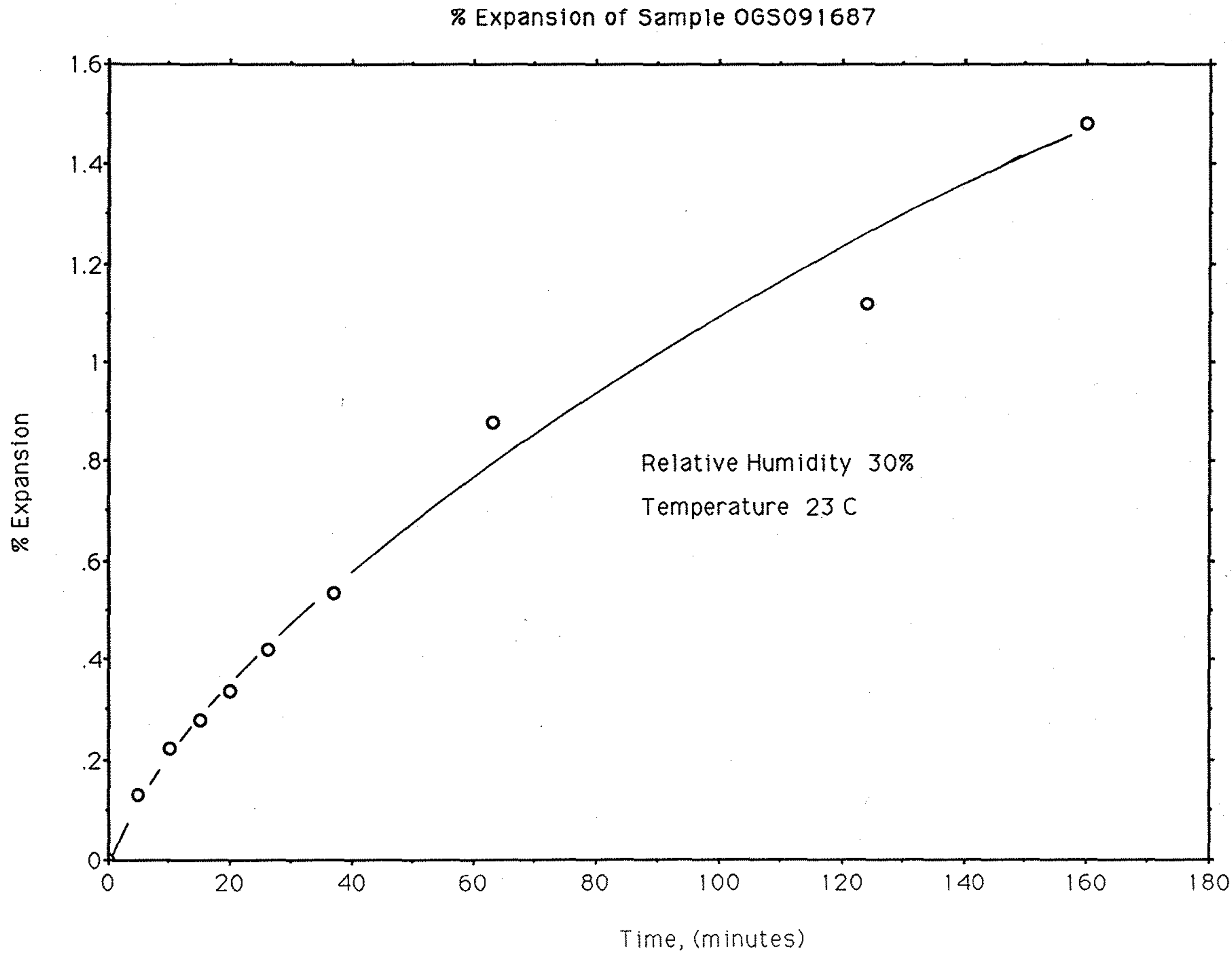

Figure 27. **Expansion of OGS091687 versus time.**

were deficient in tricalcium aluminate and free lime. No phosphorous bearing mineral(s) could be identified in the XRD diffractograms.

Chemical and mineralogical studies of the LGS samples indicated trends similar to those that were observed for the OGS samples. In general, the SO_3 content increased sharply as the power plant neared the maintenance shutdown period (see Figure 28). Mineralogically speaking, this corresponded to an abrupt increase in the amount of anhydrite present in the samples. Again, the concentration of tetracalcium trialuminate sulfate appeared to be nearly constant throughout the study. None of the LGS physical test paste specimens behaved anomalously, however, it is pertinent to add that the two specimens nearest to both shutdown and start up were of such limited quantity that physical tests could not be performed. The sample taken just before shutdown (LGS092787) had a SO_3 content of 6.1%, this sample fails to meet SO_3 criteria in ASTM C 618 specifications. The sample taken immediately after start up (LGS102787) had milo in it. Milo is a grain that is commonly used in place of sand to blast the residue off of the electrostatic precipitator plates during clean out operations. Obviously, the sample containing milo would not meet ASTM C 618 specifications. The ASTM composite sampling procedure would have probably missed rejecting both of these samples because they would have been diluted with four other samples before testing was initiated.

Again, the bulk sodium oxide content of the fly ash appeared to play an important role in the strength development of fly ash pastes. Figure 29 illustrates this fact for the LGS and OGS samples. Eight data points from Lansing fly ash paste tests were included in the figure to help expand the scale of the vertical axis. The trend line indicated on the

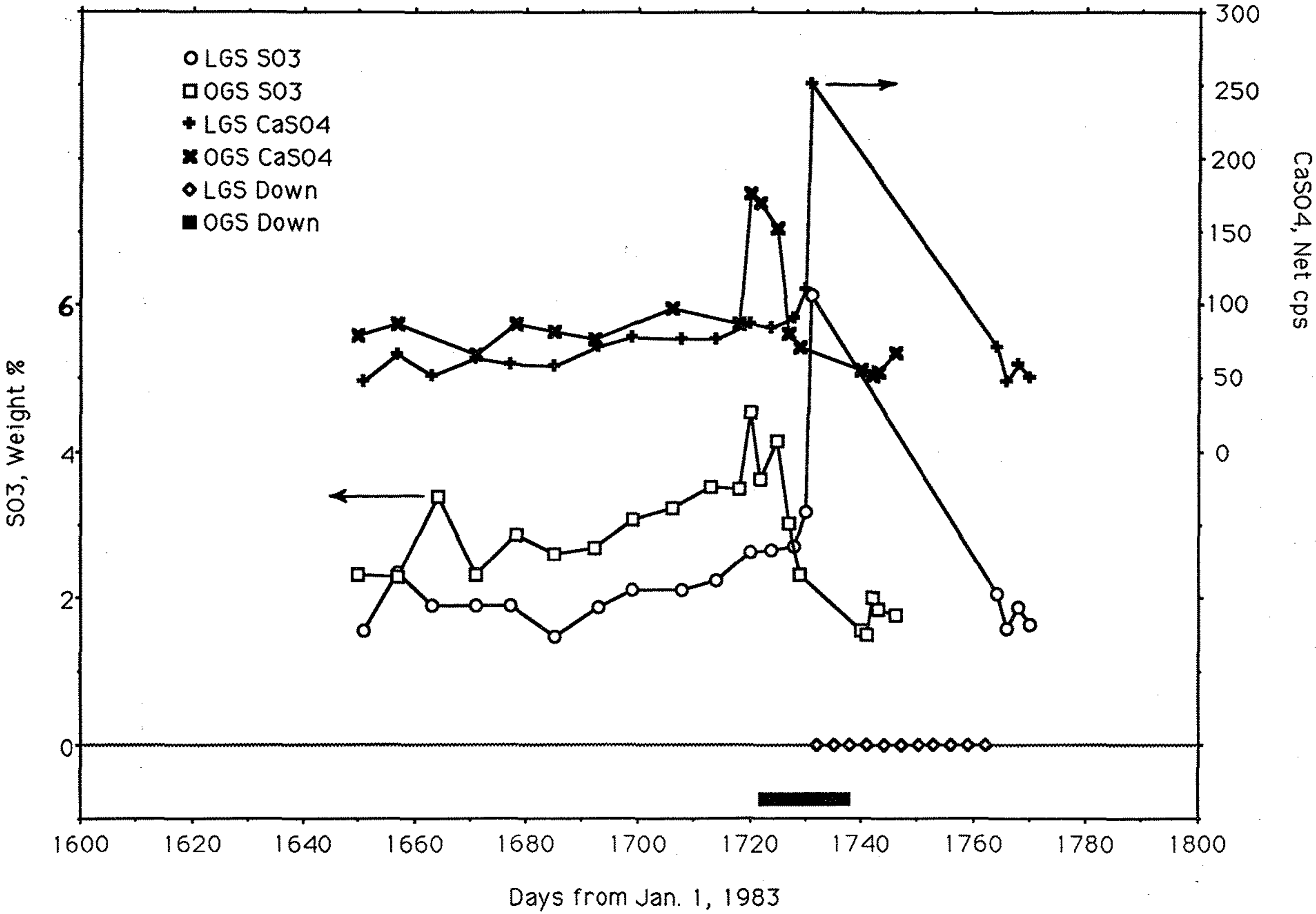

Figure 28. Sulfur trioxide and anhydrite concentrations in LGS and OGS fly ashes as a function of sampling date.

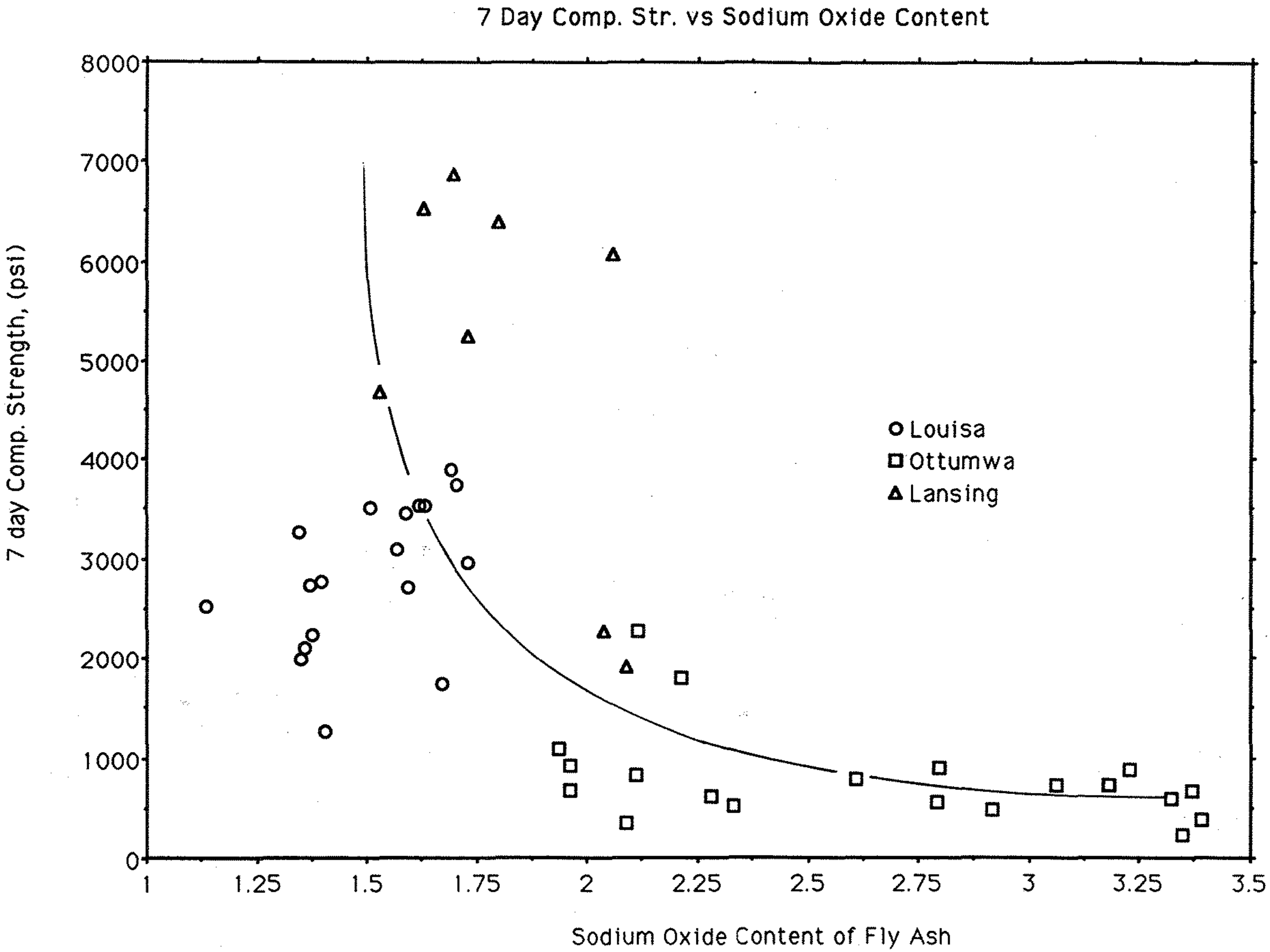

Figure 29. **Seven day paste compressive strength vs. sodium oxide content.**

figure, was drawn by hand and it does not represent a least-squares fit. In general, when the sodium oxide content of the bulk fly ash exceeds about 2.5% the compressive strength of the paste is reduced. However, one must be very cautious when interpreting Figure 29 because OGS fly ash is the only ash with sodium oxide contents above 2.5%. Also, as we explained earlier, the manner in which the sodium is contained in the fly ash is of extreme importance because different minerals (and/or glasses) contribute different amounts of sodium to the pore solution. A detailed investigation of the pore solution present in the fly ash paste specimens is needed before one can deduce firm conclusions about the influence of alkalis on fly ash pastes.

SUMMARY AND CONCLUSIONS

In summary, a detailed investigation has been made of the physical, chemical and mineralogical characteristics of Iowa high-calcium (Class C) fly ashes. Samples from five Iowa power plants were monitored, as a function of sampling date, to assess the variability of the different ash sources. Fly ash samples obtained during "normal" and "upset" power plant operating conditions were investigated during this study.

ASTM C 311 test methods (with minor modifications) were used to characterize the physical properties (i.e., moisture content, loss on ignition, soundness, fineness, pozzolanic activity and specific gravity) and chemical-physical properties (i.e., bulk chemistry, available alkalis plus the physical tests mentioned earlier) of over 800 fly ash samples; 685 of the ash samples were subjected to physical testing while 189 samples (mostly composite samples) were subjected to chemical-physical testing. About 250 of the physical test samples were also subjected to a paste testing program. The paste tests were used to assess the cementitious characteristics of the various fly ash sources. The paste testing program was also used to identify which of the fly ash samples would be subjected to detailed chemical and mineralogical studies. The results of this research effort, directed toward the development of a rational characterization method for Iowa fly ashes, can be summarized as follows.

1 - The results of ASTM physical and chemical testing, which are commonly used to classify fly ash for use as a mineral admixture in portland cement concrete, show little variation with time, irrespective of ash source. However, part of the reason for the lack of variability in the chemical testing phase of this project can be directly attributed to the ASTM composite sampling scheme. None of the fly ash samples tested during this research project failed to meet ASTM C 618 specifications

(this statement ignores two ash samples that were obtained from Louisa Generating Station during shutdown and start up operations).

2 - The available alkali test (described in ASTM C 311) tends to underestimate the amount of alkalis that can be released from Iowa high-calcium fly ashes.

3 - The results of the paste testing program indicated that the physical properties of fly ash pastes can change dramatically (by a factor of 5 to 10 in some instances) in short periods of time. The program also linked the power plant maintenance schedule and sodium carbonate coal pre-treatment at Ottumwa generating station, to cyclical trends in fly ash paste strength properties. Fly ash properties (both chemical and physical) generally change drastically immediately before or after a maintenance outage.

4 - There were no significant correlations observed between the ASTM tests and the fly ash paste testing program.

5 - Strong correlations were observed between several of the variables studied in the fly ash paste testing program. The most obvious correlations were between 7-day and 28-day compressive strengths, between compressive strength and temperature rise, and between initial and final set.

6 - Fly ash paste mixes exhibited significant differences in volume stability characteristics depending on the mode of curing (i.e., air curing or humid curing). However, in most instances the shrinkage/expansive tendencies of the fly ash pastes were not severe.

7 - X-ray diffraction analysis indicated that all of the fly ashes contained the same major crystalline compounds plus a significant portion of glassy material. The crystalline compounds identified in the fly ashes were: lime, periclase, alpha-quartz, anhydrite and a mineral very similar to tricalcium aluminate. Many of the fly ashes also contained tetracalcium trialuminate sulfate and a ferrite spinel. The concentrations of these crystalline compounds changed significantly in ashes sampled from the various power plants, they also changed in samples taken from a single power plant at different sampling times. Hence, mineralogy appears to play

a very important role in determining the physical properties of fly ash pastes. Two different types of glass were found in the various fly ashes. The major glass type appears to consist mostly of calcium, aluminum and silicon; this glass was soluble in hydrochloric acid. The minor glass type found in the fly ashes was nearly insoluble in hydrochloric acid; this glass was very similar to those that are commonly found in Class F fly ashes (i.e., more siliceous in character).

8 - Both bulk mineralogy and bulk chemistry were found to depend heavily on the particle size fraction of a given fly ash that was being investigated. Typically, the alkaline earth elements (Ca, Mg, Sr and Ba) tended to accumulate in the smaller particle size fractions at the expense of Si. Mineralogically, anhydrite and the calcium aluminate silicate glass phase were enriched in the smaller particle size fractions at the expense of alpha-quartz.

9 - Chemical, mineralogical and physical testing indicated that sodium, the sulfate bearing minerals (or bulk SO_3), lime and tricalcium aluminate contents of the fly ashes all appeared to play important roles in the development of hydration products in the paste specimens. All of the fly ash paste specimens studied in this research project contained similar reaction (hydration) products. The fly ash pastes that exhibited high compressive strengths normally contained monosulfoaluminate and straetlingite as the major hydration products, along with minor amounts of ettringite. The weak fly ash pastes always contained ettringite as a major (often only) constituent. The weak pastes occasionally contained lesser amounts of monosulfoaluminate and straetlingite. The exact link between chemistry, mineralogy and the physical properties of fly ash pastes have not been exactly defined by this research project.

RECOMMENDATIONS

I. Fly Ash Certification Testing

We strongly recommend consideration be given to the following changes in the fly ash testing program that is currently used to certify Iowa Class C fly ash sources for use in portland cement concrete.

- The available alkali test should be removed from the fly ash chemical testing scheme. It could be replaced with either a total alkali test or a soluble alkali test. At present, we would suggest a total alkali test since we already have a good data base containing total alkali information for most Iowa fly ashes.

- The moisture content test should be removed from both the physical and chemical-physical test requirements for Class C fly ashes. Class C fly ashes generally do not contain free water because they quickly form hydration products with water. Hence, a bulk loss on ignition test at 750 C much like the one that is currently used to assay portland cement is suggested. Chemical assays could be reported on an as-received basis, which for practical purposes is identical to reporting the fly ash assays on a dry basis.

- A decision must be made concerning the method that will be used to obtain chemical-physical test samples. Currently the composite sampling scheme defined by ASTM C 311 is being used. However, the results of this research has shown that the composite sampling method tends to smooth out variability in the test results. We therefore suggest the adoption of a simple grab sample technique for obtaining chemical-physical test samples. The grab sample could be chosen at random from each group of five physical test specimens (the same group of samples that we presently combine in equal portions to make a composite sample). This procedure would also eliminate the repetition of the six basic tests (moisture content, loss on ignition, soundness, fineness, specific gravity, and pozzolanic activity) that are currently performed on both physical and chemical-physical samples.

II. Fly Ash Construction Utilization

We strongly recommend caution be exercised in utilizing ash produced immediately prior to shutdown and after start up from any power plant. Results of this study indicate that these ashes may have a high concentration of sulfate bearing minerals. Alkalis (mainly sodium) also tend to be quite high immediately before shutdown in power plants that use sodium carbonate doping.

- For portland cement concrete, use of these ashes could potentially lead to efflorescence problems (sodium sulfate) or increase the potential of future sulfate attack for applications where this is of concern.

- For soil or base stabilization where high application rates of fly ash might be used, highly expansive reactions could potentially occur.

It is recommended that consideration be given to increasing the intensity of sampling and testing of fly ash during these periods.

III. Fly Ash Characterization

As has been shown in this study, fly ash is a highly complex material both chemically and mineralogically. This makes the development of simple and rapid characterization methods and tests extremely difficult, if not impossible, at our current level of knowledge. From a practical engineering standpoint and as interim methods, we recommend the following.

- Portland Cement Concrete Utilization

  For fly ash use in p.c. concrete applications, it is our opinion that characterization be accomplished by rapid (1 hour procedure) x-ray fluorescence and diffraction analyses. These results can be quickly compared to the data base presented in this report. Although this is not a field procedure, it is currently our most reliable indicator of ash properties.

- Soil and Base Stabilization

  For stabilization use, strength and setting properties of the ash are of primary importance.

  Strength One inch by one inch paste cubes can be easily made in the field, and tested using a simple hydraulic loading device. The 28 day strength can be estimated from 4 hour strength (R=0.73), 1 day strength (R=0.83) or 7 day strength (R=0.93). The 28 day strength is approximately equal to 1.3 times the 7 day strength.

  Setting Properties Setting characteristics can be evaluated from fly ash pastes using a soil hand penetrometer to estimate initial set. Final set can be estimated from initial set data (FS = 1.6 x IS, R = 0.91).

IV. Future Research

We recommend that an investigation be made concerning the pore solution chemistry of Iowa Class C fly ashes. Such a study would definitely enhance the information produced in this project, and it would lead to a better description of the physical-chemical behavior of Iowa Class C fly ashes, which at present must be classified as unpredictable. These fly ashes are truly expansive cements, and their properties have yet to be exploited fully. Only continuing research will lead to a higher utilization of our fly ash resources.

ACKNOWLEDGEMENTS

The cooperation and assistance of Mr. Lon Zimmerman and Midwest Fly Ash and Materials, Inc., Sioux City, Iowa, in Providing fly ash samples has been essential to the project. Also, the personnel at both Ottumwa Generating Station, and Louisa Generating Station, have been essential to the development of relationships between physical test data and power plant operating parameters. And finally, we would like to acknowledge the efforts of researchers at the MARL, both graduate and undergraduate students, who helped generate reams of data concerning fly ash over the past several years. We thank all of these people for their contributions to this research project.

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GENERAL INFORMATION (Fiscal year 1988)

A.) Power Plant Information

1.) Name of power plant: Council Bluffs #3

2.) Location: Council Bluffs, Iowa

3.) Utility Company (owner): Iowa Power & Light

4.) Year power plant came on line: 1978

5.) Net (maximum) generating capacity (MW): 700

6.) Actual output for 1987 (MW): 3679264.2 MWh

7.) Boiler type (or manufacturer): Babcock - Wilcox PC

8.) Precipitator type: ESP (Hot side)

a.) Is an additive used to enhance the precipitators performance? Yes, $NaCO_3$
(If yes, what is the additive and its approximate dosage (lb/ton coal): 1 lb./ton

9.) Tentative maintenance schedule for 1988: Sept. 4 weeks

10.) Name and phone number of a person who is employed at the power plant and who is technically capable of answering questions regarding the design and operation of the power plant.

Name: W.S. Waldron Phone #: 366-5304

Title: Operations Supt.

11.) Start up fuel (assuming plant was totally shutdown):

#2 fuel oil & pulverized coal

B.) Coal Information

1.) **Coal Source (geographical location):** Powder River, Gillette Wyo.

2.) **Name of Mine(s):** Eagle Butte - Belle Ayr

3.) **Name(s) of mining company(s):** AMAX

4.) **Duration of coal contract (or date when current contract expires):**

Expires Dec. 31, 1997

5.) **Is anything other than coal burnt at the power plant? (If yes, then how much is burnt per pound of coal).** Coal Only

C. Fly Ash Information

1.) **Annual ash production (Tons/year):** 100,000

2.) **Storage capacity of silo (tons):** 4000

3.) **Method of loading trucks (i.e. pneumatic, auger, etc.):** gravity - chute

4.) **Number of loading stations at silo:** one

5.) **Approximate amount of fly ash sold per year (Tons):** 14,000-20,000

6.) **Most common method used to dispose of the unused fly ash (landfill, sluice pond, etc.):** pond

a.) **Where is the location of the disposal site?:**

adjacent to plant

7.) **How are fly ash samples obtained from the power plant (i.e., grab samples from trucks, composite sampling, etc.)?:**

grab samples from truck

GENERAL INFORMATION (Fiscal year 1988)

A.) Power Plant Information

1.) **Name of power plant:** Lansing (#4)

2.) **Location:** R.R.1, Lansing, IA

3.) **Utility Company (owner):** Interstate Power Co.

4.) **Year power plant came on line:** 1977

5.) **Net (maximum) generating capacity (MW):** 260

6.) **Actual output for 1987 (MW):** 1,059,763 MWh

7.) **Boiler type (or manufacturer):** Riley Stoker - Turbo

8.) **Precipitator type:** ESP (hot side)

   a.) **Is an additive used to enhance the precipitators performance?** No
   (If yes, what is the additive and its approximate dosage (lb/ton coal):

9.) **Tentative maintenance schedule for 1988:**

Mtce. Outages: Feb. 28- Mar. 5
May 29 - June 11
Aug. 28- Sept. 3
Nov. 27- Dec. 10

10.) **Name and phone number of a person who is employed at the power plant and who is technically capable of answering questions regarding the design and operation of the power plant.**

Name: Dave Espersen　　**Phone #:** 319-538-4717

Title: Plant Superintendent

11.) **Start up fuel (assuming plant was totally shutdown):**
#2 fuel oil

B.) Coal Information

1.) **Coal Source (geographical location):** Wyoming

2.) **Name of Mine(s):** Eagle Butte / Bel Ayr

3.) **Name(s) of mining company(s):** AMAX

4.) **Duration of coal contract (or date when current contract expires):**

approx. 1996

5.) **Is anything other than coal burnt at the power plant? (If yes, then how much is burnt per pound of coal).**

No, other than #2 fuel oil.

C. Fly Ash Information

1.) **Annual ash production (Tons/year):** approx. 25,000 tons/yr.

2.) **Storage capacity of silo (tons):** 150 tons (permanent silo)
150 tons (temporary silo-Midwest Fly Ash's)

3.) **Method of loading trucks (i.e. pneumatic, auger, etc.):**

gravity / pneumatic

4.) **Number of loading stations at silo:** one

5.) **Approximate amount of fly ash sold per year (Tons):** 10,000 tons

6.) **Most common method used to dispose of the unused fly ash (landfill, sluice pond, etc.):** landfill

a.) **Where is the location of the disposal site?:**

Winneshiek County Landfill - Frankville, IA

7.) **How are fly ash samples obtained from the power plant (i.e., grab samples from trucks, composite sampling, etc.)?:**

grab samples from trucks

GENERAL INFORMATION (Fiscal year 1987)

A.) Power Plant Information

1.) Name of power plant: Louisa Generating Station

2.) Location: Louisa County

3.) Utility Company (owner): Iowa-Illinois Gas and Electric Company

4.) Year power plant came on line: 1983

5.) Net (maximum) generating capacity (MW): 650

6.) Actual output for 1986 (MW): 650

7.) Boiler type (or manufacturer): Babcock & Wilcox

8.) Precipitator type: Hot side - Weighted wire/Opzel Plate

a.) Is an additive used to enhance the precipitators performance? NO
(If yes, what is the additive and its approximate dosage (lb/lb coal):

9.) Tentative maintenance schedule for 1987:

Turbine/Generator inspection
mid September through October

10.) Name and phone number of a person who is employed at the power plant and who is technically capable of answering questions regarding the design and operation of the power plant.

Name: Lance Nicholson Phone #: (319)262-8020

Title: Operation Engineer

11.) Start up fuel (assuming plant was totally shutdown):

Natural gas or fuel oil

B.) Coal Information

1.) Coal Source (geographical location): Powder River Basin, Gillette, Wyoming

2.) Name of Mine(s): Cordero

3.) Name(s) of mining company(s): Sunoco Energy Development Company (Sunedco)

4.) Duration of coal contract (or date when current contract expires):
December 31, 2002

5.) *Is anything other than coal burnt at the power plant?* (If yes, then how much is burnt per pound of coal).
NO

C. Fly Ash Information

1.) Annual ash production (Tons/year): 71,760 (1986)

2.) Storage capacity of silo (tons): 3,500

3.) Method of loading trucks (i.e. pneumatic, auger, etc.): Down spout with pneumatic valves

4.) Number of loading stations at silo: one

5.) Approximate amount of fly ash sold per year (Tons): 100%

6.) Most common method used to dispose of the unused fly ash (landfill, sluice pond, etc.): all flyash is sold.

a.) Where is the location of the disposal site?:

7.) How are fly ash samples obtained from the power plant (i.e., grab samples from trucks, composite sampling, etc.)?:
Automatic composite sampling of flyash entering the silo.

GENERAL INFORMATION (Fiscal year 1988)

A.) Power Plant Information

1.) **Name of power plant:** Ottumwa Generating Station

2.) **Location:** R.R.4, Chillicothe, IA 52548 (physical location/truck address)
P.O. Box 219, Ottumwa,IA 52501 (mailing address)

3.) **Utility Company (owner):** Iowa Southern Utilities, Inc.

4.) **Year power plant came on line:** 1981

5.) **Net (maximum) generating capacity (MW):** 675 MWN

6.) **Actual output for 1987 (MW):** 3,550,720 MWh gross; 3,334,684 MWh net

7.) **Boiler type (or manufacturer):** Combustion Engineering - controlled circulation

8.) **Precipitator type:** Joy Western - hot side

a.) **Is an additive used to enhance the precipitators performance?** Yes, sodium carbonate

(If yes, what is the additive and its approximate dosage (lb/ton coal): 1 to 3 lbs/tons of coal

9.) **Tentative maintenance schedule for 1988:**

4/1/88 through 4/22/88
also
2 weeks scheduled October 1988

10.) **Name and phone number of a person who is employed at the power plant and who is technically capable of answering questions regarding the design and operation of the power plant.**

Name: Rick Grubb/Jay Dixson **Phone #:** 515-935-4302

Title: Superintendent/Supervisor of Operations

11.) **Start up fuel (assuming plant was totally shutdown):** Fuel oil #2

B.) Coal Information

1.) **Coal Source (geographical location):** Powder River Basin Wyoming

2.) **Name of Mine(s):** Cordero

3.) **Name(s) of mining company(s):** Sunedco

4.) **Duration of coal contract (or date when current contract expires):**

20 year contract ends around 2000

5.) **Is anything other than coal burnt at the power plant? (If yes, then how much is burnt per pound of coal).** No

C. Fly Ash Information

1.) **Annual ash production (Tons/year):** 83,000, 1987

2.) **Storage capacity of silo (tons):** 3,500 tons

3.) **Method of loading trucks (i.e. pneumatic, auger, etc.):** gravity feed

4.) **Number of loading stations at silo:** 2

5.) **Approximate amount of fly ash sold per year (Tons):** 35,635, 1987

6.) **Most common method used to dispose of the unused fly ash (landfill, sluice pond, etc.):** Strip mine reclamation

a.) **Where is the location of the disposal site?:** 5 miles north of the plant

7.) **How are fly ash samples obtained from the power plant (i.e., grab samples from trucks, composite sampling, etc.)?:** grab samples

GENERAL INFORMATION (Fiscal year 1988)

A.) Power Plant Information

1.) **Name of power plant:** Port Neal #4

2.) **Location:** 13 miles south of Sioux City, Iowa

3.) **Utility Company (owner):** Iowa Public Service Co.

4.) **Year power plant came on line:** 1979

5.) **Net (maximum) generating capacity (MW):** 600

6.) **Actual output for 1987 (MW):** 2,969,615 MWh

7.) **Boiler type (or manufacturer):** pulverized Coal, Foster Wheeler

8.) **Precipitator type:** hot side ESP, converted to cold side after 12/1/88

a.) **Is an additive used to enhance the precipitators performance?** Yes

(If yes, what is the additive and its approximate dosage (lb/ton coal): Na_2CO_3 on coal prior to combustion (through 12/1/88)

9.) **Tentative maintenance schedule for 1988:**

1 week outage June 3 - June 10
12 week outage Sept 4 - Nov. 25

10.) **Name and phone number of a person who is employed at the power plant and who is technically capable of answering questions regarding the design and operation of the power plant.**

Name: Steve Adamson **Phone #:** (712) 277-7972

Title: Chemical Engineer

11.) **Start up fuel (assuming plant was totally shutdown):**

Fuel oil ignitors

B.) Coal Information

1.) **Coal Source (geographical location):** Powder River Basin, Northeastern Wyoming

2.) **Name of Mine(s):** Caballo

3.) **Name(s) of mining company(s):**

Carter Mining Co. (division of Exxon Coal USA, Inc.)

4.) **Duration of coal contract (or date when current contract expires):**
through Dec. 31, 1998

5.) **Is anything other than coal burnt at the power plant? (If yes, then how much is burnt per pound of coal).**
No

C. Fly Ash Information

1.) **Annual ash production (Tons/year):** (1987) 100,183

2.) **Storage capacity of silo (tons):** 2 @ approx. 2,700 tons each

3.) **Method of loading trucks (i.e. pneumatic, auger, etc.):** dry gravity fill

4.) **Number of loading stations at silo:** 1

5.) **Approximate amount of fly ash sold per year (Tons):** (1987) 36,168

6.) **Most common method used to dispose of the unused fly ash (landfill, sluice pond, etc.):** dry landfill

a.) **Where is the location of the disposal site?:**
Southeast corner of plant site

7.) **How are fly ash samples obtained from the power plant (i.e., grab samples from trucks, composite sampling, etc.)?:**
grab samples from trucks

GENERAL INFORMATION (Fiscal year 1987)

A.) Power Plant Information

1.) Name of power plant: Muscatine Power and Water Unit 9

2.) Location: Muscatine, Iowa

3.) Utility Company (owner): Muscatine Power and Water

4.) Year power plant came on line: 1983

5.) Net (maximum) generating capacity (MW): 157 mw

6.) Actual output for 1986 (MW): 892,869,200 Gross mw:
814,420,800 Net mw:

7.) Boiler type (or manufacturer): Combustion Engineering - Pulverized coal

8.) Precipitator type: Research Cottrell - cold side

a.) Is an additive used to enhance the precipitators performance? No
(If yes, what is the additive and its approximate dosage (lb/lb coal):

9.) Tentative maintenance schedule for 1987:

Scheduled outage
3/8/87 - 4/5/87 (actual)
10/25/87 - 11/22/87

10.) Name and phone number of a person who is employed at the power plant and who is technically capable of answering questions regarding the design and operation of the power plant.

Name: Ray Danz   Phone #: 319/263-2631 Ext. 395

Title: Operations Supt.

11.) Start up fuel (assuming plant was totally shutdown): Fuel oil

B.) Coal Information

1.) Coal Source (geographical location): West-Central Illinois (50-60 miles east of Quincy, Illinois)

2.) Name of Mine(s): Industry Mine

3.) Name(s) of mining company(s): Freeman United

4.) Duration of coal contract (or date when current contract expires): 1998

5.) Is anything other than coal burnt at the power plant? (If yes, then how much is burnt per pound of coal). No

C. Fly Ash Information

1.) Annual ash production (Tons/year): 14,000 tons/year

2.) Storage capacity of silo (tons): 3,200

3.) Method of loading trucks (i.e. pneumatic, auger, etc.): Dry fly ash can only be loaded pneumatically

4.) Number of loading stations at silo: One

5.) Approximate amount of fly ash sold per year (Tons): 0

6.) Most common method used to dispose of the unused fly ash (landfill, sluice pond, etc.): MP&W owned & operated landfill

a.) Where is the location of the disposal site?: Approximately 12 miles southwest of power plant

7.) How are fly ash samples obtained from the power plant (i.e., grab samples from trucks, composite sampling, etc.)?: Grab samples from bottom of precipitator hoppers or pneumatic unloading system at fly ash silo.

GENERAL INFORMATION (Fiscal year 1988)

A.) Power Plant Information

1.) **Name of power plant:** Port Neal #2

2.) **Location:** 12 mi. south of Sioux City, IA

3.) **Utility Company (owner):** Iowa Public Service Co.

4.) **Year power plant came on line:** 1972

5.) **Net (maximum) generating capacity (MW):** 290 Net

6.) **Actual output for 1987 (MW):** 756,269 MWh

7.) **Boiler type (or manufacturer):** pulverized Fuel, Foster Wheeler

8.) **Precipitator type:** ESP (cold side)

a.) **Is an additive used to enhance the precipitators performance?** Yes

(If yes, what is the additive and its approximate dosage (lb/ton coal): SO_3

9.) **Tentative maintenance schedule for 1988:**

Outage April 15-May 29

10.) **Name and phone number of a person who is employed at the power plant and who is technically capable of answering questions regarding the design and operation of the power plant.**

Name: Steve Adamson **Phone #:** (712) 277-7972

Title: Chemical Engineer

11.) **Start up fuel (assuming plant was totally shutdown):**

Natural gas ignitors

B.) Coal Information

1.) **Coal Source (geographical location):** Hanna Basin, South Central Wyoming

2.) **Name of Mine(s):** Seminoe II

3.) **Name(s) of mining company(s):**

Energy Development Co. (subsidiary of Arch Mineral)

4.) **Duration of coal contract (or date when current contract expires):**

through Jan. 31, 1993

5.) **Is anything other than coal burnt at the power plant? (If yes, then how much is burnt per pound of coal).**

No

C. Fly Ash Information

1.) **Annual ash production (Tons/year):** (1987) 38,209

2.) **Storage capacity of silo (tons):** 1 @ approx. 2,000 tons

3.) **Method of loading trucks (i.e. pneumatic, auger, etc.):** dry gravity fill

4.) **Number of loading stations at silo:** 1

5.) **Approximate amount of fly ash sold per year (Tons):** (1987) 1,646

6.) **Most common method used to dispose of the unused fly ash (landfill, sluice pond, etc.):** mostly dry landfill, some to pond

a.) **Where is the location of the disposal site?:**

southern portion of plant site

7.) **How are fly ash samples obtained from the power plant (i.e., grab samples from trucks, composite sampling, etc.)?:**

grab samples from trucks

GENERAL INFORMATION (Fiscal year 1988)

A.) Power Plant Information

1.) **Name of power plant:** Port Neal #3

2.) **Location:** 12 miles south of Sioux City, Iowa

3.) **Utility Company (owner):** Iowa Public Service Co.

4.) **Year power plant came on line:** 1975

5.) **Net (maximum) generating capacity (MW):** 515

6.) **Actual output for 1987 (MW):** 1,627,356 MWh

7.) **Boiler type (or manufacturer):** pulverized coal, Foster Wheeler

8.) **Precipitator type:** ESP (cold side)

  a.) **Is an additive used to enhance the precipitators performance?** No
  (If yes, what is the additive and its approximate dosage (lb/ton coal):

9.) **Tentative maintenance schedule for 1988:**

No outage scheduled

10.) **Name and phone number of a person who is employed at the power plant and who is technically capable of answering questions regarding the design and operation of the power plant.**

Name: Steve Adamson **Phone #:** (712) 277-7972

Title: Chemical Engineer

11.) **Start up fuel (assuming plant was totally shutdown):**

Either natural gas or oil ignitors

B.) Coal Information

1.) **Coal Source (geographical location):** Hanna Basin, South Central Wyoming

2.) **Name of Mine(s):** Rosebud

3.) **Name(s) of mining company(s):**

Rosebud Coal Sales Co. (subsidiary of Peter Kewitland Sons)

4.) **Duration of coal contract (or date when current contract expires):**

through Dec. 31, 1988

5.) **Is anything other than coal burnt at the power plant? (If yes, then how much is burnt per pound of coal).**

No

C. Fly Ash Information

1.) **Annual ash production (Tons/year):** (1987) 66,486

2.) **Storage capacity of silo (tons):** 1 @ approx. 2,000 tons

3.) **Method of loading trucks (i.e. pneumatic, auger, etc.):** dry gravity fill

4.) **Number of loading stations at silo:** 1

5.) **Approximate amount of fly ash sold per year (Tons):** (1987) 2,605

6.) **Most common method used to dispose of the unused fly ash (landfill, sluice pond, etc.):** mostly dry landfill, some to pond

a.) **Where is the location of the disposal site?:**

southern portion of plant site

7.) **How are fly ash samples obtained from the power plant (i.e., grab samples from trucks, composite sampling, etc.)?:**

grab sample from trucks

GENERAL INFORMATION (Fiscal year 1987)

A.) Power Plant Information

1.) **Name of power plant:** M.L. Kapp Station

2.) **Location:** 2001 Beaver Channel Parkway, Clinton, IA 52732

3.) **Utility Company (owner):** Interstate Power Company

4.) **Year power plant came on line:** 1967

5.) **Net (maximum) generating capacity (MW):** 210

6.) **Actual output for 1986 (MW):** 1,010,297 MWh

7.) **Boiler type (or manufacturer):** Combustion Engineering

8.) **Precipitator type:** Electrostatic Precipitator by Joy (Western Precip)

a.) **Is an additive used to enhance the precipitators performance?** No

(If yes, what is the additive and its approximate dosage (lb/lb coal):

9.) **Tentative maintenance schedule for 1987:**

April 19 - May 23 1987

10.) **Name and phone number of a person who is employed at the power plant and who is technically capable of answering questions regarding the design and operation of the power plant.**

Name: Wm. C. Todtz   Phone #: (319)243-2611

Title: Plant Supt.

11.) **Start up fuel (assuming plant was totally shutdown):**

Natural gas

B.) **Coal Information**

1.) **Coal Source (geographical location):** Southern Illinois

2.) **Name of Mine(s):** Spartan Mine
Burning Star #3

3.) **Name(s) of mining company(s):**

Ziegler/Consolidation

4.) **Duration of coal contract (or date when current contract expires):**

Consolidation - December 31, 1987
Ziegler - December 31, 1992

5.) **Is anything other than coal burnt at the power plant? (If yes, then how much is burnt per pound of coal).**

Natural gas for start up and shut down

C. **Fly Ash Information**

1.) **Annual ash production (Tons/year):** approx. 51,000 tons

2.) **Storage capacity of silo (tons):** 300 tons

3.) **Method of loading trucks (i.e. pneumatic, auger, etc.):** auger and gravity

4.) **Number of loading stations at silo:** 1

5.) **Approximate amount of fly ash sold per year (Tons):** approx. 6,000 tons

6.) **Most common method used to dispose of the unused fly ash (landfill, sluice pond, etc.):** Sluiced to pond, then dug out & hauled to landfill.

a.) **Where is the location of the disposal site?:**

R.R. #1 Clinton, IA

7.) **How are fly ash samples obtained from the power plant (i.e., grab samples from trucks, composite sampling, etc.)?:**

From bottom of silo

Appendix B

(Repeatability Test Results)

Verification of physical testing methods

The first task undertaken during the second year of the project was to verify the repeatability of the testing methods for fly ash pastes. The repeatability of the paste testing methods was evaluated by making mixes on three different days using two different fly ashes. The two fly ashes that were chosen for the repeatability tests exhibited physical properties that encompassed the properties observed for most of the fly ash pastes studied so far. The two fly ash samples chosen for testing were from Ottumwa generating station (sampling date 2/25/85), and Lansing power plant (sampling date 3/29/85). The influence of water/fly ash ratio and mode of curing on the physical properties of fly ash pastes have also been studied.

In general, the repeatability tests indicated that the methods used for characterizing the physical properties of the fly ash pastes were adequate (see Tables I and II, Appendix B). Typically, the coefficients of variation for the compressive strength tests were about 10 to 20%. Hence, the tests are not precise enough to compare samples whose strengths differ by less than about 40%. It is pertinent to mention, however, that in this study, strength variations of greater than a factor of 5 (i.e., 500%) have been observed in a single power plant (Ottumwa Generating Station). Strength variations between power plants can also vary by about a factor of five. Thus, the tests were adequate for studying trends in the compressive strength of fly ash pastes.

Results of the remaining tests (i.e., volume stability, setting time and temperature rise) are also summarized in Tables I and II (Appendix B). In general, the results are reproducible on a day to day basis. In fact, the results agree reasonably well with tests performed on the same fly ash samples two years earlier (see Table III in Appendix B). There were modest discrepancies between the air cured expansion values, setting time values (both initial and final set) and the ΔT values obtained over the two year time span, but these may be attributed to changing laboratory conditions or aging of the bulk fly ash samples.

The influence of three different methods of curing on compressive strength of fly ash pastes was also investigated during the second year of the project. The three methods investigated were: (1) air curing (i.e., ambient humidity about 30 to 60% RH), (2) curing in plastic bags (i.e., moist curing, denoted as "normal" curing), and (3) curing in lime saturated water. Ambient temperatures 70 ± 5 ° F (21 ± 3 °C) were utilized throughout the study. The results of the study are illustrated in Figures 1 and 2 (Appendix B). The results indicated that the moist curing methods (curing in plastic bags or under water) were needed to ensure that no long-term strength retrogression occurred. At curing times of less than about 7 days, all three curing methods produced similar results. The underlying cause of the strength retrogression in the air cured fly ash pastes is still being studied.

The results of varying the water/fly ash ratio of pastes made with the Lansing fly ash are summarized in Table IV (Appendix B). In general, the results were similar to those observed for portland cement specimens because the decrease in compressive strength was inversely proportional to the water/fly ash ratio. This is in accordance with Abram's law, a limiting case of Feret's law, which is commonly applied to cement materials [3]. A plot of 7 day compressive strength versus water/fly ash ratio is shown in Figure 3 (Appendix B). Similar results were obtained with specimens cured for other periods of time.

Air cured expansion (i.e., drying shrinkage) of the paste specimens tended to increase with water/fly ash ratio. The results of the humid cured expansion test tended to decrease with increasing water/fly ash ratio.

Setting time of the fly ash paste specimens (both initial and final set) appeared to be independent of water/fly ash ratio for the range of values studied in this investigation (w/fa = 0.27 to 0.55). This may be important to the field utilization of fly ash grouts or slurries because it indicates that some type of retarder must be used to delay the flash setting characteristics of the mixtures. Increasing the water content will increase the fluidity of the mixture but it may not significantly alter the setting time for some fly ashes.

Table I, Appendix B

Repeatability test on Lansing Fly Ash, sampling date: 3/29/85.

	DAY 1		DAY 2		DAY 3		OVERALL	
	Mean	Std. Dev.	MEAN	Std. Dev.	MEAN	Std. Dev.	Mean	Std. Dev.
COMPRESSIVE STRENGTH (PSI)								
4-HOUR	---	---	2010	427	2096	195	2053	301
1-DAY	3171	132	3146	451	3321	230	3213	274
7-DAY	4915	850	4558	268	4356	427	4610	552
14-DAY	6039	807	5627	477	5172	370	5613	629
28-DAY	6134	---	4644	308	4680	---	5080	787
56-DAY	4499	1066	5822	816	5680	411	5334	943
VOLUME STABILITY (% exp. @ 28-days)								
Air Cured	-0.068	----	-0.062	---	-0.084	---	-0.071	0.011
Humid Cured	---	----	0.125	---	0.121	---	0.123	---
SET TIME (min.)								
Initial	9.5	---	10.0	---	10.5	---	10.0	0.5
Final	12.0	---	11.5	---	11.5	---	11.7	0.3
TEMPERATURE RISE								
ΔT (°C)	14.5	---	15.2	---	15.3	---	15.0	0.4
Peak Temp. (°C)	40.5	---	40.2	---	41.3	---	40.7	.6
Time to Peak(min)	23	---	22	---	20.5	---	21.8	1.3

Table II; Appendix B

Repeatability test on Ottumwa Fly Ash, sampling date: 2/25/85.

	DAY 1		DAY 2		DAY 3		OVERALL	
	Mean	Std. Dev.	MEAN	Std. Dev.	MEAN	Std. Dev.	Mean	Std. Dev.
COMPRESSIVE STRENGTH (PSI)								
4-HOUR	601	138	574	78	635	46	603	87
1-DAY	752	43	814	82	629	24	744	92
7-DAY	993	36	1014	179	886	159	964	139
14-DAY	1264	---	1131	175	1009	150	1118	163
28-DAY	1079	121	1054	100	760	127	964	184
56-DAY	1038	---	1101	343	1168	191	1110	223
VOLUME STABILITY (% exp. @ 28-days)								
Air Cured	-0.035	----	-0.037	---	-0.046	---	-0.039	0.006
Humid Cured	0.002	----	-0.001	---	0.016	---	0.006	0.009
SET TIME (min.)								
Initial	16	---	18	---	18	---	17.3	1.2
Final	25	---	27	---	29	---	27	2.0
TEMPERATURE RISE								
ΔT (°C)	4.3	---	6.9	---	4.7	---	5.3	1.4
Peak Temp. (°C)	30.3	---	29.9	---	29.7	---	30.0	0.3
Time to Peak(min)	56	---	53	---	61	---	56.7	4.0

Table III. Appendix B

Prior Results of Testing for Lansing (3/29/85) and Ottumwa (2/25/87) Fly Ash

LANSING FLY ASH (3/29/85), Testing Date: 7/1/85

COMPRESSIVE STRENGTH (PSI)

	Mean	Std. Dev.
4-HOUR	2143	134
1-DAY	3190	381
7-DAY	5370	370
14-DAY	5337	520
28-DAY	6203	335

VOLUME STABILITY (% exp. @ 28-days)

Air Cured	-0.009	---
Humid Cured	0.170	---

SET TIME (min.)

Initial	8	---
Final	10	---

TEMPERATURE RISE

ΔT (°C)	16.6	---
Peak Temp. (°C)	40.6	---
Time to Peak(min)	18.5	---

Table III (continued), Appendix B

OTTUMWA FLY ASH (2/25/85), Testing Date: 7/1/85

COMPRESSIVE STRENGTH (PSI)

	Mean	Std. Dev.
4-HOUR	448	104
1-DAY	550	166
7-DAY	700	52
14-DAY	890	128
28-DAY	950	72

VOLUME STABILITY (% exp. @ 28-days)

Air Cured	Broke	---
Humid Cured	0.0	---

SET TIME (min.)

Initial	12	---
Final	18.5	---

TEMPERATURE RISE

ΔT (°C)	7.3	---
Peak Temp. (°C)	29.8	---
Time to Peak(min)	57	---

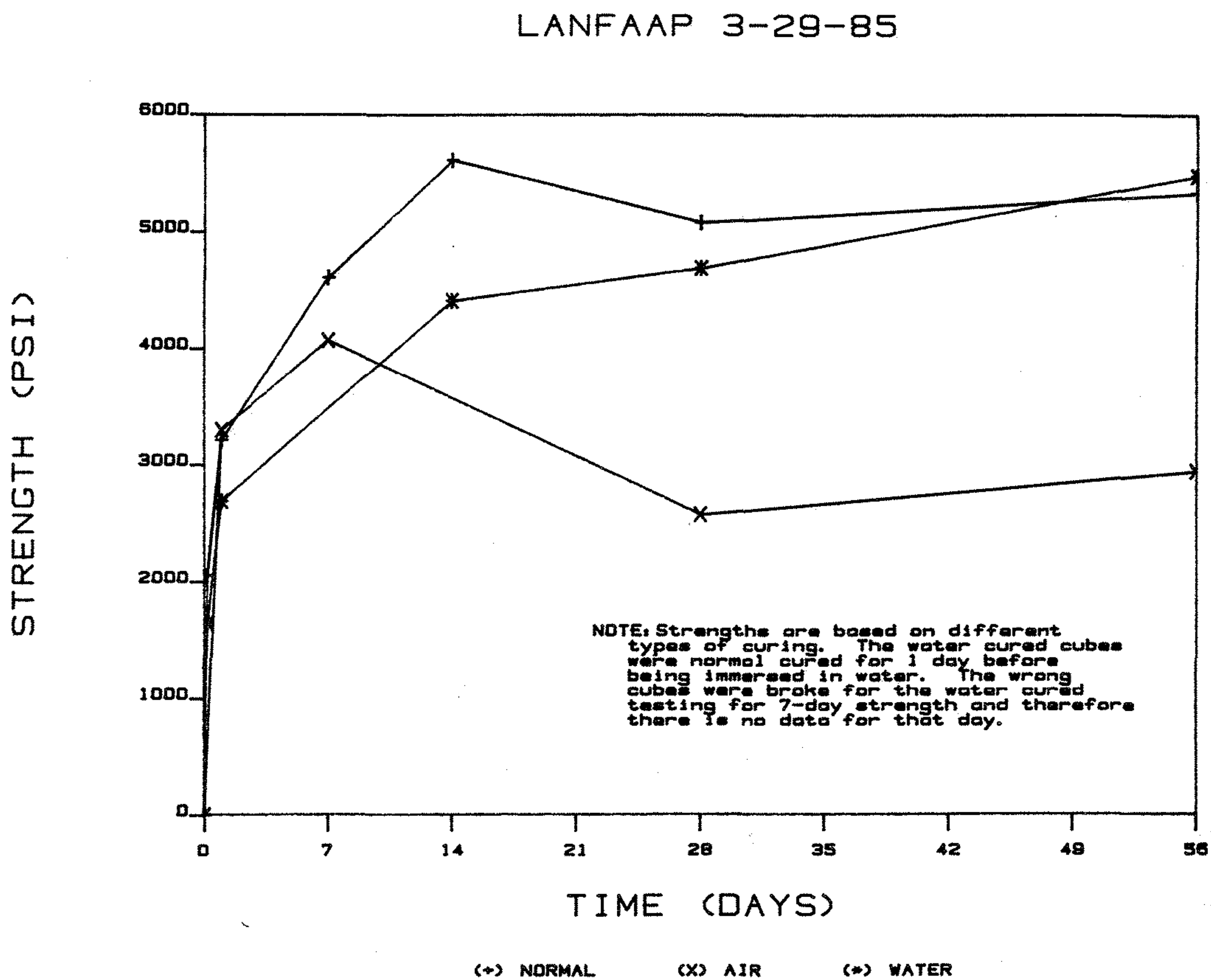

Figure 1, Appendix B

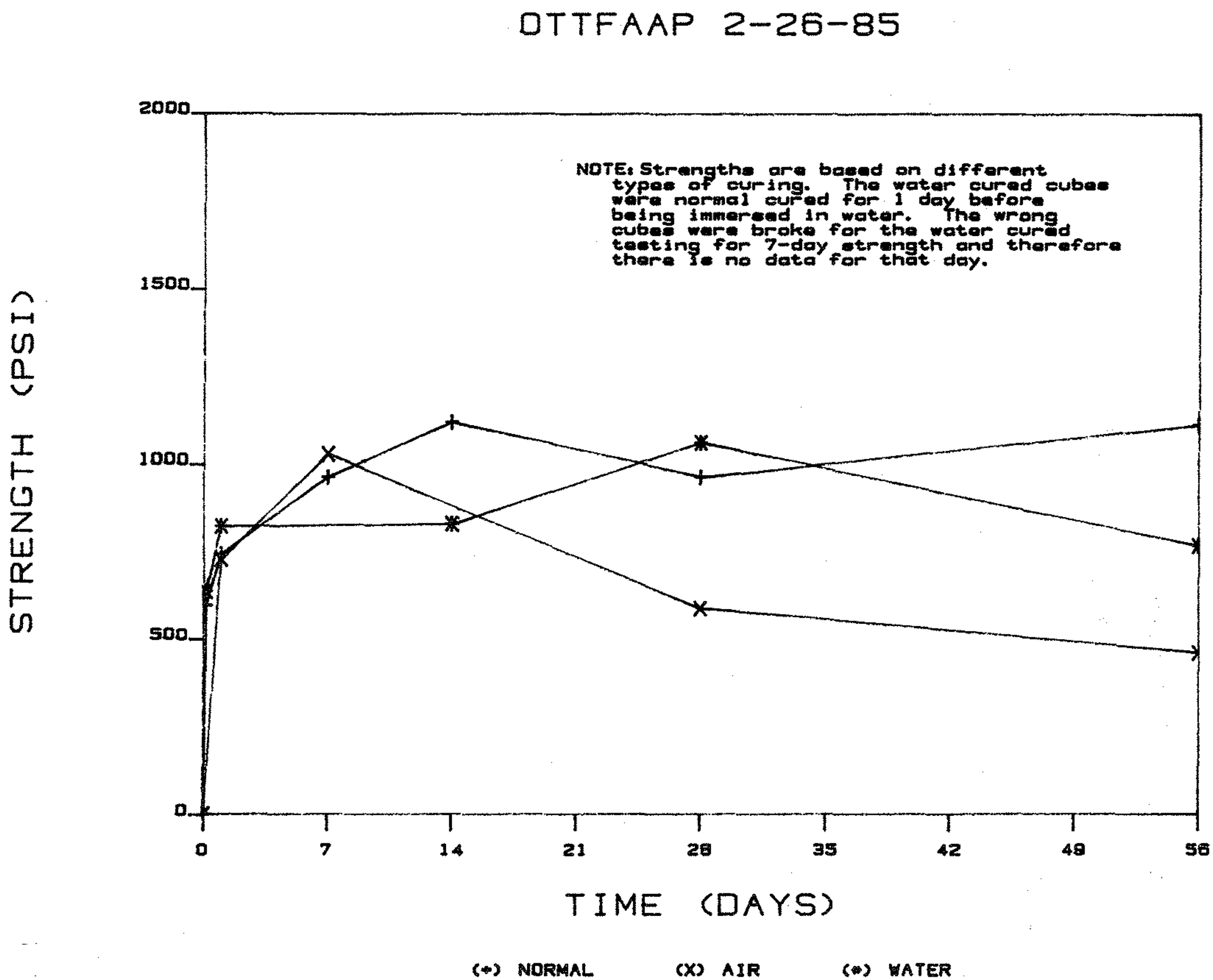

Figure 2. Appendix B

Table IV

Physical properties for Lansing fly ash pastes at different water/fly ash ratios.

LANSING FLY ASH (3/29/85)

	Water/fly ash Ratio			
STRENGTH (PSI)	0.27	0.35	0.45	0.55
4-HOUR	2053	1041	659	429
1-DAY	3213	1607	1053	652
7-DAY	4610	3012	2082	1135
14-DAY	5613	3577	2444	1478
28-DAY	5080	4491	2857	1863
VOLUME STABILITY (% expansion, 28-days curing)				
Air Cured	-0.07	-0.11	-0.12	-0.16
Humid Cured	0.12	0.19	0.15	0.12
SET TIME (min.)				
Initial	10.0	8.5	10.0	11.0
Final	12.0	9.5	11.0	13.0

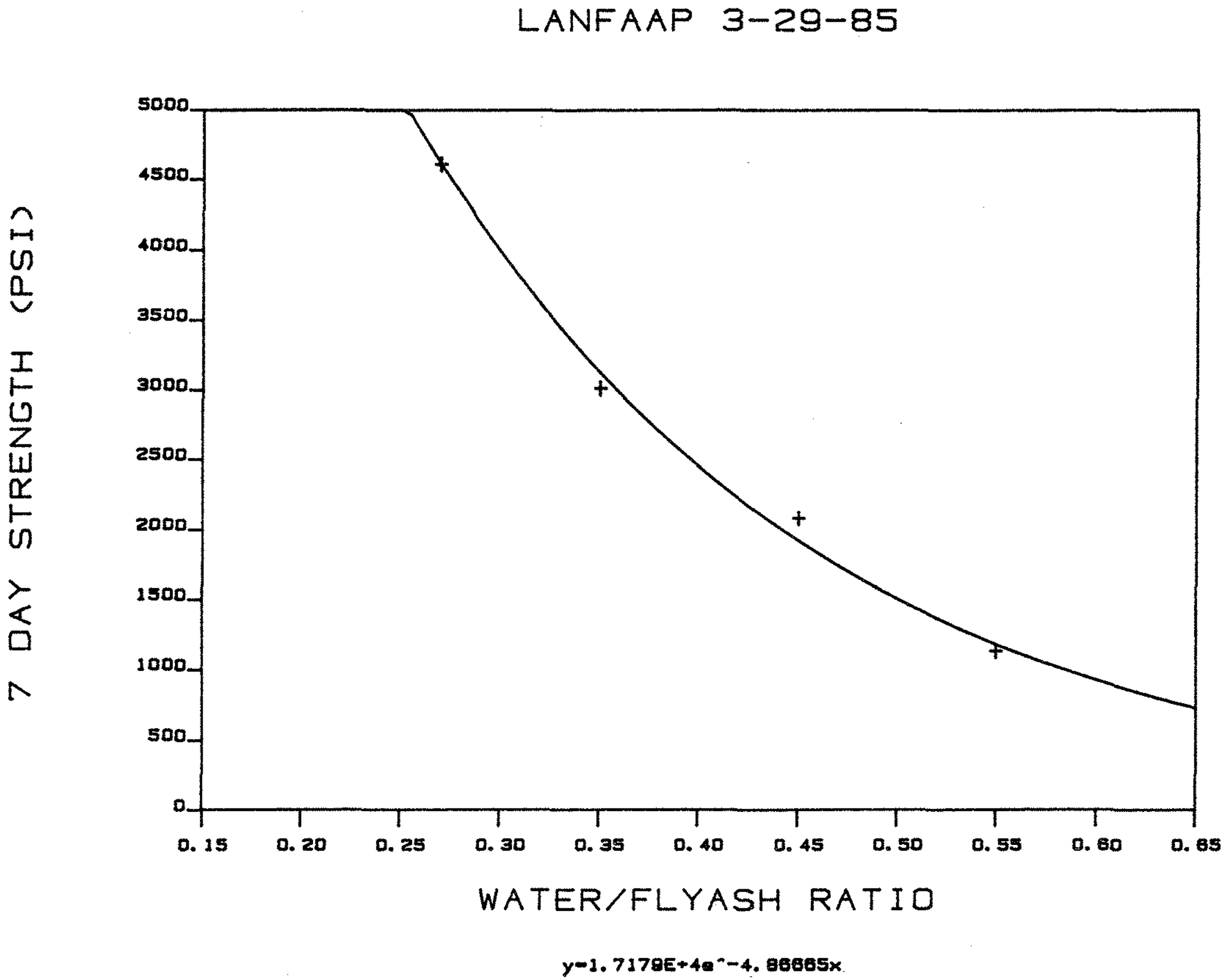

Figure 3, Appendix B

Table I, Appendix C
Chemical - physical test data

Council Bluffs Power Plant

Year →	1983			1984			1985		
	n = 4			n = 7			n = 9		
Test	$\bar{X}$	S	R**	$\bar{X}$	S	R	$\bar{X}$	S	R
Moisture content	0.07	0.02	0.03	0.06	0.03	0.07	0.09	0.06	0.20
Loss on Ignition	0.32	0.13	0.29	0.45	0.08	0.22	0.47	0.14	0.42
Fineness	10.82	3.20	6.86	11.73	2.05	6.77	13.30	3.13	9.90
7 Day Pozzolan	Not Determined			89.7	6.4	19.0	86.7	4.6	12.0
Autoclave Exp.	0.14	0.01	0.03	0.06	0.01	0.04	0.11	0.03	0.09
Specific Gravity	2.71	0.03	0.06	2.65	0.05	0.11	2.71	0.03	0.10
28-Day Pozzolan	98.8	4.0	9.0	100.9	8.3	24.0	87.9	3.7	10.0
H_2O Required	91.5	5.3	10.0	90.3	0.76	2.0	88.8	1.4	5.0
SiO_2	31.48	0.65	1.51	33.64	1.67	5.24	30.81	1.64	4.50
Al_2O_3	16.90	0.26	0.55	17.15	0.57	1.67	15.82	0.62	1.80
Fe_2O_3	5.15	0.16	0.33	5.06	0.24	0.77	5.40	0.45	1.37
SO_3	3.06	0.30	0.64	2.77	0.30	0.81	3.78	0.50	1.29
CaO	27.90	0.56	1.36	26.83	0.86	2.19	28.12	0.42	1.10
MgO	6.65	0.16	0.35	5.67	0.21	0.60	5.80	0.49	1.45
P_2O_5	0.87	0.14	0.78*	1.24	0.18	0.54	1.00	0.18	0.65
K_2O	0.33	0.04	0.08	0.34	0.04	0.13	0.28	0.04	0.11
Na_2O	1.78	0.08	0.19	1.98	0.16	0.44	1.91	0.16	0.49
TiO_2	1.36	0.04	0.08*	1.33	0.07	0.22	1.24	0.14	0.41
Avail. Alk.	1.31	0.09	0.22	1.28	0.16	0.52	1.34	0.15	0.42

*Denotes n = 3 ** R = MAX − MIN

Table I (Appendix C), continued

Council Bluffs Power Plant

Year	1986 n = 7			1987 n = 10		
Test	$\overline{X}$	S	R	$\overline{X}$	S	R
Moisture Content	0.08	0.05	0.17	0.07	0.07	0.21
Loss on Ignition	0.43	0.12	0.39	0.32	0.14	0.36
Fineness	9.97	0.85	2.3	11.30	0.95	3.6
7 Day Pozz.	91.9	3.8	9	87.0	4.4	13
Autoclave Exp.	0.10	0.04	0.10	0.12	0.02	0.07
Specific Gravity	2.71	0.02	0.07	2.73	0.02	0.07
28 Day Pozz.	90.6	6.1	15	91.0	6.1	21
H_2O Required	90.1	2.5	7	91.0	1.2	4
SiO_2	30.43	0.66	7.3	30.20	1.90	7.3
Al_2O_3	16.87	0.27	0.8	16.5	0.49	1.5
Fe_2O_3	5.33	0.15	0.4	6.5	0.45	1.5
SO_3	3.20	0.21	0.63	3.21	0.40	1.39
CaO	30.84	1.12	2.9	28.8	1.06	4.2
MgO	5.17	0.23	0.69	6.43	0.37	1.18
P_2O_5	1.34	0.20	0.67	0.76	0.21	0.68
K_2O	0.25	0.03	0.10	0.24	0.05	0.18
Na_2O	1.62	0.13	0.35	1.77	0.19	0.57
Avail Alk.	1.19	0.12	0.35	1.29	0.11	0.36

Table I, Appendix C (continued)

Lansing Power Plant

Year →	1983			1984			1985		
	n = 4			n = 4			n = 7		
Test	$\bar{X}$	S	R	$\bar{X}$	S	R	$\bar{X}$	S	R
Moisture Content	0.04	0.03	0.06	0.04	0.04	0.07	0.05	0.05	0.14
Loss on Ignition	0.44	0.27	0.56	0.29	0.05	0.11	0.47	0.18	0.56
Fineness	12.95	2.35	5.23	11.17	2.82	6.18	12.77	1.92	6.80
7-Day Pozzolan	Not Required			90.3	2.2	5.0	90.0	5.1	13.0
Autoclave Exp.	0.11	0.02	0.04	0.07	0.01	0.02	0.10	0.03	0.08
Specific Gravity	2.77	0.04	0.09	2.78	0.02	0.05	2.79	0.02	0.07
28-Day Pozzolan	85.8	7.7	18.0	91.2	8.0	19.0	86.9	5.1	16.0
H_2O Required	95.5	5.4	12.0	90.0	0.0	0.0	89.4	1.0	3.0
SiO_2	35.72	3.68	7.70	34.32	3.19	7.37	31.50	1.41	4.00
Al_2O_3	16.72	0.66	1.60	15.58	0.17	0.38	15.53	0.46	1.40
Fe_2O_3	5.54	0.22	0.52	5.68	0.42	0.97	5.94	0.38	1.20
SO_3	3.66	0.68	1.63	4.29	0.70	1.52	4.35	0.36	1.03
CaO	26.72	0.68	1.44	26.82	1.07	2.39	27.66	0.64	1.60
MgO	6.63	0.51	1.16	6.06	0.37	0.87	5.77	0.30	0.89
P_2O_5	1.00	0.30	0.57*	0.84	0.08	0.19	0.86	0.19	0.64
K_2O	0.38	0.02	0.04	0.40	0.12	0.27	0.29	0.04	0.10
Na_2O	2.05	0.20	0.45	1.88	0.05	0.10	2.06	0.24	0.71
TiO_2	1.29	0.03	0.06*	1.20	0.04	0.07	1.20	0.10	0.33
Avail. Alk.	1.42	0.11	0.25	1.33	0.11	0.24	1.44	0.22	0.57

*Denotes n = 3

Table I (Appendix C), continued

Lansing Power Plant

Year	1986 n = 8			1987 n = 8		
Test	$\overline{X}$	S	R	$\overline{X}$	S	R
Moisture Content	0.05	0.02	0.06	0.02	0.02	0.05
Loss of Ignition	0.51	0.21	0.51	0.46	0.17	0.51
Fineness	11.46	1.95	5.7	11.2	2.8	8.5
7 Day Pozz.	89.1	2.7	11	88.0	5.0	15
Autoclave Exp.	0.09	0.05	0.13	0.12	0.02	0.04
Specific Grav.	2.78	0.04	0.04	2.78	0.02	0.07
28 Day Pozz.	94.6	5.2	19	93.0	6.0	18
H_2O Required	91.2	2.4	6	92.0	2.0	5
SiO_2	30.39	0.81	2.4	30.8	1.0	2.9
Al_2O_3	16.64	0.87	0.8	16.8	0.5	1.9
Fe_2O_3	5.95	0.35	1.1	6.1	0.4	1.0
SO_3	3.57	0.44	0.51	3.69	0.38	1.03
CaO	29.30	1.68	1.5	28.7	0.7	2.1
MgO	5.77	0.64	1.35	5.87	0.69	1.99
P_2O_5	1.00	0.23	0.32	0.96	0.23	0.60
K_2O	0.26	0.05	0.10	0.24	0.03	0.08
Na_2O	1.76	0.31	0.93	1.86	0.21	0.49
Avail Alk.	1.29	0.21	0.51	1.39	0.17	0.44

Table I, Appendix C (continued)

Neal #4 Power Plant

Year →	1983			1984			1985[a]		
	n = 4			n = 6			n = 15		
Test	$\overline{X}$	S	R	$\overline{X}$	S	R	$\overline{X}$	S	R
Moisture Content	0.02	0.01	0.03	0.03	0.03	0.07	0.03	0.02	0.06
Loss on Ignition	0.17	0.01	0.03	0.31	0.06	0.14	0.31	0.04	0.14
Fineness	7.49	2.56	5.79	11.57	0.69	2.06	11.42	2.20	7.10
7-Day Pozzolan	Not Required			88.4	6.1	16.0	92.7	5.1	20.0
Autoclave Exp.	0.08	0.01	0.02	0.06	0.02	0.05	0.07	0.02	0.07
Specific Gravity	2.69	0.02	0.04	2.66	0.04	0.11	2.59	0.08	0.28
28-Day Pozzolan	104.2	8.8	19.0	90.3	5.2	14.0	95.3	6.8	25.0
H_2O Required	88.2	0.5	1.0	91.8	4.0	10.0	88.5	1.0	4.0
SiO_2	35.20	0.97	2.19	33.63	1.00	2.74	35.23	2.52	9.98
Al_2O_3	15.68	0.25	0.58	15.69	0.55	1.61	16.24	0.91	3.11
Fe_2O_3	6.20	0.13	0.24	5.83	0.26	0.68	5.59	0.50	1.67
SO_3	3.33	0.28	0.60	3.82	0.60	1.36	3.25	0.74	2.56
CaO	25.89	0.41	0.90	25.88	0.57	1.71	25.45	1.62	4.89
MgO	6.04	0.22	0.50	5.81	0.22	0.52	5.65	0.41	1.34
P_2O_5	0.76	0.05	0.09*	0.97	0.20	0.51	0.99	0.19	0.74
K_2O	0.29	0.05	0.12	0.30	0.03	0.08	0.32	0.07	0.22
Na_2O	2.08	0.12	0.29	2.54	0.19	0.43	2.20	0.23	0.78
TiO_2	1.02	0.02	0.04	1.04	0.06	0.16	1.06	0.07	0.11
Avail. Alk.	1.46	0.08	0.18*	1.57	0.16	0.39	1.39	0.27	0.89

[a]Denotes that two different coal sources were used in 1985.

*Denotes n = 3

Table I (Appendix C), continued

Neal 4 Power Plant

Year	1986 n = 9			1987 n = 12		
Test	$\overline{X}$	S	R	$\overline{X}$	S	R
Moisture Content	0.05	0.10	0.03	0.04	0.02	0.06
Loss of Ignition	0.35	0.08	0.27	0.26	0.05	0.22
Fineness	11.81	0.66	2.2	12.9	1.3	4.0
7 Day Pozz.	86.9	3.1	9	92.0	5.0	16
Autoclave Exp.	0.06	0.03	0.09	0.07	0.01	0.03
Specific Grav.	2.68	0.04	0.12	2.53	0.03	0.09
28 Day Pozz	91.9	5.4	19	99.0	6.0	23
H_2O Required	89.8	1.4	4	92.0	1.0	3
SiO_2	31.68	0.93	3.2	35.8	1.4	5.9
Al_2O_3	16.26	0.97	2.5	17.7	0.7	2.8
Fe_2O_3	6.03	0.23	0.6	5.6	0.1	0.3
SO_3	3.16	0.43	1.2	2.12	0.40	1.49
CaO	27.12	0.85	2.7	23.6	0.6	2.4
MgO	5.51	0.43	1.38	4.54	0.12	0.40
P_2O_5	1.10	0.53	1.37	1.16	0.09	0.35
K_2O	0.26	0.05	0.13	0.41	0.08	0.29
Na_2O	2.67	0.10	0.32	2.22	0.28	0.87
Avail Alk.	1.62	0.10	0.34	1.28	0.45	1.02

Table I, Appendix C (continued)

Ottumwa Power Plant

Year →	1983			1984			1985		
	n = 8			n = 17			n = 17		
Test	$\overline{X}$	S	R	$\overline{X}$	S	R	$\overline{X}$	S	R
Moisture Content	0.04	0.02	0.05	0.03	0.01	0.05	0.03	0.02	0.06
Loss on Ignition	0.24	0.05	0.14	0.26	0.05	0.21	0.25	0.06	0.21
Fineness	10.22	0.32	0.94	10.41	0.75	2.74	9.99	0.69	2.50
7-Day Pozzolan	Not Required			90.2	6.3	23.0	91.9	4.0	16.0
Autoclave Exp.	0.05	0.02	0.06	0.03	0.01	0.04	0.06	0.02	0.05
Specific Gravity	2.61	0.02	0.06	2.60	0.03	0.12	2.65	0.03	0.11
28-Day Pozzolan	103.1	10.6	30.0	97.6	5.7	20.0	94.2	6.3	23.0
H_2O Required	89.1	3.4	10.0	90.2	0.8	3.0	86.8	1.9	9.0
SiO_2	34.48	1.49	4.86	35.33	1.42	5.05	32.23	1.64	6.48
Al_2O_3	19.98	0.41	1.20	18.36	0.35	1.60	18.33	0.34	1.29
Fe_2O_3	5.23	0.14	0.44	5.19	0.16	0.63	5.44	0.40	1.28
SO_3	1.67	0.22	0.65	2.16	0.37	1.32	2.56	0.44	1.76
CaO	24.72	0.68	1.89	23.77	0.70	2.17	25.11	0.54	2.03
MgO	4.94	0.19	0.57	4.63	0.16	0.57	4.92	0.13	0.54
P_2O_5	1.41	0.30	0.92*	1.80	0.23	0.84	1.59	0.38	1.20
K_2O	0.40	0.03	0.09	0.40	0.04	0.12	0.38	0.03	0.09
Na_2O	1.96	0.24	0.67	2.58	0.16	0.55	2.13	0.52	1.95
TiO_2	1.47	0.05	0.16*	1.37	0.05	0.16	1.42	0.04	0.13
Avail. Alk.	1.41	0.18	0.59	1.54	0.30	0.84	1.54	0.33	1.32

*Denotes n = 7

Table I (Appendix C), continued

Ottumwa Power Plant

Year	1986	n = 16		1987	n = 17	
Test	$\bar{X}$	S	R	$\bar{X}$	S	R
Moisture Content	0.04	0.02	0.08	0.04	0.02	0.07
Loss of Ignition	0.30	0.07	0.22	0.29	0.06	0.23
Fineness	9.55	0.67	3.0	10.7	0.8	3.6
7-Day Pozz	93.4	5.1	21	93	6	21
Autoclave Exp.	0.02	0.03	0.09	0.07	0.02	0.06
Specific Grav.	2.68	0.02	0.08	2.63	0.04	0.13
28-Day Pozz.	98.2	5.5	20	96	9	34
H_2O Required	89.1	1.5	5	90	1	2
SiO_2	30.97	1.05	4.2	32.5	1.9	7.6
Al_2O_3	18.61	0.34	1.3	18.5	0.7	2.3
Fe_2O_3	5.97	0.21	0.8	5.6	0.2	0.7
SO_3	2.53	0.25	1.02	2.60	0.59	1.86
CaO	25.61	0.66	2.6	25.4	1.1	3.6
MgO	4.70	0.20	0.84	4.53	0.19	0.67
P_2O_5	1.65	0.18	0.70	1.51	0.33	1.41
K_2O	0.36	0.03	0.11	0.36	0.06	0.19
Na_2O	2.01	0.23	0.94	2.50	0.53	1.66
Avail Alk.	1.31	0.19	0.61	1.86	0.46	1.51

TABLE II (Appendix C)
Summary of ASTM C 311 physical testing statistics for 1983

	Ottumwa power plant		
Year	1983		
	n=39		
Test	$\overline{X}$	S	R*
Moisture Content	0.06	0.03	0.11
Loss on Ignition	0.23	0.08	0.44
Fineness	10.39	0.95	3.80
7-Day Pozzolan	Not required		
Autoclave Exp.	0.05	0.02	0.08
Specific Gravity	2.61	0.04	0.17

*R = MAX − MIN

TABLE II (Appendix C), continued
Summary of ASTM C 311 physical testing statistics for 1984

	Council Bluffs power plant			Neal 4		
Year		1984			1984	
		n=39			n=14	
Test	$\bar{X}$	S	R	$\bar{X}$	S	R
Moisture Content	0.05	0.05	0.22	0.03	0.02	0.08
Loss on Ignition	0.46	0.12	0.45	0.30	0.06	0.20
Fineness	12.56	1.46	5.91	11.30	1.56	4.97
7-Day Pozzolan	91.5	6.8	29.0	87.6	5.0	20.0
Autoclave Exp.	0.07	0.02	0.07	0.07	0.01	0.04
Specific Gravity	2.65	0.05	0.19	2.64	0.03	0.11

	Lansing power plant			Ottumwa		
Year		1984			1984	
		n=13			n=78	
Test	$\bar{X}$	S	R	$\bar{X}$	S	R
Moisture Content	0.06	0.04	0.14	0.02	0.01	0.05
Loss on Ignition	0.27	0.08	0.29	0.24	0.06	0.31
Fineness	9.46	1.18	3.86	10.53	1.07	5.06
7-Day Pozzolan	87.5	5.9	19.0	92.1	7.9	55.0
Autoclave Exp.	0.07	0.02	0.06	0.03	0.01	0.05
Specific Gravity	2.78	0.03	0.09	2.59	0.04	0.21

TABLE II (Appendix C), continued
Summary of ASTM C 311 physical testing statistics for 1985

	Council Bluffs power plant			Neal 4		
Year	1985			1985		
	n=24			n=54		
Test	$\overline{X}$	S	R	$\overline{X}$	S	R
Moisture Content	0.13	0.14	0.59	0.04	0.03	0.16
Loss on Ignition	0.48	0.29	1.35	0.31	0.07	0.31
Fineness	12.55	2.37	10.50	11.32	2.14	8.30
7-Day Pozzolan	88.6	5.2	22.0	92.2	6.2	25.0
Autoclave Exp.	0.10	0.02	0.08	0.07	0.02	0.08
Specific Gravity	2.71	0.03	0.14	2.59	0.08	0.34

	Lansing power plant			Ottumwa		
Year	1985			1985		
	n=15			n=85		
Test	$\overline{X}$	S	R	$\overline{X}$	S	R
Moisture Content	0.05	0.03	0.14	0.03	0.02	0.10
Loss on Ignition	0.48	0.14	0.50	0.24	0.06	0.24
Fineness	12.18	1.66	5.80	9.83	0.81	3.9
7-Day Pozzolan	86.8	4.2	15.0	93.8	5.6	32.0
Autoclave Exp.	0.11	0.02	0.09	0.06	0.02	0.07
Specific Gravity	2.79	0.03	0.10	2.65	0.03	0.16

TABLE II (Appendix C), continued
Summary of ASTM C 311 physical testing statistics for 1986

Year	Council Bluffs power plant 1986 n=32			Neal 4 1986 n=31		
Test	$\bar{X}$	S	R	$\bar{X}$	S	R
Moisture Content	0.07	0.06	0.19	0.05	0.03	0.15
Loss on Ignition	0.42	0.17	0.71	0.34	0.06	0.23
Fineness	9.96	1.08	4.2	11.85	0.86	3.4
7-Day Pozzolan	87.8	6.3	27.0	87.6	6.1	23.0
Autoclave Exp.	0.09	0.03	0.11	0.08	0.04	0.11
Specific Gravity	2.71	0.02	0.11	2.70	0.02	0.06

Year	Lansing power plant 1986 n=19			Ottumwa 1986 n=74		
Test	$\bar{X}$	S	R	$\bar{X}$	S	R
Moisture Content	0.03	0.03	0.09	0.03	0.03	0.13
Loss on Ignition	0.52	0.19	0.75	0.31	0.06	0.28
Fineness	11.56	2.20	7.70	9.47	0.93	4.70
7-Day Pozzolan	85.7	5.7	22.0	93.5	6.8	31.0
Autoclave Exp.	0.08	0.04	0.13	0.03	0.03	0.11
Specific Gravity	2.79	0.02	0.05	2.68	0.02	0.12

TABLE II (Appendix C), continued
Summary of ASTM C 311 physical testing statistics for 1987

	Council Bluffs power plant			Neal 4		
Year		1987			1987	
		n=29			n=54	
Test	$\overline{X}$	S	R	$\overline{X}$	S	R
Moisture Content	0.12	0.19	0.84	0.04	0.02	0.10
Loss on Ignition	0.36	0.18	0.61	0.28	0.05	0.23
Fineness	10.6	0.09	3.3	13.3	1.5	7.8
7-Day Pozzolan	88.0	4.0	18.0	93.0	4.0	22.0
Autoclave Exp.	0.13	0.01	0.06	0.06	0.01	0.04
Specific Gravity	2.73	0.02	0.10	2.52	0.02	0.10

	Lansing power plant			Ottumwa		
Year		1987			1987	
		n=14			n=83	
Test	$\overline{X}$	S	R	$\overline{X}$	S	R
Moisture Content	0.02	0.03	0.10	0.02	0.02	0.09
Loss on Ignition	0.44	0.18	0.68	0.27	0.06	0.24
Fineness	11.0	2.20	7.5	10.7	1.2	6.3
7-Day Pozzolan	90.0	5.75.0	18.0	93.0	6.0	32.0
Autoclave Exp.	0.12	0.02	0.07	0.07	0.02	0.09
Specific Gravity	2.77	0.02	0.08	2.63	0.05	0.20

Table III, Appendix C
Raw data

File: Worksheet2 Date

Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
CBF091784	0625	0.17	0.643	11.6	87	0.058	2.56
CBF091884	0626	0.02	0.435	10.6	98	0.054	2.63
NE4091984	0627	0.01	0.363	13.3	86	0.074	2.66
NE4092084	0628	0.03	0.420	12.0	87	0.080	2.65
CBF092184	0629	0.02	0.264	11.1	94	0.078	2.60
NE4092284	0630	0.00	0.376	11.2	87	0.080	2.63
CBF092484	0632	0.01	0.248	11.6	87	0.080	2.57
NE4092484	0632	0.00	0.224	8.4	86	0.078	2.65
CBF092684	0634	0.10	0.509	13.9	79	0.082	2.62
OTT092684	0634	0.05	0.230	10.8	79	0.043	2.58
NE4092784	0635	0.01	0.286	13.3	95	0.065	2.67
CBF092884	0636	0.01	0.380	13.0	91	0.086	2.59
LAN092984	0637	0.02	0.196	10.2	80	0.056	2.76
NE4092984	0637	0.00	0.272	12.0	89	0.074	2.66
CBF100284	0640	0.08	0.592	13.3	89	0.086	2.66
NE4100284	0640	0.04	0.303	9.4	81	0.074	2.67
OTT100284	0640	0.01	0.229	11.2	95	0.038	2.48
OTT100384	0641	0.00	0.244	12.5	82	0.028	2.47
CBF100484	0642	0.02	0.522	12.2	74	0.094	2.64
LAN100484	0642	0.01	0.210	10.4	92	0.048	2.73
OTT100584	0643	0.00	0.237	11.9	96	0.028	2.49
NE4100684	0644	0.01	0.317	11.4	82	0.053	2.62
OTT100884	0646	0.02	0.434	10.6	83	0.032	2.55
OTT101084	0648	0.01	0.382	12.2	82	0.043	2.56
CBF101184	0649	0.02	0.574	15.8	86	0.079	2.67
LAN101284	0650	0.08	0.312	9.7	91	0.050	2.76
OTT101284	0650	0.02	0.271	13.0	82	0.034	2.57
OTT101784	0655	0.03	0.232	10.7	87	0.044	2.59
LAN101884	0656	0.08	0.206	10.3	85	0.066	2.76
CBF102284	0660	0.03	0.542	13.7	101	0.092	2.67
LAN102684	0664	0.05	0.134	10.3	86	0.062	2.78
CBF102984	0667	0.03	0.476	13.5	99	0.077	2.64
OTT102984	0667	0.04	0.187	10.2	84	0.044	2.60
LAN110284	0671	0.08	0.248	11.0	88	0.066	2.80
OTT110584	0674	0.02	0.252	11.3	92	0.027	2.52
NE4110784	0676	0.06	0.281	9.9	97	0.066	2.56
OTT110884	0677	0.02	0.227	10.6	84	0.034	2.57
LAN110984	0678	0.07	0.238	8.6	79	0.058	2.75
OTT111484	0683	0.03	0.272	11.1	100	0.042	2.61
NE4111584	0684	0.08	0.292	9.0	79	0.056	2.64
OTT112084	0689	0.03	0.209	10.0	96	0.052	2.61
NE4112484	0693	0.02	0.336	12.8	90	0.049	2.66
CBF112684	0695	0.04	0.527	14.4	96	0.083	2.71
LAN112684	0695	0.06	0.286	10.1	81	0.088	2.80
OTT112884	0697	0.02	0.364	10.3	81	0.042	2.62
LAN120184	0700	0.03	0.266	8.9	87	0.077	2.60
NE4121084	0709	0.04	0.232	11.1	87	0.041	2.62
OTT121084	0709	0.03	0.230	9.8	95	0.030	2.63
OTT122084	0719	0.02	0.203	10.3	92	0.021	2.62
OTT011385	0744	0.01	0.150	11.6	89	0.040	2.58
OTT022085	0782	0.02	0.224	12.3	105	0.058	2.61
OTT031585	0805	0.01	0.176	11.4	109	0.074	2.60
OTT032685	0816	0.02	0.299	11.2	88	0.068	2.61
OTT040385	0824	0.01	0.280	11.1	77	0.078	2.67
OTT041085	0831	0.01	0.126	11.1	84	0.087	2.65
OTT041285	0833	0.00	0.111	10.0	90	0.076	2.64
OTT041685	0837	0.00	0.178	10.9	91	0.082	2.64
OTT041885	0839	0.00	0.140	10.5	98	0.090	2.58
OTT041985	0840	0.00	0.180	9.8	90	0.084	2.62
NE4042285	0843	0.02	0.167	15.4	95	0.099	2.63
OTT042485	0845	0.02	0.172	10.4	87	0.083	2.64

File: Worksheet2 Da

Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
OTT061984	0535	0.02	0.202	9.3	95	0.031	2.67
OTT062284	0538	0.02	0.181	9.3	97	0.031	2.68
OTT062384	0539	0.01	0.175	9.5	95	0.029	2.67
OTT062684	0542	0.02	0.190	9.9	96	0.034	2.85
OTT062784	0543	0.01	0.208	9.2	95	0.030	2.65
OTT063084	0546	0.02	0.273	10.2	94	0.028	2.63
OTT070384	0549	0.02	0.201	9.4	93	0.022	2.66
OTT070984	0555	0.03	0.232	9.7	84	0.026	2.64
CBF071084	0556	0.06	0.314	10.6	99	0.068	2.69
OTT071184	0557	0.02	0.241	9.8	93	0.038	2.62
OTT071684	0562	0.02	0.284	9.6	103	0.041	2.62
OTT071884	0564	0.01	0.283	11.6	83	0.030	2.60
OTT072084	0566	0.01	0.175	10.7	88	0.036	2.58
OTT072184	0567	0.01	0.192	10.9	90	0.042	2.58
OTT072484	0570	0.01	0.170	10.7	93	0.034	2.57
OTT072584	0571	0.02	0.180	10.8	91	0.037	2.58
CBF072784	0573	0.02	0.410	11.6	92	0.081	2.72
OTT072884	0574	0.02	0.330	11.7	90	0.022	2.59
OTT073184	0577	0.03	0.268	11.1	88	0.020	2.58
OTT080184	0578	0.03	0.270	11.9	89	0.028	2.58
OTT080284	0579	0.03	0.326	11.1	93	0.031	2.56
OTT080384	0580	0.03	0.302	11.7	89	0.032	2.55
OTT080684	0583	0.03	0.187	11.3	93	0.036	2.57
OTT080784	0584	0.03	0.321	13.3	91	0.037	2.57
CBF080984	0586	0.01	0.458	12.0	85	0.116	2.68
OTT080984	0586	0.01	0.299	11.9	93	0.031	2.59
CBF081084	0587	0.01	0.555	12.2	88	0.092	2.69
LAN081084	0587	0.04	0.329	7.7	92	0.086	2.82
OTT081084	0587	0.00	0.255	11.3	88	0.028	2.63
OTT081384	0590	0.02	0.253	10.7	99	0.028	2.62
OTT081484	0591	0.02	0.266	12.0	92	0.029	2.57
CBF081584	0592	0.03	0.704	13.0	92	0.057	2.73
OTT081584	0592	0.01	0.274	11.3	97	0.032	2.55
OTT081684	0593	0.01	0.301	11.0	93	0.032	2.58
LAN081784	0594	0.03	0.324	7.1	95	0.105	2.82
OTT081784	0594	0.00	0.333	9.6	89	0.032	2.54
CBF081884	0595	0.01	0.296	12.0	99	0.049	2.69
OTT082084	0597	0.01	0.318	10.2	100	0.037	2.56
OTT082284	0599	0.02	0.305	9.4	91	0.035	2.60
OTT082384	0600	0.00	0.199	10.1	99	0.033	2.60
CBF082484	0601	0.04	0.362	10.9	90	0.062	2.67
OTT082584	0602	0.00	0.204	9.2	83	0.038	2.62
OTT082784	0604	0.01	0.158	10.5	85	0.036	2.60
OTT082884	0605	0.00	0.197	10.2	83	0.036	2.61
OTT082984	0606	0.00	0.233	10.2	84	0.038	2.60
OTT083084	0607	0.02	0.202	10.3	74	0.036	2.61
CBF090184	0609	0.08	0.426	10.8	94	0.078	2.70
LAN090484	0612	0.15	0.421	9.4	98	0.074	2.80
OTT090484	0612	0.02	0.192	10.0	82	0.042	2.61
CBF090584	0613	0.07	0.424	12.4	85	0.067	2.69
OTT090584	0613	0.01	0.179	10.7	84	0.044	2.59
CBF090684	0614	0.04	0.454	13.8	98	0.060	2.71
CBF090784	0615	0.23	0.538	14.3	95	0.060	2.72
OTT090784	0615	0.01	0.244	10.5	94	0.034	2.62
NE4091084	0618	0.01	0.259	11.8	92	0.064	2.64
CBF091184	0619	0.03	0.305	9.9	94	0.052	2.54
LAN091284	0620	0.06	0.347	8.3	84	0.082	2.78
NE4091284	0620	0.04	0.279	11.3	89	0.070	2.66
OTT091284	0620	0.04	0.384	9.1	86	0.030	2.61
CBF091484	0622	0.12	0.528	14.4	87	0.052	2.57
CBF091684	0624	0.02	0.405	11.1	89	0.076	2.64

File: Worksheet2 Date: 11/17/88

Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
OTT032283	0081	0.07	0.190	9.8		0.075	2.57
OTT041383	0103	0.12	0.230	9.2		0.071	2.65
OTT042783	0117	0.04	0.210	10.7		0.068	2.65
OTT050483	0124	0.03	0.200	8.8		0.080	2.65
OTT050983	0129	0.02	0.260	9.4		0.079	2.62
OTT051183	0131	0.03	0.320	10.5		0.064	2.59
OTT051783	0137	0.05	0.280	10.7		0.067	2.64
OTT052783	0147	0.04	0.270	12.0		0.065	2.66
OTT060583	0156	0.03	0.180	11.1		0.058	2.64
OTT061083	0161	0.09	0.170	8.8		0.076	2.61
OTT061483	0165	0.06	0.130	12.5		0.070	2.66
OTT062283	0173	0.04	0.250	10.5		0.055	2.64
OTT062883	0179	0.10	0.320	9.9		0.045	2.66
OTT063083	0181	0.09	0.320	9.0		0.057	2.64
OTT070783	0188	0.06	0.370	9.6		0.068	2.63
OTT071383	0194	0.04	0.160	10.4		0.065	2.60
OTT071583	0196	0.05	0.210	9.9		0.049	2.61
OTT071983	0200	0.07	0.300	12.0		0.070	2.59
OTT072583	0206	0.05	0.190	9.8		0.050	2.65
OTT080183	0213	0.04	0.200	10.7		0.057	2.67
OTT080583	0217	0.05	0.540	9.3		0.052	2.64
OTT081083	0222	0.04	0.220	12.1		0.052	2.66
OTT081583	0227	0.01	0.230	11.1		0.057	2.60
OTT081883	0230	0.02	0.280	11.6		0.066	2.63
OTT082383	0235	0.01	0.230	11.2		0.052	2.57
OTT082683	0238	0.02	0.230	10.4		0.046	2.58
OTT090183	0244	0.05	0.150	9.6		0.035	2.64
OTT090683	0249	0.11	0.150	9.7		0.048	2.59
OTT091283	0255	0.09	0.170	10.2		0.058	2.57
OTT091583	0258	0.05	0.210	10.0		0.065	2.59
OTT092283	0265	0.07	0.260	10.2		0.050	2.64
OTT092983	0272	0.10	0.210	8.8		0.064	2.59
OTT100483	0277	0.12	0.150	10.7		0.000	2.58
OTT110783	• 0260	0.12	0.100	9.4		0.008	2.59
OTT101083	0283	0.11	0.120	10.4		0.003	2.50
OTT121283	0285	0.03	0.210	10.5		0.006	2.58
OTT111883	0291	0.02	0.240	10.2		0.007	2.55
OTT101983	0292	0.12	0.220	10.9		0.007	2.54
OTT103183	0304	0.11	0.100	10.6		0.010	2.59
OTT012084	0385	0.02	0.221	10.0		0.005	2.59
OTT021384	0409	0.03	0.193	8.3		-0.010	2.62
OTT030584	0429	0.02	0.220	10.2	129	0.011	2.56
OTT040384	0458	0.03	0.202	12.4	101	0.004	2.50
OTT041884	0473	0.02	0.227	12.1	112	0.034	2.57
OTT042084	0475	0.02	0.250	11.6	94	0.040	2.52
OTT042684	0481	0.01	0.201	10.0	94	0.040	2.62
CBF050384	0488	0.05	0.640	12.7	103	0.052	2.65
OTT050384	0488	0.01	0.159	9.8	95	0.040	2.60
OTT050784	0492	0.01	0.125	9.5	94	0.011	2.61
OTT051084	0495	0.04	0.403	9.3	102	0.031	2.63
OTT051484	0499	0.02	0.395	9.2	95	0.030	2.57
OTT051684	0501	0.05	0.244	8.9	91	0.027	2.62
OTT051884	0503	0.01	0.200	10.0	91	0.034	2.61
OTT052184	0506	0.03	0.214	9.5	90	0.034	2.63
OTT052384	0508	0.02	0.222	8.8	98	0.026	2.67
OTT052584	0510	0.01	0.235	8.9	100	0.025	2.61
OTT053184	0516	0.03	0.128	10.0	93	0.018	2.62
OTT060284	0518	0.03	0.261	9.3	100	0.024	2.59
OTT060584	0521	0.03	0.263	9.5	94	0.028	2.61
OTT060884	0524	0.04	0.273	9.0	99	0.026	2.60
OTT061384	0529	0.05	0.188	10.8	102	0.031	2.62

Table III, Appendix C (continued)

File: Worksheet2 Date: 11

Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
OTT091285	0986	0.01	0.287	9.3	88	0.030	2.62
NE4091385	0987	0.07	0.378	9.1	77	0.071	2.56
CBF091585	0989	0.08	0.273	9.8	84	0.108	2.74
CBF091685	0990	0.07	0.235	9.3	90	0.114	2.74
NE4091785	0991	0.07	0.359	9.2	100	0.047	2.59
CBF091885	0992	0.11	0.342	12.1	89	0.083	2.74
NE4091885	0992	0.07	0.320	11.9	102	0.050	2.61
NE4091985	0993	0.05	0.317	8.5	98	0.060	2.54
CBF092085	0994	0.08	0.334	10.7	86	0.069	2.72
OTT092085	0994	0.03	0.269	10.4	88	0.052	2.64
LAN092185	0995	0.09	0.529	12.3	94	0.096	2.75
NE4092185	0995	0.16	0.318	9.0	82	0.066	2.53
OTT092385	0997	0.02	0.270	9.1	98	0.037	2.67
OTT092585	0999	0.01	0.266	9.2	92	0.081	2.88
LAN092785	1001	0.15	0.578	9.3	95	0.088	2.76
NE4092785	1001	0.03	0.307	9.0	99	0.066	2.54
CBF093085	1004	0.04	0.246	10.2	89	0.098	2.70
OTT093085	1004	0.01	0.259	9.3	90	0.040	2.67
NE4100185	1005	0.02	0.307	9.7	100	0.046	2.49
OTT100385	1007	0.01	0.229	10.2	96	0.049	2.65
NE4100485	1008	0.02	0.265	11.9	101	0.033	2.37
OTT100485	1008	0.03	0.291	10.4	95	0.046	2.62
NE4100885	1012	0.01	0.192	12.9	102	0.026	2.36
OTT100885	1012	0.01	0.247	10.4	89	0.043	2.64
NE4101085	1014	0.02	0.266	10.5	98	0.016	2.42
OTT101085	1014	0.04	0.282	8.8	95	0.047	2.63
CBF101185	1015	0.05	0.324	7.8	89	0.081	2.65
LAN101185	1015	0.06	0.417	14.3	80	0.049	2.72
OTT101285	1016	0.02	0.327	9.0	103	0.040	2.66
NE4101485	1018	0.05	0.305	11.5	101	0.025	2.47
OTT101585	1019	0.02	0.309	8.7	100	0.045	2.65
NE4101685	1020	0.03	0.277	10.5	99	0.031	2.45
OTT101785	1021	0.04	0.284	9.6	100	0.047	2.82
NE4101985	1023	0.03	0.351	12.0	98	0.024	2.43
NE4101985	1023	0.03	0.351	12.0	98	0.024	2.43
CBF102185	1025	0.09	0.346	9.7	93	0.065	2.62
OTT102285	1026	0.05	0.260	9.6	97	0.042	2.65
OTT102585	1029	0.03	0.236	9.4	93	0.047	2.67
OTT102885	1032	0.03	0.216	9.0	95	0.058	2.66
OTT103185	1035	0.03	0.205	9.6	99	0.051	2.64
OTT110485	1039	0.02	0.301	9.5	91	0.038	2.63
OTT110685	1041	0.05	0.290	10.0	96	0.047	2.63
OTT111185	1046	0.05	0.276	9.3	93	0.048	2.61
OTT112285	1057	0.05	0.268	9.3	100	0.021	2.63
OTT040386	1189	0.06	0.255	8.6	102	0.056	2.68
LAN040786	1193	0.00	0.957	14.9	96	0.115	2.76
OTT041286	1198	0.05	0.420	8.5	109	0.070	2.68
CBF041886	1204	0.08	0.292	10.5	102	0.090	2.66
OTT042186	1207	0.03	0.257	8.7	105	0.061	2.68
LAN042586	1211	0.05	0.430	13.9	95	0.114	2.78
OTT042886	1214	0.10	0.307	8.8	107	0.064	2.69
CBF043086	1216	0.07	0.242	10.5	95	0.109	2.68
OTT050186	1217	0.03	0.268	10.3	107	0.080	2.68
CBF050686	1222	0.05	0.277	7.6	97	0.121	2.73
OTT050786	1223	0.04	0.316	8.4	106	0.073	2.75
CBF050986	1225	0.03	0.239	7.6	89	0.134	2.73
OTT050986	1225	0.03	0.266	9.0	111	0.050	2.68
OTT051386	1229	0.05	0.236	8.7	106	0.057	2.69
NE4051586	1231	0.06	0.372	9.8	98	0.106	2.70
OTT051686	1232	0.02	0.326	9.1	102	0.084	2.67
CBF051986	1235	0.10	0.571	9.8	84	0.145	2.71

File: Worksheet2 D

Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
CBF071585	0927	0.05	0.358	12.8	84	0.142	2.76
NE4071885	0930	0.03	0.312	13.1	90	0.091	2.57
OTT071985	0931	0.04	0.335	10.2	94	0.075	2.68
LAN072085	0932	0.05	0.481	12.2	85	0.136	2.80
NE4072085	0932	0.04	0.349	11.8	86	0.092	2.52
CBF072385	0935	0.08	0.494	14.3	91	0.127	2.73
NE4072385	0935	0.02	0.327	10.9	89	0.090	2.62
OTT072385	0935	0.05	0.285	9.5	92	0.062	2.69
OTT072685	0938	0.02	0.288	8.8	98	0.075	2.65
LAN072785	0939	0.07	0.414	10.2	85	0.119	2.79
NE4072785	0939	0.02	0.329	12.7	86	0.095	2.57
CBF072985	0941	0.30	0.704	12.6	86	0.062	2.68
OTT073085	0942	0.04	0.266	9.8	94	0.068	2.69
NE4073185	0943	0.04	0.379	11.7	93	0.080	2.64
OTT080185	0944	0.02	0.273	9.4	93	0.066	2.68
LAN080285	0945	0.01	0.300	11.1	84	0.110	2.81
OTT080285	0945	0.05	0.197	8.4	91	0.042	2.68
NE4080585	0948	0.05	0.318	11.3	86	0.060	2.61
OTT080585	0948	0.01	0.185	9.1	87	0.052	2.65
CBF080685	0949	0.20	0.544	13.8	92	0.078	2.72
OTT080685	0949	0.03	0.351	9.4	94	0.050	2.64
NE4080785	0950	0.03	0.255	10.4	102	0.067	2.64
OTT080785	0950	0.04	0.183	10.2	94	0.047	2.63
OTT080885	0951	0.02	0.211	9.8	96	0.048	2.62
NE4080985	0952	0.03	0.272	10.3	97	0.070	2.61
OTT080985	0952	0.03	0.218	9.6	96	0.034	2.62
LAN081085	0953	0.04	0.537	14.2	92	0.094	2.80
NE4081285	0955	0.06	0.303	10.4	86	0.070	2.60
OTT081285	0955	0.03	0.260	8.6	109	0.032	2.64
OTT081485	0957	0.04	0.249	9.6	95	0.044	2.67
NE4081585	0958	0.17	0.405	11.4	89	0.074	2.68
OTT081585	0958	0.02	0.255	9.3	98	0.054	2.67
CBF081685	0959	0.05	0.435	11.0	94	0.104	2.72
NE4081785	0960	0.02	0.353	10.0	86	0.054	2.65
NE4081985	0962	0.08	0.391	8.8	86	0.069	2.64
OTT081985	0962	0.03	0.264	8.8	97	0.054	2.67
OTT082085	0963	0.02	0.259	10.5	91	0.042	2.66
NE4082185	0964	0.05	0.282	9.8	93	0.068	2.68
NE4082385	0966	0.04	0.272	8.0	91	0.075	2.67
LAN082485	0967	0.05	0.585	11.7	85	0.112	2.81
NE4082485	0967	0.08	0.452	8.7	96	0.070	2.66
NE4082685	0969	0.07	0.313	8.5	98	0.068	2.65
OTT082685	0969	0.05	0.263	9.9	97	0.058	2.65
CBF082785	0970	0.09	0.509	10.6	93	0.095	2.70
NE4082785	0970	0.03	0.320	8.7	99	0.069	2.67
OTT082785	0970	0.06	0.278	8.7	103	0.054	2.64
NE4082885	0971	0.03	0.241	8.5	97	0.064	2.66
CBF083085	0973	0.05	0.254	12.3	84	0.095	2.70
NE4083085	0973	0.04	0.328	9.6	98	0.072	2.61
OTT083085	0973	0.04	0.310	9.9	94	0.044	2.62
NE4090485	0978	0.02	0.219	13.5	89	0.066	2.63
OTT090585	0979	0.02	0.351	8.5	99	0.044	2.63
CBF090685	0980	0.03	0.268	13.4	87	0.104	2.70
LAN090785	0981	0.02	0.335	9.7	84	0.089	2.78
NE4090885	0982	0.02	0.311	12.3	91	0.076	2.65
CBF090985	0983	0.30	0.569	13.9	87	0.103	2.70
NE4091085	0984	0.04	0.330	12.3	90	0.077	2.61
OTT091085	0984	0.02	0.277	9.1	94	0.042	2.66
CBF091185	0985	0.32	0.474	14.6	87	0.112	2.71
NE4091185	0985	0.04	0.303	11.6	87	0.074	2.58
NE4091285	0986	0.09	0.292	8.4	86	0.078	2.55

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Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
NE4043085	0851	0.04	0.326	13.9	88	0.100	2.68
NE4050185	0852	0.02	0.283	14.4	90	0.092	2.66
OTT050185	0852	0.05	0.262	12.1	92	0.054	2.68
OTT050285	0853	0.01	0.257	10.4	86	0.058	2.70
OTT050385	0854	0.04	0.228	9.5	93	0.045	2.63
OTT050785	0858	0.02	0.196	10.0	93	0.052	2.62
OTT050885	0859	0.01	0.239	9.9	92	0.066	2.68
OTT051085	0861	0.01	0.183	9.8	96	0.067	2.67
NE4051185	0862	0.01	0.300	16.3	88	0.060	2.70
LAN051385	0864	0.04	0.318	15.1	87	0.117	2.81
OTT051485	0865	0.02	0.226	10.7	88	0.056	2.74
OTT051685	0867	0.01	0.206	9.0	89	0.050	2.69
LAN052085	0871	0.03	0.268	13.3	85	0.124	2.79
NE4052085	0871	0.02	0.231	15.3	91	0.076	2.69
OTT052085	0871	0.01	0.234	9.6	91	0.061	2.67
OTT052185	0872	0.01	0.180	9.8	86	0.069	2.68
NE4052285	0873	0.01	0.223	15.4	99	0.080	2.69
OTT052385	0874	0.01	0.247	8.7	104	0.069	2.70
CBF052485	0875	0.07	0.463	15.6	99	0.090	2.69
CBF052485	0875	0.07	0.463	15.6	99	0.090	2.69
OTT052885	0879	0.03	0.222	9.6	98	0.068	2.68
NE4052985	0880	0.02	0.220	14.1	94	0.077	2.64
OTT053085	0881	0.03	0.157	9.2	101	0.072	2.70
OTT060185	0883	0.01	0.187	9.5	95	0.072	2.70
NE4060385	0885	0.02	0.208	13.5	91	0.100	2.61
OTT060485	0886	0.01	0.177	10.7	93	0.075	2.70
OTT060585	0887	0.02	0.125	9.8	102	0.071	2.68
OTT060685	0888	0.02	0.219	10.4	96	0.074	2.67
CBF060785	0889	0.60	1.580	18.3	92	0.096	2.67
NE4060785	0889	0.03	0.161	13.6	89	0.089	2.61
OTT060785	0889	0.01	0.186	9.8	98	0.073	2.69
OTT060885	0890	0.02	0.268	9.8	90	0.071	2.68
OTT061085	0892	0.03	0.170	11.4	88	0.073	2.62
NE4061285	0894	0.04	0.279	15.3	93	0.092	2.64
OTT061285	0894	0.05	0.150	11.0	94	0.064	2.64
CBF061385	0895	0.28	0.956	13.4	88	0.110	2.66
OTT061385	0895	0.02	0.141	11.0	93	0.084	2.63
LAN061585	0897	0.02	0.768	12.4	91	0.121	2.82
OTT061785	0899	0.08	0.169	10.2	100	0.076	2.66
OTT061885	0900	0.03	0.146	10.1	91	0.086	2.65
NE4061985	0901	0.04	0.467	10.6	92	0.092	2.60
OTT061985	0901	0.03	0.284	8.8	89	0.069	2.65
OTT062185	0903	0.10	0.284	9.7	92	0.070	2.62
CBF062585	0907	0.12	0.497	12.8	87	0.117	2.71
LAN062585	0907	0.04	0.630	11.9	85	0.114	2.81
NE4062585	0907	0.08	0.472	10.2	84	0.093	2.60
OTT062585	0907	0.02	0.299	9.3	98	0.074	2.60
OTT062685	0908	0.02	0.304	9.4	98	0.073	2.63
OTT062885	0910	0.03	0.246	9.7	82	0.075	2.65
CBF070185	0913	0.01	0.303	12.7	77	0.122	2.75
OTT070185	0913	0.03	0.234	9.7	85	0.076	2.58
NE4070285	0914	0.05	0.364	10.1	88	0.100	2.60
OTT070385	0915	0.02	0.208	10.0	90	0.070	2.58
LAN070685	0918	0.06	0.519	12.7	84	0.129	2.79
NE4070685	0918	0.02	0.302	10.6	80	0.097	2.61
CBF070885	0920	0.09	0.599	13.8	80	0.132	2.74
NE4070885	0920	0.02	0.269	10.5	90	0.083	2.53
OTT070885	0920	0.03	0.288	9.4	90	0.074	2.58
NE4071285	0924	0.04	0.337	11.5	83	0.093	2.58
OTT071285	0924	0.03	0.263	10.1	97	0.090	2.65
LAN071385	0925	0.03	0.454	12.3	86	0.117	2.80

File: Worksheet2 Date

Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
OTT100986	1378	0.01	0.334	10.9	92	0.012	2.69
OTT101086	1379	0.00	0.329	10.0	89	0.004	2.66
LAN101586	1384	0.01	0.415	9.3	90	0.060	2.80
OTT101586	1384	0.00	0.274	9.6	86	0.000	2.65
OTT101786	1386	0.01	0.293	9.6	89	0.003	2.66
OTT102186	1390	0.02	0.261	10.3	90	0.014	2.65
LAN102286	1391	0.02	0.431	14.6	80	0.054	2.79
OTT102386	1392	0.03	0.255	10.0	89	0.014	2.65
LAN102786	1396	0.00	0.582	11.8	82	0.067	2.78
OTT102986	1398	0.03	0.345	10.3	90	0.013	2.67
OTT103186	1400	0.00	0.239	10.7	85	0.011	2.67
LAN110386	1403	0.00	0.591	13.0	80	0.069	2.80
CBF110586	1405	0.04	0.371	9.8	75	0.059	2.71
CBF110686	1406	0.11	0.409	9.8	80	0.062	2.70
OTT111086	1410	0.01	0.239	11.1	91	0.011	2.68
CBF120886	1438	0.02	0.300	11.0	85	0.069	2.72
OTT121586	1445	0.02	0.243	9.3	83	0.015	2.68
OTT.011587	1476	0.05	0.306	9.9	82	0.018	2.67
OTT.021587	1507	0.00	0.292	10.9	83	0.065	2.62
OTT.031687	1536	0.03	0.324	10.5	80	0.080	2.67
OTT.040287	1553	0.02	0.259	10.6	80	0.049	2.65
OTT.040887	1559	0.01	0.338	11.8	95	0.089	2.67
OTT.041187	1562	0.02	0.319	11.4	89	0.092	2.63
OTT.041587	1566	0.04	0.314	12.1	85	0.105	2.66
OTT.041787	1568	0.04	0.335	12.0	86	0.095	2.68
LAN.042087	1571	0.04	0.710	11.2	85	0.136	2.74
OTT.042187	1572	0.02	0.370	14.5	82	0.091	2.68
OTT.042387	1574	0.01	0.309	10.2	87	0.107	2.64
OTT.042487	1575	0.02	0.329	9.0	78	0.105	2.63
LAN.042787	1578	0.00	0.810	15.8	83	0.138	2.72
OTT.042887	1579	0.04	0.334	9.7	95	0.104	2.64
OTT.042987	1580	0.03	0.333	9.8	89	0.099	2.60
LAN.050487	1585	0.00	0.593	12.9	91	0.142	2.80
OTT.050587	1586	0.02	0.354	9.3	95	0.086	2.62
OTT.050887	1589	0.01	0.248	9.8	91	0.081	2.64
LAN.051087	1591	0.04	0.455	11.6	80	0.147	2.77
NE4.051287	1593	0.00	0.320	17.5	87	0.075	2.54
NE4.051287	1593	0.04	0.295	15.0	91	0.078	2.54
NE4.051587	1596	0.03	0.380	13.6	91	0.065	2.52
NE4.051887	1599	0.01	0.345	12.6	87	0.077	2.50
NE4.051987	1600	0.00	0.360	13.8	89	0.086	2.54
LAN.052087	1601	0.00	0.370	8.8	93	0.148	2.78
NE4.052487	1605	0.02	0.316	12.2	99	0.074	2.53
LAN.052687	1607	0.02	0.293	8.8	87	0.125	2.79
NE4.052787	1608	0.03	0.324	13.4	92	0.071	2.56
NE4.053087	1611	0.03	0.279	12.9	95	0.055	2.52
LAN.053187	1612	0.02	0.299	9.9	89	0.113	2.79
NE4.060287	1614	0.03	0.274	11.6	85	0.060	2.54
NE4.060487	1616	0.02	0.249	11.9	97	0.063	2.54
NE4.060687	1618	0.06	0.233	14.7	93	0.059	2.55
NE4.060987	1621	0.01	0.259	9.7	94	0.065	2.50
OTT.060987	1621	0.02	0.205	12.0	86	0.038	2.58
OTT.061187	1623	0.00	0.169	12.6	99	0.034	2.54
CBF.061287	1624	0.04	0.234	9.2	87	0.095	2.70
NE4.061287	1624	0.02	0.244	12.7	88	0.081	2.51
NE4.061587	1627	0.01	0.267	13.3	101	0.059	2.52
OTT.061587	1627	0.02	0.234	14.3	83	0.037	2.59
OTT.061787	1629	0.03	0.324	12.3	88	0.064	2.62
NE4.061887	1630	0.06	0.204	12.6	93	0.068	2.52
NE4.062187	1633	0.02	0.258	11.3	92	0.066	2.49
OTT.062287	1634	0.02	0.351	12.5	96	0.069	2.64

File: Worksheet2 Dat

Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
CBF072486	1301	0.03	0.399	11.8	86	0.075	2.74
NE4072486	1301	0.03	0.239	11.7	83	0.017	2.70
OTT072486	1301	0.04	0.399	9.2	84	0.011	2.69
NE4072586	1302	0.03	0.264	10.2	80	0.024	•
OTT072586	1302	0.02	0.409	9.4	81	0.012	2.71
LAN073086	1307	0.04	0.737	12.1	87	0.064	2.80
OTT073086	1307	0.11	0.444	9.6	89	0.005	2.70
OTT073186	1308	0.05	0.350	9.6	88	0.008	2.71
CBF080186	1309	0.07	0.534	11.7	77	0.104	2.71
OTT080486	1312	0.02	0.344	10.3	96	0.005	2.68
OTT080786	1315	0.03	0.170	9.4	93	0.003	2.63
CBF080886	1316	0.07	0.344	10.6	93	0.110	2.74
LAN081186	1319	0.07	0.434	10.2	85	0.047	2.79
OTT081186	1319	0.03	0.169	10.4	86	0.007	2.64
CBF081286	1320	0.20	0.448	9.5	80	0.106	2.73
OTT081386	1321	0.01	0.227	10.6	86	0.008	2.65
OTT081486	1322	0.03	0.194	8.7	96	0.007	2.66
LAN081886	1326	0.02	0.428	10.0	86	0.044	2.80
OTT081886	1326	0.03	0.310	9.8	90	0.006	2.66
CBF081986	1327	0.08	0.521	9.7	83	0.088	2.71
OTT081986	1327	0.02	0.326	9.4	94	0.010	2.67
OTT082086	1328	0.03	0.314	9.2	95	0.001	2.66
CBF082286	1330	0.20	0.737	9.1	79	0.070	2.71
OTT082286	1330	0.03	0.225	7.9	95	0.002	2.64
OTT082386	1331	0.03	0.206	7.9	94	0.009	2.69
LAN082586	1333	0.02	0.288	10.2	84	0.049	2.77
CBF082686	1334	0.20	0.799	11.2	86	0.058	2.70
OTT082786	1335	0.01	0.344	8.8	86	0.007	2.68
OTT082886	1336	0.02	0.309	9.5	87	0.005	2.67
CBF082986	1337	0.17	0.916	10.2	88	0.059	2.69
OTT082986	1337	0.00	0.326	8.6	93	0.004	2.68
OTT090286	1341	0.00	0.348	9.4	89	0.004	2.69
OTT090386	1342	0.01	0.299	9.1	93	0.004	2.70
CBF090486	1343	0.03	0.325	7.8	85	0.053	2.70
OTT090486	1343	0.03	0.328	10.2	86	0.000	2.67
CBF090586	1344	0.01	0.319	10.9	86	0.050	2.70
CBF090686	1345	0.02	0.362	9.6	87	0.048	2.71
OTT090686	1345	0.00	0.348	9.7	94	-0.010	2.69
CBF090886	1347	0.03	0.294	10.8	86	0.046	2.69
LAN090886	1347	0.00	0.392	9.5	81	0.055	2.80
OTT090886	1347	0.01	0.330	8.9	91	0.000	2.70
OTT090986	1348	0.00	0.324	9.1	100	0.007	2.69
CBF091086	1349	0.04	0.410	10.6	88	0.072	2.72
OTT091186	1350	0.04	0.343	9.7	91	0.008	2.69
OTT091286	1351	0.02	0.351	8.7	97	0.008	2.69
LAN091586	1354	0.01	0.305	7.2	91	0.055	2.77
OTT091586	1354	0.00	0.341	10.3	97	0.011	2.69
CBF091686	1355	0.11	0.475	9.6	88	0.051	2.63
OTT091686	1355	0.01	0.317	10.1	101	0.014	2.69
OTT091786	1356	0.01	0.372	10.4	94	0.012	2.68
OTT091986	1358	0.01	0.368	10.4	93	0.012	2.68
OTT092286	1361	0.03	0.397	11.5	91	0.012	2.69
LAN092386	1362	0.00	0.799	12.9	84	0.051	2.77
OTT092486	1363	0.02	0.284	11.2	95	0.011	2.69
OTT092686	1365	0.04	0.339	10.4	92	0.007	2.67
LAN092986	1368	0.02	0.515	11.7	82	0.065	2.76
OTT092986	1368	0.06	0.313	10.3	80	0.011	2.66
OTT100286	1371	0.09	0.448	12.1	91	0.004	2.67
LAN100686	1375	0.00	0.203	8.1	85	0.051	2.81
OTT100686	1375	0.04	0.386	11.1	99	0.011	2.68
OTT100886	1377	0.00	0.333	11.0	88	0.015	2.67

File: Worksheet2 Date: 11/17/88

Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
LAN052086	1236	0.04	0.754	13.7	92	0.174	2.80
NE4052086	1236	0.02	0.343	11.4	91	0.107	2.69
OTT052186	1237	0.02	0.293	7.4	99	0.068	2.72
NE4052386	1239	0.03	0.313	12.4	95	0.110	2.69
OTT052386	1239	0.02	0.333	8.1	104	0.050	2.72
CBF052786	1243	0.02	0.294	9.4	99	0.110	2.71
NE4052886	1244	0.02	0.264	11.8	79	0.111	2.70
OTT052886	1244	0.01	0.376	9.3	103	0.067	2.70
CBF053086	1246	0.02	0.315	8.8	88	0.130	2.70
NE4053186	1247	0.02	0.276	10.4	82	0.094	2.70
OTT053186	1247	0.01	0.235	8.6	96	0.063	2.70
NE4060386	1250	0.02	0.390	11.9	86	0.125	2.70
OTT060486	1251	0.02	0.355	9.1	100	0.070	2.70
CBF060586	1252	0.02	0.208	8.5	98	0.120	2.72
NE4060686	1253	0.05	0.403	11.1	86	0.129	2.72
OTT060686	1253	0.02	0.394	8.3	91	0.069	2.68
NE4060886	1255	0.05	0.389	10.7	88	0.108	2.70
CBF060986	1256	0.16	0.660	10.2	92	0.104	2.68
NE4061086	1257	0.04	0.414	12.0	86	0.104	2.71
NE4061286	1259	0.03	0.391	12.8	97	0.105	2.72
OTT061286	1259	0.04	0.366	8.6	90	0.066	2.71
OTT061386	1260	0.02	0.293	8.6	93	0.068	2.71
NE4061486	1261	0.05	0.399	12.8	77	0.104	2.73
CBF061686	1263	0.05	0.258	9.0	90	0.127	2.70
NE4061686	1263	0.09	0.397	12.2	95	0.107	2.70
NE4061786	1264	0.08	0.473	12.5	92	0.106	2.71
OTT061786	1264	0.08	0.279	8.2	98	0.082	2.70
NE4061986	1266	0.03	0.324	11.2	100	0.117	2.73
OTT061986	1266	0.09	0.324	8.4	95	0.087	2.69
NE4062186	1268	0.04	0.264	12.0	95	0.106	2.73
CBF062386	1270	0.12	0.437	10.6	84	0.112	2.70
OTT062386	1270	0.05	0.367	9.1	88	0.093	2.70
NE4062486	1271	0.03	0.384	11.6	89	0.127	2.70
OTT062486	1271	0.05	0.286	8.9	93	0.088	2.71
CBF062686	1273	0.07	0.324	10.3	93	0.104	2.72
OTT062686	1273	0.05	0.283	9.2	91	0.096	2.69
NE4062786	1274	0.02	0.339	12.4	85	0.115	2.68
NE4062986	1276	0.04	0.390	11.5	88	0.129	2.68
CBF070186	1278	0.04	0.427	10.7	92	0.090	2.72
OTT070186	1278	0.02	0.304	9.5	97	0.087	2.69
LAN070286	1279	0.02	0.573	10.7	92	0.130	2.80
NE4070286	1279	0.08	0.440	12.0	89	0.116	2.69
OTT070386	1280	0.03	0.271	8.8	95	0.091	2.70
NE4070786	1284	0.04	0.360	12.5	85	0.108	2.68
OTT070786	1284	0.05	0.364	9.3	86	0.099	2.70
NE4070886	1285	0.08	0.284	11.4	86	0.101	2.72
CBF071086	1287	0.08	0.384	10.7	91	0.032	2.72
OTT071086	1287	0.13	0.215	9.1	91	0.073	2.71
NE4071186	1288	0.02	0.295	11.7	89	0.029	2.70
NE4071386	1290	0.17	0.400	12.8	78	0.033	2.71
LAN071486	1291	0.09	0.560	13.9	74	0.121	2.80
NE4071586	1292	0.03	0.333	11.5	92	0.035	2.70
NE4071686	1293	0.02	0.249	13.2	90	0.031	2.69
OTT071686	1293	0.04	0.308	9.4	90	0.002	2.71
NE4071786	1294	0.07	0.315	13.1	89	0.026	2.67
CBF071886	1295	0.03	0.508	10.8	84	0.093	2.68
NE4071986	1296	0.07	0.349	13.2	84	0.029	2.67
LAN072186	1298	0.07	0.530	11.9	82	0.062	2.80
NE4072186	1298	0.08	0.337	11.4	88	0.023	2.68
OTT072186	1298	0.08	0.299	9.2	88	0.014	2.70
NE4072386	1300	0.02	0.269	12.2	77	0.018	2.67

Table III, Appendix C (continued)

File: Worksheet2 Date: 1

Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
OTT.102087	1754	0.03	0.221	10.7	98	0.060	2.62
OTT.102287	1756	0.02	0.230	10.9	97	0.057	2.62
OTT.102387	1757	0.02	0.218	9.5	92	0.060	2.62
NE4.102487	1758	0.04	0.247	14.9	95	0.072	2.54
OTT.102787	1761	0.01	0.157	10.4	104	0.051	2.61
OTT.102987	1763	0.02	0.192	10.5	103	0.040	2.54
NE4.110287	1767	0.04	0.243	15.2	90	0.056	2.54
OTT.110387	1768	0.02	0.158	10.0	107	0.037	2.55
OTT.110587	1770	0.02	0.190	10.6	95	0.041	2.55
OTT.110987	1774	0.02	0.182	12.5	92	0.048	2.51
NE4.111187	1776	0.06	0.226	12.0	96	0.068	2.48
OTT.111187	1776	0.02	0.177	11.9	93	0.057	2.52
OTT.111687	1781	0.01	0.219	11.8	93	0.068	2.54
OTT.112587	1790	0.05	0.239	13.4	97	0.060	2.56
Samples	685	685	685	685	644	685	684
Min	0081	0.00	0.100	7.1	74	-0.010	2.38
Max	1790	0.85	1.580	18.3	129	0.174	2.82
Range	1709	0.85	1.480	11.2	55	0.184	0.46
Average	1108	0.04	0.313	10.9	91	0.066	2.65
St Dev	0448	0.06	0.132	1.7	7	0.034	0.08
87 Samples	180	180	180	180	180	180	180
87 Min	1476	0.00	0.126	8.2	78	0.018	2.46
87 Max	1790	0.85	0.810	17.5	110	0.153	2.80
87 Range	0314	0.85	0.684	9.3	32	0.135	0.34
87 Average	1675	0.04	0.298	11.5	92	0.083	2.62
87 St Dev	0061	0.08	0.111	1.8	6	0.030	0.09

File: Worksheet2 Date

Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
OTT.082187	1694	0.01	0.247	8.2	95	0.074	2.65
CBF.082287	1695	0.07	0.455	11.3	92	0.140	2.72
NE4.082487	1697	0.02	0.329	11.4	95	0.074	2.46
OTT.082587	1698	0.01	0.248	9.8	93	0.079	2.62
CBF.082687	1699	0.05	0.687	11.9	95	0.126	2.78
NE4.082787	1700	0.01	0.311	11.6	107	0.060	2.47
OTT.082887	1701	0.02	0.286	10.2	101	0.106	2.66
OTT.082987	1702	0.03	0.339	9.2	97	0.098	2.65
OTT.083187	1704	0.00	0.315	10.2	101	0.100	2.65
OTT.090187	1705	0.02	0.336	8.2	97	0.100	2.64
OTT.090287	1706	0.01	0.278	8.9	98	0.105	2.64
NE4.090387	1707	0.06	0.221	11.2	92	0.065	2.46
OTT.090387	1707	0.01	0.230	9.8	98	0.098	2.64
CBF.090487	1708	0.03	0.314	9.8	79	0.127	2.71
OTT.090487	1708	0.01	0.291	9.5	88	0.088	2.64
CBF.090587	1709	0.85	0.776	11.6	87	0.121	2.68
OTT.090587	1709	0.07	0.188	10.0	93	0.079	2.63
OTT.090687	1710	0.07	0.208	10.0	95	0.069	2.63
OTT.090887	1712	0.05	0.250	9.8	86	0.088	2.63
NE4.090987	1713	0.08	0.394	13.4	86	0.065	2.51
OTT.091087	1714	0.05	0.233	10.2	92	0.095	2.62
NE4.091287	1716	0.02	0.269	13.4	94	0.056	2.53
OTT.091287	1716	0.01	0.262	9.0	86	0.083	2.67
CBF.091487	1718	0.52	0.715	10.2	88	0.119	2.71
CBF.091587	1719	0.36	0.712	10.0	87	0.134	2.70
NE4.091587	1719	0.04	0.222	12.4	100	0.068	2.51
OTT.091587	1719	0.00	0.263	10.9	89	0.112	2.64
CBF.091687	1720	0.20	0.405	9.2	95	0.136	2.78
CBF.091787	1721	0.39	0.622	11.6	91	0.118	2.69
OTT.091787	1721	0.03	0.322	9.4	88	0.092	2.68
CBF.091887	1722	0.03	0.276	9.7	92	0.141	2.73
NE4.091887	1722	0.00	0.387	13.3	89	0.076	2.50
CBF.091987	1723	0.07	0.442	9.7	97	0.132	2.73
CBF.092187	1725	0.03	0.290	10.2	89	0.140	2.73
OTT.092287	1726	0.07	0.325	9.7	95	0.085	2.65
CBF.092387	1727	0.06	0.316	10.2	89	0.148	2.73
CBF.092487	1728	0.03	0.278	9.8	84	0.139	2.72
OTT.092487	1728	0.02	0.308	10.4	96	0.089	2.63
CBF.092587	1729	0.04	0.204	8.8	85	0.135	2.73
NE4.092587	1729	0.00	0.226	12.1	90	0.075	2.53
CBF.092887	1732	0.05	0.255	9.6	87	0.139	2.72
NE4.092987	1733	0.04	0.182	13.3	98	0.065	2.53
NE4.100387	1737	0.04	0.193	12.2	90	0.055	2.49
CBF.100587	1739	0.03	0.166	11.5	88	0.128	2.73
CBF.100687	1740	0.05	0.301	10.6	85	0.125	2.76
OTT.100687	1740	0.04	0.216	10.2	96	0.062	2.61
CBF.100787	1741	0.04	0.191	10.7	82	0.125	2.74
NE4.100787	1741	0.02	0.238	13.1	91	0.067	2.48
OTT.100787	1741	0.01	0.180	10.1	92	0.051	2.61
OTT.100987	1743	0.00	0.248	10.8	80	0.061	2.59
NE4.101087	1744	0.02	0.266	14.0	90	0.064	2.51
OTT.101287	1746	0.01	0.230	11.0	95	0.061	2.54
OTT.101387	1747	0.01	0.231	11.0	84	0.053	2.52
CBF.101487	1748	0.02	0.279	12.1	87	0.150	2.75
NE4.101487	1748	0.02	0.255	14.0	94	0.086	2.49
CBF.101587	1749	0.01	0.250	11.8	83	0.137	2.74
OTT.101587	1749	0.01	0.192	10.6	98	0.046	2.57
CBF.101687	1750	0.02	0.261	11.6	88	0.153	2.74
OTT.101687	1750	0.02	0.207	11.3	91	0.050	2.56
NE4.101787	1751	0.03	0.259	12.7	90	0.058	2.48
NE4.102087	1754	0.04	0.229	14.2	87	0.063	2.51

File: Worksheet2 Date: 11/17/88

Sample Name	Day No (1/1/83)	MC	LOI	Fine	7 Day Poz	Auto clave	SG
NE4.062487	1636	0.04	0.221	12.4	93	0.057	2.50
OTT.062487	1636	0.01	0.402	11.4	98	0.073	2.65
CBF.062687	1638	0.08	0.205	11.1	92	0.122	2.70
NE4.062687	1638	0.06	0.224	13.2	100	0.048	2.51
OTT.062787	1639	0.06	0.260	9.9	92	0.063	2.61
CBF.062987	1641	0.04	0.207	11.0	92	0.131	2.74
LAN.062987	1641	0.04	0.126	8.5	92	0.098	2.73
NE4.062987	1641	0.09	0.284	12.4	96	0.062	2.49
OTT.063087	1642	0.08	0.329	11.1	96	0.064	2.61
NE4.070187	1643	0.04	0.276	11.5	89	0.071	2.52
LAN.070287	1644	0.03	0.289	8.3	89	0.101	2.77
NE4.070287	1644	0.01	0.249	11.9	90	0.064	2.54
OTT.070287	1644	0.04	0.349	11.1	100	0.061	2.60
NE4.070487	1646	0.04	0.282	11.6	90	0.056	2.52
OTT.070687	1648	0.02	0.276	10.5	88	0.062	2.59
CBF.070787	1649	0.10	0.282	10.7	89	0.111	2.74
NE4.070787	1649	0.16	0.339	14.5	90	0.048	2.52
OTT.070887	1650	0.05	0.304	10.6	97	0.067	2.66
NE4.071087	1652	0.07	0.242	12.2	97	0.061	2.49
LAN.071387	1655	0.00	0.401	9.8	89	0.086	2.78
OTT.071387	1655	0.07	0.290	10.0	100	0.057	2.65
OTT.071487	1656	0.00	0.243	10.1	96	0.056	2.67
NE4.071687	1658	0.09	0.267	13.8	92	0.061	2.55
OTT.071687	1658	0.01	0.226	10.8	93	0.067	2.67
CBF.071787	1659	0.05	0.287	11.4	84	0.122	2.73
OTT.071787	1659	0.03	0.244	10.4	97	0.062	2.65
LAN.072087	1662	0.00	0.409	10.0	98	0.082	2.75
OTT.072087	1662	0.00	0.250	12.7	92	0.088	2.68
NE4.072187	1663	0.03	0.363	13.9	89	0.068	2.54
OTT.072187	1663	0.02	0.254	11.8	88	0.092	2.70
CBF.072287	1664	0.14	0.324	11.0	82	0.142	2.76
OTT.072287	1664	0.00	0.256	11.2	84	0.095	2.66
OTT.072387	1665	0.03	0.316	11.5	87	0.086	2.68
CBF.072487	1666	0.02	0.371	10.7	88	0.123	2.73
NE4.072487	1666	0.02	0.413	15.3	96	0.061	2.53
OTT.072487	1666	0.03	0.333	10.2	92	0.092	2.66
CBF.072787	1669	0.16	0.285	11.0	90	0.125	2.73
LAN.072887	1670	0.00	0.541	13.4	98	0.105	2.77
NE4.072887	1670	0.02	0.273	14.3	94	0.069	2.53
OTT.072887	1670	0.09	0.248	11.2	93	0.088	2.69
OTT.073087	1672	0.08	0.251	10.7	103	0.068	2.66
NE4.073187	1673	0.04	0.249	15.2	93	0.071	2.54
LAN.080387	1676	0.02	0.551	12.5	91	0.111	2.79
OTT.080387	1676	0.03	0.226	10.9	99	0.082	2.69
NE4.080487	1677	0.06	0.279	11.5	92	0.062	2.50
OTT.080487	1677	0.02	0.239	10.2	91	0.085	2.68
OTT.080687	1679	0.02	0.203	10.0	97	0.081	2.66
LAN.080787	1680	0.10	0.378	12.6	91	0.105	2.79
NE4.080787	1680	0.01	0.240	14.2	95	0.058	2.52
OTT.080787	1680	0.00	0.277	9.8	99	0.079	2.68
NE4.081187	1684	0.05	0.281	14.6	94	0.060	2.49
OTT.081187	1684	0.03	0.272	10.1	97	0.078	2.71
OTT.081287	1685	0.01	0.234	10.4	95	0.065	2.70
NE4.081387	1686	0.06	0.242	15.3	90	0.051	2.52
OTT.081387	1686	0.02	0.257	10.4	95	0.062	2.65
NE4.081787	1690	0.02	0.341	15.6	88	0.055	2.53
OTT.081787	1690	0.01	0.306	11.3	102	0.064	2.64
NE4.081887	1691	0.03	0.283	15.0	88	0.051	2.53
OTT.081987	1692	0.00	0.303	11.2	110	0.089	2.63
OTT.082087	1693	0.01	0.288	9.7	96	0.079	2.64
NE4.082187	1694	0.04	0.309	14.6	92	0.062	2.55

Table III, Appendix C (continued)

Sample Name	Day No (1/1/83)	SiO2	Al2O3	Fe2O3	SO3	CaO	MgO	P2O5	K2O	Na2O	TiO2	SrO	BaO	MC	LOI	AA	Fine (Corr)	28 Day Poz	H2O Reqd	7 Day Poz	Auto-clave	SG
LOUCOMP03	0530	37.5	18.7	5.2	1.31	24.2	4.88	1.98	0.36	1.80	1.39			0.02	0.15	1.02	6.8	88	90	92	0.030	2.61
OTTCOMP12	0530	34.4	18.1	5.0	1.78	24.0	4.96	2.23	0.37	2.64	1.33			0.03	0.20	1.73	9.9	93	90	97	0.030	2.61
CBF061484	0534	34.2	17.4	4.9	2.70	27.0	5.56	1.14	0.38	1.97	1.42			0.07	0.31	1.03	7.7	117	90	84	0.060	2.62
AME070384	0549	37.0	16.7	5.3	4.30	22.7	5.06	0.96	0.62	2.22	1.29			0.04	0.37	1.04	13.6	85	90	72	0.060	2.58
LAN070384	0549	31.0	15.4	6.3	4.16	27.7	6.19	0.86	0.27	1.90	1.17			0.01	0.26	1.26	10.0	98	90	91	0.080	2.81
OTTCOMP13	0556	34.1	18.3	5.3	2.11	24.4	4.60	1.86	0.37	2.83	1.42			0.05	0.28	1.87	8.8	95	90	91	0.030	2.66
LOUCOMP04	0559	36.2	16.6	5.6	1.44	24.8	4.84	1.87	0.38	1.99	1.45			0.24	0.34	0.90	7.4	102	90	94	0.030	2.62
OTTCOMP14	0565	35.2	18.5	5.5	2.32	24.1	4.68	2.04	0.36	2.58	1.36			0.02	0.30	1.72	10.3	95	90	96	0.030	2.64
NE2071884	0566	51.4	20.8	9.1	2.10	12.9	3.81	0.62	1.67	0.28	0.79			0.06	0.35	0.34	15.3	92	90	71	0.050	2.36
NE4071884	0566	34.7	18.6	5.9	3.21	25.7	6.00	1.29	0.30	2.38	1.13			0.01	0.27	1.51	12.5	95	90	95	0.050	2.64
NE4072384	0572	33.0	15.8	5.9	3.88	28.1	6.05	1.13	0.25	2.43	1.05			0.08	0.36	1.45	11.1	89	90	79	0.060	2.64
OTTCOMP15	0576	33.8	18.3	5.2	2.08	23.9	4.39	1.85	0.40	2.51	1.36			0.05	0.27	1.08	10.5	102	90	87	0.030	2.57
OTTCOMP16	0584	34.5	18.5	5.3	2.34	23.6	4.43	1.65	0.40	2.34	1.39			0.04	0.24	1.03	11.2	97	90	95	0.030	2.54
CBFCOMP01	0593	33.9	16.4	5.1	3.31	27.9	5.83	1.10	0.33	1.94	1.37			0.04	0.53	1.19	11.6	93	90	80	0.090	2.68
OTTCOMP17	0593	34.8	18.4	5.3	2.08	23.6	4.48	1.72	0.41	2.48	1.34			0.01	0.38	1.15	11.0	107	90	94	0.040	2.60
OTTCOMP18	0596	38.2	18.6	5.1	2.00	22.3	4.42	1.73	0.48	2.78	1.28			0.02	0.32	1.10	10.5	105	90	98	0.030	2.59
OTTUMWA00	0600	35.5	18.4	5.3	2.27	24.1	4.75	1.99	0.37	2.89	1.39			0.01	0.30	1.82	9.9	94	90	85	0.040	2.61
OTTCOMP19	0613	33.1	18.0	5.2	2.66	24.5	4.62	1.87	0.37	2.57	1.37			0.01	0.22	1.79	9.9	87	89	85	0.040	2.61
AME090684	0618	38.1	17.3	5.0	3.35	22.8	5.14	0.92	0.59	1.99	1.30			0.02	0.34	1.14	11.4	95	89	73	0.050	2.46
CBFCOMP02	0620	34.2	18.0	5.2	2.54	26.7	5.69	1.14	0.38	1.66	1.38			0.09	0.81	1.31	12.2	98	90	88	0.070	2.71
OTTCOMP20	0620	34.9	18.0	5.2	2.74	24.5	4.68	1.79	0.38	2.73	1.43			0.02	0.24	1.72	10.4	96	90	86	0.040	2.60
CBFCOMP03	0635	35.3	17.3	5.1	2.79	25.7	5.60	1.27	0.36	2.07	1.28			0.09	0.46	1.34	12.4	95	90	91	0.050	2.60
NE4COMP01	0641	31.9	15.6	5.7	4.61	25.9	5.53	0.87	0.29	2.80	1.06			0.04	0.37	1.79	11.6	91	90	89	0.080	2.65
CBFCOMP04	0646	33.5	17.0	5.1	2.50	25.7	5.46	1.23	0.35	1.85	1.20			0.05	0.46	1.25	12.2	98	90	95	0.070	2.60
LANCOMP01	0646	32.8	15.8	5.8	4.78	27.4	5.96	0.86	0.35	1.84	1.20			0.08	0.34	1.38	9.1	93	90	89	0.090	2.78
OTTCOMP21	0649	36.8	18.4	5.2	2.88	22.3	4.58	1.48	0.48	2.60	1.32			0.04	0.28	1.48	11.5	98	90	87	0.040	2.54
CLI101584	0656	52.8	20.0	12.6	2.78	9.0	1.82	0.08	2.09	1.25	0.68			0.04	1.25	0.77	15.5	87	94	71	0.010	2.38
NE4COMP02	0657	34.3	15.8	5.8	4.57	25.8	5.69	0.87	0.33	2.74	1.07			0.03	0.30	1.54	11.5	87	90	87	0.070	2.63
AME100484	0663	39.7	17.1	5.9	4.40	22.8	5.02	0.89	0.58	2.33	1.16			0.06	0.38	1.65	11.0	79	90	75	0.080	2.49
OTTCOMP22	0669	36.9	18.1	5.4	2.14	23.8	4.81	1.60	0.43	2.57	1.40			0.03	0.24	1.80	11.2	104	90	84	0.040	2.58
LANCOMP02	0677	38.4	15.5	5.6	4.68	25.3	6.02	0.73	0.54	1.84	1.17			0.06	0.23	1.22	9.9	80	90	88	0.060	2.76
CBFCOMP05	0698	34.4	17.4	5.4	3.04	27.2	6.06	1.19	0.34	2.29	1.31			0.08	0.49	1.55	14.4	101	92	91	0.070	2.64
OTTCOMP23	0698	37.1	18.4	5.3	2.45	24.3	4.73	1.84	0.42	2.67	1.44			0.03	0.21	1.73	9.9	95	92	78	0.030	2.61
NE4FAAP00	0790	35.2	15.4	5.8	4.24	26.5	5.99	0.74	0.25	2.49	1.04			0.01	0.35	1.54	12.9	89	88	88	0.070	2.66
OTTFAAP00	0790	34.6	18.5	4.8	3.68	24.9	5.28	1.11	0.42	3.28	1.43			0.01	0.38	1.97	11.3	100	83	87	0.060	2.58
NE4031985	0811	31.1	14.9	5.6	4.56	26.8	5.62	0.77	0.24	2.23	1.04			0.00	0.24	1.56	15.0	94	90	86	0.110	2.69
LANFAAP00	0822	31.1	15.9	5.3	3.94	28.1	5.72	1.25	0.27	1.62	1.35			0.00	0.35	1.13	12.8	89	91	90	0.110	2.79
AME040285	0823	34.3	17.0	6.2	5.95	23.4	5.01	0.92	0.70	2.64	1.10			0.03	0.39	1.71	19.1	72	91	70	0.080	2.51
CBFCOMP01	0823	29.3	15.1	6.9	4.20	28.5	6.20	1.00	0.30	2.00	1.00			0.01	0.56	1.34	19.1	84	92	80	0.140	2.70
OTTCOMP01	0830	31.7	18.1	4.8	2.57	24.4	4.89	1.81	0.41	2.73	1.39			0.00	0.23	2.05	11.3	88	92	91	0.080	2.61
RAWHIDE00	0830	23.1	12.6	4.3	*	28.5	3.67	1.01	0.31	1.18	0.95			1.01	1.22	1.09	13.1	81	90	79	0.060	2.56
GIESE0000	0834	32.1	18.9	5.3	1.72	25.5	4.67	1.74	0.40	1.73	1.39			0.05	0.15	1.31	10.2	94	89	85	0.060	2.57
NE2041685	0839	50.1	20.3	7.3	2.04	12.8	3.18	0.78	1.68	0.20	0.82			0.02	0.16	0.30	23.3	90	89	68	0.080	2.23
OTTCOMP02	0844	31.6	17.7	4.9	3.18	24.3	4.78	1.81	0.40	3.13	1.35			0.02	0.29	2.16	10.6	82	89	92	0.080	2.63
CBF042585	0850	28.6	16.3	5.1	4.19	28.6	5.07	1.01	0.30	1.81	1.38			0.04	0.40	1.20	14.9	86	89	90	0.120	2.68
LANSING00	0852	30.3	14.7	8.5	4.60	28.2	5.94	0.65	0.27	2.12	1.02			0.03	0.21	1.27	16.8	79	89	93	0.120	2.80
OTTCOMP03	0859	32.4	18.0	5.2	2.14	24.0	4.74	1.94	0.42	2.08	1.36			0.02	0.28	1.63	10.4	99	86	92	0.030	2.68
CBF051085	0866	29.0	15.8	5.2	4.37	28.1	5.54	1.10	0.30	1.91	1.19			0.12	0.48	1.34	16.2	86	87	83	0.090	2.74
OTTCOMP04	0873	32.8	18.1	6.1	2.34	25.7	4.84	1.70	0.34	2.04	1.47			0.01	0.17	1.55	10.2	66	89	91	0.080	2.68
NE4COMP01	0879	34.4	15.7	5.7	3.50	28.2	6.21	0.93	0.28	2.29	1.03			0.02	0.27	1.55	15.9	96	88	93	0.090	2.70

Sample Name	Day No (1/1/83)	SiO2	Al2O3	Fe2O3	SO3	CaO	MgO	P2O5	K2O	Na2O	TiO2	SrO	BaO	MC	LOI	AA	Fine (Corr)	28 Day Poz	H2O Reqd	7 Day Poz	Auto-clave	SG
OTTCOMP05	0887	30.8	18.0	5.9	2.30	26.0	5.02	2.13	0.33	1.83	1.43			0.02	0.17	1.50	10.1	94	88	97	0.070	2.69
OTTCOMP06	0894	32.3	18.1	5.9	2.27	25.4	4.89	2.18	0.36	1.87	1.39			0.04	0.21	1.48	9.2	98	86	96	0.070	2.68
NE4COMP02	0900	35.8	15.8	5.9	3.33	25.5	5.91	0.95	0.32	2.28	1.03			0.05	0.24	1.87	14.1	95	88	90	0.080	2.62
LAN061985	0901	32.8	15.6	6.2	4.37	27.9	6.04	0.87	0.26	2.26	1.22			0.02	0.77	1.70	12.4	86	88	91	0.120	2.82
OTTCOMP07	0903	38.0	18.7	5.7	2.34	24.7	5.02	2.00	0.39	1.82	1.38			0.05	0.19	1.43	10.4	93	86	91	0.060	2.64
NE4062185	0909	36.6	15.9	5.9	3.53	25.6	6.04	0.99	0.32	2.40	1.02			0.03	0.32	1.68	10.1	84	90	89	0.090	2.54
CBF000000	0914	31.0	15.1	6.2	4.06	28.5	6.52	0.94	0.21	2.27	1.06			0.02	0.34	1.62	10.8	85	88	83	0.150	2.76
OTTCOMP08	0915	32.8	18.8	5.1	2.47	25.0	4.93	1.33	0.40	1.52	1.41			0.02	0.25	1.29	9.5	87	86	89	0.070	2.63
CBFCOMP02	0922	32.6	16.4	6.0	3.06	27.7	5.55	1.37	0.32	1.83	1.33			0.21	0.78	1.45	14.7	85	88	82	0.110	2.70
NE4COMP03	0922	35.5	16.1	6.4	3.33	25.8	6.75	1.00	0.33	2.17	1.02			0.06	0.38	1.73	10.7	97	88	84	0.090	2.56
LANCOMP01	0930	29.2	15.6	6.0	4.50	28.1	5.69	0.87	0.27	2.08	1.20			0.07	0.47	1.64	12.4	93	89	83	0.120	2.80
OTTCOMP09	0934	33.3	19.0	5.3	2.94	25.1	4.87	1.14	0.41	2.01	1.46			0.03	0.33	1.59	9.8	89	86	90	0.050	2.62
NE4COMP04	0942	32.4	16.3	5.6	3.25	26.4	5.68	1.02	0.32	2.01	1.04			0.04	0.30	1.48	12.1	87	86	93	0.060	2.57
OTTCOMP10	0949	30.8	18.5	5.7	2.75	25.4	4.85	1.44	0.39	2.13	1.44			0.02	0.21	1.60	9.1	96	86	93	0.060	2.68
PCS080285	0949	53.7	20.2	16.9	2.20	5.4	1.10	0.06	2.38	0.97	1.00			0.09	6.00	1.04	21.1	73	94	59	0.030	2.32
PCS080865	0956	55.5	20.9	16.6	2.00	4.4	1.20	0.01	2.49	1.11	1.05			0.11	5.41	1.05	16.7	80	96	67	*	2.34
CBFCOMP03	0959	31.8	15.3	5.7	4.01	28.9	6.04	0.91	0.27	2.03	1.19			0.15	0.81	1.49	12.9	94	88	92	0.110	2.72
NE4COMP05	0959	34.3	15.6	6.1	3.41	26.2	5.74	0.88	0.30	1.91	1.04			0.06	0.27	1.34	10.7	88	88	104	0.070	2.62
OTTCOMP11	0959	34.4	18.7	5.4	2.69	25.1	4.94	1.40	0.42	2.15	1.48			0.04	0.24	1.42	9.8	105	86	96	0.050	2.62
OTTCOMP12	0969	31.3	18.5	5.7	2.33	25.2	4.85	1.94	0.39	2.41	1.40			0.03	0.32	1.65	8.8	102	86	98	0.040	2.66
LANCOMP02	0973	31.7	15.2	6.0	4.39	27.8	6.02	0.78	0.27	2.33	1.13			0.04	0.54	1.62	11.2	88	89	99	0.110	2.79
NE4COMP06	0973	33.6	15.8	6.1	3.64	26.8	5.78	0.93	0.27	2.31	1.04			0.06	0.35	1.61	9.2	82	88	91	0.070	2.65
AMECOMP01	0979	37.0	18.8	5.8	5.71	23.1	4.73	1.08	0.69	2.79	1.40			0.03	0.33	1.75	16.8	74	91	70	0.090	2.57
NE4COMP07	0984	33.3	15.8	6.2	3.76	27.2	5.80	0.85	0.25	2.10	1.03			0.03	0.32	1.46	9.2	93	89	97	0.070	2.64
NE2091185	0992	49.4	19.9	7.2	2.00	14.2	3.50	0.85	1.62	0.25	0.81			0.21	0.74	0.28	13.1	93	89	78	0.050	2.28
NE4091785	0994	37.8	18.0	4.7	2.00	22.8	5.00	1.48	0.42	2.56	1.22			0.02	0.30	1.05	8.8	107	89	98	0.060	2.53
CBFCOMP04	0997	33.1	15.8	5.2	3.20	27.5	5.90	0.89	0.29	1.80	1.31			0.07	0.37	1.26	12.1	92	89	90	0.100	2.70
NE4COMP08	0997	33.9	16.0	6.0	3.20	26.3	5.90	0.81	0.30	1.76	1.01			0.06	0.38	1.17	11.5	92	89	93	0.070	2.62
OTTCOMP13	0997	30.9	18.0	5.8	3.00	25.6	4.80	1.24	0.35	2.36	1.44			0.06	0.26	1.65	9.6	90	88	89	0.050	2.64
CBFCOMP05	1000	30.1	15.7	5.4	3.70	28.5	6.20	0.72	0.23	1.78	1.30			0.10	0.37	1.20	10.4	87	89	89	0.100	2.72
NE4092485	1000	41.1	17.8	4.5	2.10	22.3	4.90	1.20	0.46	2.38	1.21			0.02	0.28	1.12	11.8	102	89	95	0.040	2.42
LANCOMP03	1004	33.2	15.6	5.8	3.80	28.9	5.60	0.82	0.36	1.92	1.21			0.14	0.56	1.35	11.0	95	90	87	0.090	2.77
NE4COMP09	1004	35.0	16.7	5.5	2.80	25.3	5.60	1.03	0.34	1.69	1.05			0.02	0.30	1.09	9.7	102	89	94	0.060	2.57
OTTCOMP14	1008	30.7	18.2	5.5	2.40	25.3	4.91	1.38	0.36	1.91	1.40			0.02	0.31	1.27	9.9	97	86	82	0.040	2.66
NE4COMP10	1027	38.5	17.7	5.0	2.09	22.4	4.87	1.21	0.46	2.28	1.10			0.03	0.31	0.84	9.8	101	89	96	0.040	2.45
OTTCOMP15	1027	32.4	18.4	5.4	2.27	25.6	5.04	0.98	0.37	1.33	1.45			0.04	0.25	0.84	10.2	94	87	96	0.040	2.64
OTTCOMP16	1035	29.5	18.4	5.3	1.92	25.4	4.97	1.53	0.37	1.68	1.41			0.01	0.20	1.18	9.6	101	87	92	0.050	2.65
MARQUETTE	1042	44.3	19.6	6.7	2.08	15.8	3.60	0.38	0.98	4.84	0.88			0.03	0.83	2.79	7.6	90	89	86	0.040	2.44
CBFCOMP06	1048	31.8	16.9	4.8	3.22	27.7	5.19	1.05	0.32	1.79	1.41			0.09	0.35	1.21	9.2	92	89	91	0.070	2.66
LANCOMP04	1048	32.2	18.1	5.8	4.93	26.6	5.15	0.81	0.31	2.14	1.25			0.06	0.41	1.36	12.8	88	90	87	0.040	2.75
LANSING	1128	31.5	16.1	6.7	3.79	29.1	5.51	0.77	0.23	1.91	1.03	0.39	0.64	0.04	0.24	1.55	9.1	80	88	86	0.118	2.82
CBF.021986	1146	31.4	16.6	5.4	3.49	32.1	5.69	1.45	0.18	1.53	1.04	0.45	0.66	0.01	0.24	1.10	10.3	84	88	91	0.153	2.76
NE4.021286	1146	33.2	18.0	5.7	2.37	25.4	4.87	2.08	0.34	2.28	1.02	0.54	0.86	0.05	0.29	1.57	12.1	96	89	91	0.067	2.60
NTARIO.022486	1151	40.7	19.1	4.8	1.49	13.1	2.70	0.55	0.69	6.92	0.99	0.56	0.97	0.10	0.31	3.42	13.0	96	87	69	0.055	2.45
AME.020786	1155	26.8	16.4	7.0	4.60	27.0	5.01	1.01	0.56	1.82	0.92	0.37	0.82	2.31	4.09	1.57	9.7	74	96	71	0.047	2.43
NE2.030386	1150	44.6	19.3	6.9	1.86	15.4	3.39	0.92	1.49	0.48	0.93	0.20	0.33	0.13	0.90	0.43	13.1	79	94	77	0.085	2.34
NE3.020586	1159	40.2	20.6	11.6	1.71	14.7	3.84	1.03	1.32	0.17	0.98	0.17	0.33	0.00	0.10	0.75	10.8	103	91	78	0.083	2.61
NE4(Cabalo)	1159	32.8	18.1	5.7	2.38	26.1	4.71	2.09	0.33	2.79	1.02	0.64	0.86	0.04	0.31	1.74	11.8	98	89	90	0.074	2.63
LAN.030786	1166	31.6	16.0	6.3	3.95	30.3	5.77	0.80	0.29	1.95	1.01	0.39	0.82	0.07	0.45	1.41	10.7	91	90	85	0.114	2.79
OTT.031386	1168	29.6	19.0	6.0	2.45	27.3	4.55	1.02	0.38	2.13	1.09	0.46	0.72	0.06	0.20	1.57	9.3	109	87	101	0.079	2.64

Table III, Appendix C (continued)

Sample Name	Day No (1/1/83)	SiO_2	Al_2O_3	Fe_2O_3	SO_3	CaO	MgO	P_2O_5	K_2O	Na_2O	TiO_2	SrO	BaO	MC	LOI	AA	Fine (Corr)	28 Day Poz	H2O Reqd	7 Day Poz	Auto-clave	SG
RAWHIDE	1179	27.1	10.4	6.4	10.80	31.1	3.81	0.91	0.23	1.31	1.08	0.36	0.52	0.49	3.34	1.00	30.0	57	98	64	0.073	2.64
AME.032186	1181	32.0	16.0	6.7	5.25	26.4	5.19	1.03	0.50	2.44	1.02	0.36	0.55	0.16	0.60	1.77	13.1	74	93	73	0.106	2.60
NE3.031886	1182	40.4	18.5	9.1	1.79	18.1	4.21	0.82	1.39	0.20	0.90	0.19	0.35	0.00	0.37	0.27	17.1	106	91	65	0.143	2.62
CBF.040486	1195	30.4	17.4	5.1	3.10	32.4	5.33	1.71	0.24	1.61	1.03	0.49	0.70	0.08	0.42	1.25	10.6	99	89	99	0.119	2.69
NBC.041686	1210	34.0	15.6	5.7	2.43	27.4	5.96	0.91	0.25	1.73	0.94	0.43	0.77	0.03	0.27	1.28	13.8	110	88	77	0.113	2.67
NOS.042486	1210	32.9	15.3	6.4	3.05	27.7	5.75	0.76	0.22	1.62	0.93	0.44	0.69	0.06	0.45	1.44	11.1	99	89	87	0.118	2.72
COR.102865	1216	44.5	19.5	6.1	0.69	13.8	2.55	1.70	0.68	2.72	0.94	0.44	0.54	0.09	2.45	1.27	12.1	112	89	87	0.040	2.41
NE3.042986	1218	43.1	18.3	8.6	1.51	17.4	4.40	0.73	1.44	0.27	0.89	0.19	0.35	0.07	0.11	0.31	18.2	106	90	78	0.175	2.49
OTTCOMP1	1222	29.7	18.7	6.2	2.74	25.3	4.47	1.44	0.38	2.45	1.09	0.45	0.69	0.08	0.23	1.36	8.3	103	87	98	0.073	2.69
NE4.051286	1228	32.4	15.8	6.3	3.31	27.0	5.43	0.88	0.22	2.34	0.97	0.41	0.73	0.04	0.23	1.56	10.5	101	88	86	0.091	2.69
CBFCOMP1	1235	30.1	16.9	5.5	3.21	29.5	4.90	1.30	0.26	1.78	1.07	0.42	0.67	0.04	0.41	1.37	8.2	95	89	92	0.120	2.71
LANCOMP1	1235	30.1	16.4	5.8	3.57	29.9	6.51	0.92	0.30	1.73	1.01	0.44	0.61	0.02	0.71	1.36	14.8	98	89	89	0.139	2.78
OTTCOMP2	1235	32.0	19.3	6.1	2.28	24.9	4.74	1.54	0.40	1.56	1.10	0.48	0.70	0.03	0.31	1.10	9.1	105	88	92	0.070	2.69
LAN.052086	1249	29.2	16.1	5.9	3.97	30.3	6.71	0.81	0.20	2.07	1.04	0.40	0.62	0.04	0.75	1.54	13.7	86	90	92	0.174	2.80
NE4COMP1	1253	31.7	16.0	6.0	3.37	27.7	5.61	0.87	0.23	2.40	0.97	0.42	0.72	0.03	0.26	1.84	11.0	92	90	89	0.110	2.70
OTTCOMP3	1253	33.8	19.2	6.2	1.88	25.1	4.56	1.53	0.41	1.51	1.11	0.45	0.71	0.02	0.27	1.13	8.7	103	88	98	0.065	2.72
NE4COMP2	1264	31.2	15.6	6.0	3.48	26.1	6.09	0.81	0.24	2.19	0.95	0.42	0.72	0.04	0.42	1.62	11.5	97	90	84	0.109	2.72
CBFCOMP2	1265	31.1	17.1	5.5	2.86	29.8	5.13	1.42	0.28	1.80	1.08	0.43	0.69	0.10	0.32	1.33	8.9	97	88	95	0.117	2.70
NE3.061986	1271	42.6	20.1	9.9	1.77	18.4	4.00	0.74	1.38	0.20	0.79	0.20	0.31	0.03	0.33	0.28	10.2	95	89	75	0.105	2.54
NE4COMP3	1273	31.5	15.7	6.1	3.32	27.9	5.65	0.72	0.27	2.08	0.95	0.46	0.96	0.03	0.35	1.60	12.4	94	90	90	0.028	2.72
OTTCOMP4	1273	30.6	18.5	6.2	2.30	25.4	4.40	2.08	0.39	1.97	1.07	0.51	0.80	0.05	0.39	1.44	8.7	100	88	88	0.001	2.70
OTTCOMP5	1286	30.0	18.6	6.2	2.68	26.4	4.78	1.38	0.33	1.89	1.09	0.46	0.66	0.03	0.31	1.31	8.1	90	88	92	-0.007	2.70
FREEMONT	1286	59.3	23.7	4.7	0.48	1.8	1.30	0.46	1.77	1.17	0.70	0.16	0.21	0.50	4.88	0.87	28.2	75	104	61	-0.016	2.02
NE4COMP4	1289	31.5	15.6	5.9	3.25	27.3	5.43	0.78	0.28	2.13	0.94	0.41	0.70	0.06	0.50	1.51	12.1	92	90	87	0.028	2.68
NE2.070786	1291	41.7	19.0	8.7	1.76	15.2	3.25	0.95	1.46	0.22	0.70	0.18	0.34	0.14	0.50	0.26	12.8	103	89	85	0.044	2.43
NBCCOMP1	1293	34.6	18.3	5.8	2.14	27.0	5.87	1.01	0.32	1.45	0.98	0.43	0.74	0.13	0.35	1.11	13.0	94	90	94	0.025	2.70
NOSCOMP1	1293	32.4	16.1	6.3	3.32	27.6	5.92	0.76	0.24	1.74	0.96	0.41	0.69	0.10	0.55	1.23	11.5	88	90	84	0.052	2.70
NE2.071686	1300	42.2	19.5	9.0	1.52	15.1	3.34	0.96	1.48	0.23	0.92	0.14	0.31	0.05	0.44	0.26	17.1	80	91	69	0.052	2.38
NE3.071886	1300	39.9	16.9	8.7	1.63	20.1	3.95	0.99	1.38	0.31	0.86	0.30	0.45	0.04	0.17	0.20	13.6	88	89	71	0.069	2.57
NE4COMP5	1300	30.0	15.8	6.3	3.56	27.8	5.87	0.64	0.22	2.38	0.95	0.41	0.74	0.06	0.33	1.50	12.2	87	89	85	0.031	2.69
NE4COMP6	1305	30.9	15.7	6.3	3.44	26.8	5.71	0.85	0.21	2.31	0.96	0.44	0.66	0.06	0.43	1.64	12.7	82	93	82	0.018	2.67
OTTCOMP6	1305	29.8	18.5	6.4	2.72	26.3	4.58	1.40	0.32	2.31	1.10	0.44	0.66	0.08	0.42	1.51	9.6	89	90	89	0.012	2.70
LANCOMP2	1308	29.9	16.1	5.8	3.57	29.9	6.15	1.09	0.24	1.60	0.94	0.43	0.67	0.06	0.72	1.29	13.0	103	91	90	0.060	2.79
CBFCOMP3	1312	30.5	16.8	5.4	3.04	30.3	5.24	1.24	0.27	1.71	1.05	0.42	0.66	0.08	0.52	1.16	11.2	91	90	90	0.051	2.71
NE3.080586	1319	36.7	17.2	9.6	1.89	21.9	3.97	1.08	1.20	0.31	0.88	0.30	0.46	0.04	0.16	0.29	9.5	98	91	78	0.073	2.62
OTTCOMP7	1320	31.7	18.5	6.0	2.37	25.4	4.63	1.85	0.38	1.94	1.08	0.49	0.74	0.05	0.29	0.96	10.1	90	89	92	0.004	2.68
NE2.080886	1321	45.0	20.7	9.5	1.67	15.1	3.34	0.81	1.49	0.21	0.90	0.14	0.29	0.22	0.35	0.28	11.3	91	90	67	0.056	2.39
RAWHIDE	1321	19.7	11.7	6.0	14.60	30.2	3.64	1.38	0.25	1.51	0.83	0.33	0.56	1.00	3.00	1.37	12.4	•	•	•	0.011	2.68
SLUDGE	1321	33.0	11.7	6.1	1.69	9.7	13.90	7.30	0.60	0.66	1.00	0.04	0.18	0.20	0.57	0.56	40.4	•	•	•	-0.010	2.85
GEN.080786	1322	49.6	20.5	12.3	1.91	8.5	1.50	0.24	1.60	1.32	1.02	0.16	0.24	0.08	0.78	0.96	13.4	84	93	•	-0.023	2.42
WES.080786	1322	32.3	17.7	5.8	2.82	26.2	5.14	1.18	0.39	2.26	1.04	0.35	0.76	0.03	0.35	1.54	14.5	92	91	•	0.039	2.69
ALM.081386	1326	29.1	18.3	5.6	4.94	29.9	6.80	0.67	0.20	1.87	1.02	0.40	0.61	0.01	0.32	1.37	10.3	77	93	•	0.081	2.80
NBCCOMP2	1327	36.2	18.2	6.0	1.91	25.6	5.38	1.06	0.31	1.39	0.97	0.43	0.71	0.07	0.19	0.62	13.4	92	92	82	0.025	2.66
NOSCOMP2	1327	32.7	15.8	6.2	3.20	27.2	5.58	0.81	0.21	1.88	0.96	0.42	0.70	0.12	0.37	1.40	11.6	88	92	78	0.064	2.72
NE2.081586	1329	44.6	19.5	9.1	1.69	15.2	3.23	0.84	1.48	0.23	0.90	0.14	0.30	0.18	0.54	0.30	11.1	90	92	55	0.057	2.40
CBFCOMP4	1333	29.2	16.6	5.1	3.46	31.7	6.09	1.04	0.23	1.48	1.03	0.43	0.62	0.10	0.46	1.07	10.6	84	95	86	0.079	2.72
OTTCOMP8	1335	32.0	18.5	5.7	2.31	24.7	4.55	1.58	0.39	1.94	1.09	0.47	0.67	0.04	0.22	1.15	8.8	96	91	100	0.004	2.66
LANCOMP3	1347	31.1	16.5	5.8	3.56	29.6	5.46	0.98	0.28	1.72	1.02	0.41	0.86	0.03	0.36	1.31	10.1	84	94	96	0.044	2.78
OTTCOMP9	1347	30.9	18.8	5.9	2.51	25.1	4.57	1.53	0.38	2.06	1.09	0.45	0.69	0.03	0.21	1.19	9.7	100	92	93	-0.001	2.68
NE2.090286	1348	45.8	19.8	9.1	1.67	14.8	3.15	0.78	1.53	0.25	0.92	0.16	0.28	0.11	0.46	0.31	12.6	90	91	68	0.056	2.43

Sample Name	Day No (1/1/83)	SiO_2	Al_2O_3	Fe_2O_3	SO_3	CaO	MgO	P_2O_5	K_2O	Na_2O	TiO_2	SrO	BaO	MC	LOI	AA	Fine (Corr)	28 Day Poz	H2O Reqd	7 Day Poz	Auto-clave	SG
CBFCOMP5	1350	30.3	16.7	5.3	3.26	30.4	4.90	1.23	0.27	1.45	1.03	0.51	0.63	0.18	0.63	1.02	9.0	84	92	90	0.055	2.70
OTTCOMP10	1350	31.7	18.1	5.9	2.52	25.3	4.47	1.83	0.35	2.12	1.07	0.49	0.74	0.02	0.25	1.48	9.6	97	88	102	0.003	2.68
GEN.091086	1355	49.5	21.5	11.9	2.09	8.2	1.28	0.19	1.57	1.37	1.09	0.17	0.24	0.10	0.80	0.92	11.0	90	93	68	-0.035	2.39
WES.091186	1355	31.3	17.6	5.6	2.80	26.6	5.46	1.22	0.34	2.58	1.04	0.38	0.74	0.03	0.24	1.86	12.8	93	92	81	0.052	2.67
OTTCOMP11	1361	30.7	18.0	5.8	2.83	25.5	4.81	1.77	0.33	2.24	1.08	0.48	0.72	0.09	0.40	1.47	9.8	100	90	93	0.011	2.69
NBCCOMP3	1368	34.6	18.0	6.0	2.20	26.3	5.68	1.03	0.28	1.55	0.98	0.43	0.70	0.04	0.25	1.05	12.4	82	92	90	0.032	2.63
NE3.100186	1371	34.1	16.8	9.2	2.33	25.2	4.22	1.14	1.06	0.43	0.87	0.30	0.43	0.04	0.22	0.47	9.8	83	94	72	•	2.61
OTTCOMP12	1375	29.8	18.4	5.8	2.87	26.1	6.24	1.65	0.30	2.09	1.09	0.47	0.60	0.04	0.26	1.57	10.1	103	89	96	0.015	2.69
LANCOMP4	1377	30.2	16.8	5.6	3.46	30.4	5.36	1.01	0.24	1.14	1.13	0.45	0.61	0.08	0.60	0.88	10.5	94	94	91	0.065	2.78
NE3.100786	1382	32.3	16.4	7.4	2.73	27.3	6.58	0.97	0.41	1.34	0.93	0.42	0.64	0.04	0.23	1.01	7.4	87	94	83	0.060	2.65
OTTCOMP13	1384	30.6	18.4	5.7	2.64	25.2	4.86	1.64	0.34	2.12	1.08	0.46	0.68	0.01	0.38	1.44	11.3	95	90	93	0.012	2.68
NE2.100386	1385	33.6	17.5	9.3	2.89	23.9	5.05	1.00	1.09	0.47	0.80	0.23	0.37	0.01	0.39	0.51	10.8	98	94	70	•	2.56
ALM.101686	1390	29.2	16.8	5.8	4.28	29.9	5.91	0.91	0.24	1.29	1.02	0.43	0.62	0.06	0.85	0.86	10.4	85	94	82	0.062	2.76
GEN.101386	1390	48.8	22.2	9.5	1.87	10.1	1.90	0.47	1.43	1.39	1.04	0.29	0.17	0.02	0.90	0.57	12.9	98	91	67	-0.018	2.45
WES.101586	1390	30.7	17.0	5.6	3.34	29.3	5.84	1.12	0.27	1.87	1.00	0.40	0.68	0.04	0.35	1.40	11.4	96	94	82	0.062	2.76
LANCOMP5	1396	29.7	16.8	5.6	3.76	30.4	5.55	1.01	0.26	1.39	1.02	0.42	0.64	0.03	0.38	1.09	10.7	95	94	87	0.058	2.79
NOSCOMP3	1399	33.3	15.7	6.3	3.32	27.7	5.66	0.82	0.22	1.92	0.98	0.42	0.71	0.10	0.46	1.42	10.3	81	93	81	0.057	2.70
NOSCOMP4	1399	32.2	15.7	6.1	3.06	28.2	5.67	0.74	0.19	1.80	0.96	0.42	0.68	0.04	0.43	1.28	12.4	82	92	74	0.065	2.73
OTTCOMP14	1398	31.0	18.3	5.6	2.66	25.3	4.95	1.77	0.34	1.90	1.07	0.46	0.72	0.03	0.35	1.17	10.0	100	90	89	0.006	2.67
NE2.101786	1400	33.1	17.5	9.3	3.10	22.8	6.50	0.87	1.09	0.50	0.88	0.16	0.32	0.07	0.50	0.45	12.3	96	96	58	0.150	2.50
WES.111086	1410	30.9	18.0	5.4	3.03	27.9	5.71	1.08	0.36	2.47	1.05	0.35	0.78	0.00	0.23	1.70	11.9	81	92	94	0.057	2.68
ALM.111286	1417	29.7	17.3	5.5	4.20	30.7	6.48	0.99	0.26	1.74	1.07	0.40	0.66	•	0.32	1.28	10.7	97	91	91	0.071	2.77
GEN.111286	1417	47.0	23.4	10.3	1.57	8.4	1.66	0.50	1.56	0.84	1.10	0.24	0.15	0.05	1.79	0.41	13.8	94	94	80	-0.021	2.39
NE2.120586	1449	38.4	18.8	9.5	2.72	18.4	4.07	0.90	1.34	0.37	0.91	0.15	0.31	0.12	0.39	0.34	10.8	94	94	70	0.081	2.52
OTTCOMP15	1452	31.4	18.6	5.9	2.40	28.5	4.87	1.84	0.35	1.88	1.09	0.48	0.73	0.02	0.30	1.04	9.9	92	91	81	0.016	2.68
NOSCOMP5	1469	31.8	16.5	6.4	3.03	28.1	5.95	1.03	0.24	1.94	0.98	0.46	0.74	0.01	0.37	1.44	10.3	85	94	80	0.053	2.68
ALM.123086	1474	29.7	17.0	5.6	4.70	30.8	5.63	1.02	0.21	1.44	1.04	0.42	0.63	0.04	0.34	1.11	7.2	89	91	83	0.062	2.76
CBF.010987	1476	27.6	17.3	5.8	3.17	31.0	6.43	1.29	0.22	1.48	1.01	0.47	0.69	0.01	0.25	1.13	12.3	92	91	84	0.080	2.72
GEN.010987	1474	48.3	18.8	11.6	2.14	10.2	1.80	0.21	1.50	1.72	0.98	0.20	0.25	0.12	1.10	1.07	13.5	90	92	72	-0.022	2.40
WES.010987	1476	30.6	17.8	5.4	3.14	27.9	5.86	1.22	0.32	2.58	1.03	0.36	0.73	0.02	0.30	1.72	14.6	87	91	85	0.064	2.67
PPA.012687	1488	22.2	13.1	4.7	12.10	31.1	3.12	0.97	0.24	1.20	0.84	0.31	0.43	2.37	4.78	1.07	11.6	70	92	70	-0.010	2.50
SHE.012287	1494	32.5	17.5	7.2	1.86	26.5	4.72	1.71	0.31	1.64	1.05	0.46	0.72	0.05	0.15	1.20	14.6	76	92	64	0.021	2.68
UNI.021887	1517	41.0	16.6	20.2	1.50	2.9	0.64	0.18	1.90	0.35	0.79	0.01	0.03	0.06	13.47	0.80	17.3	70	108	52	0.000	2.36
NSP-Alma King	1522	17.5	13.7	8.8	8.40	31.5	6.60	2.20	0.60	3.40	1.00	0.40	0.90	•	2.00	•	•	•	•	•	•	•
ALM.030587	1531	30.0	17.1	6.2	4.58	30.8	5.84	1.32	0.19	0.97	1.03	0.49	0.84	0.00	0.25	0.78	6.8	84	91	91	0.120	2.78
CBF.030487	1531	29.2	17.0	7.1	3.52	28.3	6.68	0.81	0.24	2.02	1.02	0.41	0.60	0.00	0.26	1.40	12.6	84	92	81	0.120	2.71
GEN.030587	1531	46.5	18.2	10.6	2.13	11.5	1.96	0.19	1.39	2.05	0.96	0.26	0.31	0.04	0.54	1.37	12.6	86	90	75	0.031	2.38
NE2.030287	1531	43.6	19.6	8.9	1.71	13.9	3.33	0.90	1.49	0.24	0.94	0.17	0.30	0.00	0.42	0.36	14.2	89	93	70	0.088	2.42
WES.030587	1531	32.8	17.5	5.2	2.82	26.4	5.80	1.13	0.33	2.84	1.04	0.36	0.69	0.04	0.32	1.81	14.6	88	90	84	0.099	2.64
NICCOMP1	1536	30.1	19.3	5.8	3.24	28.9	5.06	1.07	0.29	1.86	1.11	0.43	0.68	0.00	0.22	1.55	13.0	92	91	84	0.101	2.64
NOSCOMP1	1538	34.5	15.4	6.5	2.71	28.3	5.42	0.92	0.27	1.94	0.99	0.42	0.67	0.01	0.35	1.39	12.4	88	90	78	0.108	2.63
NOSCOMP2	1536	36.0	15.9	6.4	2.83	26.7	5.34	0.91	0.25	1.85	0.98	0.42	0.69	0.01	0.33	1.48	10.5	91	92	78	0.114	2.66
LAN.032887	1552	37.2	16.7	5.9	3.60	28.7	5.43	1.04	0.24	1.88	1.06	0.44	0.64	0.00	0.61	1.27	15.1	95	95	88	0.110	2.75
NICCOMP2	1559	34.5	14.8	5.9	2.64	28.3	5.61	0.97	0.23	1.77	0.95	0.43	0.74	0.16	0.51	1.26	16.1	79	94	72	0.124	2.66
NE2.040287	1560	49.0	20.4	9.4	1.40	9.1	2.53	1.07	1.83	0.17	0.91	0.20	0.32	0.11	0.37	0.29	13.7	95	94	76	0.031	2.34
OTTCOMP1	1573	31.0	18.2	5.7	2.83	25.0	4.60	1.55	0.33	2.96	1.06	0.54	0.66	0.04	0.41	2.50	11.4	91	91	83	0.092	2.66
LANCOMP1	1586	29.9	16.8	6.3	3.66	29.3	7.12	0.72	0.24	2.04	1.06	0.40	0.61	0.02	0.74	1.53	14.3	90	95	84	0.141	2.77
NICCOMP3	1588	32.7	15.4	5.9	2.96	28.8	6.37	0.74	0.74	1.72	0.95	0.41	0.69	0.02	0.29	1.20	16.5	91	93	82	0.129	2.63
NE4.050787	1588	39.3	15.7	5.6	3.33	22.1	4.35	1.12	0.64	2.84	0.98	0.41	0.62	0.02	0.27	1.61	12.0	84	91	82	0.082	2.58
NOSCOMP3	1588	36.6	15.6	6.1	2.66	26.7	5.43	0.88	0.26	1.81	0.98	0.41	0.70	0.02	0.30	1.32	13.1	85	92	77	0.104	2.61

Table III, Appendix C (continued)

Sample Name	Day No (1/1/83)	SiO2	Al2O3	Fe2O3	SO3	CaO	MgO	P2O5	K2O	Na2O	TiO2	SrO	BaO	MC	LOI	AA	Fine (Corr)	28 Day Poz	H2O Reqd	7 Day Poz	Auto-clave	SG
NOSCOMP4	1558	34.9	15.5	6.7	3.01	27.5	5.75	0.76	0.27	1.83	0.96	0.43	0.67	0.02	0.71	1.37	13.3	90	94	89	0.117	2.66
OTTCOMP2	1588	30.8	18.0	5.8	3.34	25.6	4.65	1.47	0.32	3.21	1.07	0.44	0.66	0.02	0.35	2.61	10.1	90	91	86	0.093	2.64
NE3.051987	1609	46.1	17.8	8.1	1.27	15.4	4.05	0.75	1.60	0.26	0.89	0.18	0.34	0.04	0.19	0.38	14.5	99	92	60	0.100	2.50
NE4COMP1	1609	35.8	17.6	5.5	2.18	24.0	4.82	1.34	0.38	2.38	1.04	0.45	0.69	0.04	0.30	1.82	15.5	102	92	92	0.074	2.55
LANCOMP2	1616	31.3	15.7	6.6	4.09	28.7	6.50	0.74	0.21	2.09	0.96	0.42	0.61	0.03	0.35	1.64	9.0	94	92	94	0.124	2.78
CBF.060887	1621	34.9	17.0	6.3	2.22	26.6	5.57	0.90	0.38	1.45	1.06	0.41	0.60	0.01	0.19	1.17	11.8	102	92	94	0.087	2.68
NBCCOMP4	1623	31.5	17.9	5.8	2.54	26.6	5.06	0.98	0.33	1.69	1.04	0.48	0.87	0.08	0.25	1.33	16.6	101	93	82	0.099	2.62
NOSCOMP5	1623	36.0	16.4	6.2	2.92	26.9	5.76	0.72	0.31	1.78	0.99	0.41	0.65	0.04	0.36	1.35	13.6	98	91	84	0.099	2.67
OTTCOMP3	1623	32.1	18.4	5.7	2.61	25.7	4.65	1.69	0.35	2.61	1.08	0.47	0.70	0.08	0.29	2.12	11.2	98	91	84	0.080	2.65
NE4COMP2	1624	35.2	18.0	5.5	1.89	23.4	4.57	1.28	0.39	2.13	1.08	0.44	0.87	0.03	0.25	1.74	11.9	105	94	96	0.082	2.54
ALM.061987	1636	31.3	17.5	5.7	3.30	29.2	5.34	1.39	0.26	1.61	1.07	0.48	0.70	0.06	0.76	1.21	16.5	96	95	99	0.107	2.71
COH.061987	1636	47.5	20.9	6.4	1.30	13.6	4.64	0.17	0.95	0.43	0.91	0.21	0.73	0.08	1.01	0.48	16.2	109	94	87	0.038	2.55
GEN.061987	1636	41.0	22.1	11.5	3.16	10.7	2.36	0.38	1.10	1.05	1.12	0.25	0.27	0.19	5.61	0.75	17.2	84	98	67	0.012	2.43
OTTCOMP4	1636	37.6	17.3	6.1	1.72	23.6	4.39	1.50	0.45	1.60	1.08	0.48	0.80	0.02	0.25	1.11	13.1	109	91	95	0.055	2.59
WES.061987	1636	30.9	17.8	5.3	3.04	27.4	5.64	1.17	0.34	2.60	1.05	0.42	0.77	0.06	0.33	1.98	13.3	88	92	88	0.118	2.68
LAN.061987	1637	31.3	16.9	6.7	3.73	29.0	6.13	1.32	0.22	1.65	1.04	0.53	0.68	0.05	0.49	1.30	9.6	94	90	85	0.110	2.78
NE4COMP3	1641	36.6	18.0	5.5	1.92	23.9	4.54	1.21	0.38	2.01	1.05	0.43	0.65	0.05	0.24	1.58	12.2	103	92	92	0.063	2.50
CLINTON	1643	54.9	18.7	14.3	1.25	4.8	1.09	0.18	2.13	1.02	1.05	0.00	0.01	0.13	1.40	0.85	19.6	95	94	67	0.013	2.31
MUSCATINE	1643	33.0	16.0	37.2	1.50	2.4	0.50	0.20	1.61	0.14	1.00	0.00	0.00	0.36	0.91	0.32	9.2	84	93	65	0.007	3.23
NE4COMP4	1650	36.3	17.8	5.6	1.84	23.7	4.46	1.13	0.38	1.98	1.04	0.42	0.64	0.03	0.28	1.44	12.5	97	93	97	0.063	2.51
NBCCOMP5	1652	35.2	18.4	5.8	2.39	25.3	4.53	1.13	0.49	1.83	1.07	0.42	0.68	0.03	0.31	1.39	18.6	91	91	83	0.051	2.55
NOSCOMP6	1652	33.9	16.9	6.2	3.13	27.6	5.64	0.85	0.31	1.91	0.98	0.43	0.70	0.04	0.32	1.49	10.2	107	90	86	0.116	2.67
OTTCOMP5	1652	33.5	18.5	5.5	2.12	25.4	4.64	1.38	0.39	1.89	1.09	0.49	0.66	0.03	0.30	1.57	10.9	103	90	94	0.055	2.62
MARSHALLTOWN	1656	40.7	17.2	18.6	2.22	4.8	1.00	0.96	2.97	0.56	1.11	0.02	0.02	0.16	4.18	0.54	1.5	125	94	108	-0.042	2.71
PRAIRIE CREEK	1656	51.2	18.7	15.4	1.43	3.9	0.89	0.12	2.20	1.18	1.12	0.01	0.04	0.13	4.08	1.08	18.0	78	100	55	0.005	2.27
CBFCOMP1	1665	31.0	16.2	6.4	2.96	28.6	5.99	0.80	0.25	1.63	0.98	0.42	0.63	0.06	0.25	1.25	10.8	98	90	85	0.109	2.73
NE4COMP5	1665	35.6	17.7	5.7	2.01	24.2	4.60	1.15	0.36	2.10	1.05	0.42	0.65	0.08	0.24	0.82	12.6	102	91	90	0.061	2.51
OTTCOMP6	1665	32.1	18.2	6.5	2.44	26.3	4.54	1.49	0.32	1.82	1.07	0.46	0.65	0.06	0.29	1.23	10.6	96	90	97	0.065	2.65
OTTCOMP7	1669	30.2	17.9	5.9	3.10	26.6	4.33	1.39	0.29	2.71	1.06	0.43	0.62	0.05	0.31	2.06	11.0	78	90	89	0.079	2.67
LANCOMP3	1671	31.6	17.6	6.9	3.30	28.3	5.15	1.23	0.29	1.65	1.06	0.45	0.66	0.03	0.35	1.31	10.5	98	92	95	0.104	2.76
NBC.071787	1672	32.1	19.0	5.4	2.23	25.8	4.71	1.11	0.41	1.84	1.08	0.43	0.87	0.13	0.29	0.88	18.8	96	92	88	0.082	2.58
NOS.071787	1672	35.3	16.6	5.9	3.06	26.8	5.59	0.73	0.32	1.73	0.98	0.42	0.64	0.12	0.33	1.14	6.5	98	90	95	0.113	2.64
OTTCOMP8	1683	31.4	18.0	5.8	2.76	26.3	4.79	2.08	0.32	2.52	1.03	0.52	0.78	0.07	0.18	1.75	10.4	93	90	98	0.078	2.68
NBC.080487	1685	34.4	18.5	5.8	2.40	27.0	5.27	1.10	0.35	1.84	1.44	0.48	0.78	0.00	0.34	1.11	15.7	89	92	90	0.087	2.60
CHEROKEE	1686	52.0	24.4	4.9	0.41	8.5	1.61	0.85	0.91	1.92	0.98	0.26	0.44	0.01	0.61	0.60	24.5	78	98	66	0.012	2.16
COMMANCHE	1686	29.5	16.3	5.3	3.72	28.9	5.08	1.66	0.20	4.69	1.04	0.51	0.65	0.01	1.62	3.42	9.9	56	95	55	*	2.74
PAWNEE	1686	28.2	17.2	5.7	3.59	30.9	5.90	0.85	0.23	1.62	1.05	0.40	0.66	0.00	0.44	1.23	11.5	86	92	93	0.149	2.68
NE4COMP6	1690	35.6	17.7	5.8	1.99	23.9	4.75	1.09	0.39	2.16	1.05	0.41	0.65	0.03	0.31	0.85	14.0	107	92	98	0.060	2.54
OTTCOMP9	1693	31.3	18.1	5.9	2.60	25.3	4.49	2.31	0.38	2.72	1.03	0.54	0.83	0.01	0.31	1.72	10.1	102	90	99	0.084	2.68
COAL CREEK	1697	47.3	17.3	7.2	1.20	18.1	5.30	0.20	1.70	*	0.60	0.26	0.68	0.05	0.05	*	*	*	*	*	*	*
AME.080487	1698	34.5	17.5	5.7	3.17	23.5	5.87	1.26	0.64	2.14	1.08	0.29	0.65	0.12	0.44	1.62	12.1	87	94	66	0.114	2.55
NE2.082187	1699	46.7	21.0	9.1	1.21	8.5	2.40	0.91	1.55	0.13	0.93	0.15	0.28	0.21	0.38	0.17	12.3	98	91	80	0.041	2.24
CBFCOMP2	1700	30.0	16.0	6.5	3.20	29.0	6.74	0.74	0.22	1.64	0.98	0.41	0.66	0.11	0.55	1.23	11.4	87	90	88	0.130	2.73
NE4COMP7	1700	36.4	18.2	5.8	1.85	23.4	4.43	1.19	0.45	2.18	1.05	0.43	0.96	0.08	0.38	0.80	15.0	97	92	92	0.060	2.50
LANCOMP4	1704	30.1	17.0	5.7	3.09	27.8	5.79	0.97	0.26	1.69	1.04	0.50	0.64	0.04	0.52	1.20	11.9	87	91	80	0.130	2.77
OTTCOMP10	1707	30.0	18.3	5.2	3.00	24.8	4.40	1.48	0.32	2.88	1.07	0.48	0.87	0.05	0.35	1.80	9.8	96	90	95	0.089	2.65
NBCCOMP6	1713	33.8	16.9	6.0	2.54	26.9	5.26	0.97	0.31	1.79	1.02	0.43	0.70	0.07	0.32	1.30	16.2	91	91	83	0.100	2.59
NOSCOMP7	1713	34.6	18.1	6.2	2.52	25.8	5.03	1.04	0.36	1.65	1.04	0.43	0.69	0.04	0.40	1.30	11.2	107	90	101	0.090	2.63
OTTCOMP11	1713	32.9	19.4	5.4	3.28	27.3	4.95	1.15	0.34	3.26	1.56	0.39	0.80	0.02	0.35	2.31	9.5	89	89	86	0.100	2.64
OTTCOMP12	1718	33.6	19.2	5.4	3.04	26.8	4.75	1.25	0.36	2.79	1.52	0.39	0.80	0.07	0.34	2.00	9.9	94	89	104	0.080	2.63
NE4COMP8	1721	35.5	17.5	5.5	2.12	23.0	4.63	1.12	0.42	2.15	1.34	0.41	0.64	0.07	0.23	0.91	11.5	92	92	92	0.069	2.50
NOS.090887	1721	35.2	17.3	6.8	2.82	26.8	5.16	0.87	0.31	1.81	1.28	0.41	0.77	0.05	0.32	1.10	8.8	88	91	95	0.089	2.56
CBFCOMP3	1726	30.6	15.8	6.6	3.26	29.0	6.75	0.73	0.22	1.93	0.96	0.41	0.63	0.21	0.54	1.27	9.0	89	92	86	0.135	2.73
CBFCOMP4	1732	30.3	16.1	6.4	3.26	29.2	6.47	0.62	0.20	1.85	0.98	0.40	0.62	0.15	0.44	1.40	11.6	89	91	94	0.153	2.72
UNI.091787	1733	42.5	16.3	20.8	1.89	1.8	0.56	0.12	1.99	0.27	0.97	0.03	0.05	3.40	15.61	0.73	20.5	80	105	64	0.019	2.32
OTTCOMP13	1734	30.8	17.7	5.8	3.59	26.2	4.48	0.90	0.27	3.22	1.47	0.40	0.80	0.03	0.29	2.62	10.5	81	91	91	0.101	2.65
NBCCOMP7	1741	34.1	15.8	5.7	2.48	26.5	5.62	0.90	0.30	1.73	0.98	0.41	0.69	0.05	0.28	1.09	14.4	95	92	87	0.103	2.56
NOSCOMP8	1741	35.0	17.7	6.1	2.56	25.4	4.88	1.01	0.36	1.62	1.32	0.42	0.66	0.07	0.26	1.17	9.9	104	91	94	0.078	2.63
CBFCOMP5	1743	29.7	16.4	6.7	3.42	28.9	6.52	0.60	0.21	1.78	1.01	0.39	0.62	0.04	0.23	1.38	10.8	96	91	93	0.133	2.75
NE4COMP9	1743	35.5	17.7	5.5	2.00	23.2	4.50	1.10	0.39	1.97	1.05	0.41	0.62	0.04	0.21	0.91	12.6	100	92	94	0.068	2.52
AME.100787	1746	36.6	16.5	6.1	4.94	19.7	4.67	1.14	0.83	2.15	1.11	0.25	0.54	0.02	0.24	1.68	17.6	78	94	67	0.071	2.51
OTTCOMP14	1753	33.7	19.3	5.6	1.86	23.7	4.28	1.66	0.43	2.03	1.08	0.49	0.73	0.04	0.21	1.50	10.9	97	89	94	0.044	2.58
NE4COMP10	1755	33.4	18.5	5.6	2.18	24.0	4.63	0.98	0.35	2.06	1.09	0.41	0.60	0.03	0.25	0.89	12.7	96	92	94	0.056	2.49
AME.101587	1756	33.7	17.8	4.8	3.57	21.3	4.71	1.15	0.81	2.18	1.12	0.25	0.52	0.00	0.29	1.74	19.6	81	94	78	0.103	2.55
LAN.102387	1757	30.6	16.7	6.7	4.01	29.0	6.14	0.75	0.22	2.14	1.08	0.41	0.63	0.01	0.23	1.59	8.6	100	92	90	0.100	2.79
OTTCOMP15	1762	33.8	19.4	5.7	1.90	24.9	4.58	1.55	0.44	2.08	1.10	0.47	0.78	0.03	0.22	1.50	10.2	112	89	90	0.045	2.60
NOS.102487	1763	33.0	19.8	5.3	1.75	25.1	4.34	1.01	0.41	1.71	1.06	0.38	0.60	0.04	0.25	1.30	13.6	104	91	105	0.060	2.63
NE4.103087	1767	34.6	18.2	5.5	2.11	24.5	4.40	1.17	0.37	2.67	1.08	0.42	0.64	0.03	0.18	1.60	12.4	100	92	93	0.068	2.58
CBFCOMP6	1769	29.3	16.4	7.0	3.48	29.4	6.66	0.61	0.24	1.63	0.90	0.40	0.63	0.03	0.22	1.30	11.3	90	91	89	0.129	2.73
NBCCOMP8	1783	31.5	16.8	6.3	3.26	29.1	6.16	0.80	0.27	1.79	0.98	0.42	0.70	0.03	0.23	1.30	15.1	90	92	84	0.114	2.69
OTTCOMP16	1783	34.6	19.5	5.8	1.79	23.7	4.35	1.59	0.46	1.98	1.08	0.49	0.74	0.03	0.22	1.50	10.7	94	91	99	0.050	2.59
AME.111787	1784	34.2	18.7	5.5	3.24	22.1	5.21	1.12	0.70	1.97	1.11	0.27	0.60	0.03	0.27	1.60	14.8	88	95	79	0.064	2.60
NE3.120187	1803	38.9	19.1	9.1	1.85	18.5	4.78	0.87	1.35	0.26	0.91	0.22	0.30	0.04	0.14	0.60	12.2	94	94	83	0.141	2.58
NOSCOMP9	1804	36.6	16.7	6.4	2.26	25.6	5.44	0.93	0.36	1.60	0.82	0.42	0.67	0.03	0.29	1.20	11.6	100	92	89	0.098	2.61
LAN.121387	1817	29.3	17.1	6.3	4.12	29.9	5.68	0.92	0.24	1.91	1.02	0.42	0.66	0.00	0.36	1.30	12.5	82	91	80	0.131	2.82
OTT.121587	1817	33.6	19.8	5.5	2.09	24.0	4.30	1.26	0.42	2.29	1.08	0.44	0.67	0.02	0.23	1.70	10.9	106	91	96	0.081	2.55
CBF.122287	1818	29.0	19.5	7.1	3.61	29.1	6.51	0.68	0.20	1.91	0.98	0.41	0.62	0.02	0.24	1.30	11.5	81	94	89	0.134	2.75
Samples	324	323	323	323	322	323	323	319	323	322	319	187	187	322	324	320	322	318	318	280	316	322
Min	0039	17.5	10.4	4.3	0.41	1.8	0.50	0.01	0.18	0.13	0.58	0.00	0.00	0.00	0.05	0.17	0.0	58	80	52	-0.042	2.02
Max	1818	59.3	24.4	37.2	14.60	32.4	13.90	7.30	2.97	6.92	1.36	0.56	0.97	3.40	15.61	3.42	80.4	125	108	108	0.175	3.23
Range	1779	41.8	14.0	32.9	14.19	30.6	13.40	7.29	2.79	6.79	0.98	0.56	0.97	3.40	15.56	3.25	80.4	69	25	54	0.217	1.21
Average	1123	35.0	17.5	6.5	2.80	24.0	4.94	1.12	0.55	1.65	1.10	0.37	0.60	0.09	0.63	1.29	12.2	93	91	86	0.069	2.62
St Deviation	0501	6.1	1.8	2.8	1.38	6.1	1.33	0.56	0.50	0.78	0.19	0.12	0.19	0.28	1.47	0.48	5.0	9	3	10	0.040	0.13

TABLE IV (APPENDIX C)
Type I Portland Cements used for pozzolanic activity, autoclave expansion testing

Year→ Oxide	1983 wt%	1984 wt%			1985 wt%		
		A	B	AVG.	A	B	AVG.
CaO	63.0	62.8	62.4	62.6	63.9	63.3	63.6
SiO_2	21.3	21.9	22.2	22.0	21.7	22.3	22.0
Al_2O_3	4.29	4.03	4.32	4.18	4.32	4.50	4.41
Fe_2O_3	3.01	2.97	1.62	2.29	1.64	1.70	1.67
SO_3	2.65	2.37	2.71	2.54	2.57	2.69	2.63
MgO	2.32	2.58	2.23	2.40	3.03	2.63	2.83
K_2O	0.57	0.42	0.57	0.50	0.48	0.59	0.54
Na_2O	0.16	0.26	0.36	0.31	0.28	0.26	0.27
TiO_2	0.22	0.24	0.23	0.24	0.23	0.24	0.24
Average compressive strength (psi)							
7-day	Not available			4700			4800
28-day	5500			6000			6100
Autoclave Expansion							
% expansion							

Year→ Oxide	1986 wt%				1987 wt%
	A	B	C	AVG.	
CaO	63.8	63.1	63.4	63.4	63.7
SiO_2	21.9	21.2	21.5	21.5	21.80
Al_2O_3	4.71	4.86	4.05	4.54	4.46
Fe_2O_3	2.34	2.33	3.15	2.61	2.38
SO_3	2.58	2.72	2.33	2.54	2.46
MgO	1.93	2.20	2.87	2.33	2.73
K_2O	0.84	1.05	0.34	0.74	0.70
Na_2O	0.08	0.06	0.22	0.12	0.20
TiO_2	0.24	0.25	0.23	0.24	0.24
Average compressive strength (psi)					
7-day	5110	5290	5100	5200	4900
28-day	5700	6040	6340	6000	5700
Autoclave Expansion					
% expansion					0.04

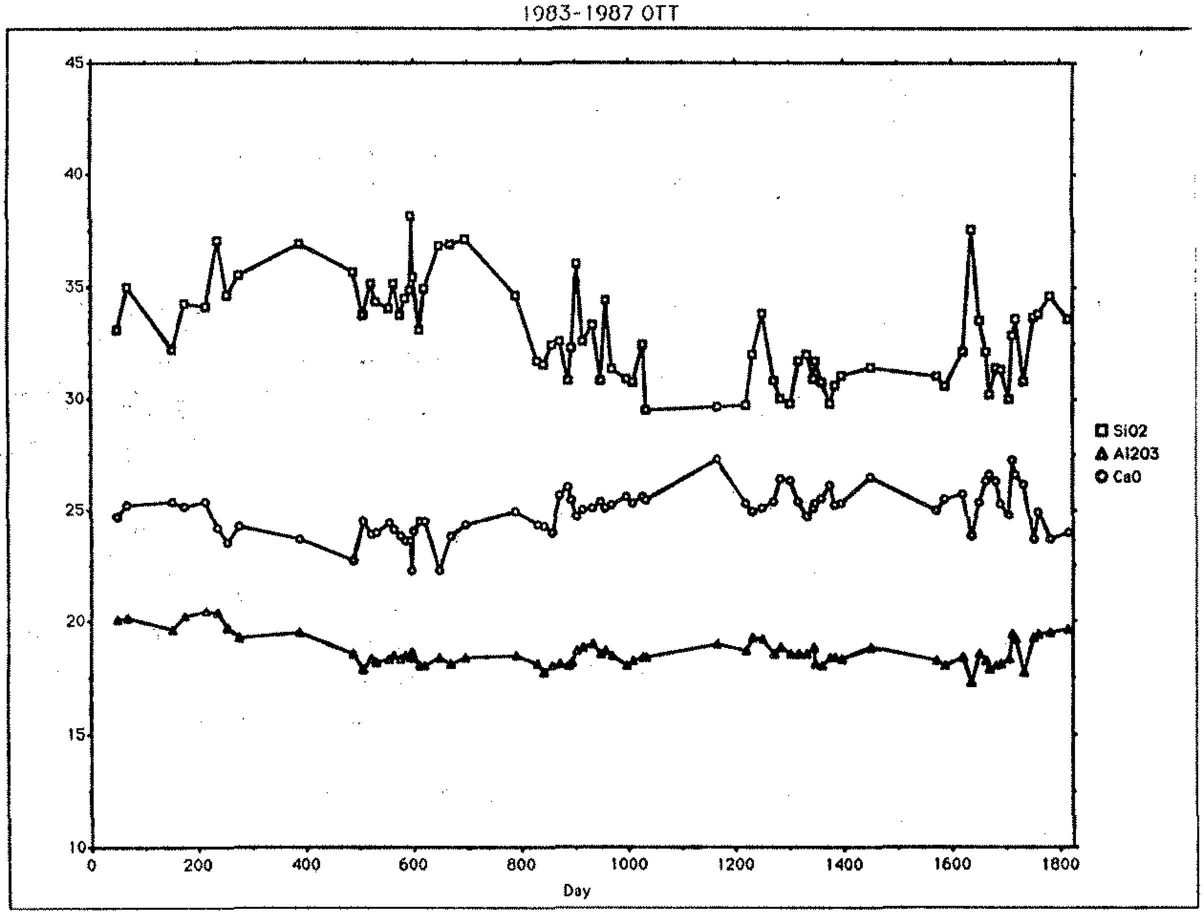


Figure 1, Appendix C

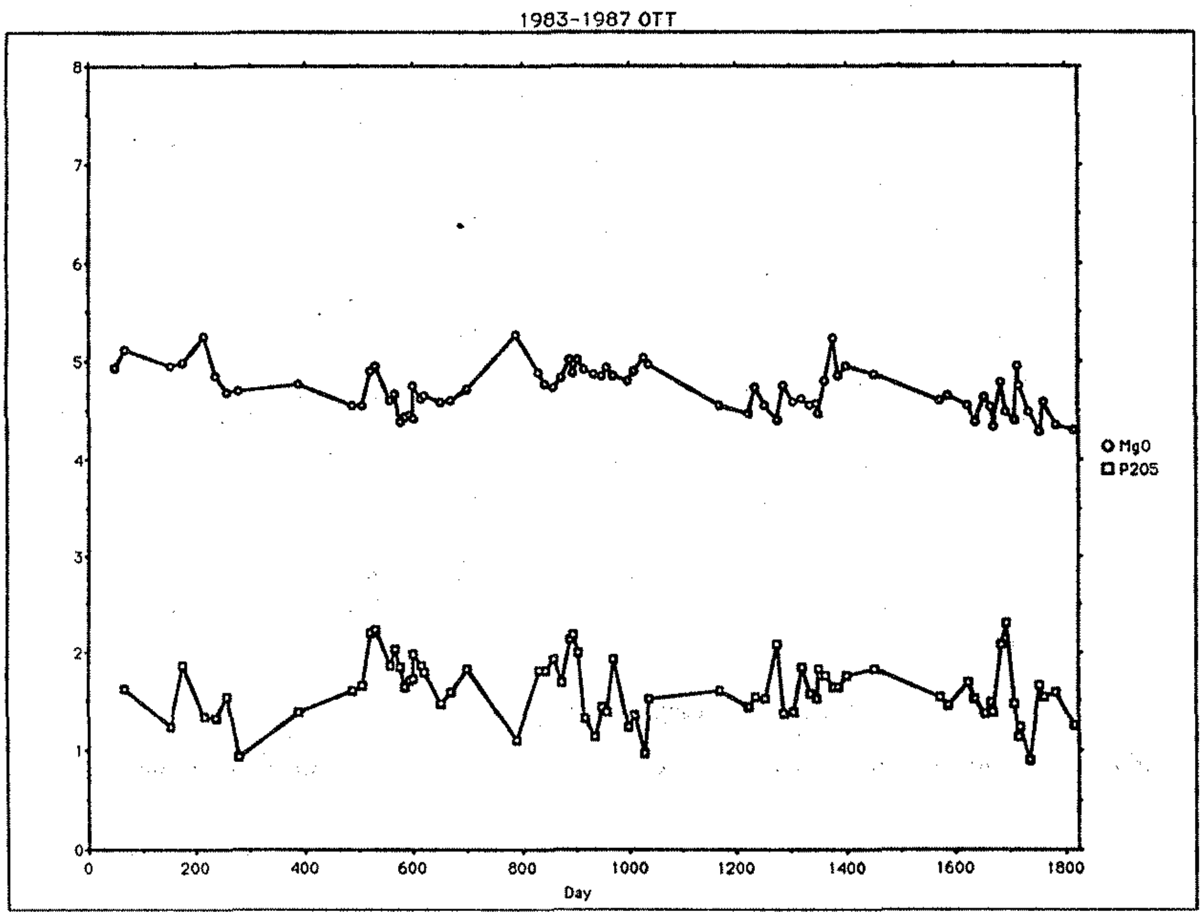


Figure 2, Appendix C

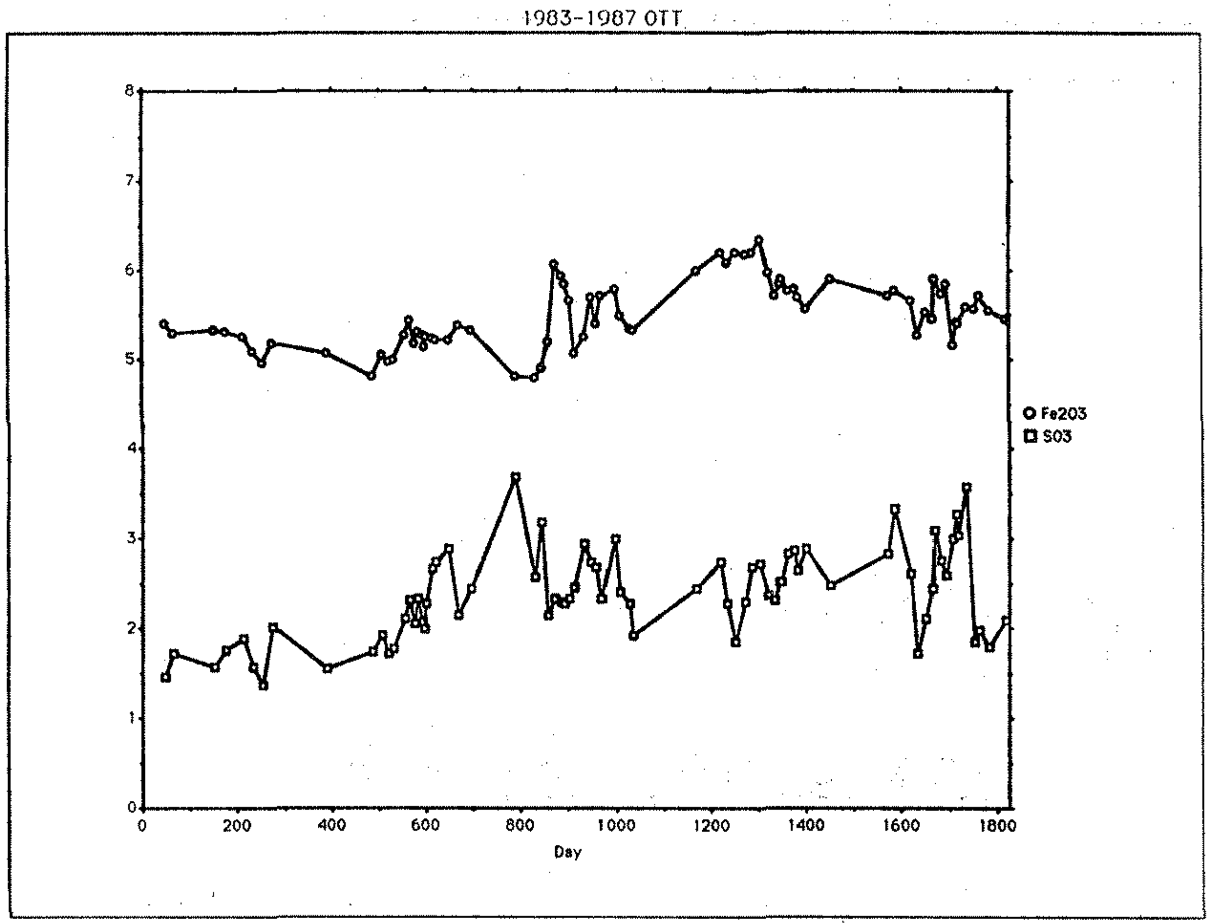


Figure 3, Appendix C

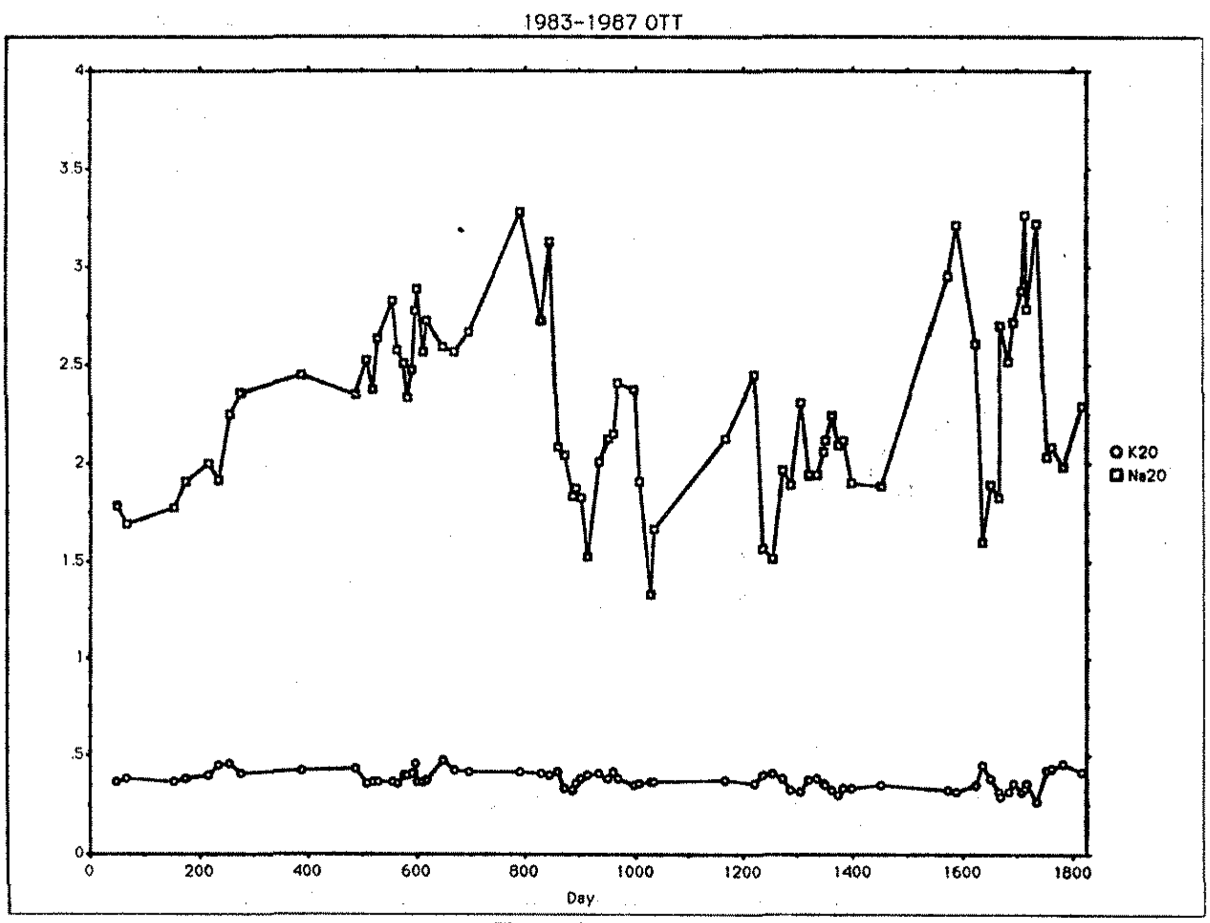


Figure 4, Appendix C

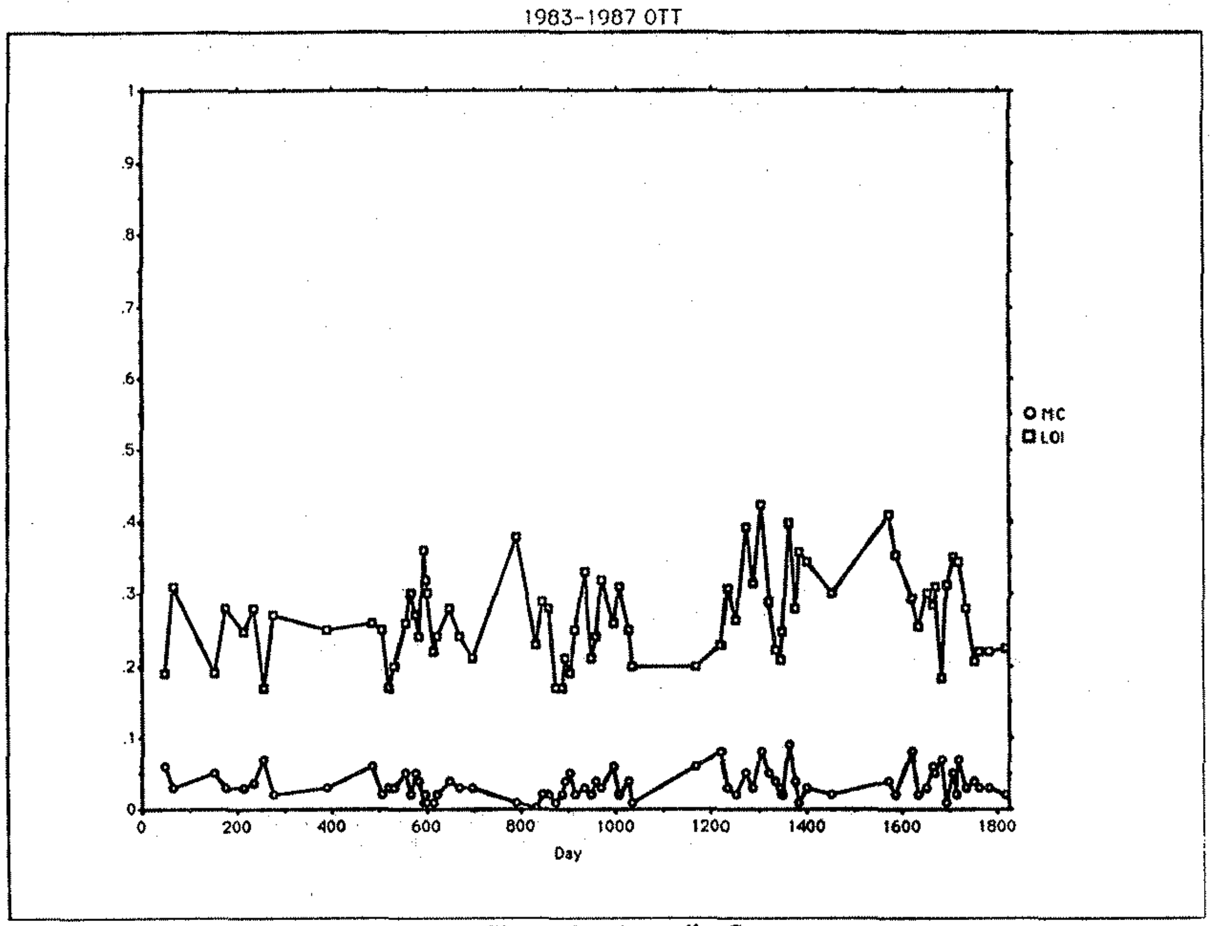


Figure 5, Appendix C

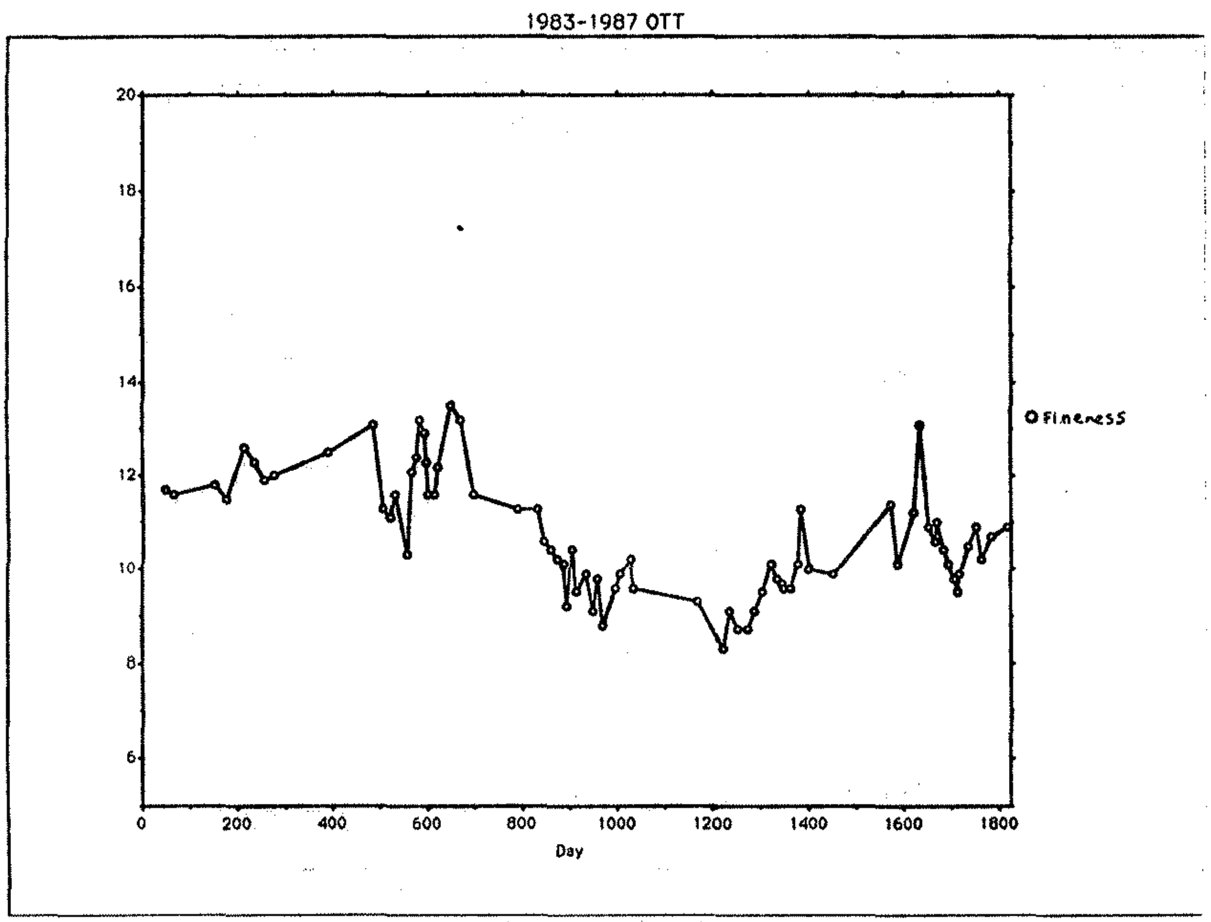
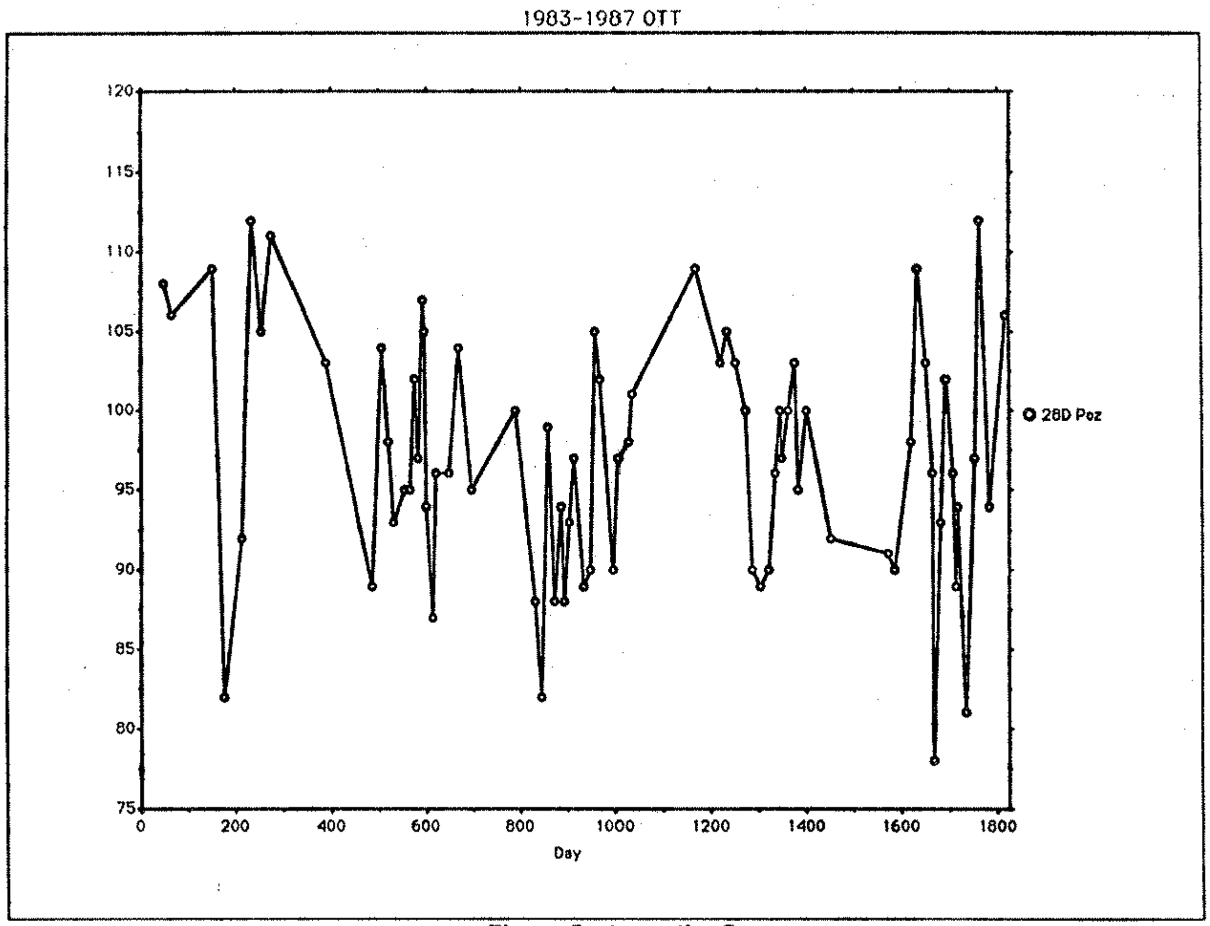


Figure 6, Appendix C



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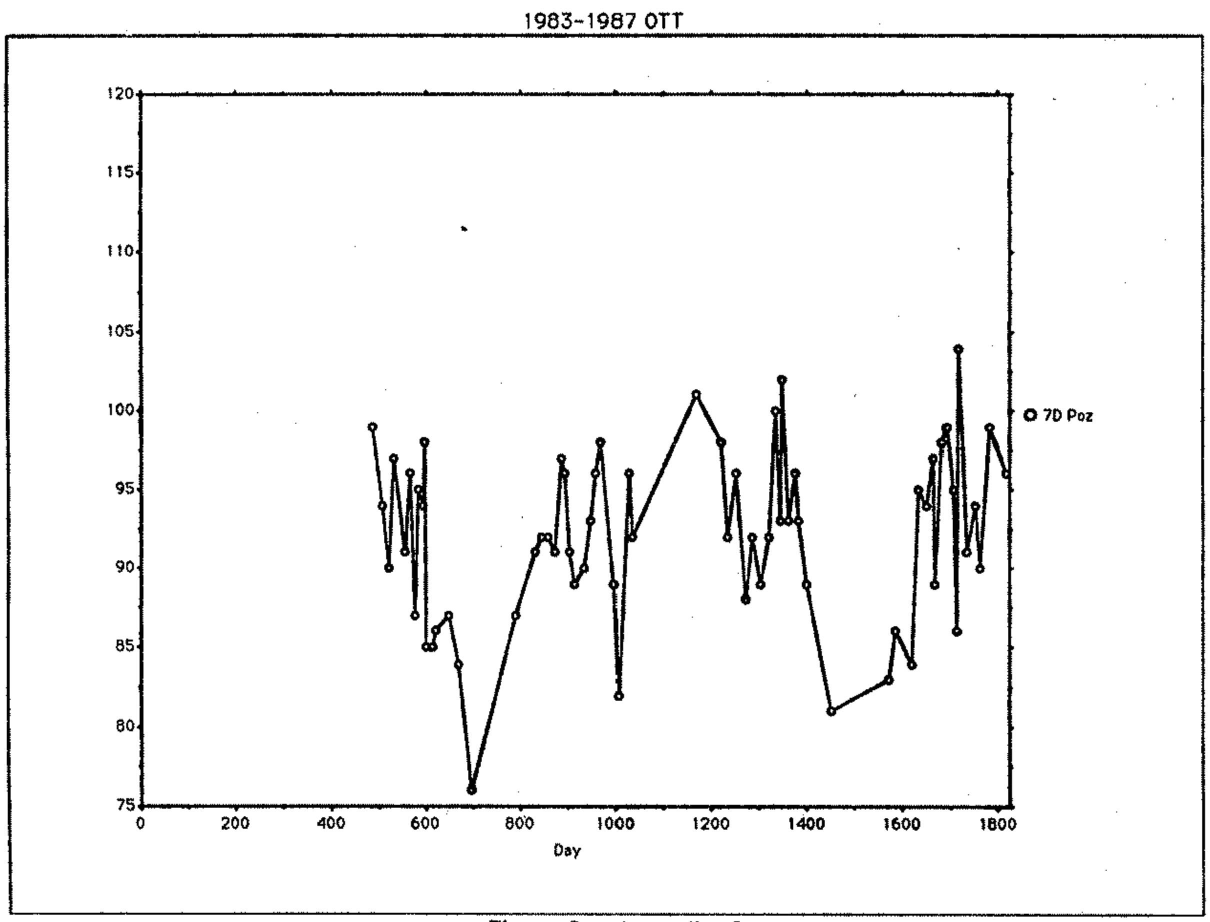


Figure 8, Appendix C

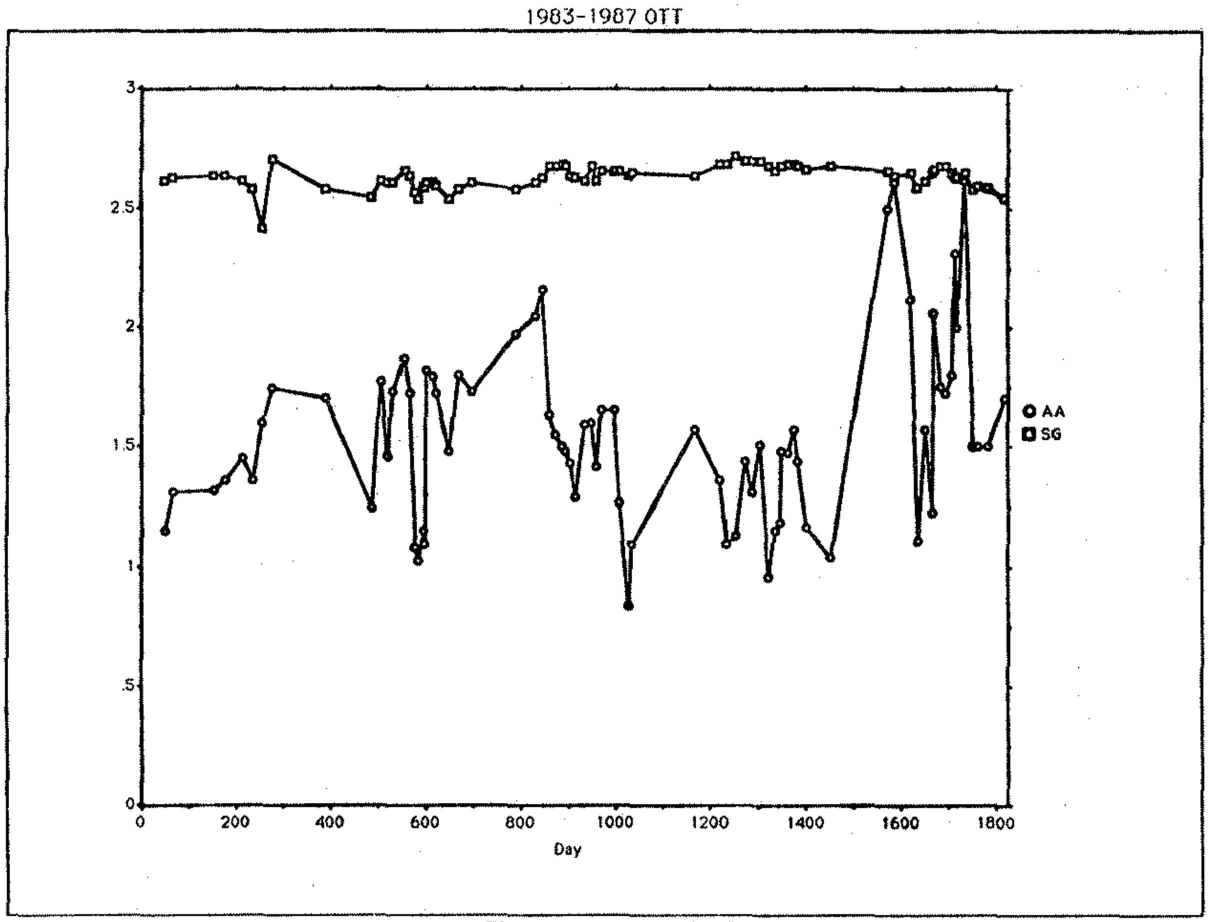


Figure 9, Appendix C

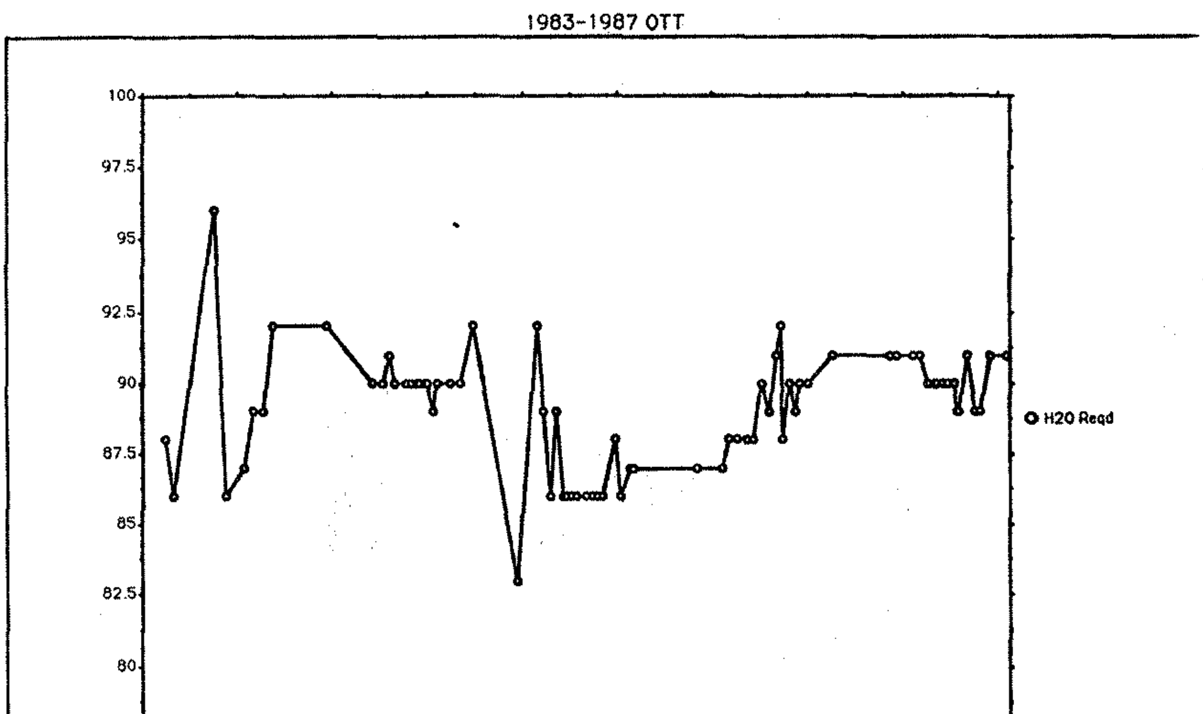


Figure 10, Appendix C

1983-1987 OTT

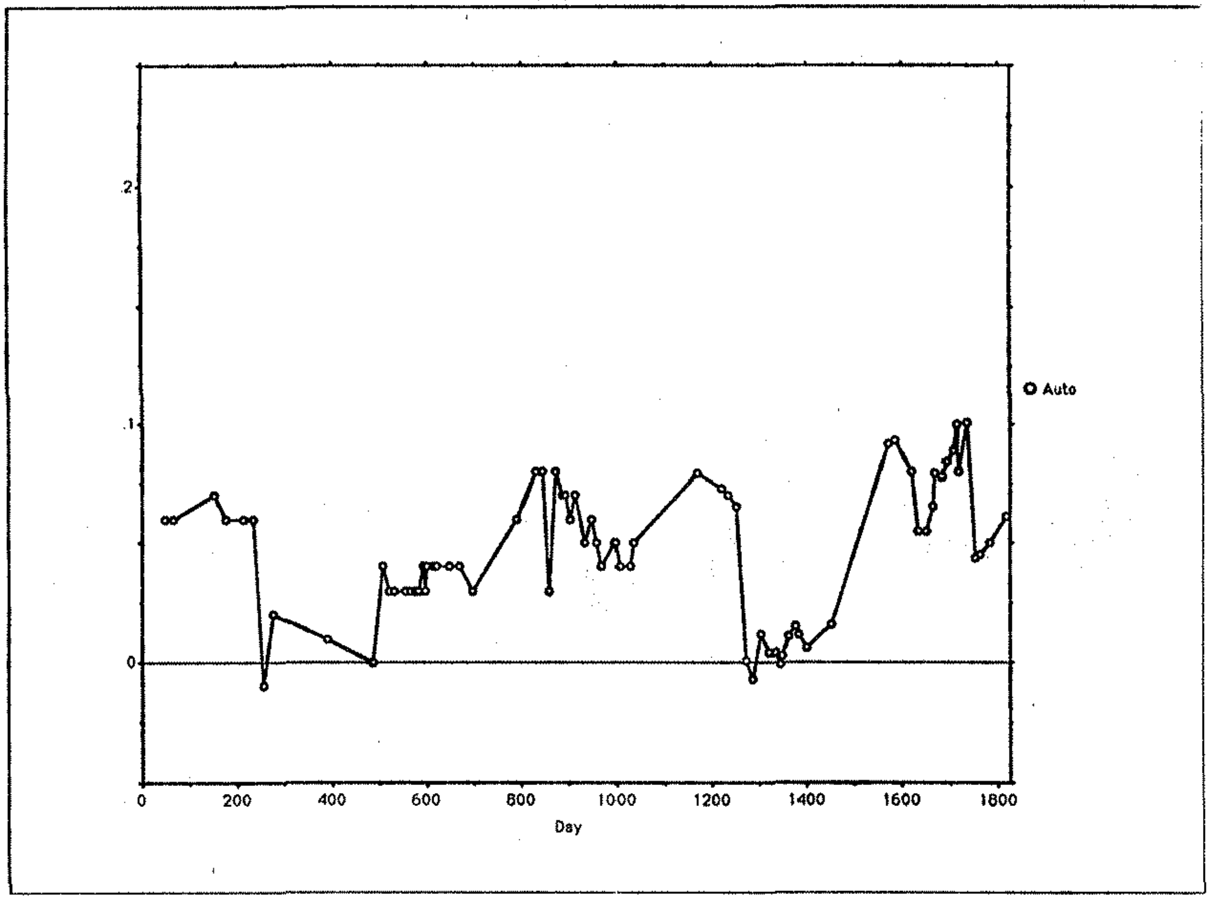


Figure 11, Appendix C

OTT Routine Tests

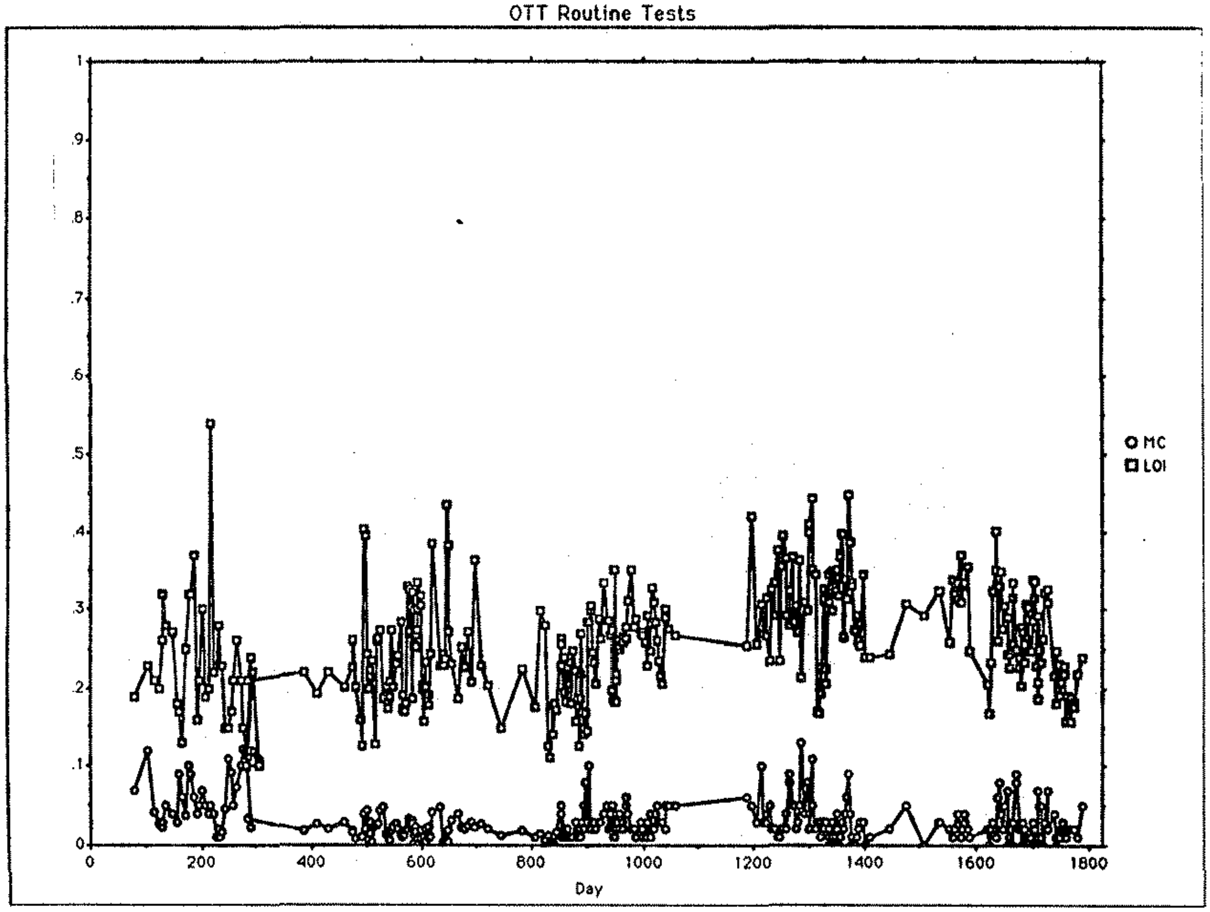


Figure 12, Appendix C

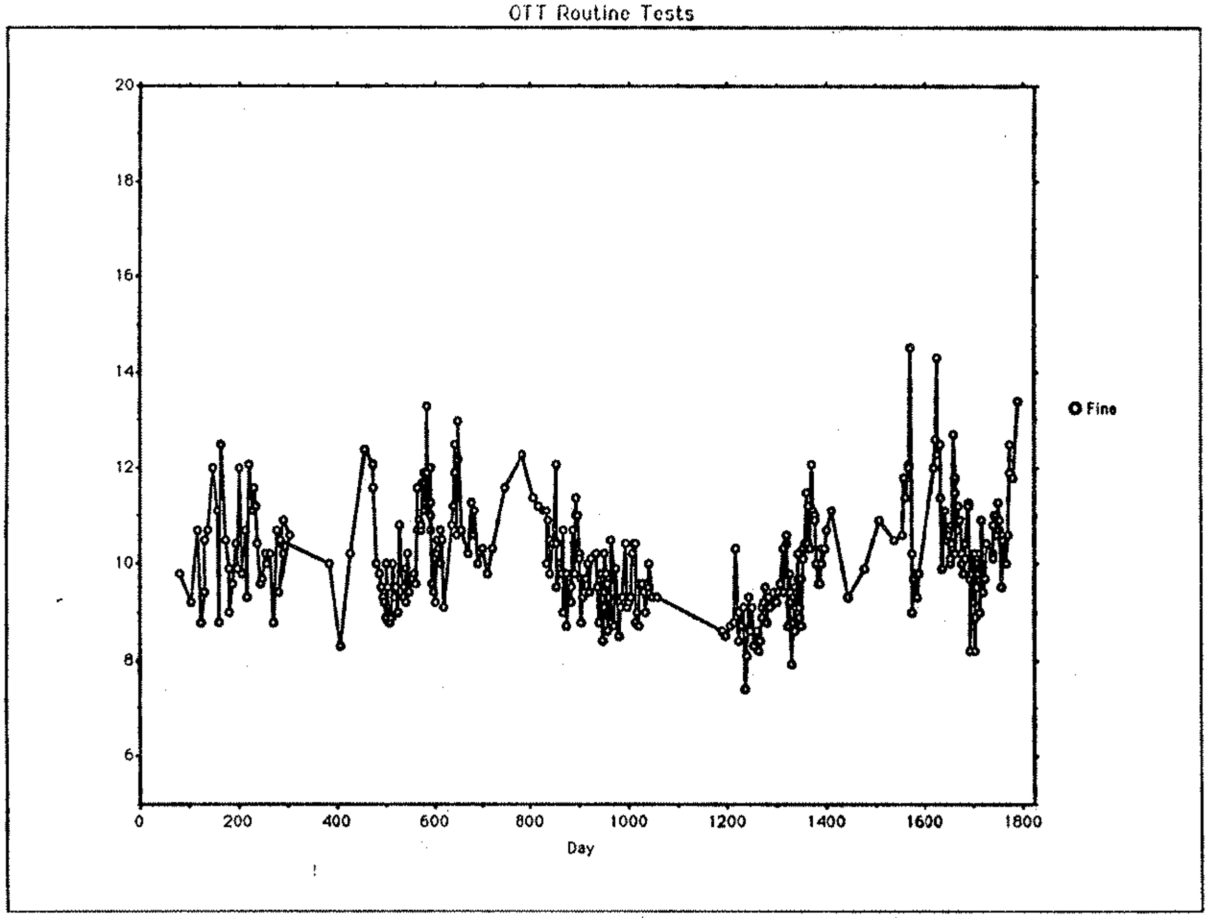


Figure 13, Appendix C

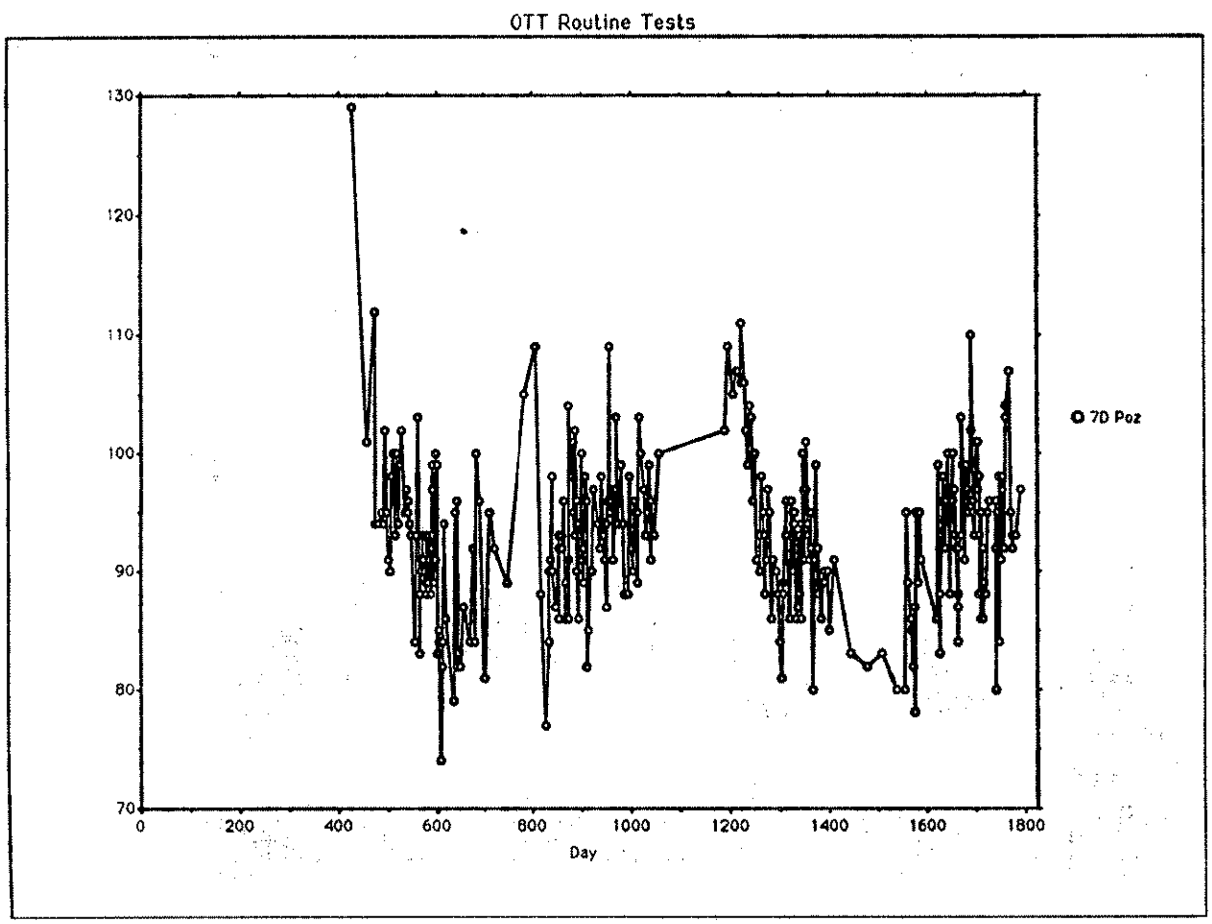


Figure 14, Appendix C

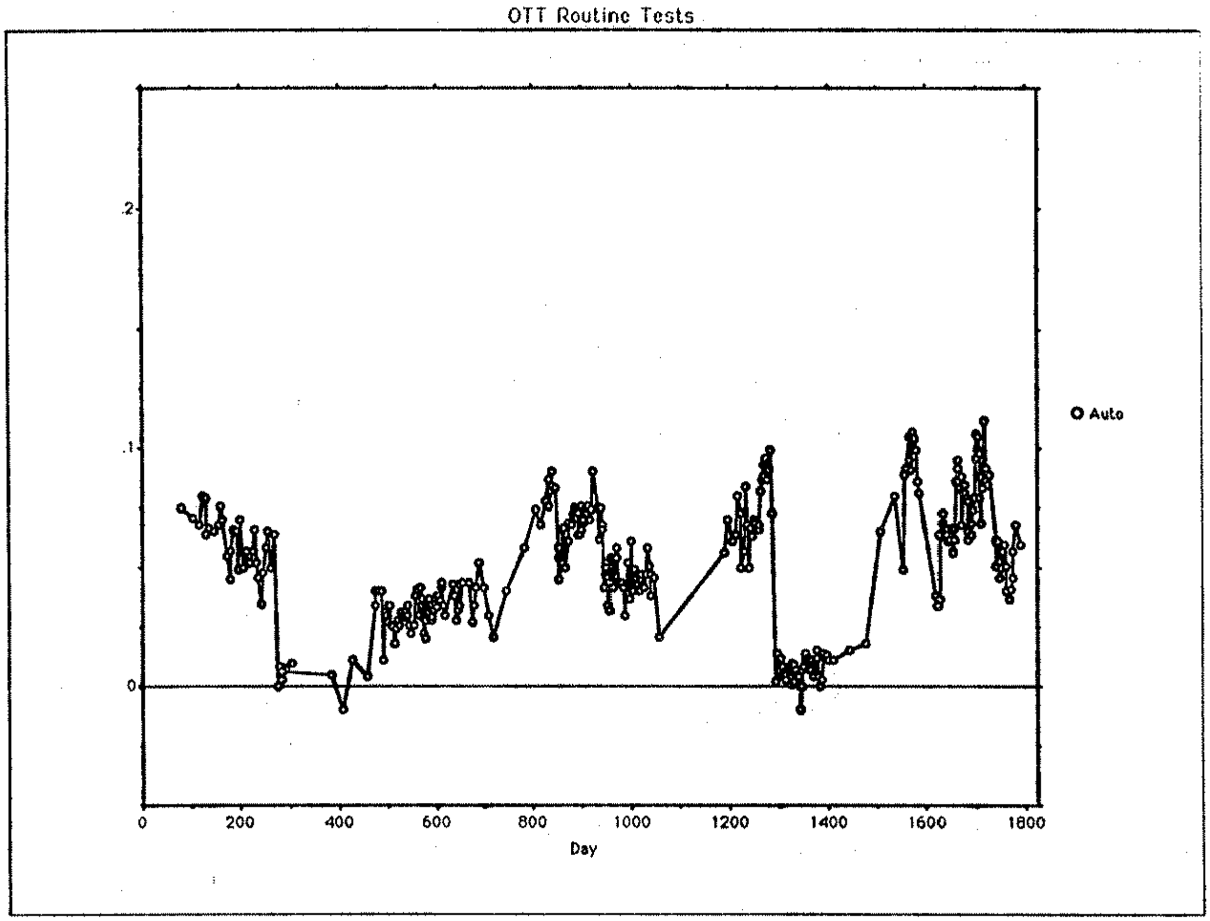


Figure 15, Appendix C

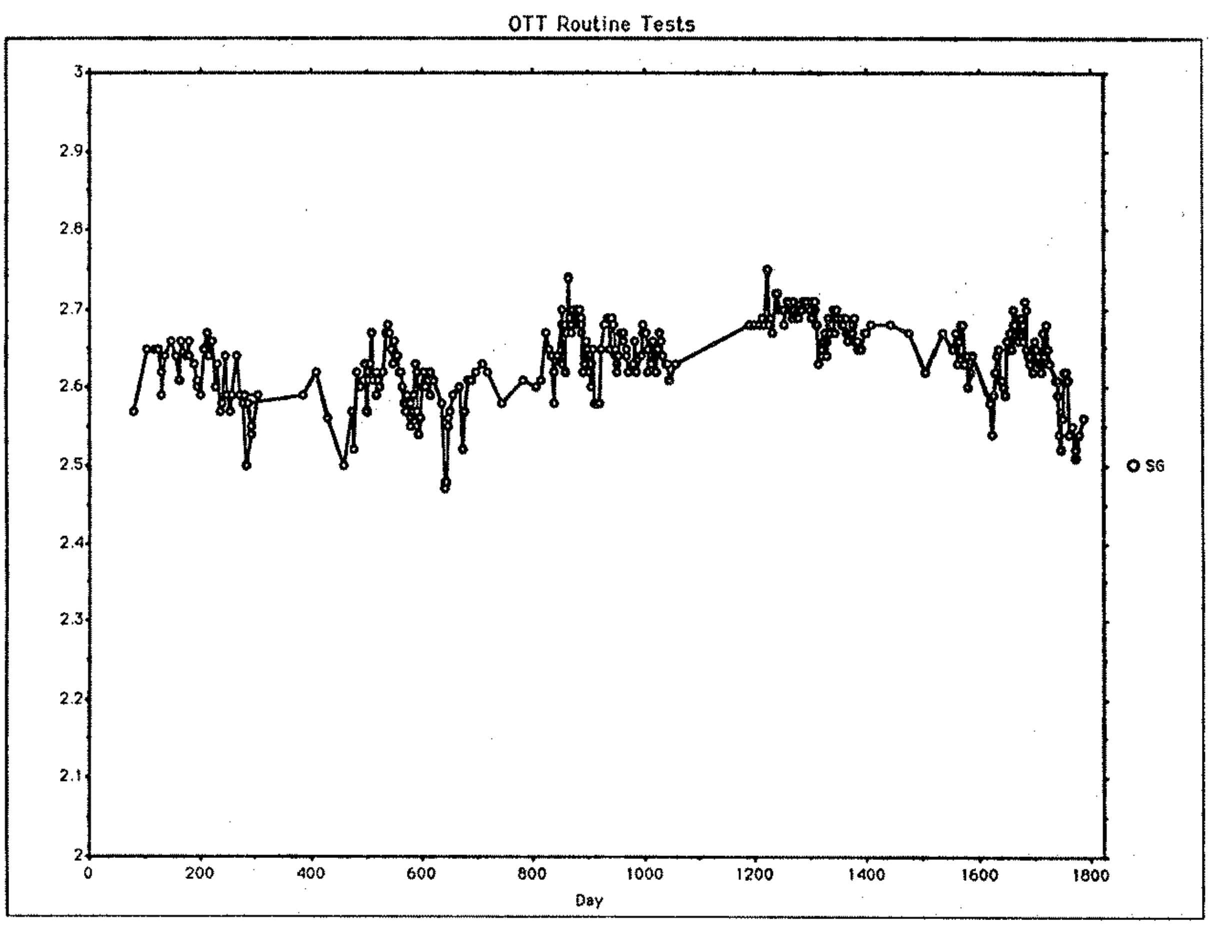


Figure 16, Appendix C

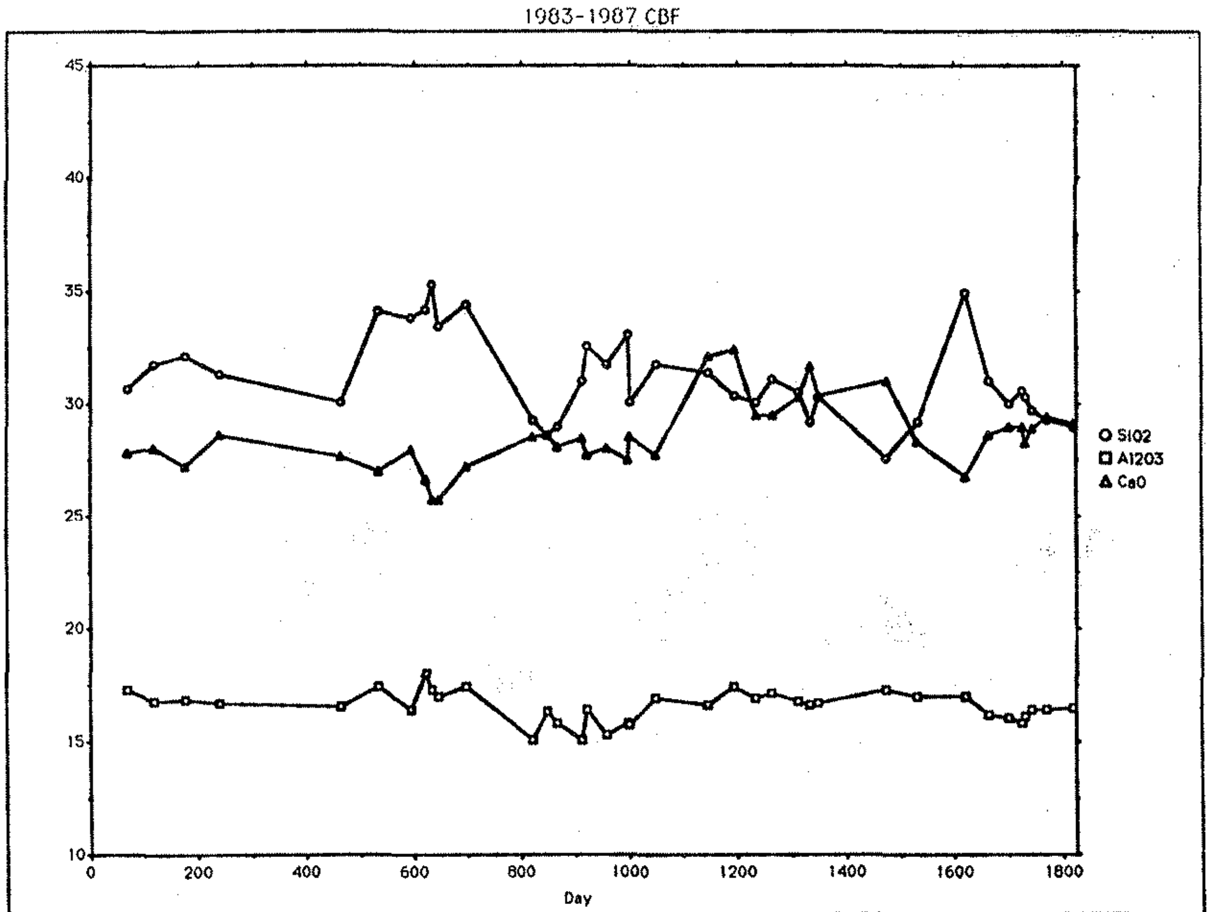


Figure 17, Appendix C

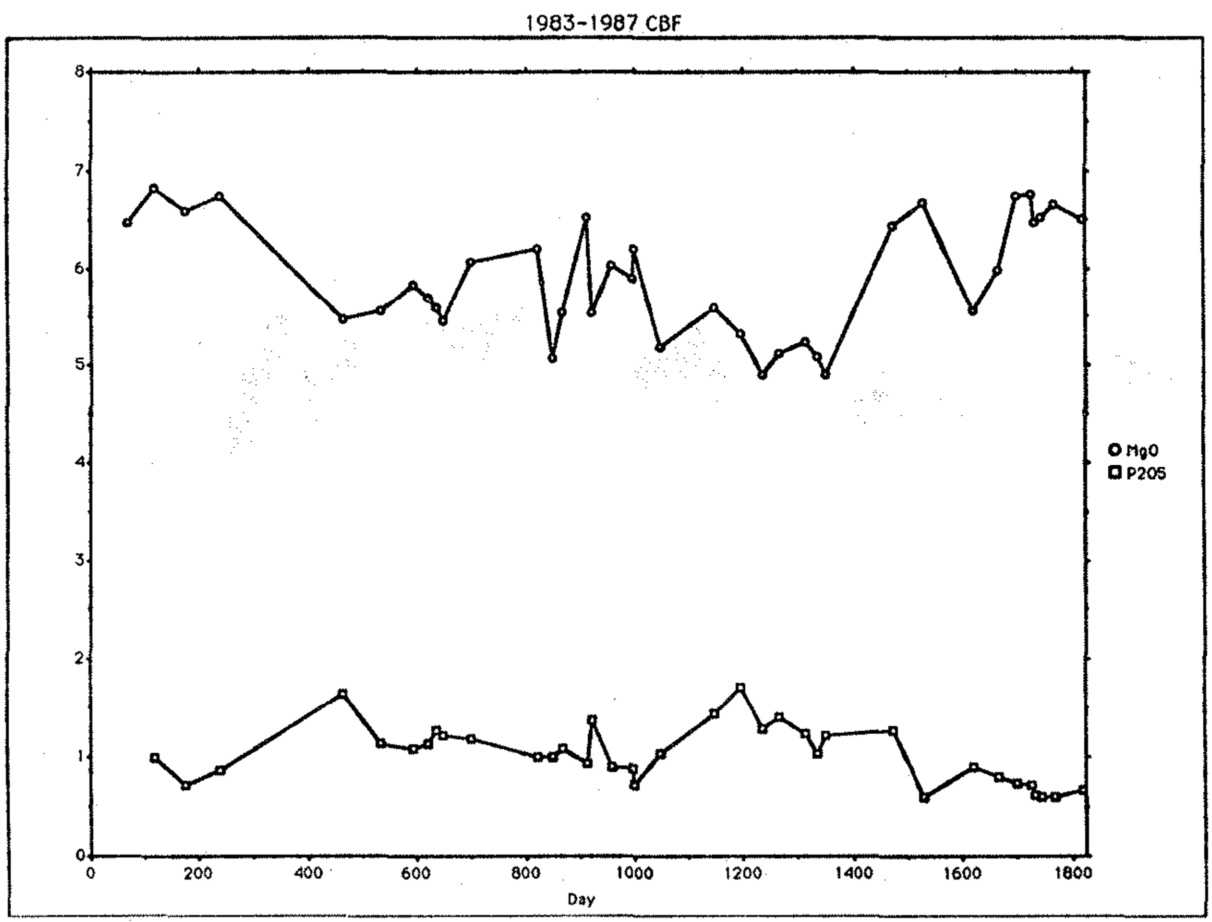


Figure 18, Appendix C

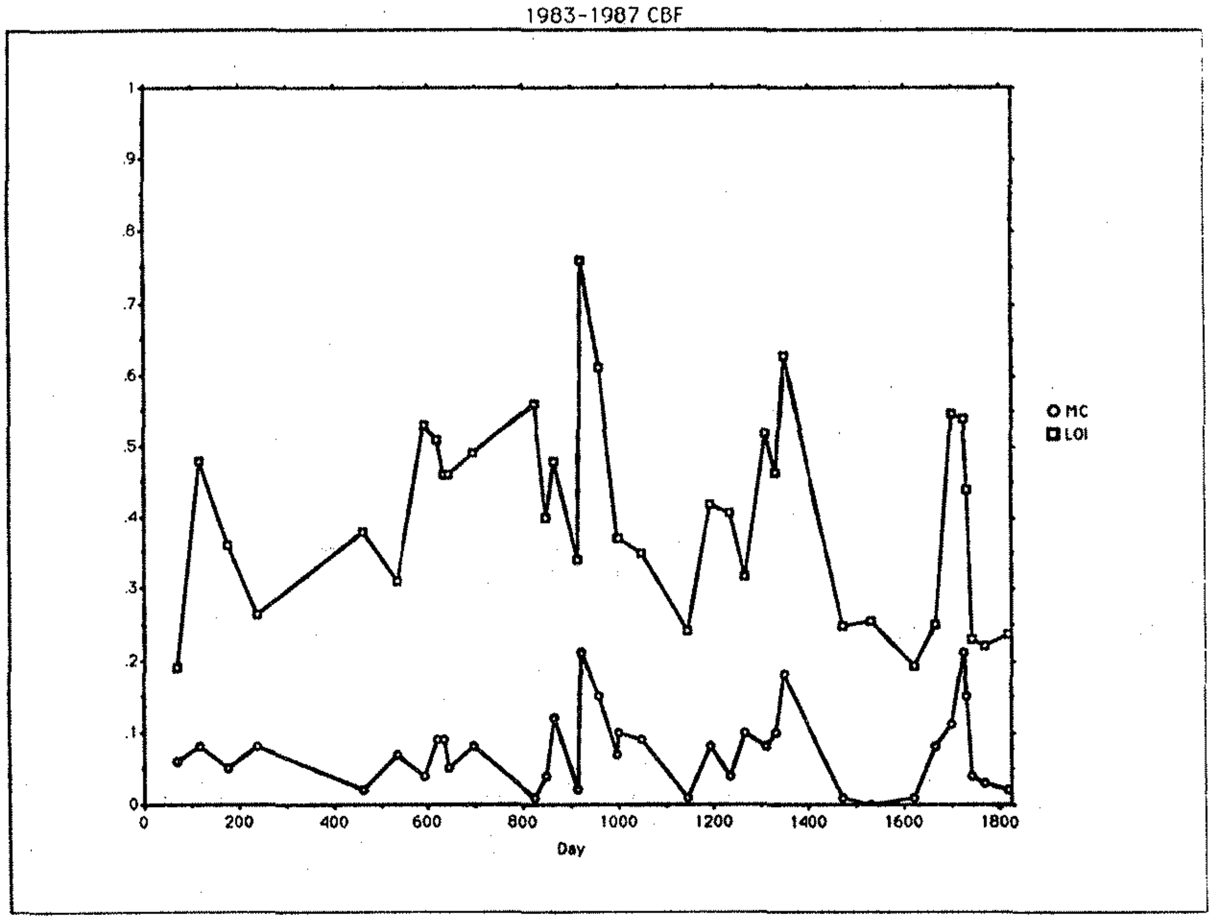


Figure 19, Appendix C

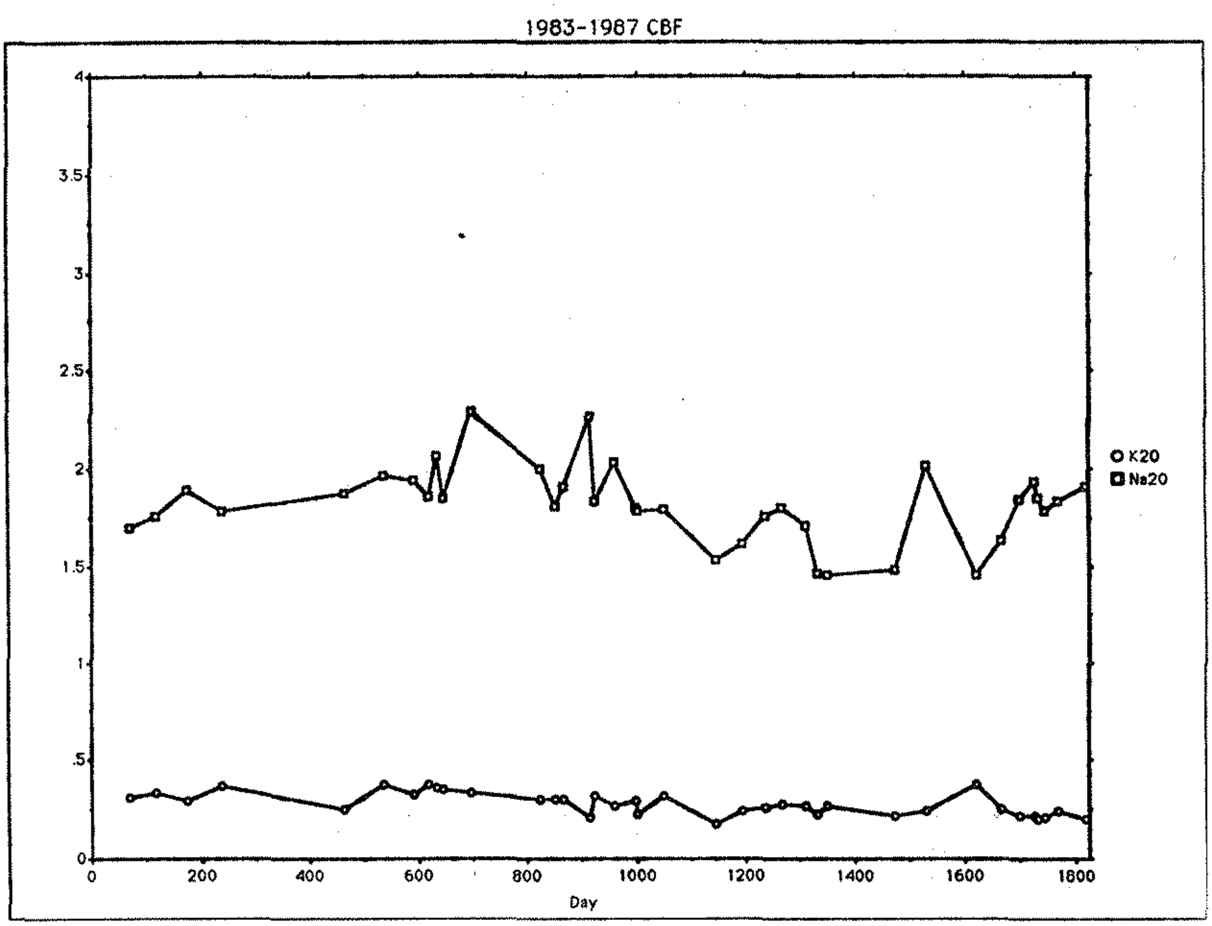


Figure 20, Appendix C

1983-1987 CBF

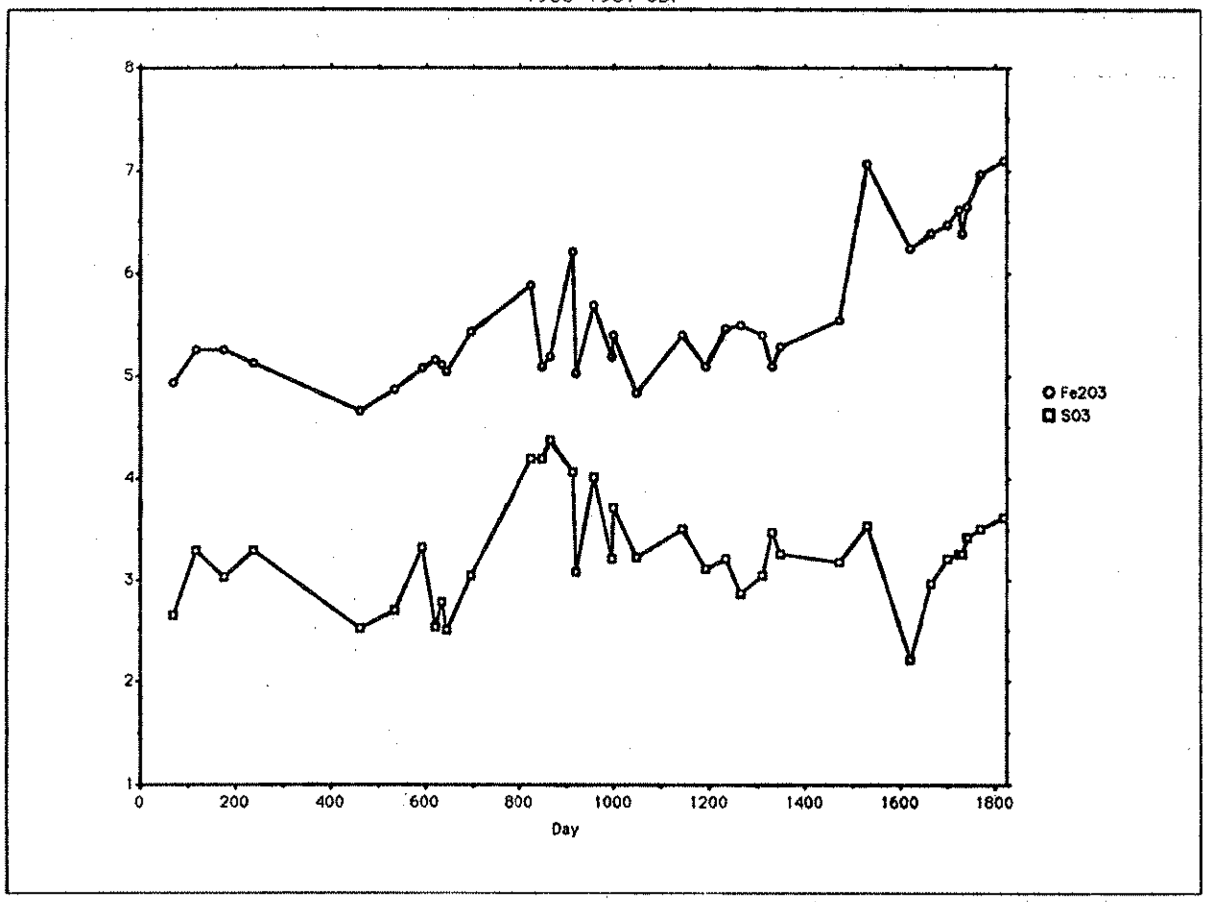


Figure 21, Appendix C

1983-1987 CBF

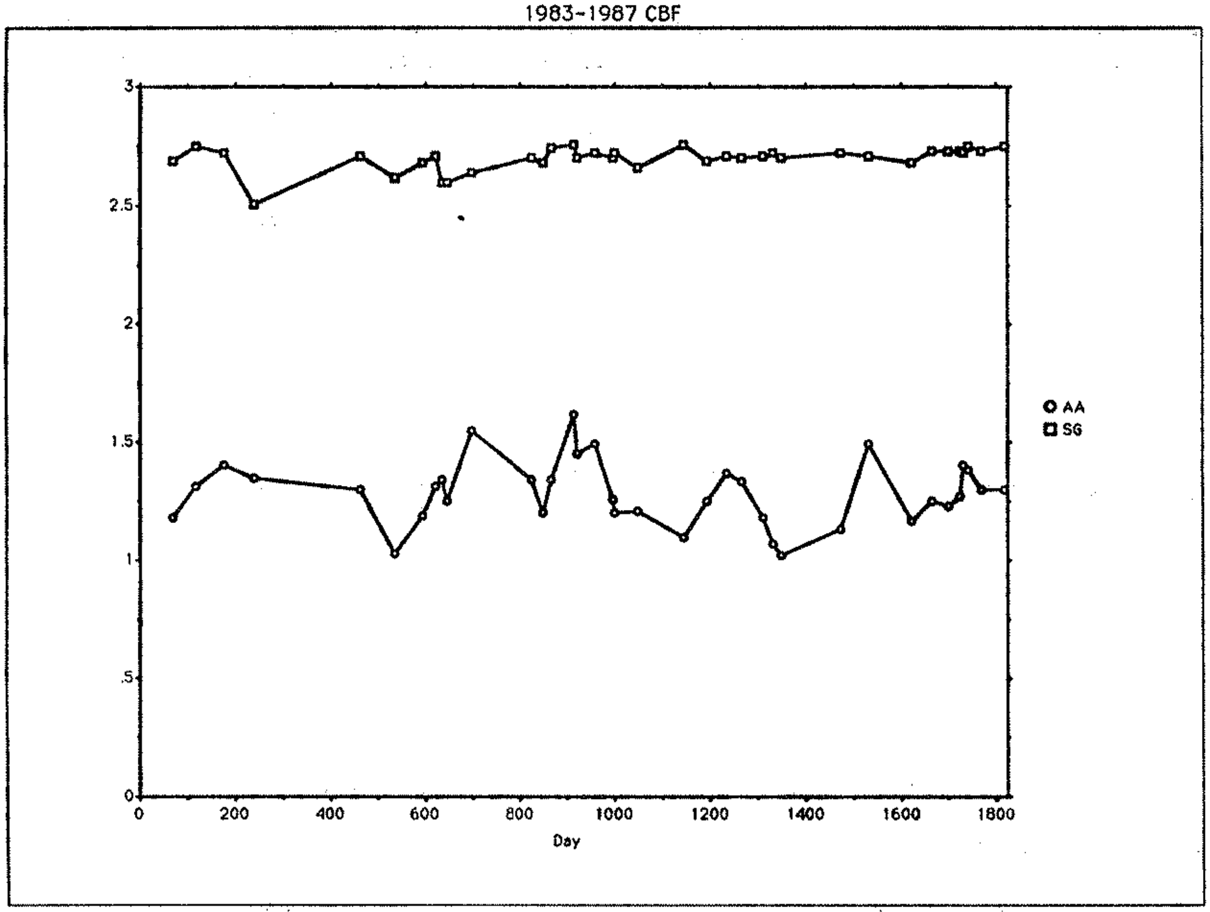


Figure 22, Appendix C

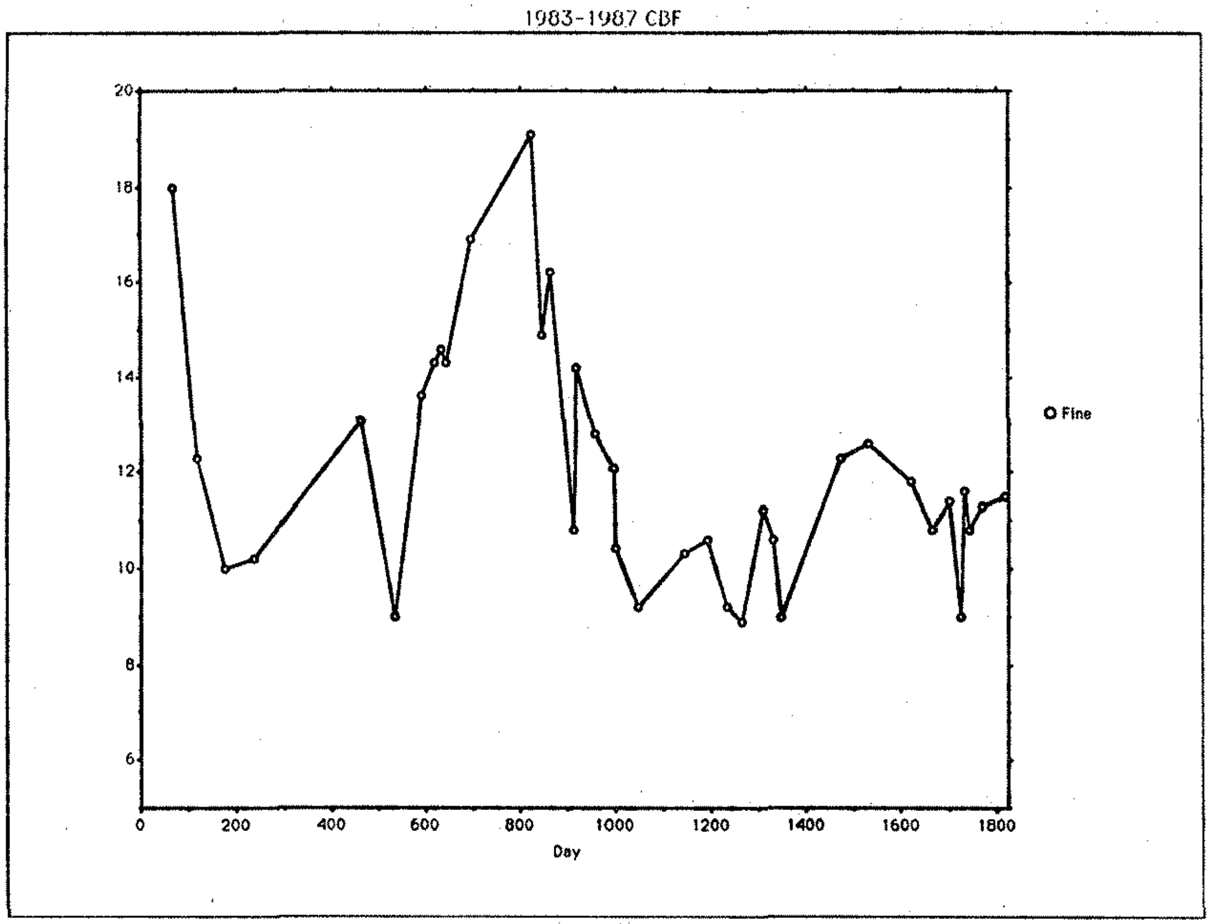


Figure 23, Appendix C

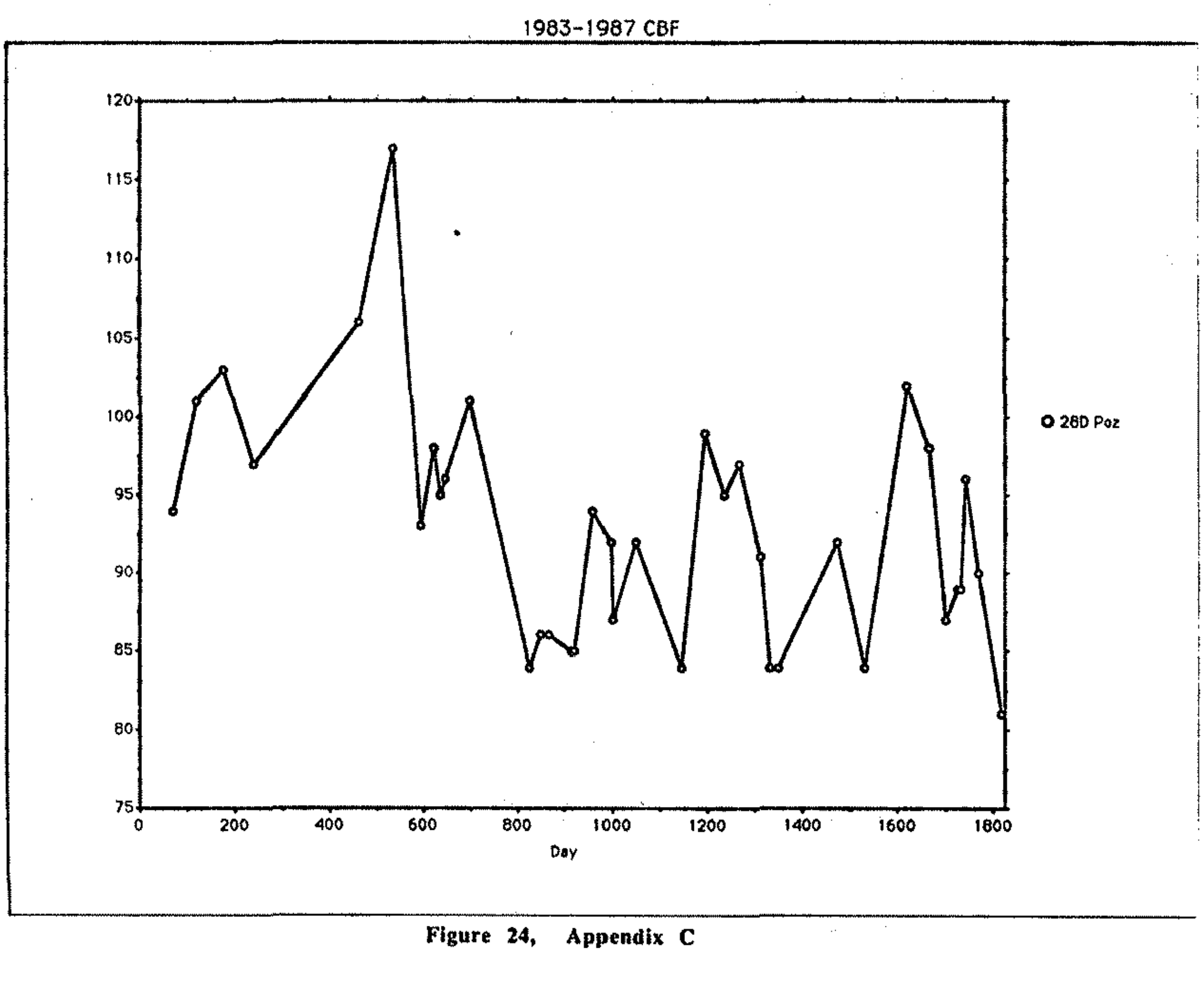


Figure 24, Appendix C

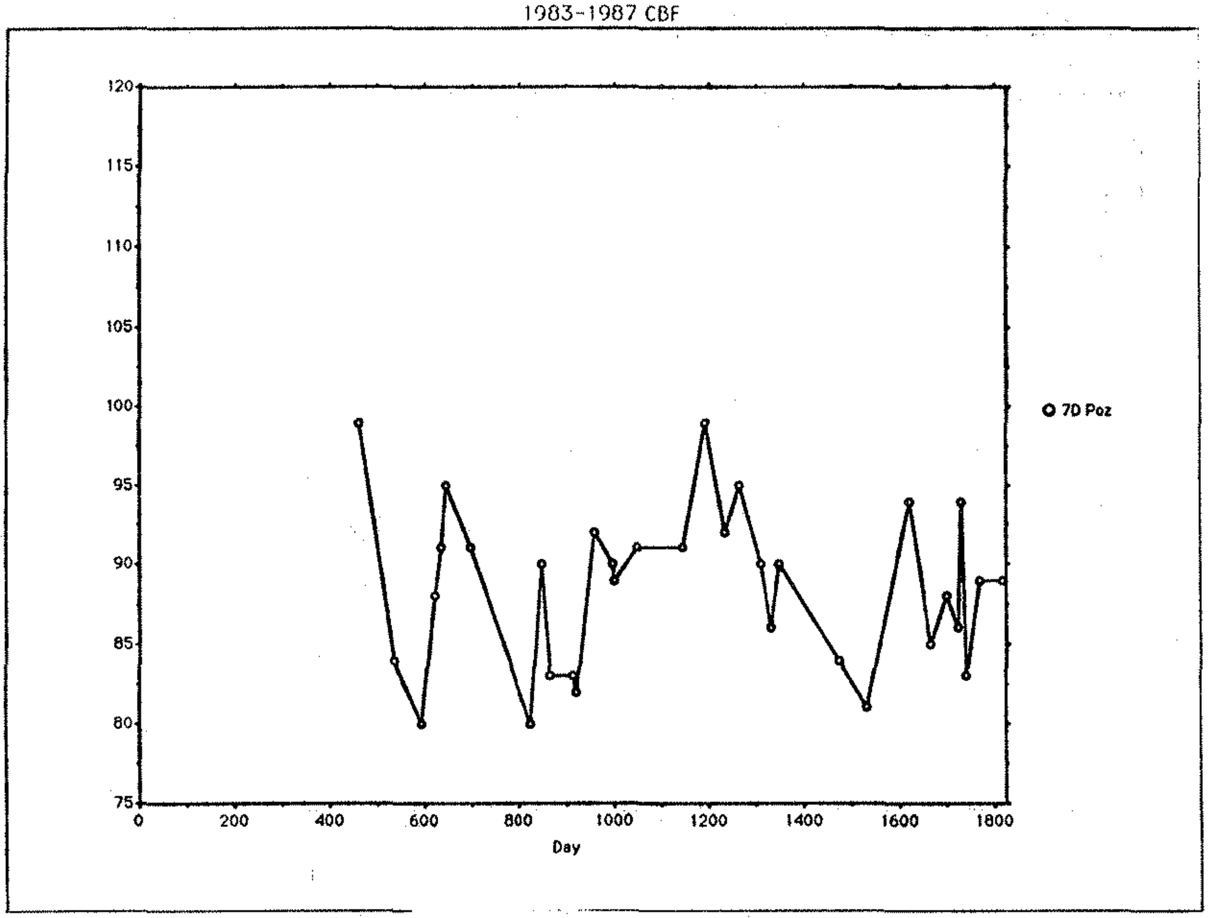


Figure 25, Appendix C

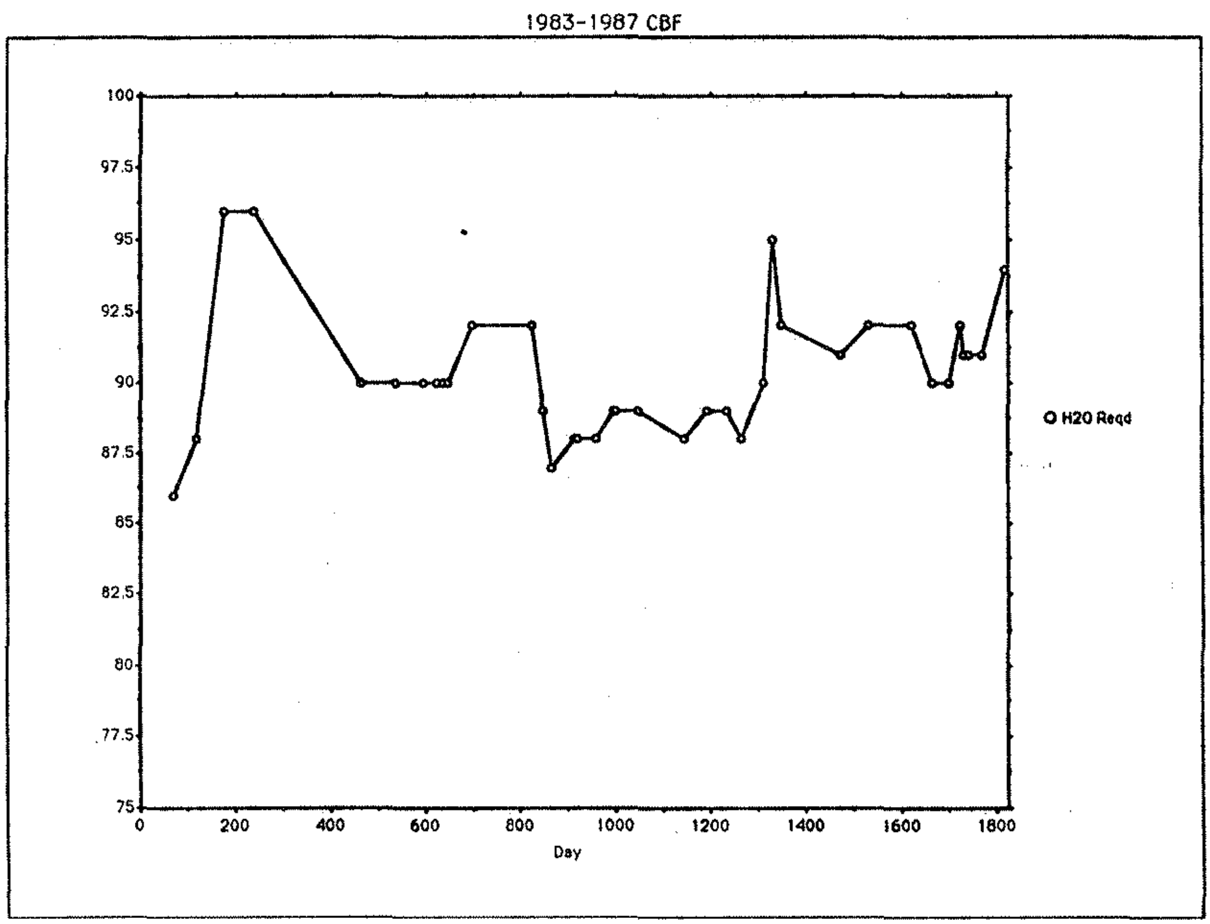


Figure 26, Appendix C

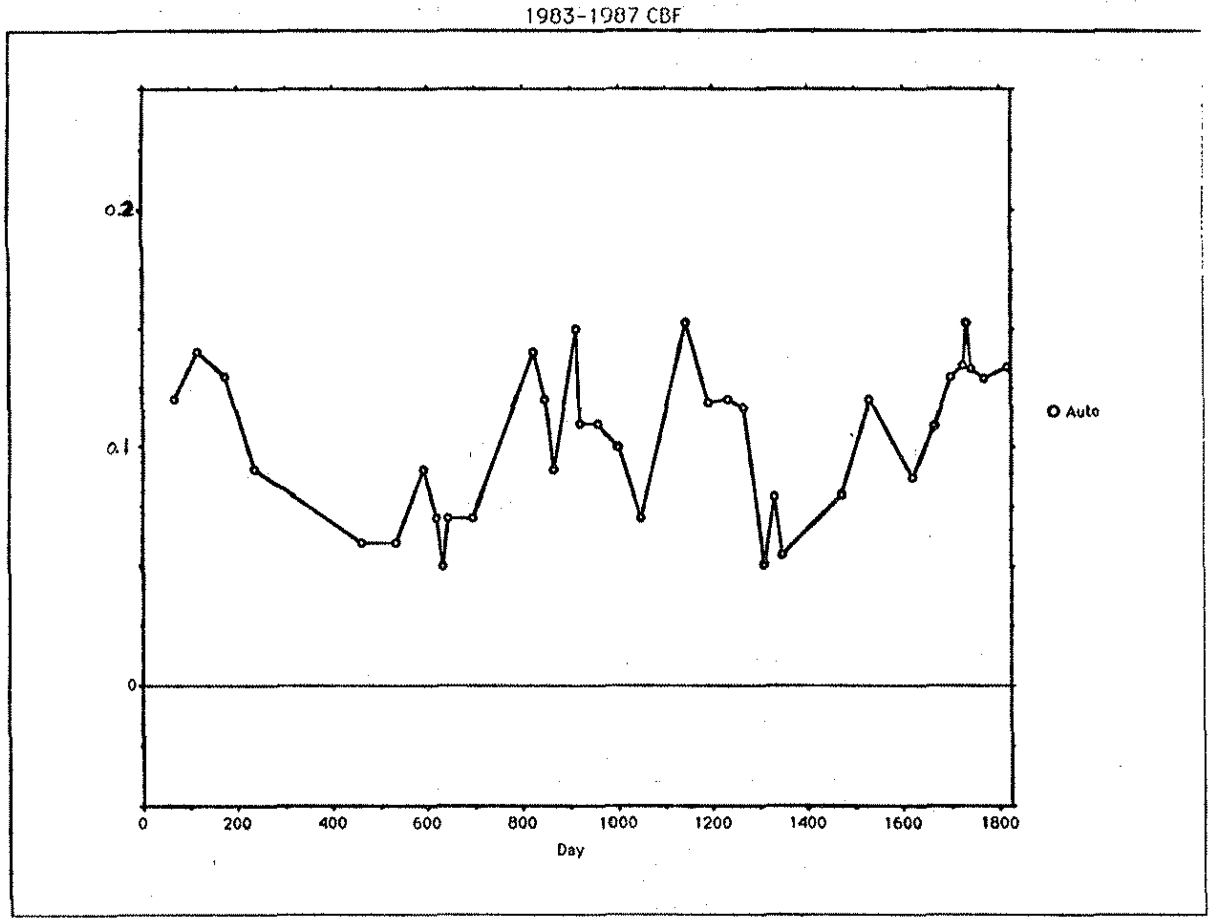


Figure 27, Appendix C

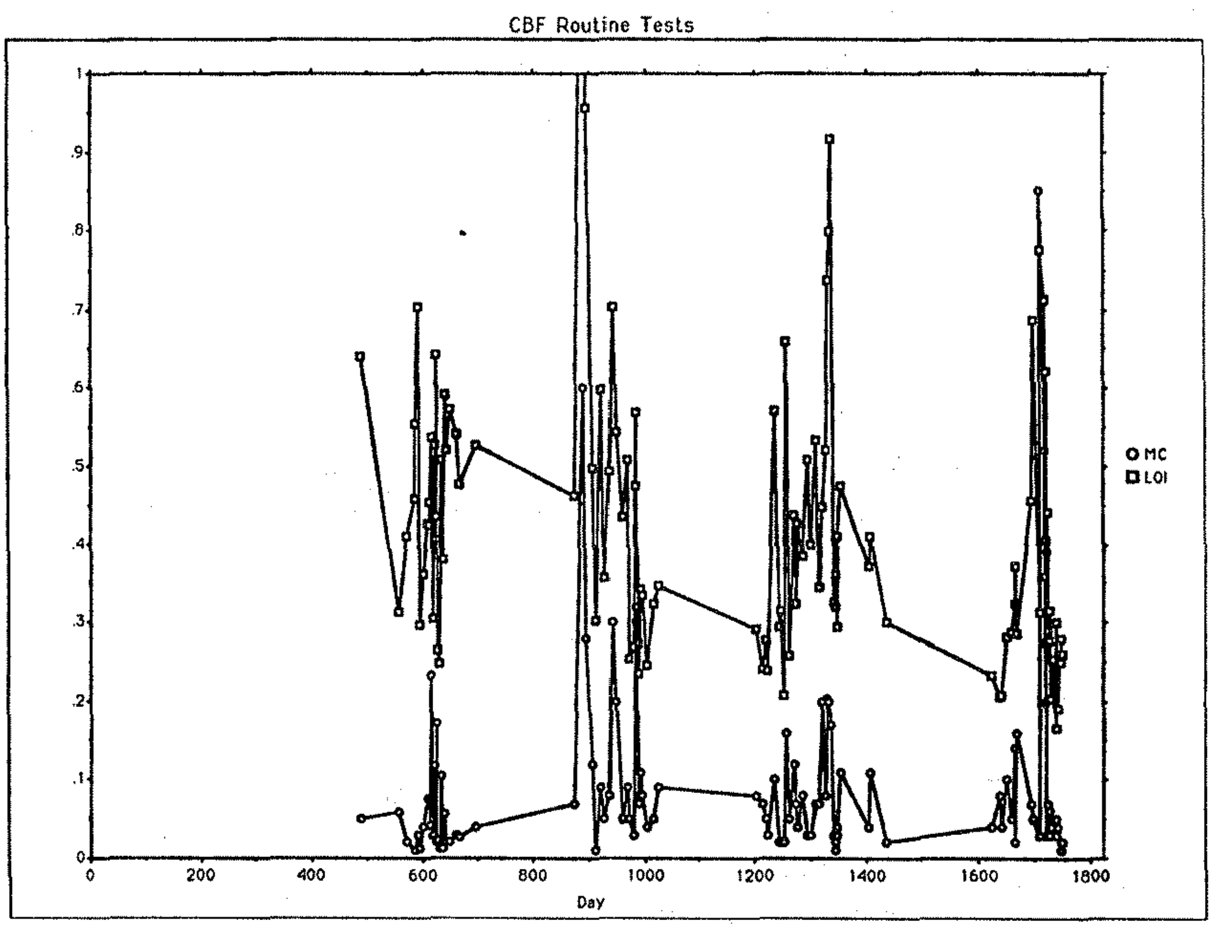


Figure 28, Appendix C

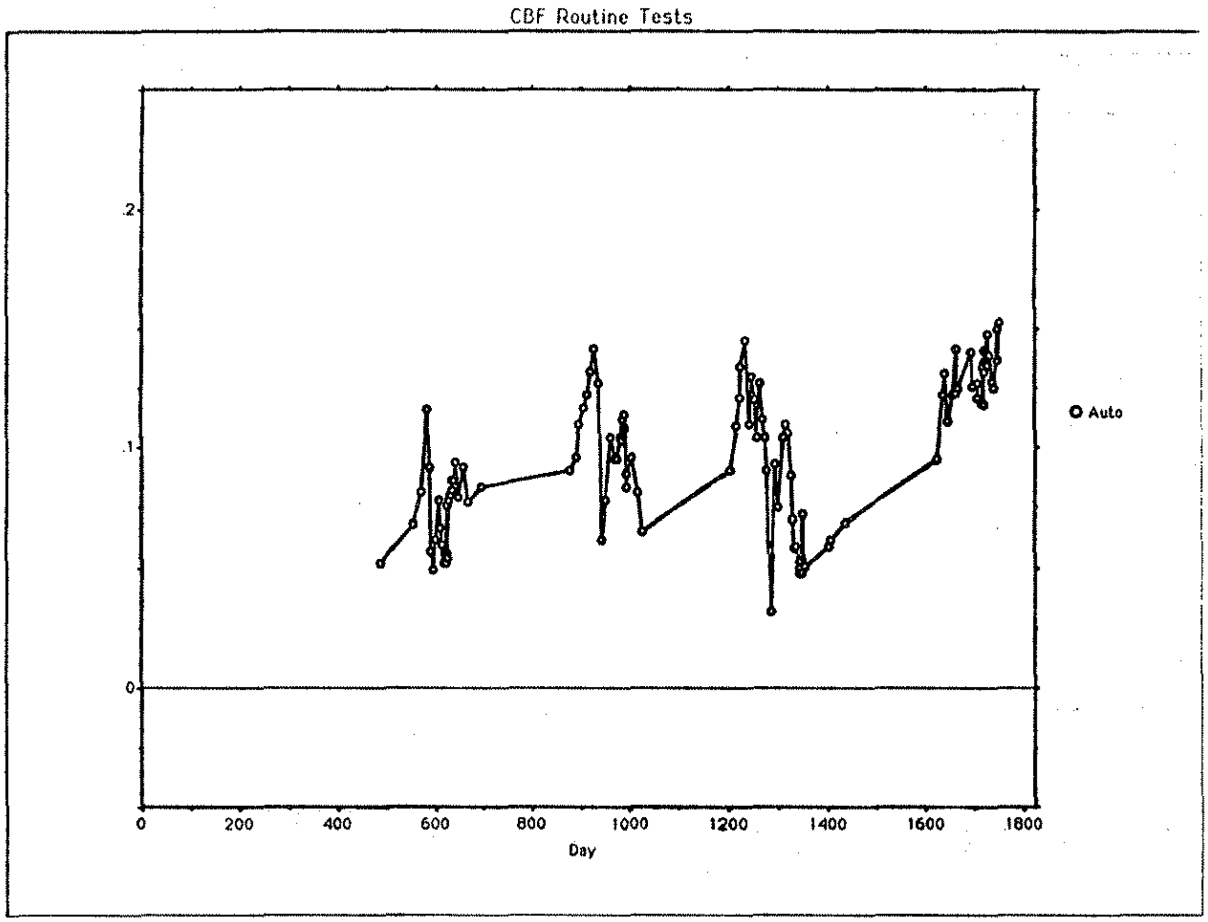


Figure 29, Appendix C

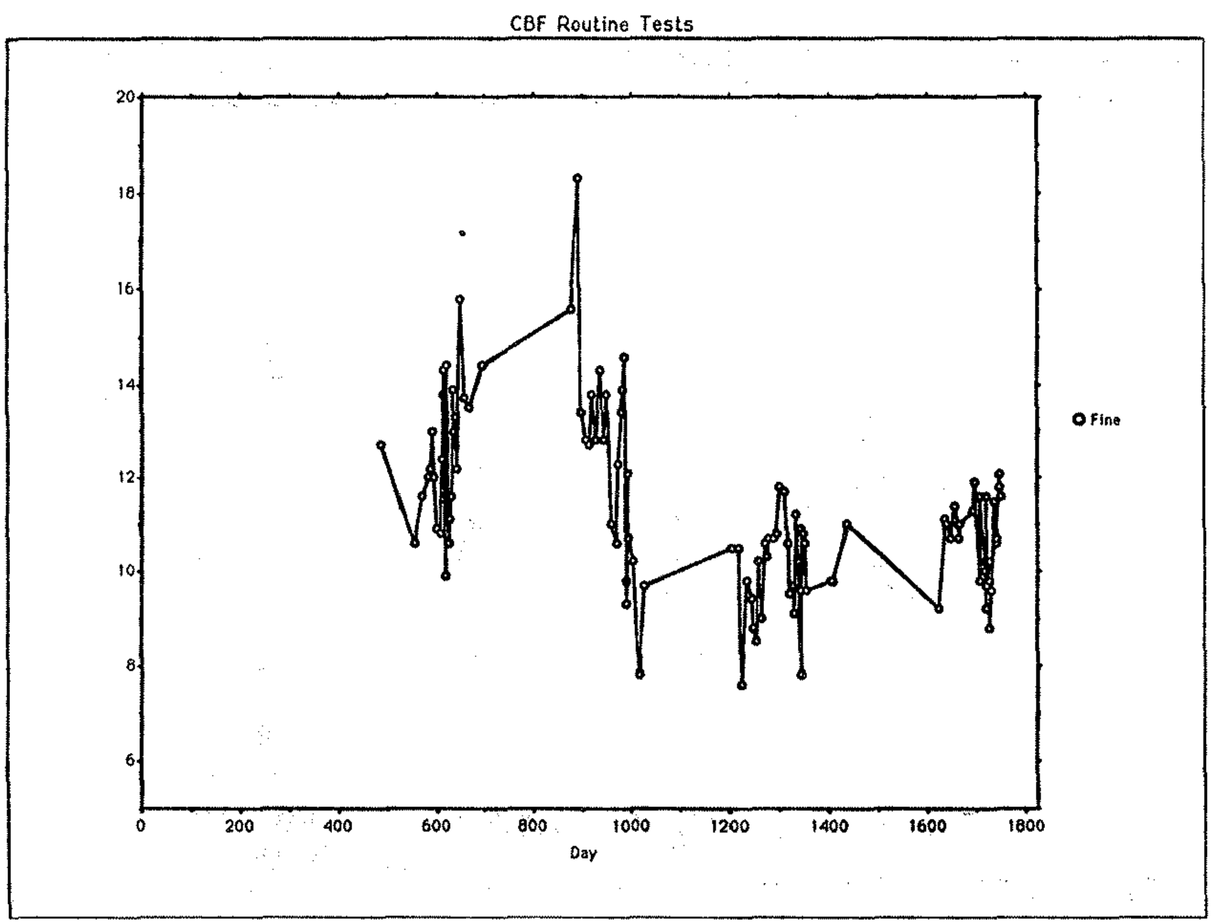


Figure 30, Appendix C

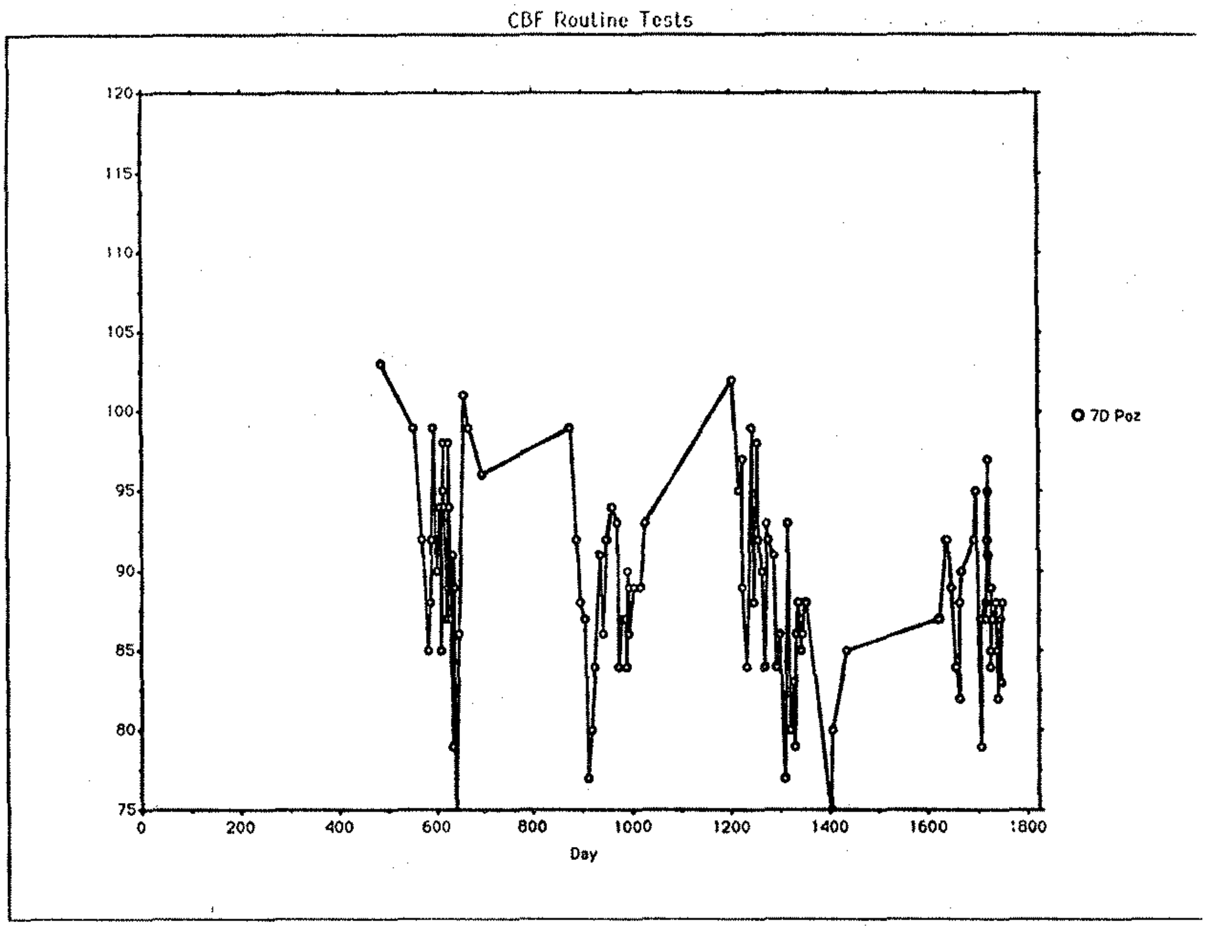


Figure 31, Appendix C

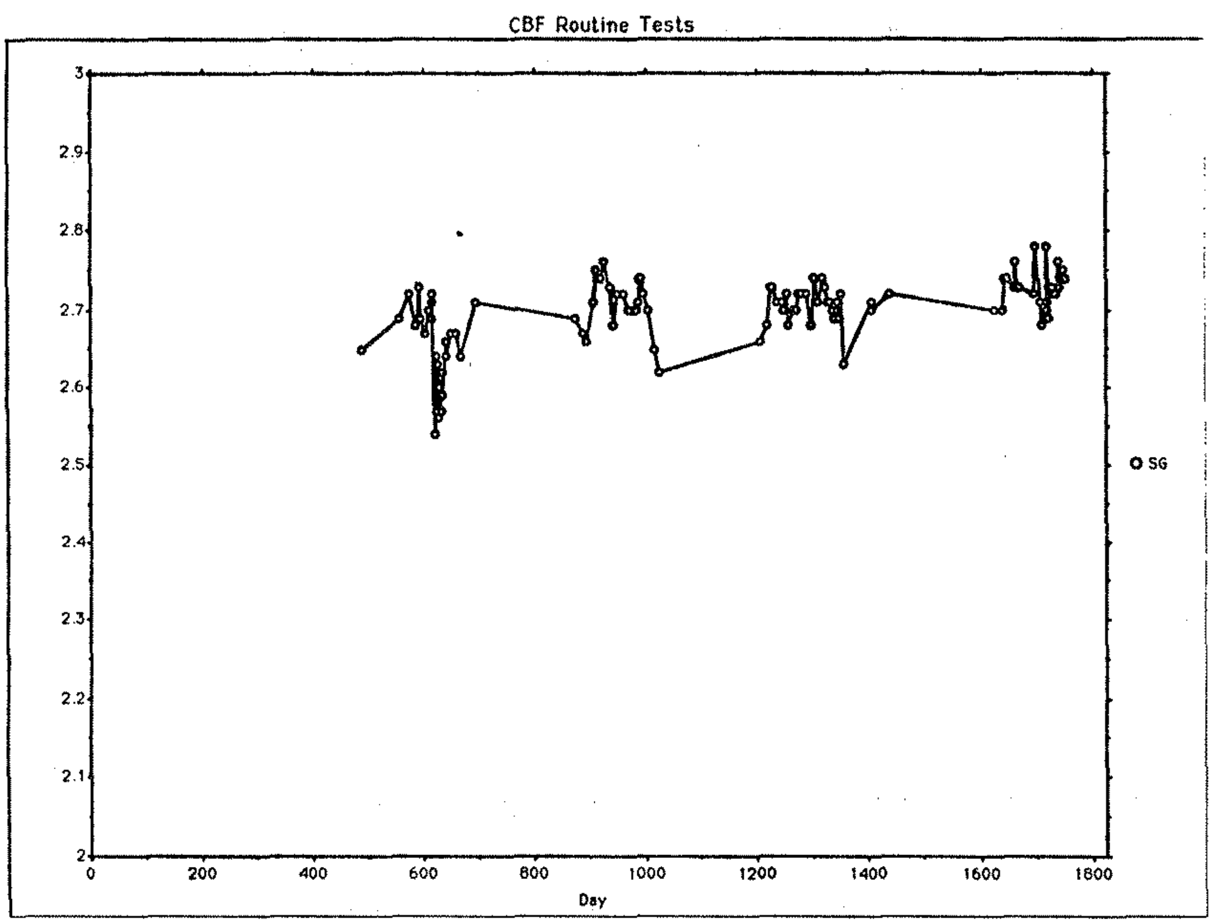


Figure 32, Appendix C

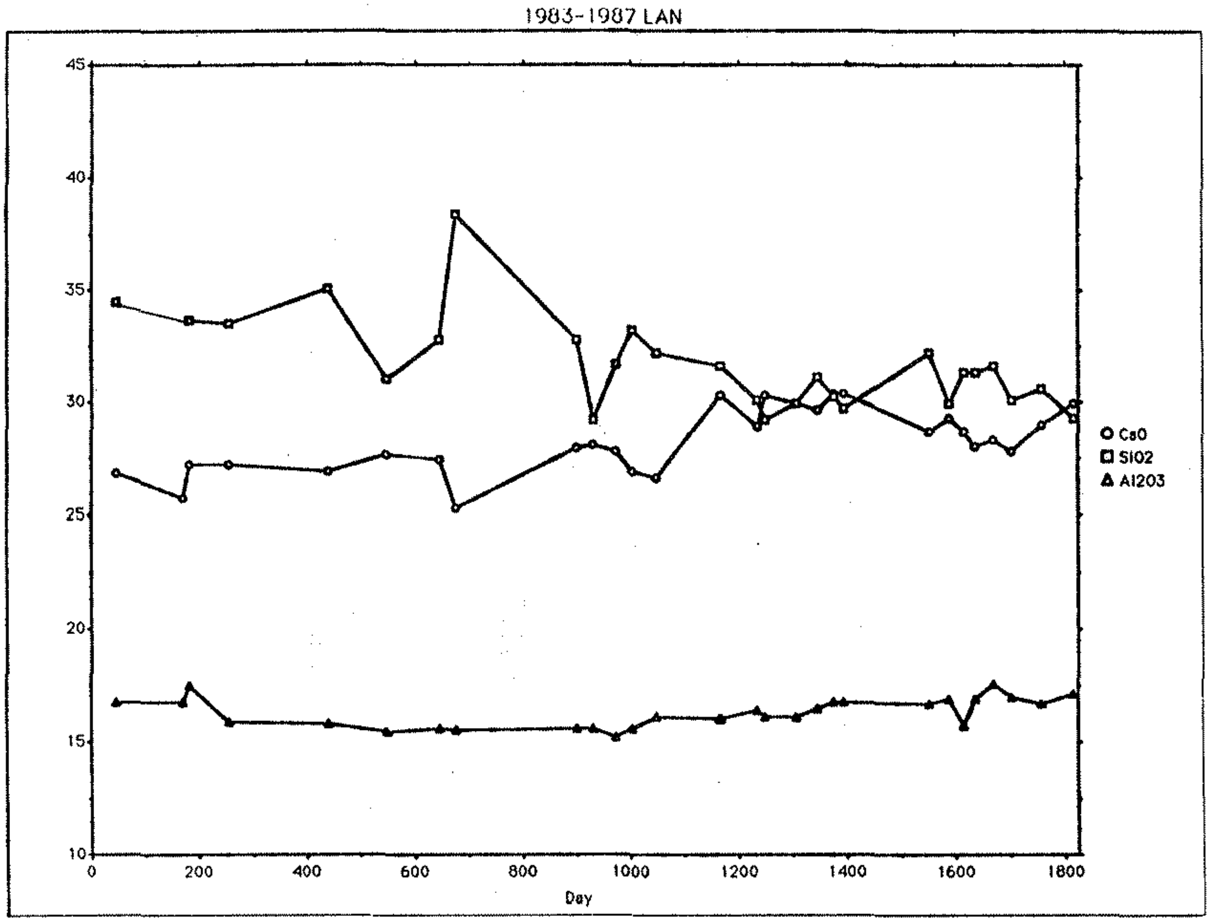


Figure 33, Appendix C

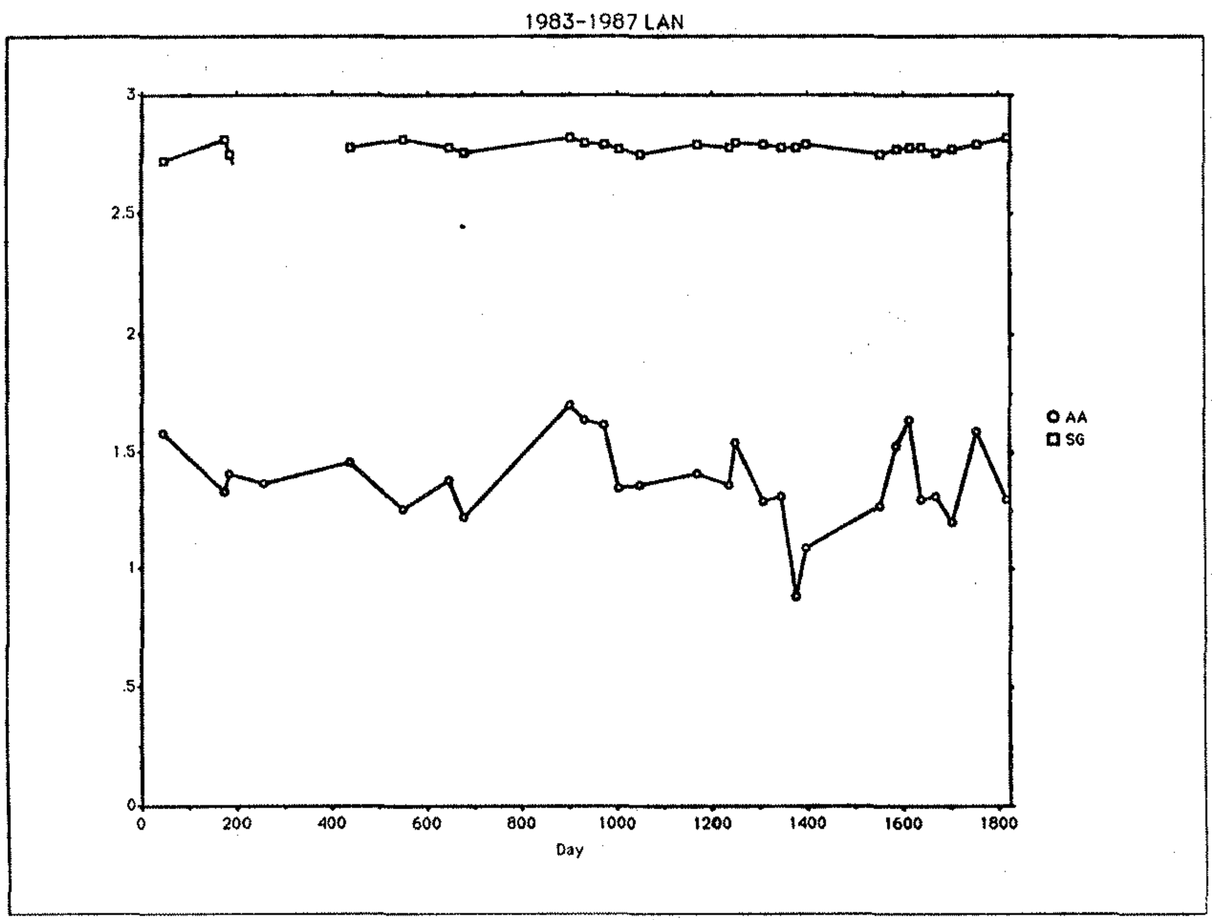


Figure 34, Appendix C

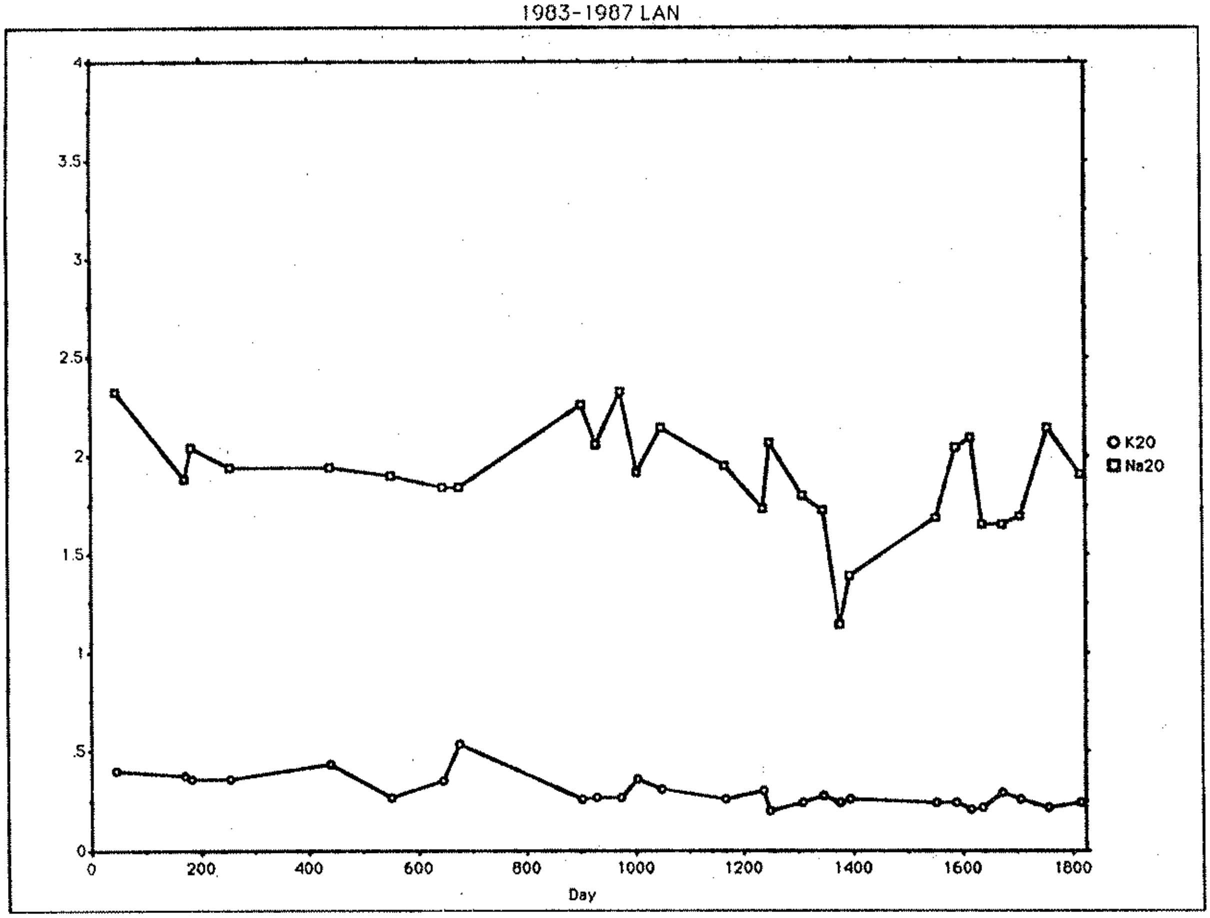


Figure 35, Appendix C

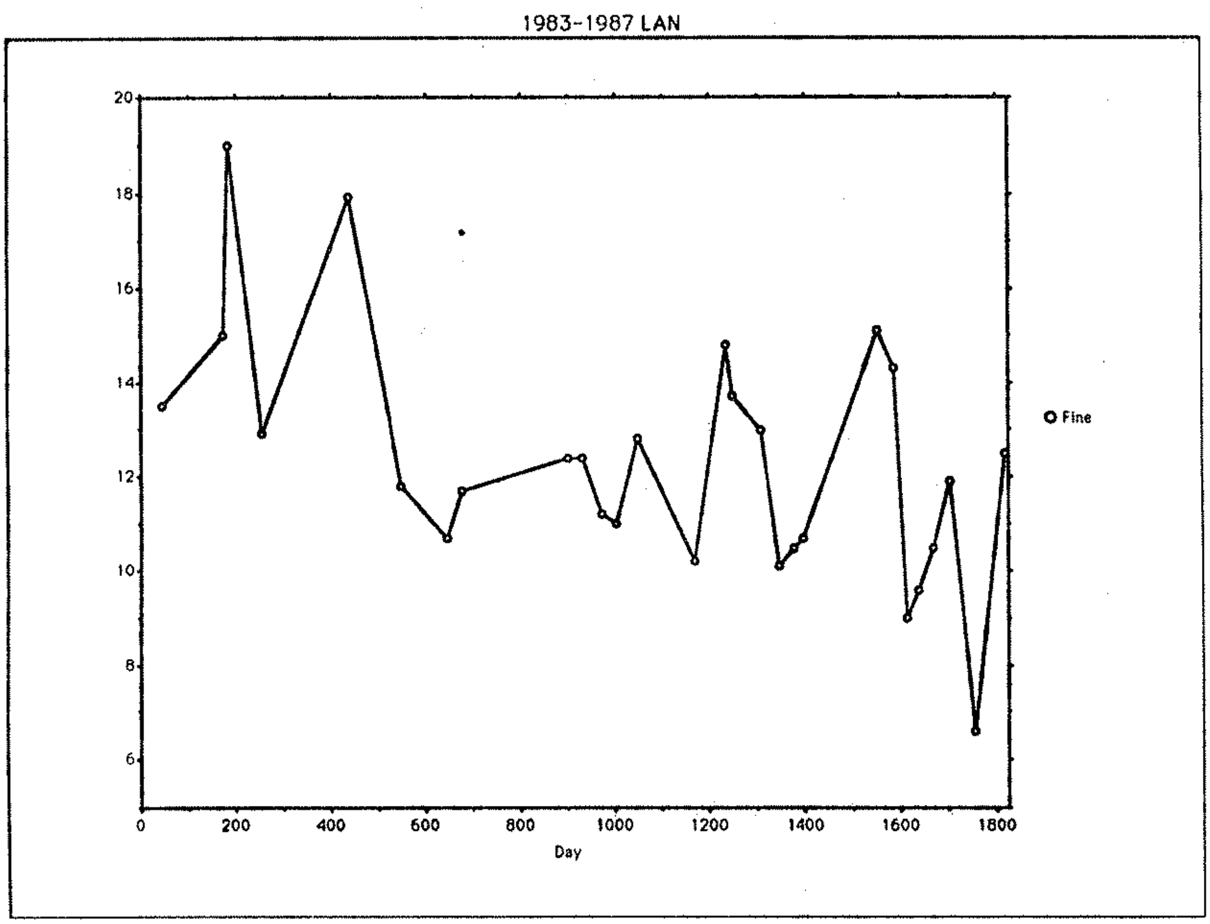


Figure 36, Appendix C

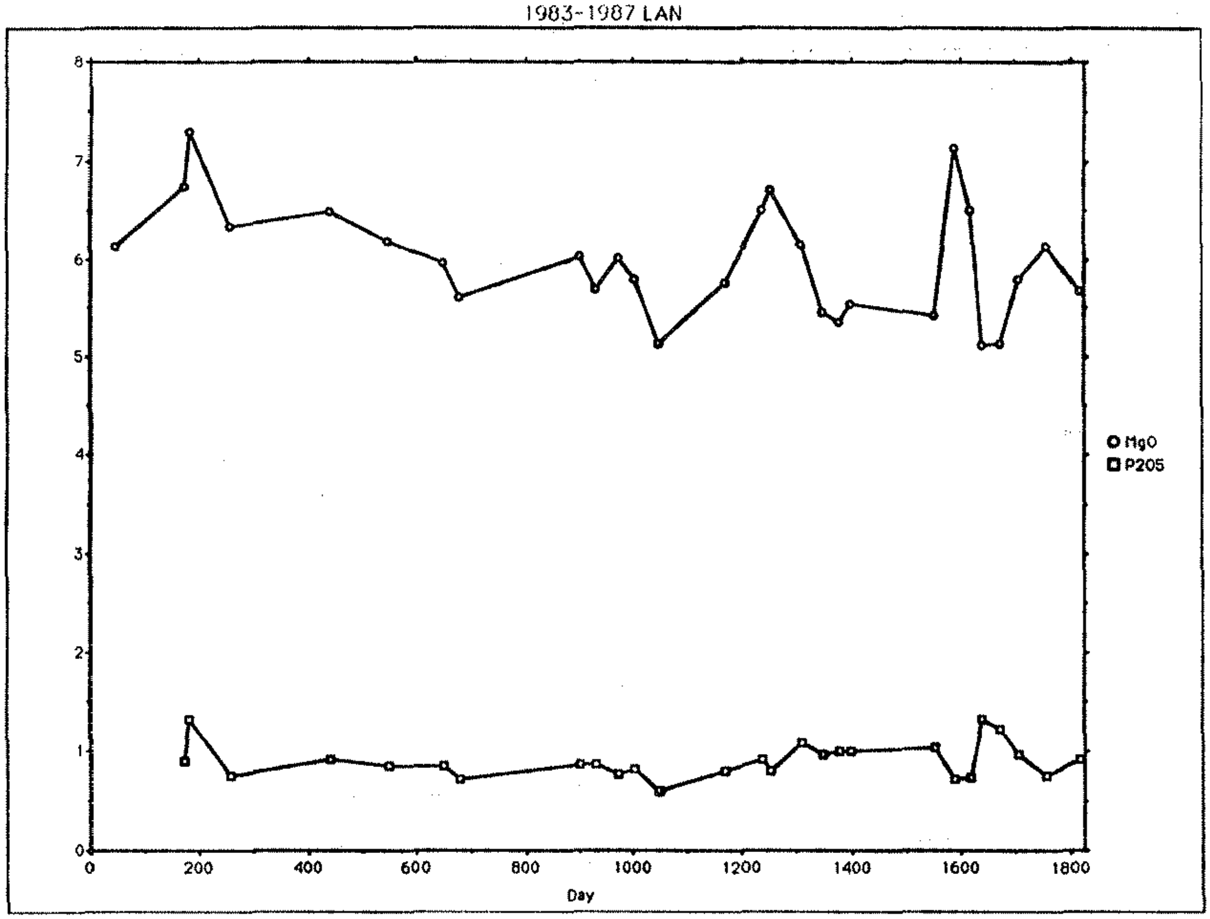


Figure 37, Appendix C

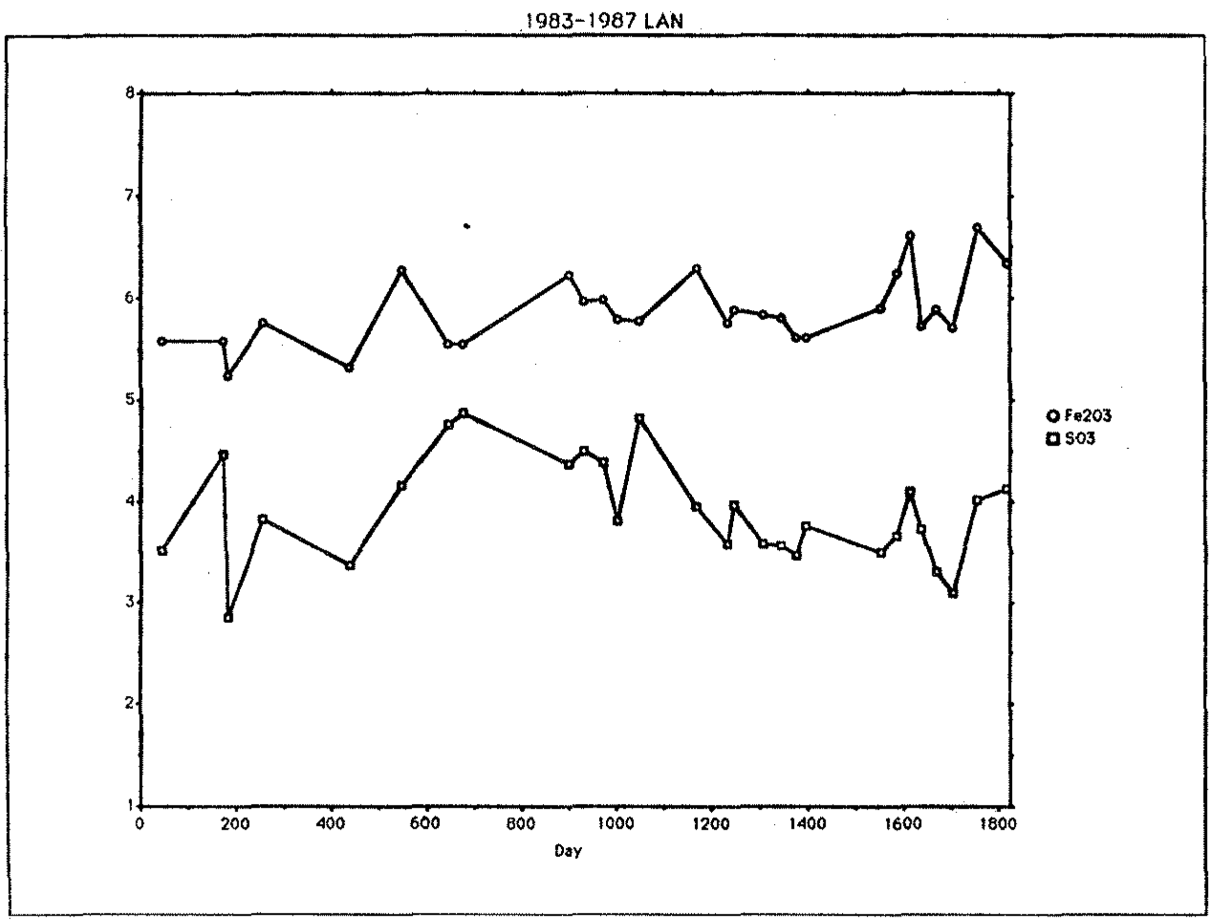


Figure 38, Appendix C

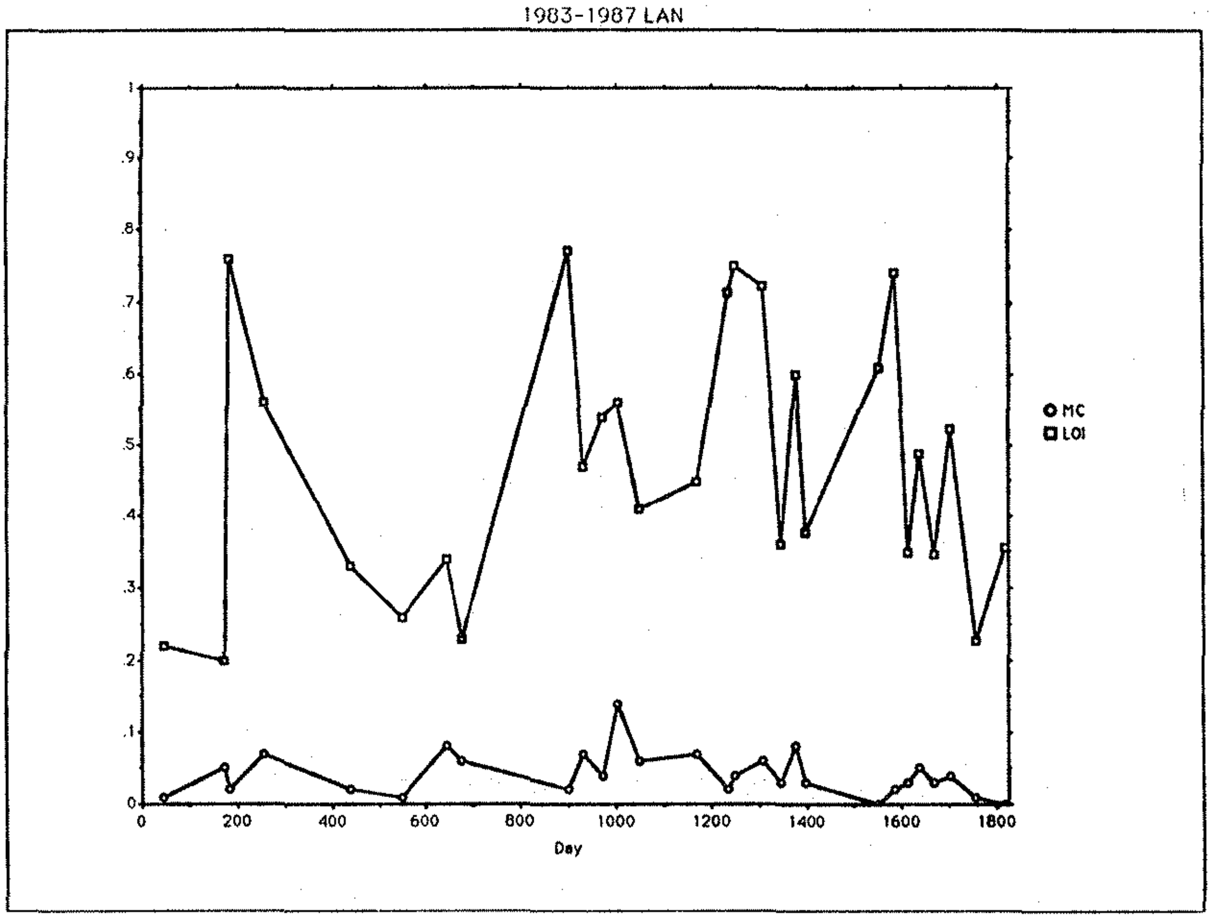


Figure 39, Appendix C

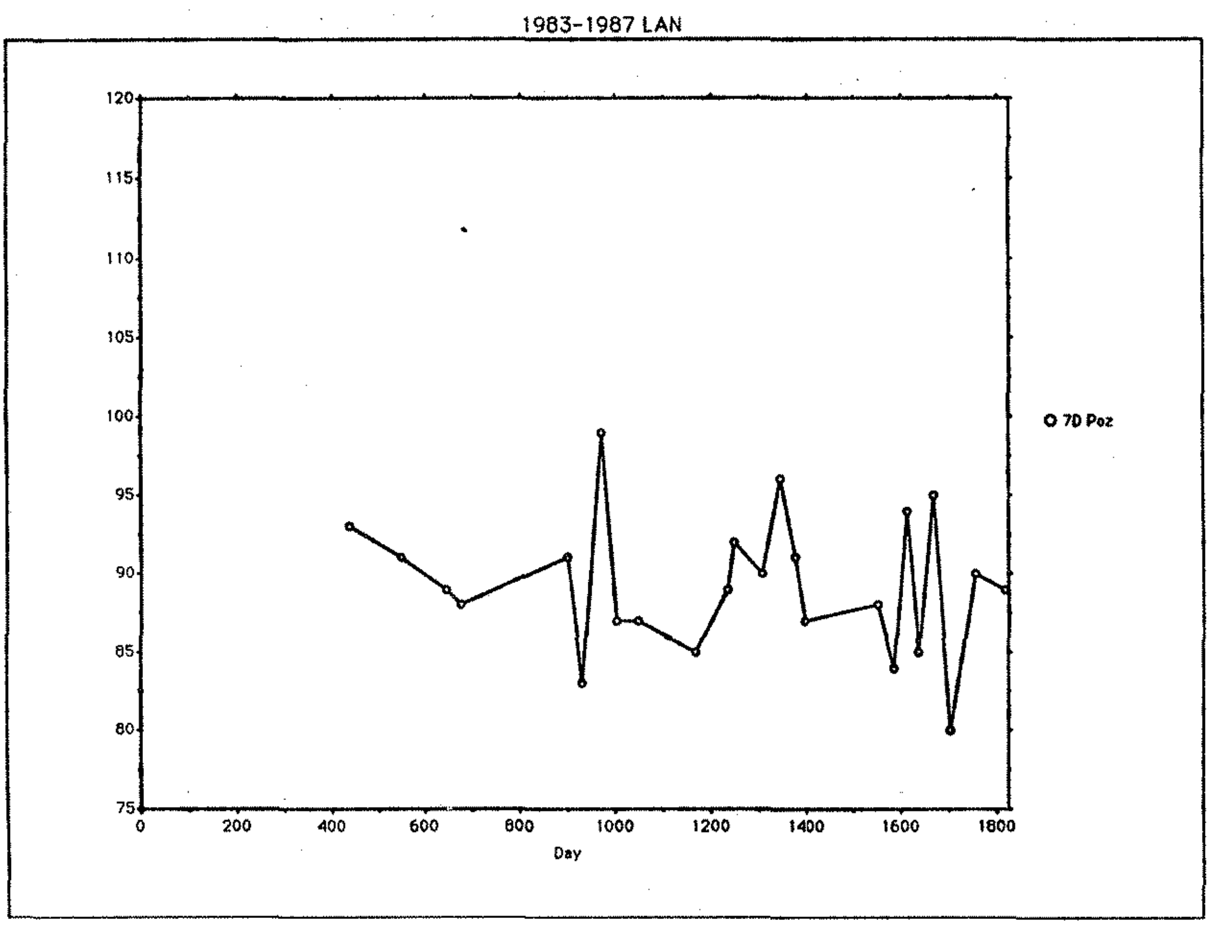


Figure 40, Appendix C

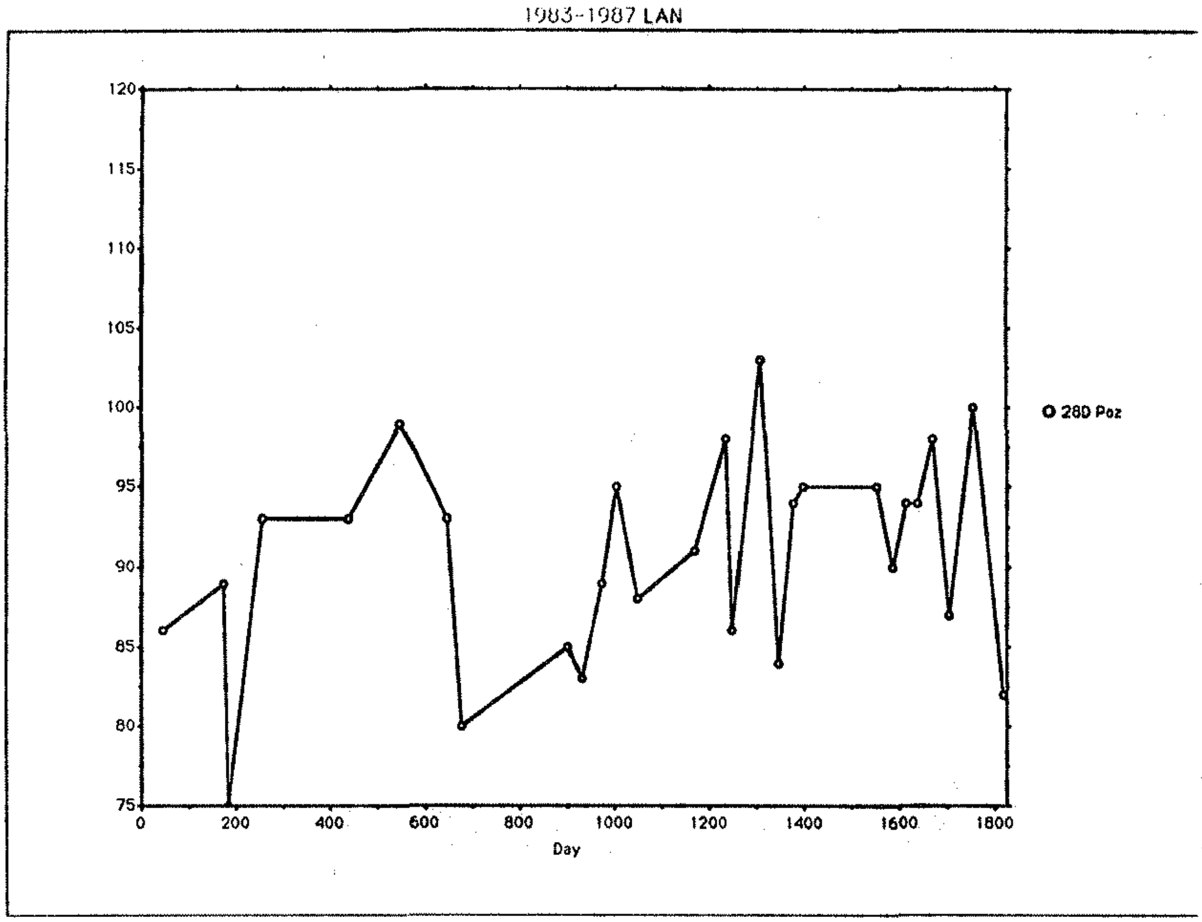
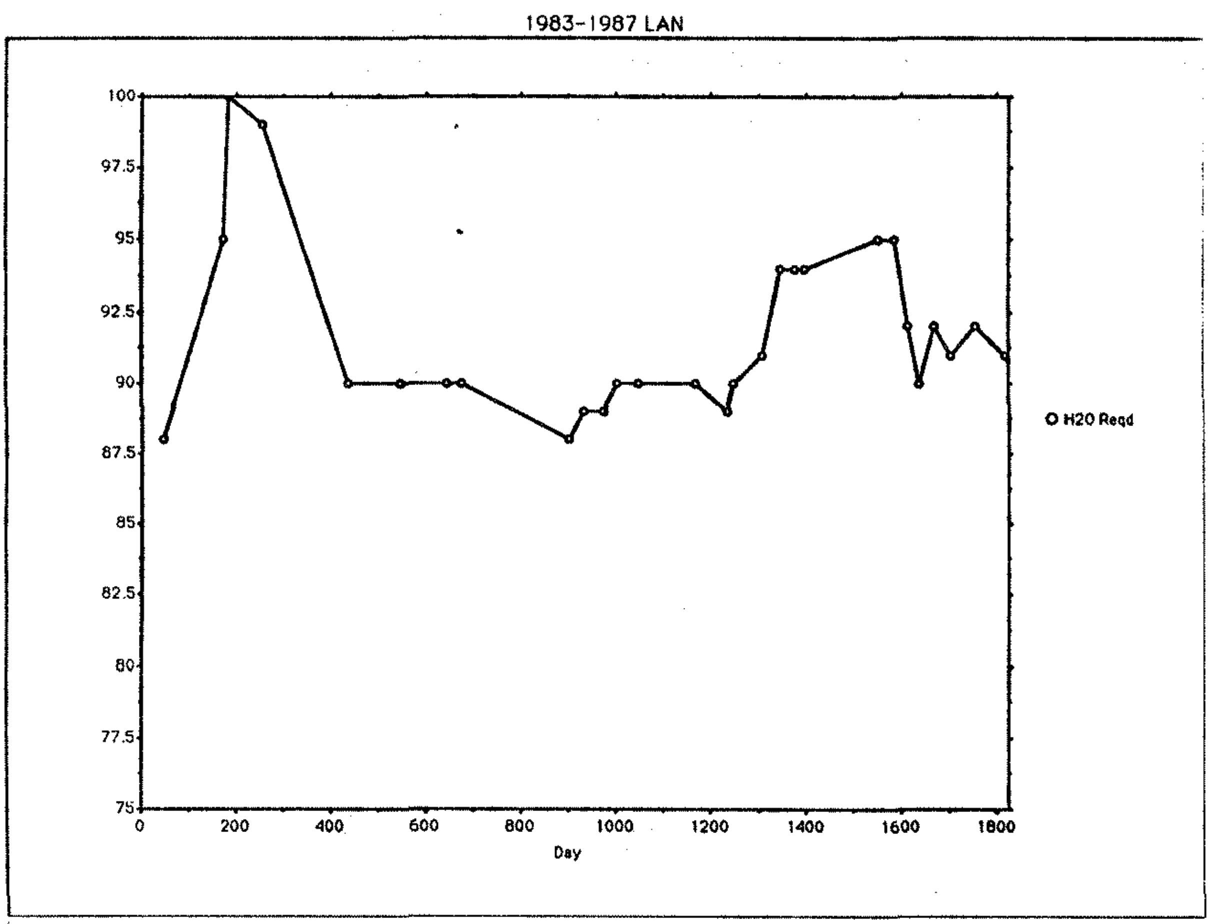


Figure 41, Appendix C



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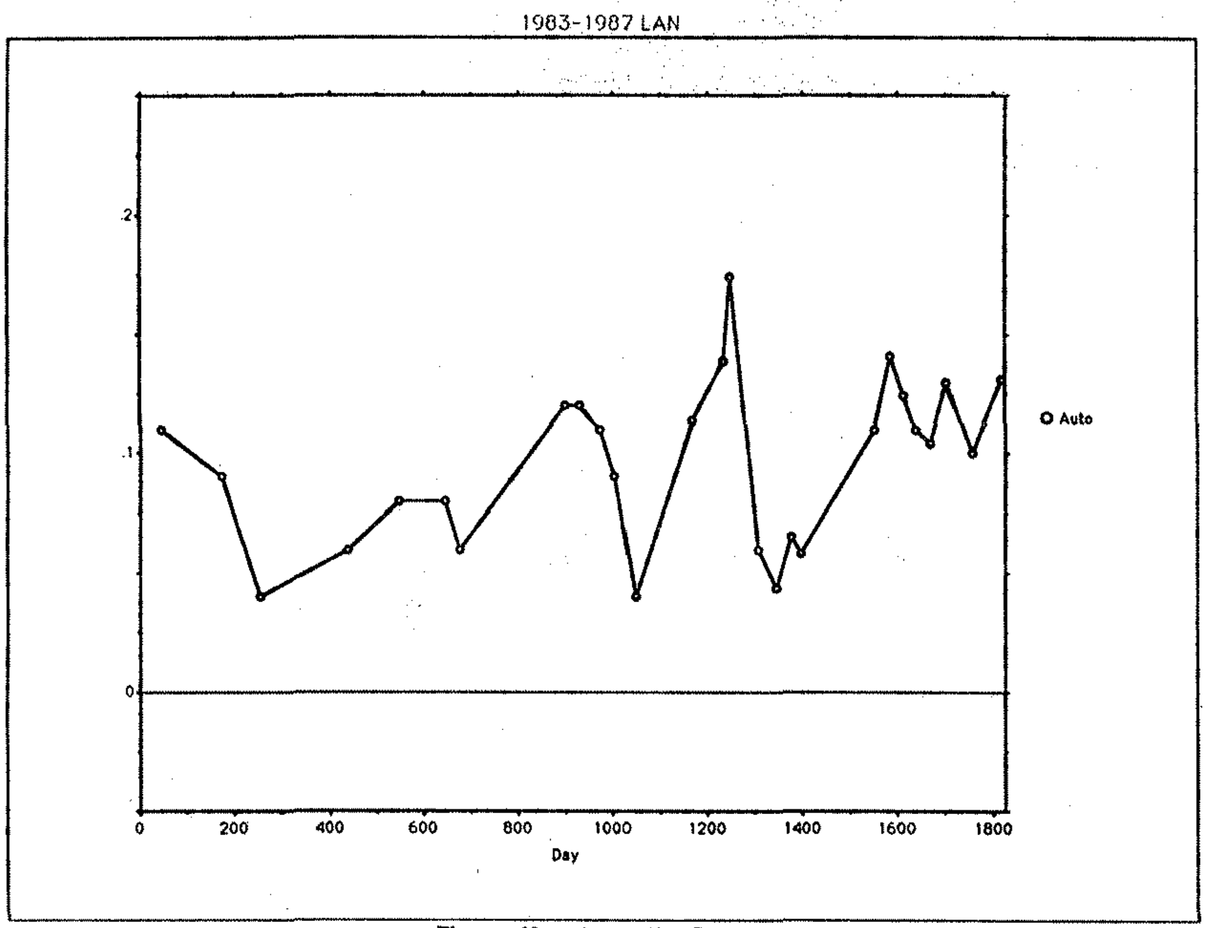


Figure 43, Appendix C

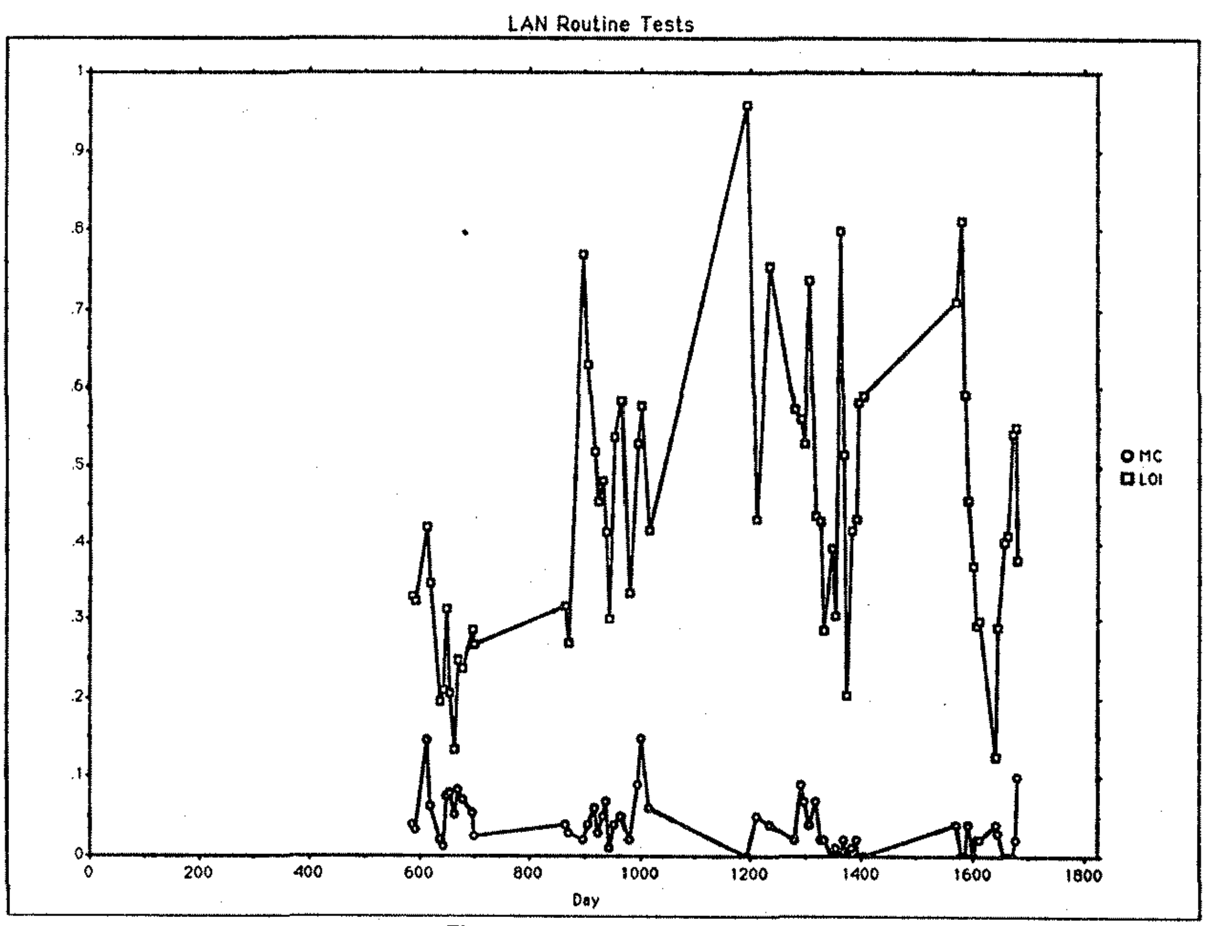


Figure 44, Appendix C

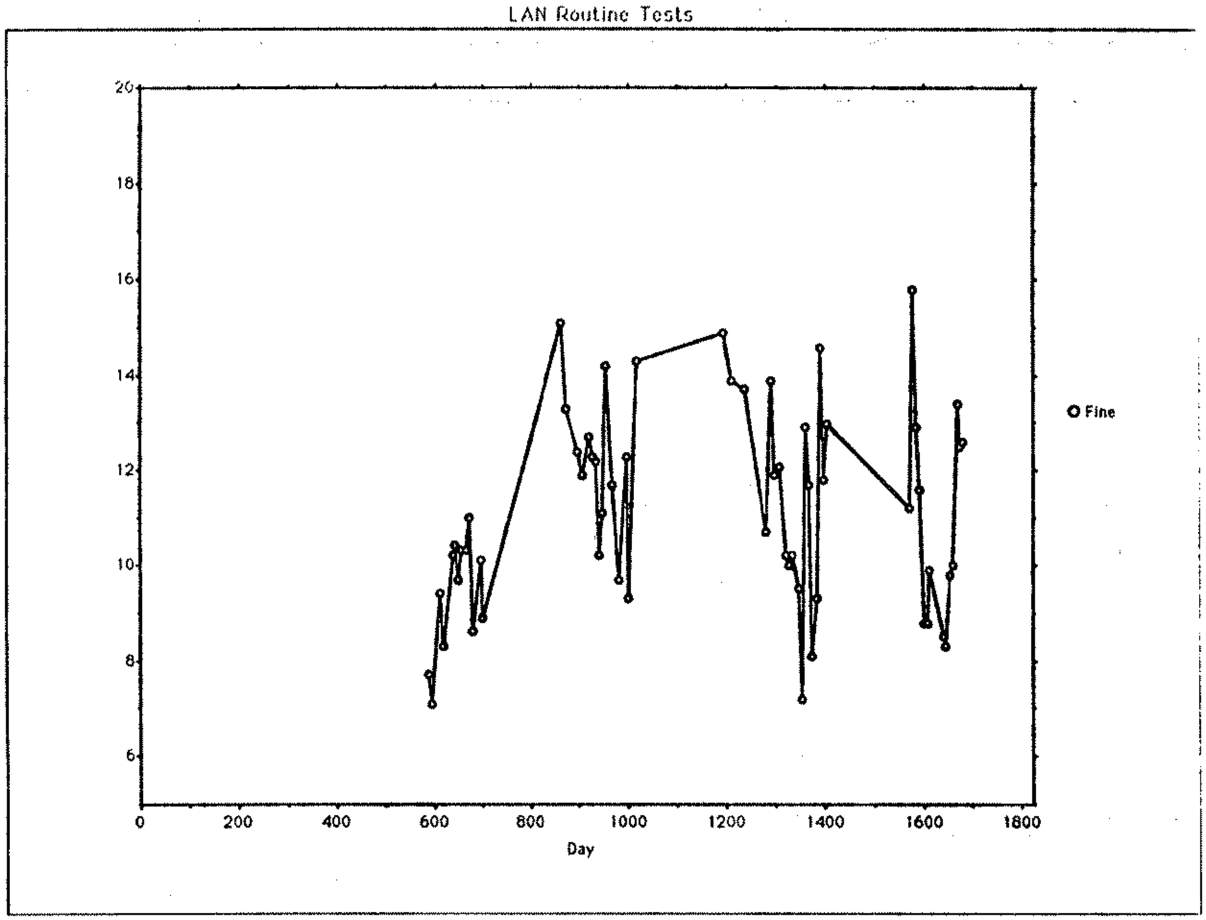


Figure 45, Appendix C

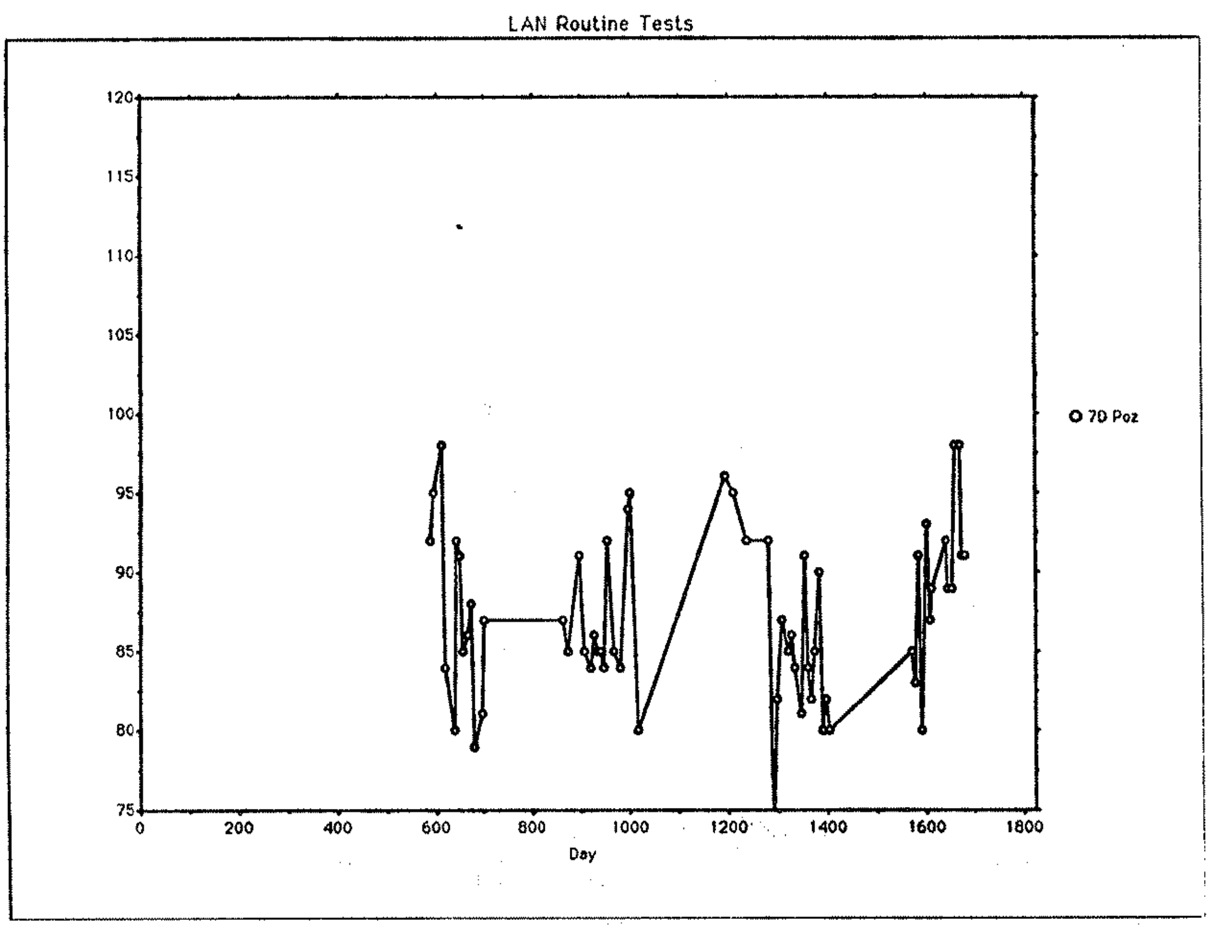
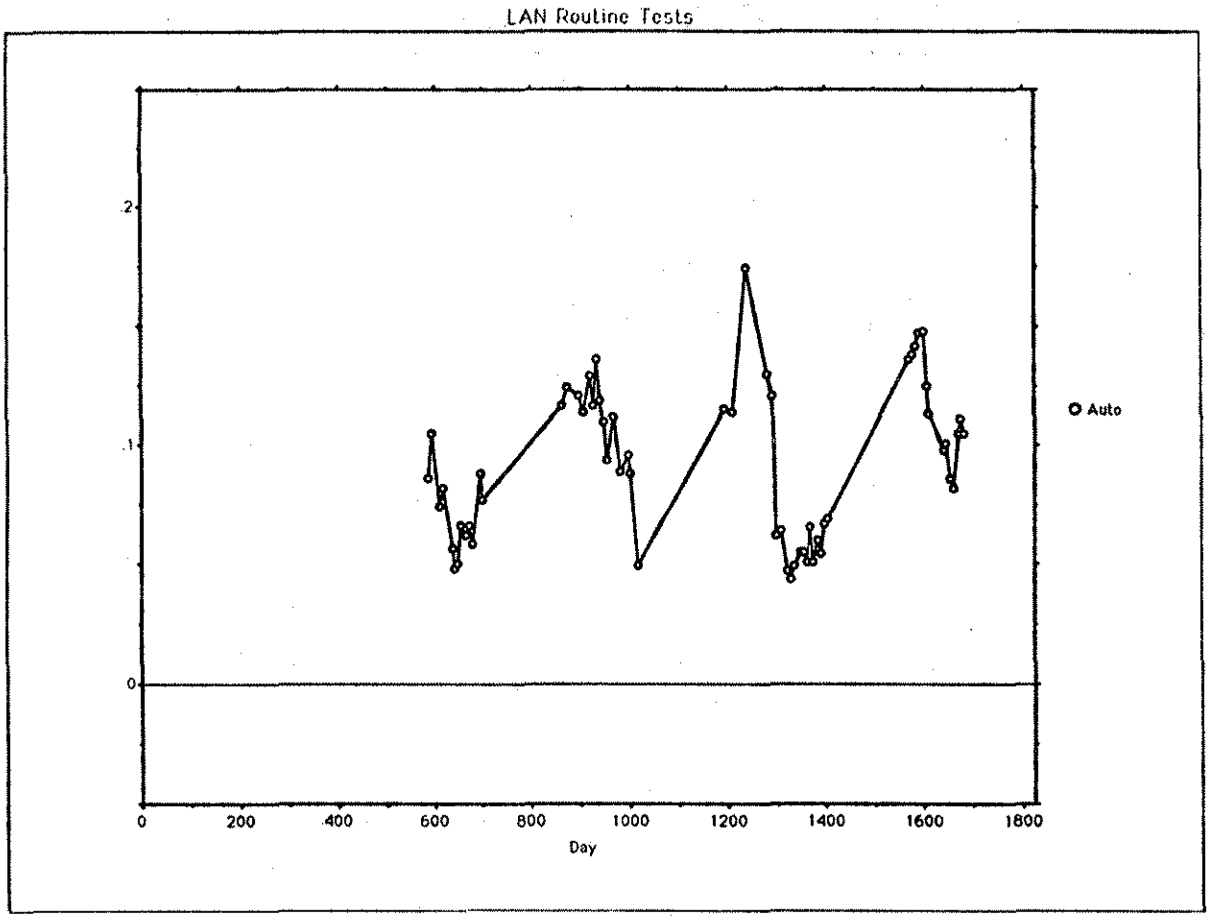


Figure 46, Appendix C



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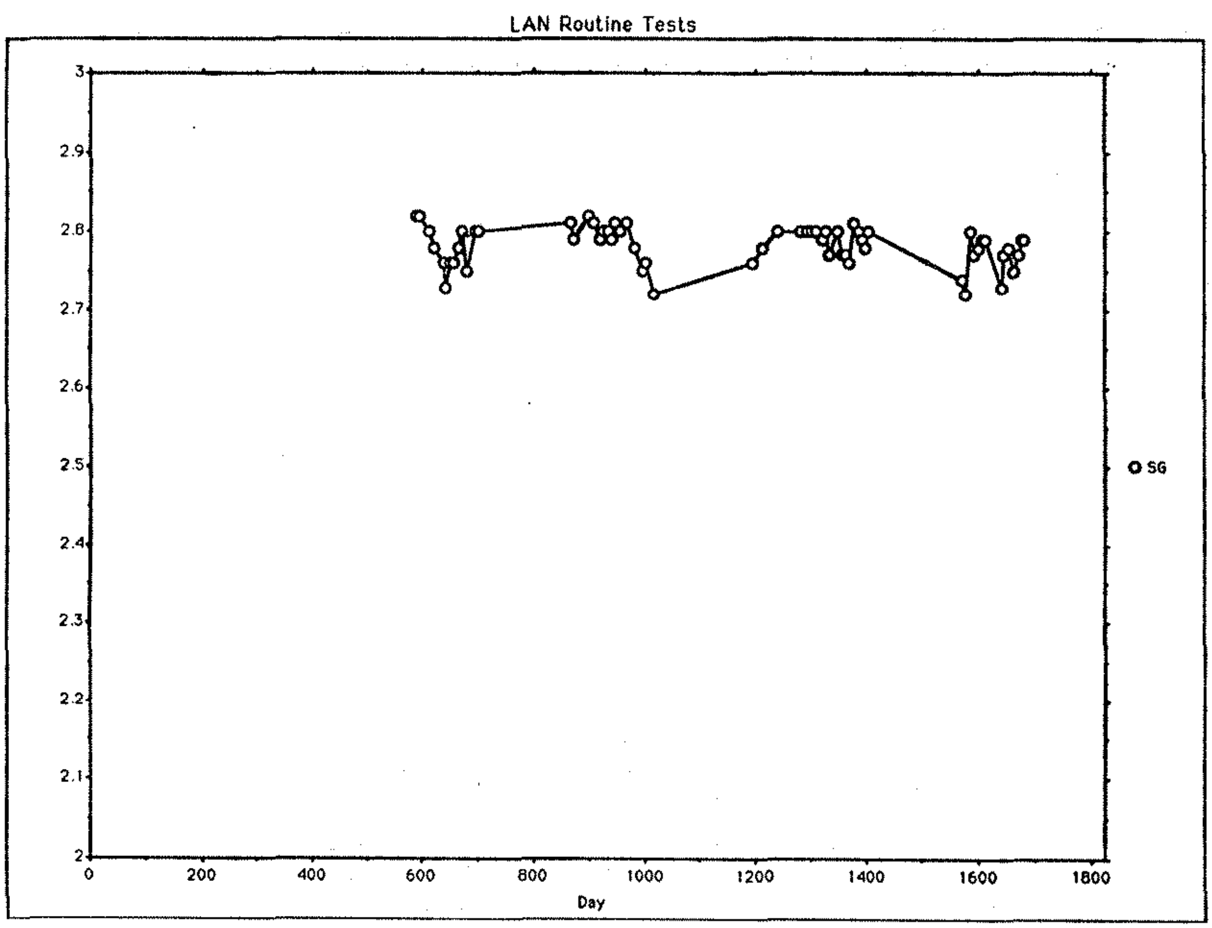

Figure 48, Appendix C

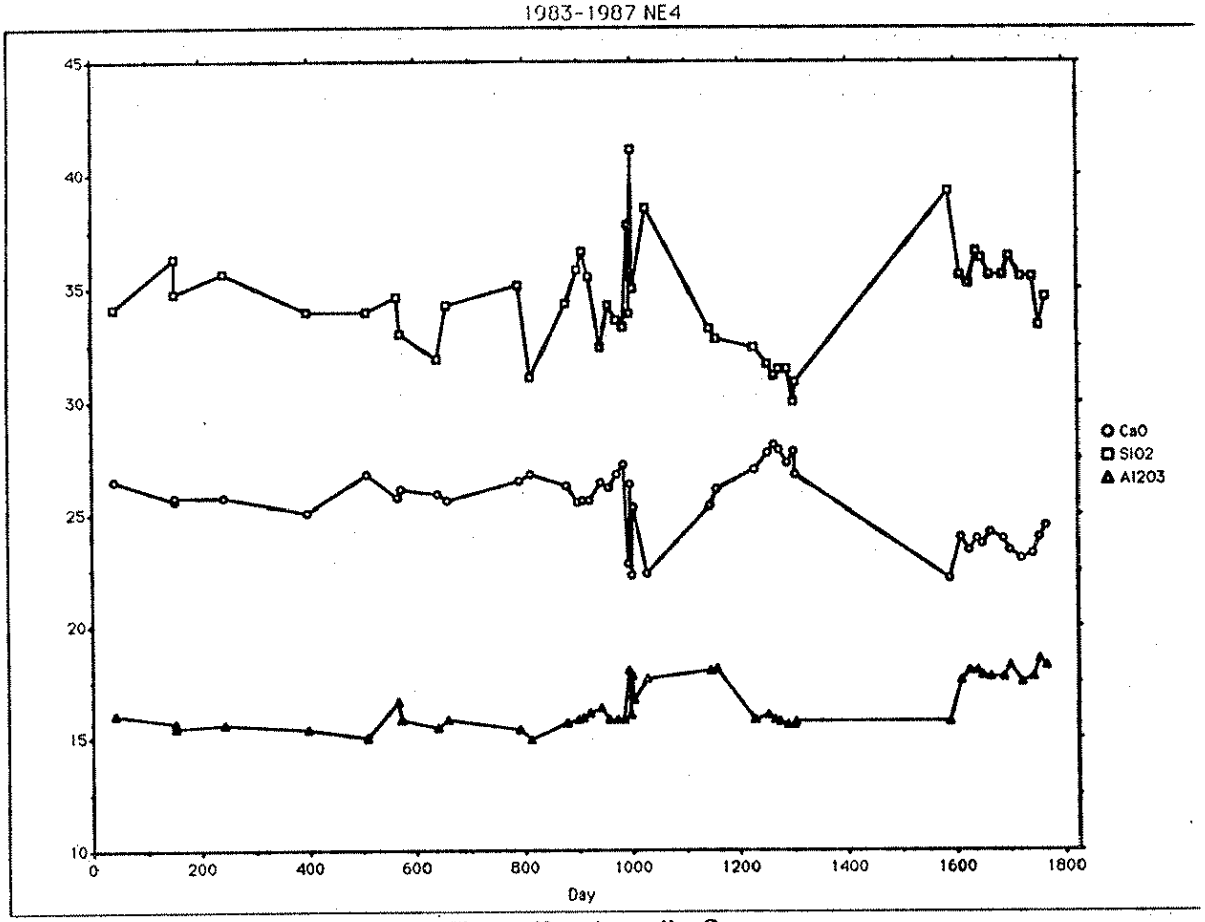

Figure 49, Appendix C

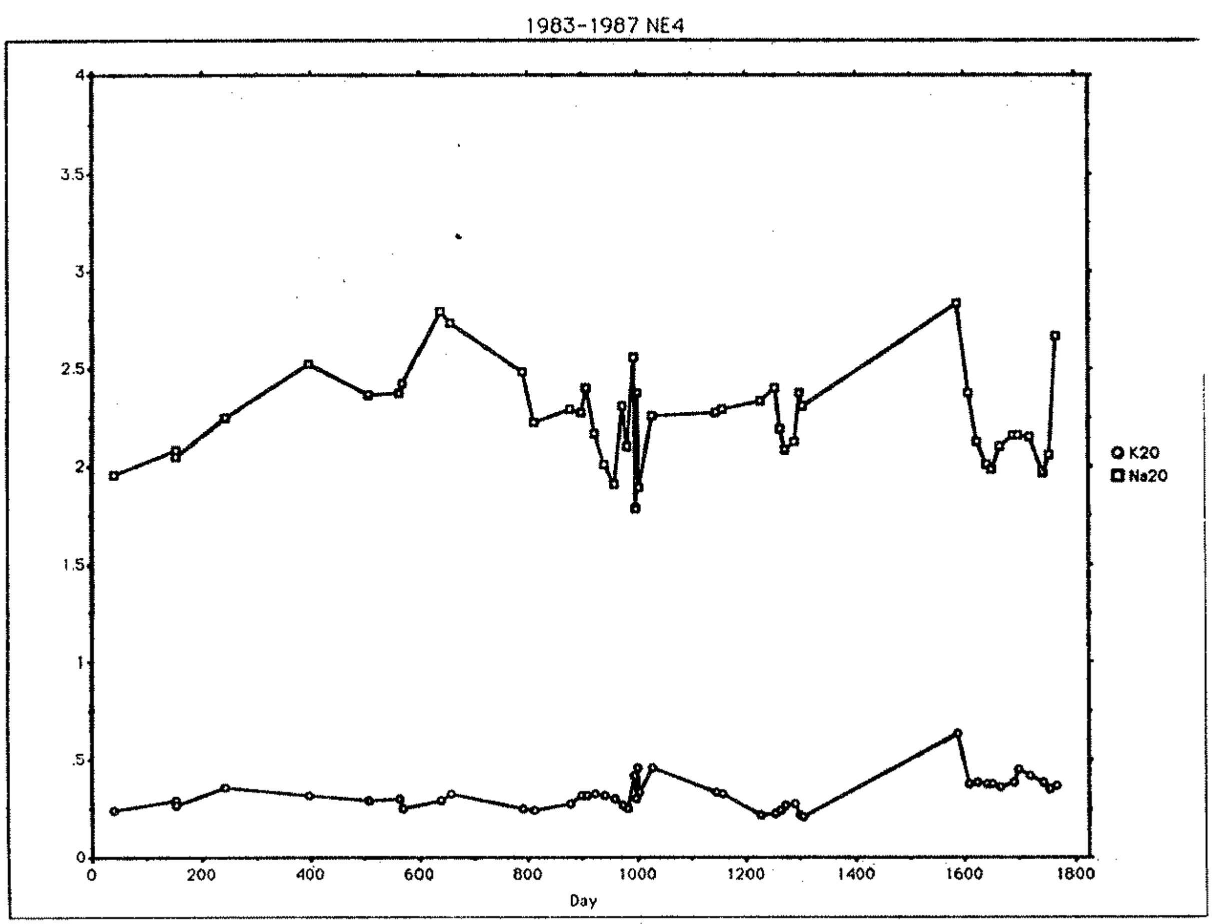

Figure 50, Appendix C

1983-1987 NE4

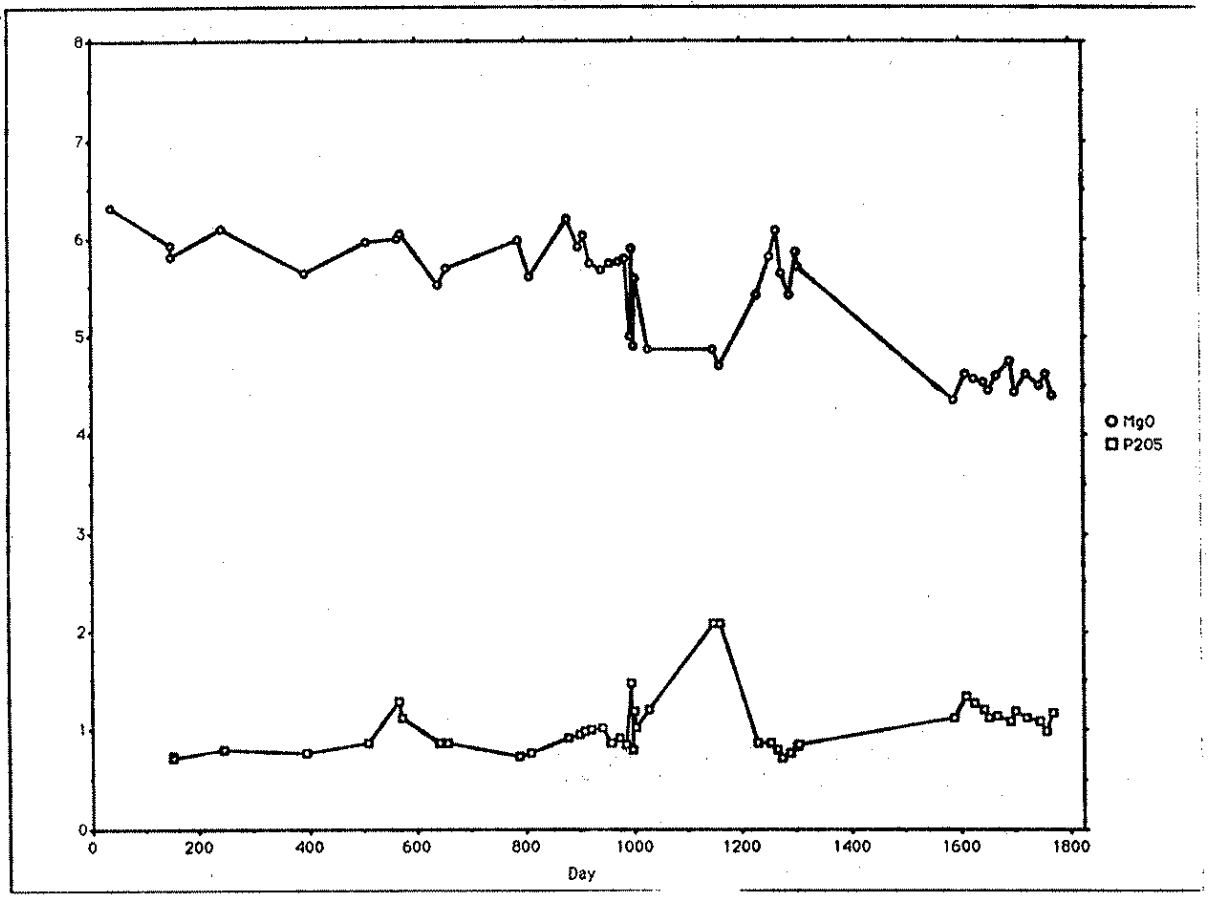

Figure 51, Appendix C

1983-1987 NE4

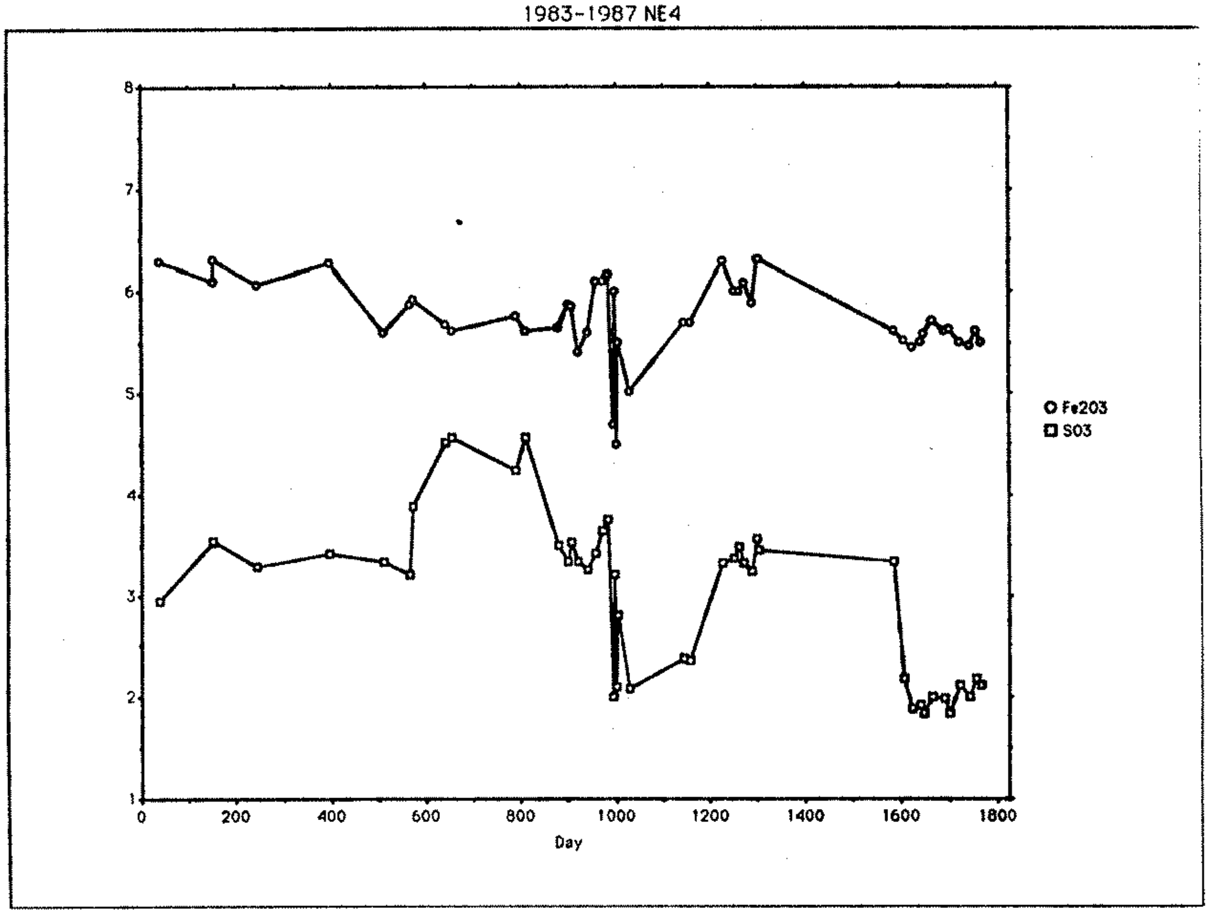

Figure 52, Appendix C

1983-1987 NE4

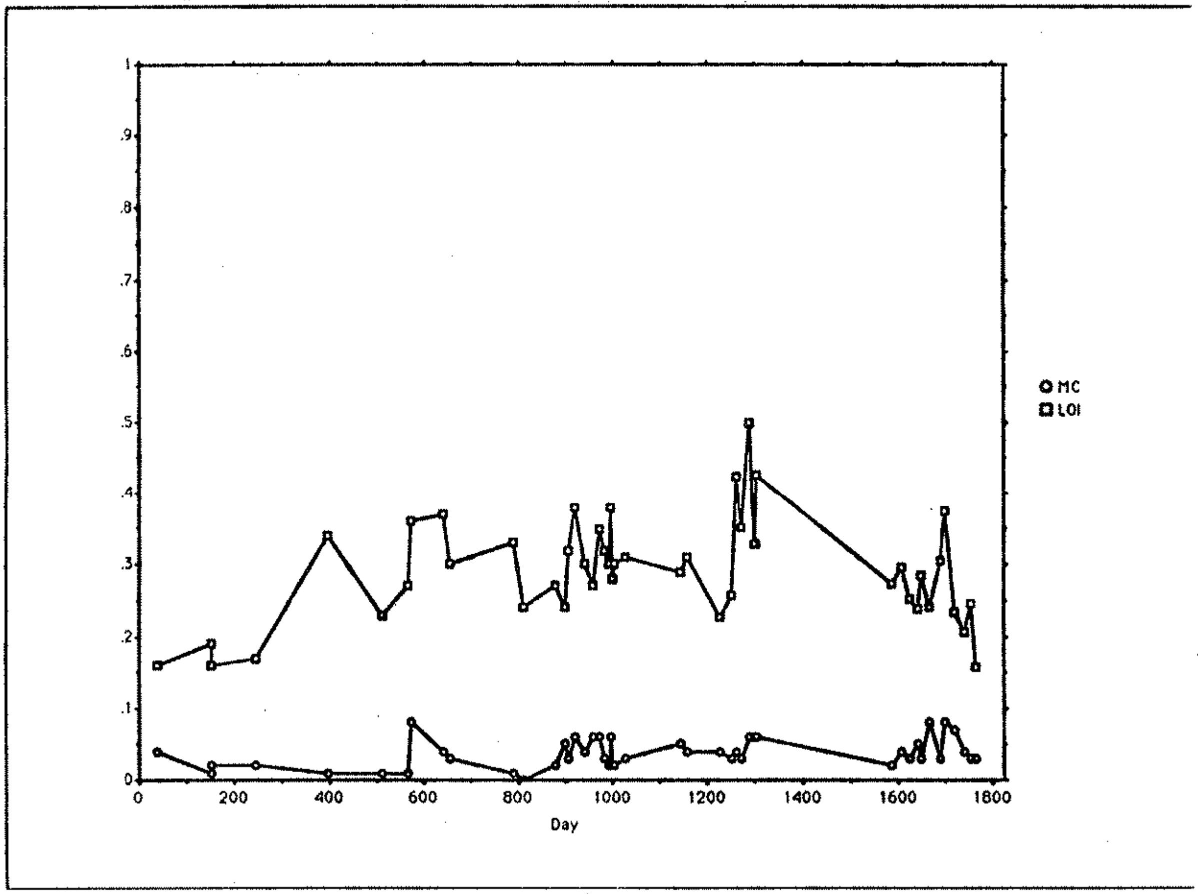

Figure 53, Appendix C

1983-1987 NE4

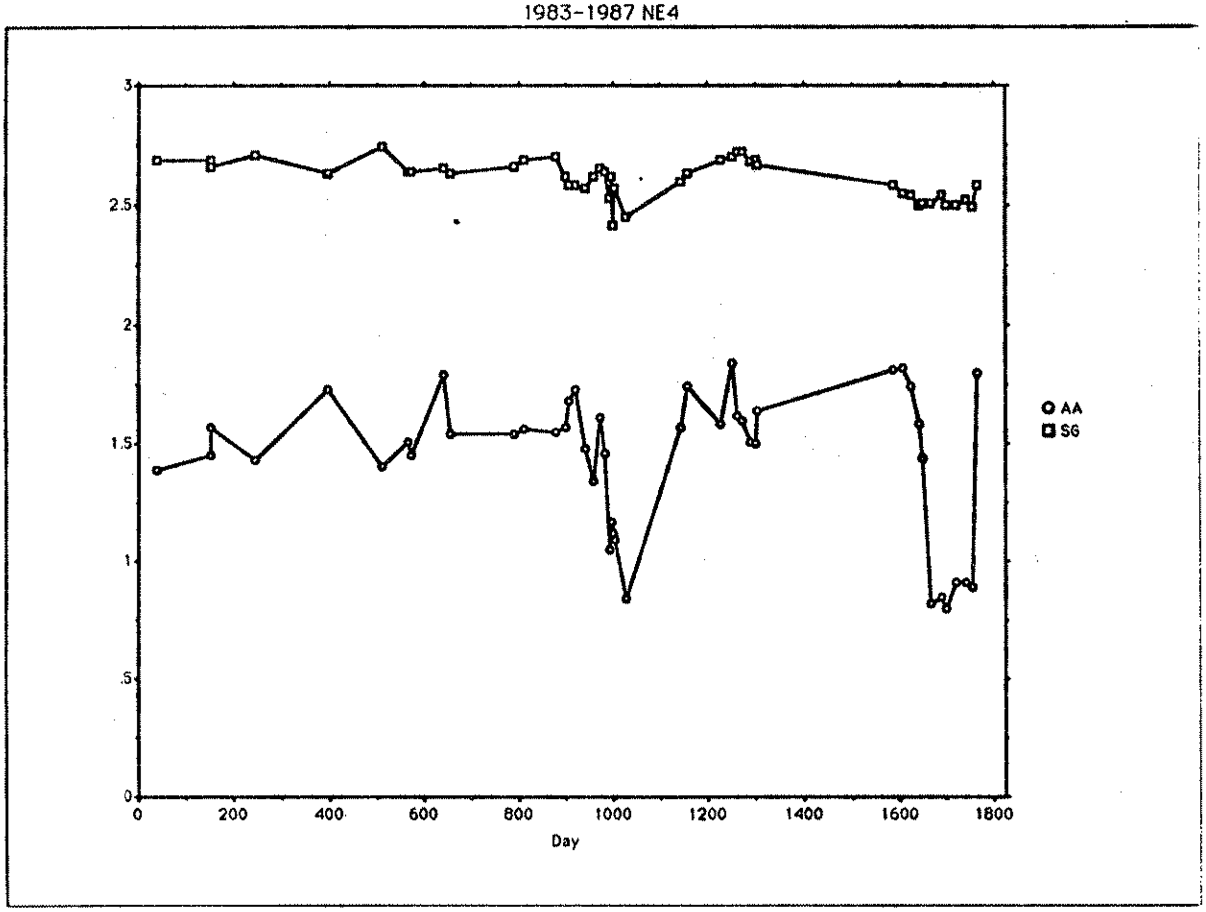

Figure 54, Appendix C

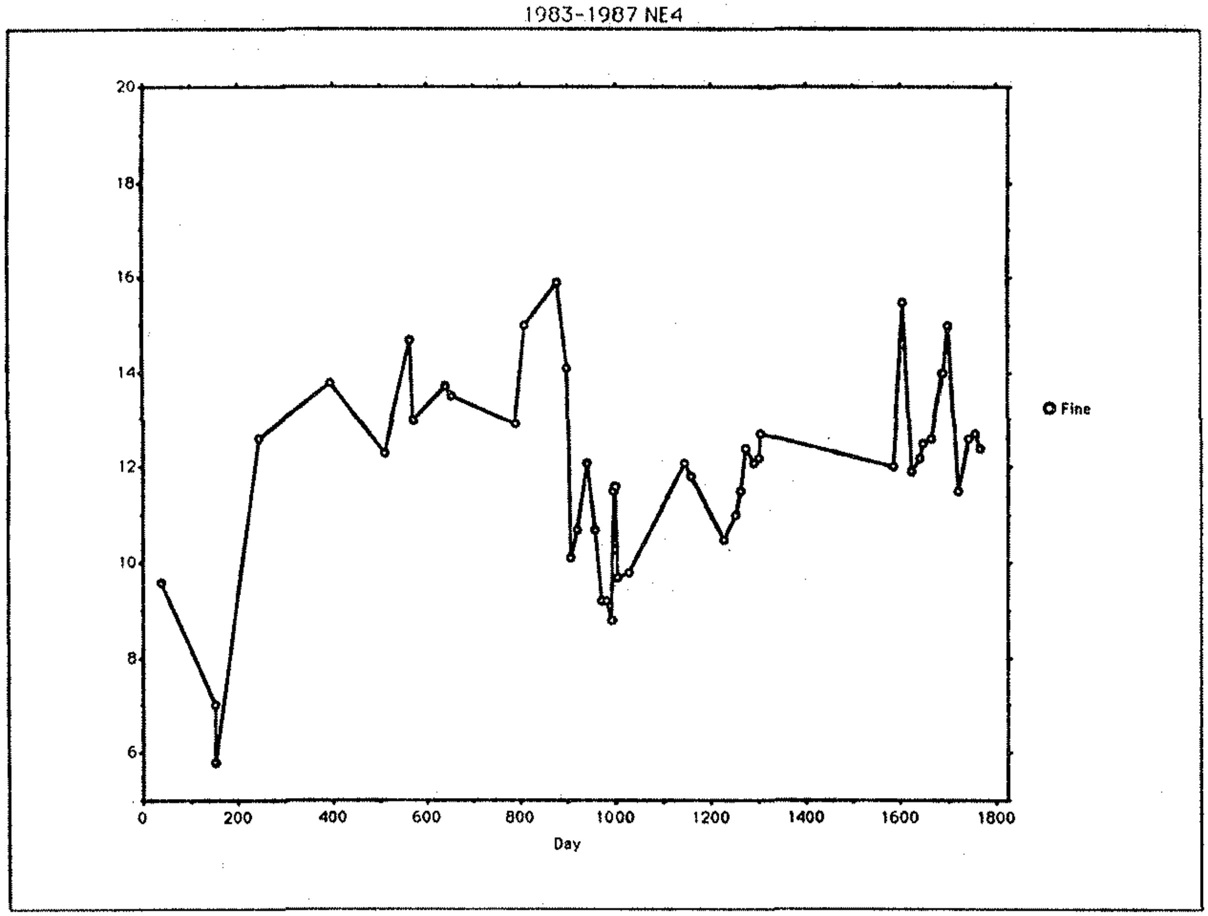

Figure 55, Appendix C

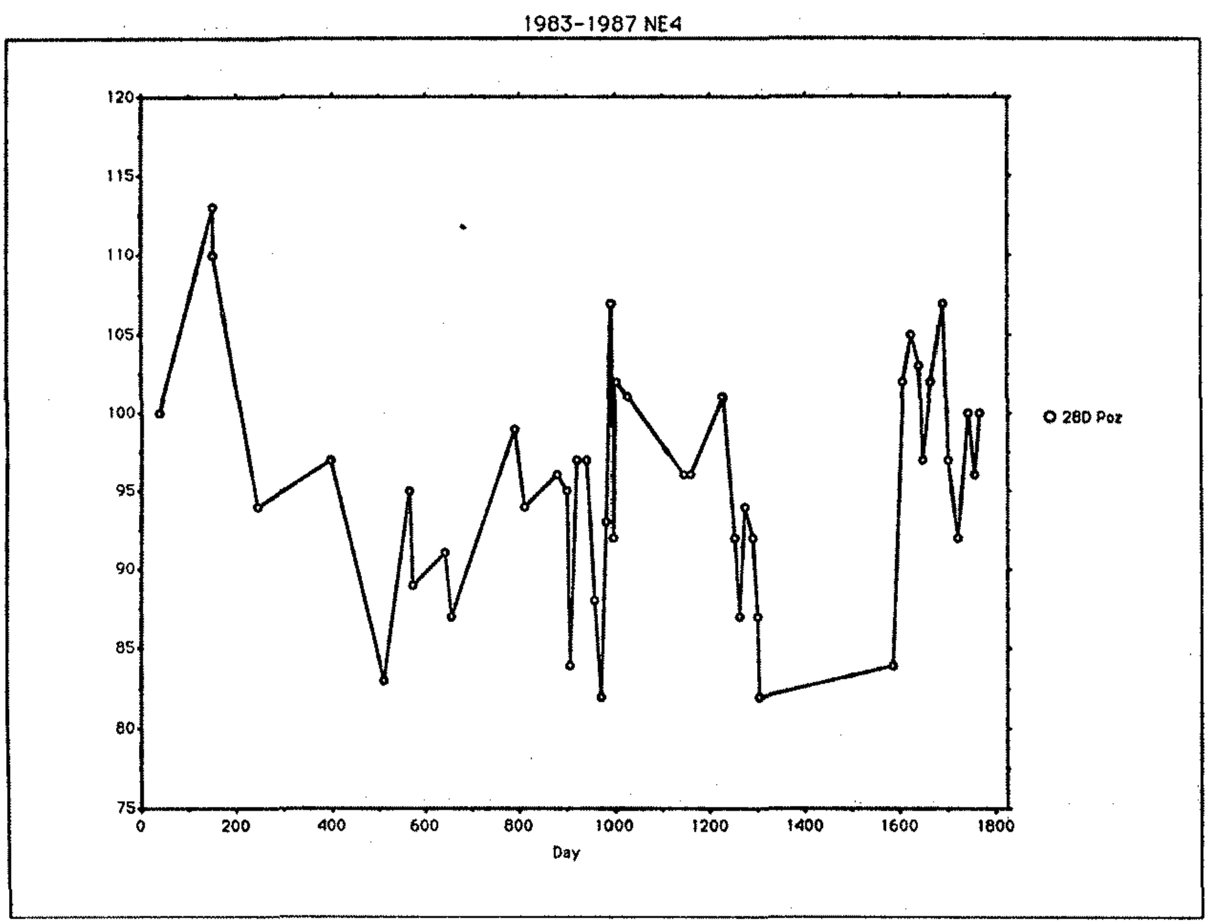

Figure 56, Appendix C

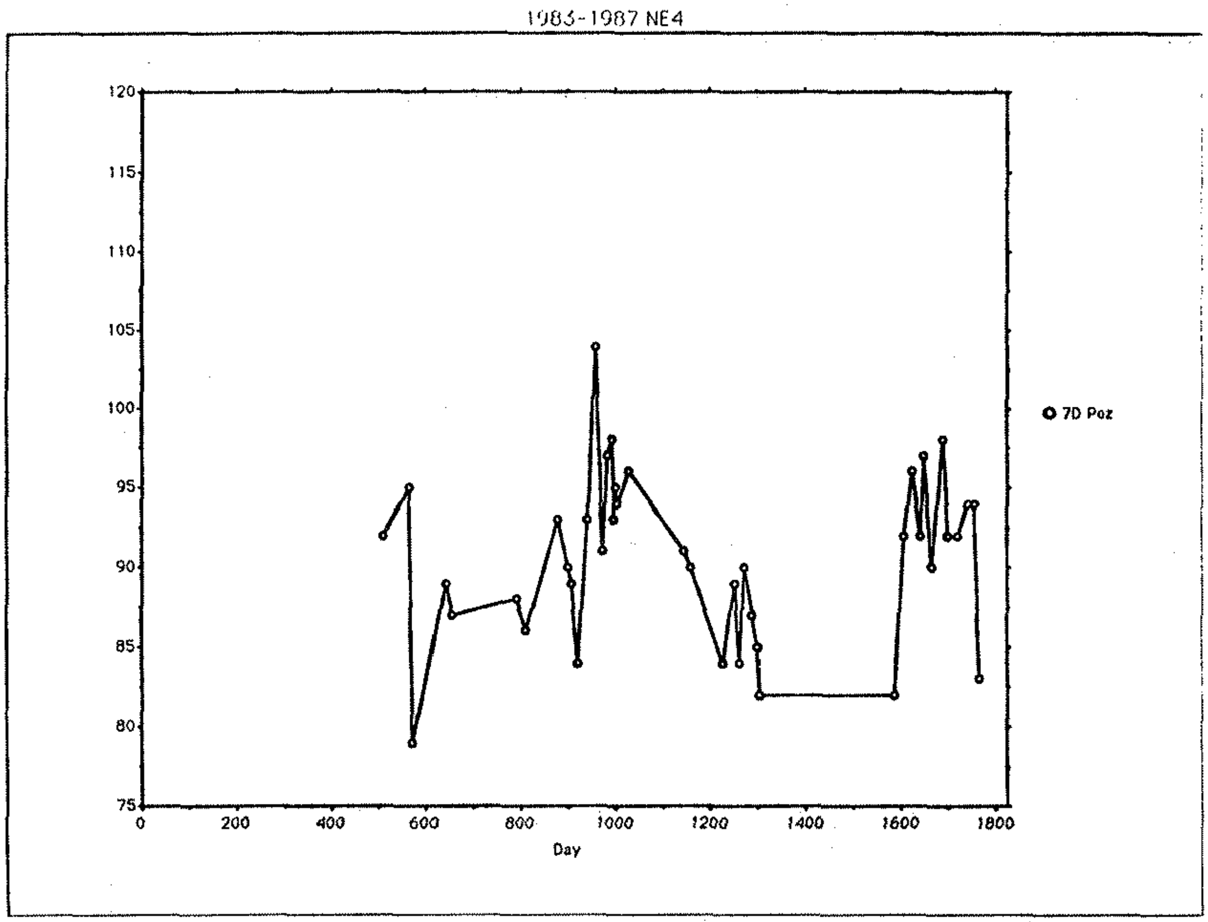

Figure 57, Appendix C

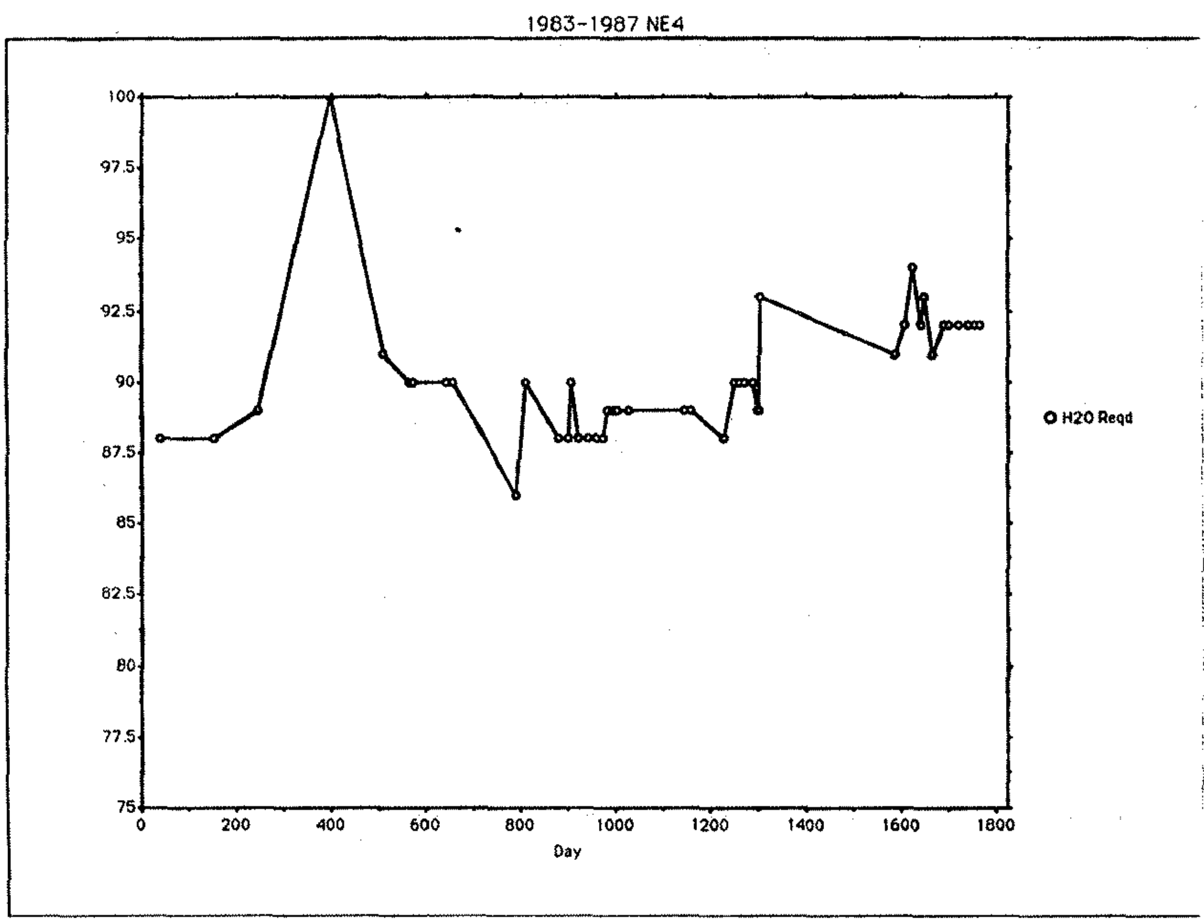

Figure 58, Appendix C

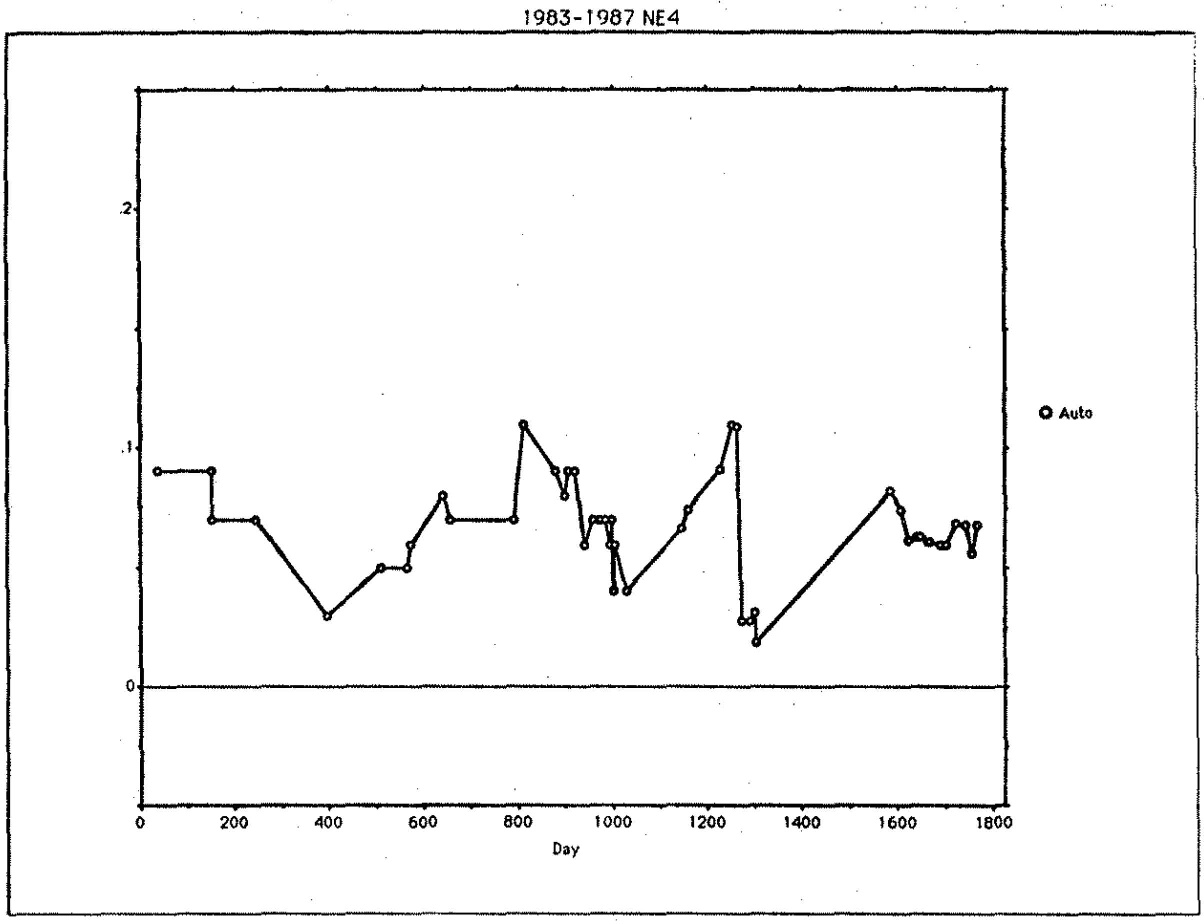

Figure 59, Appendix C

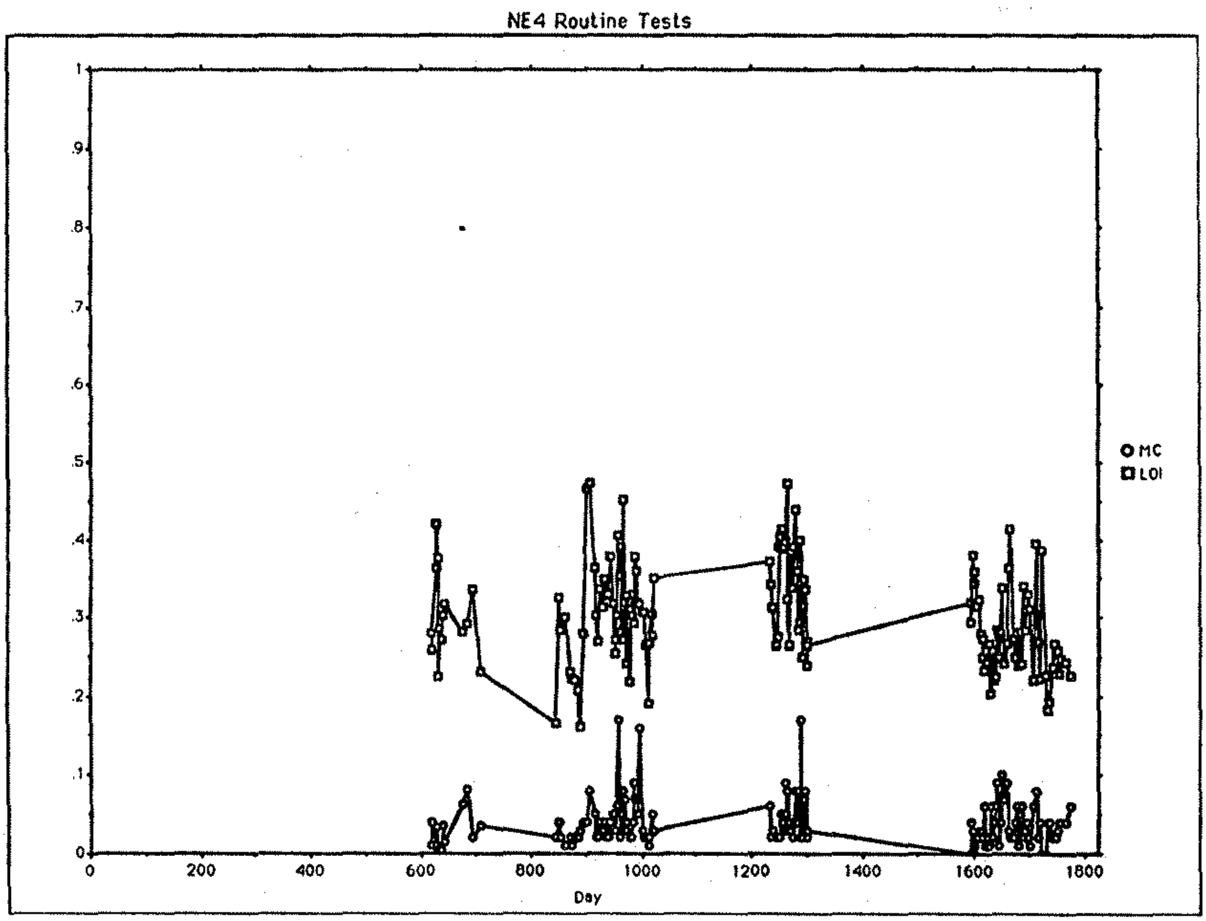

Figure 60, Appendix C

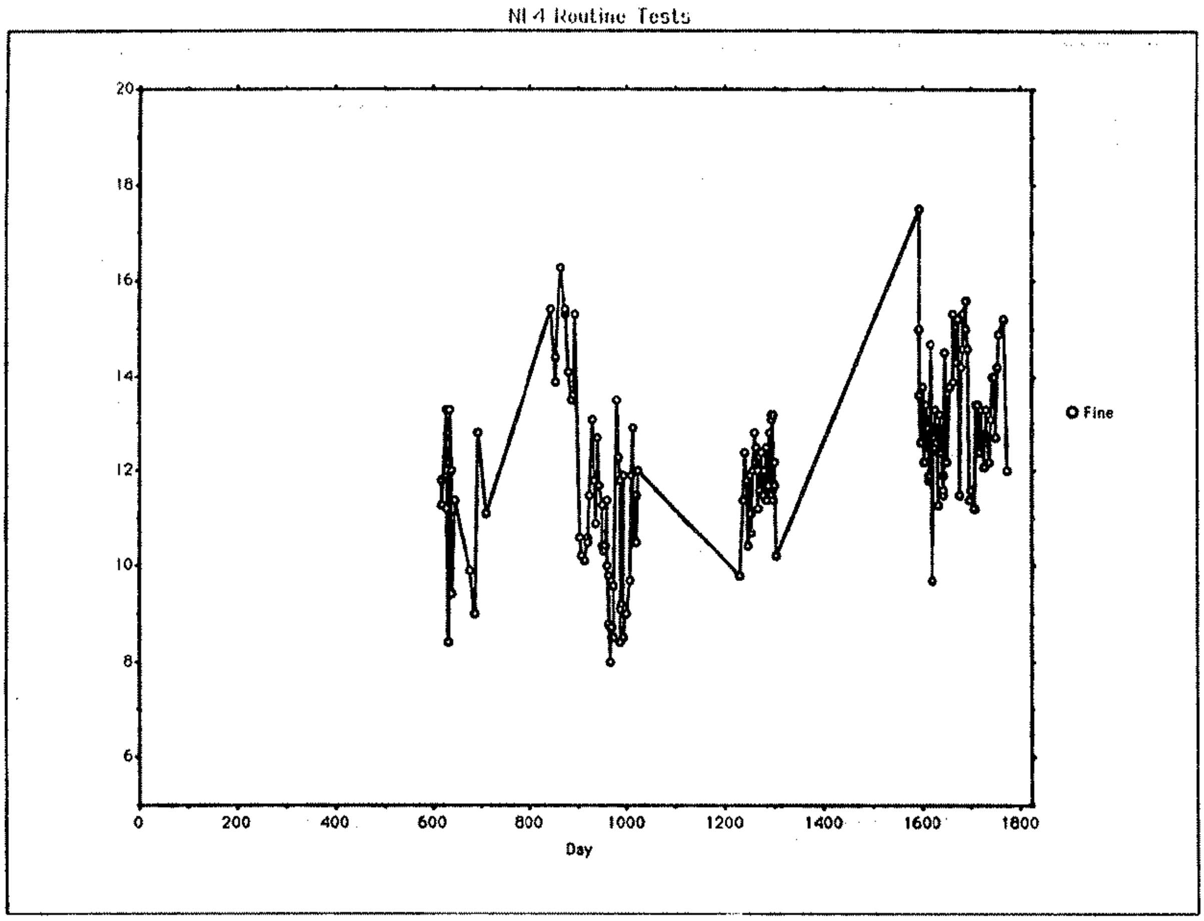

Figure 61, Appendix C

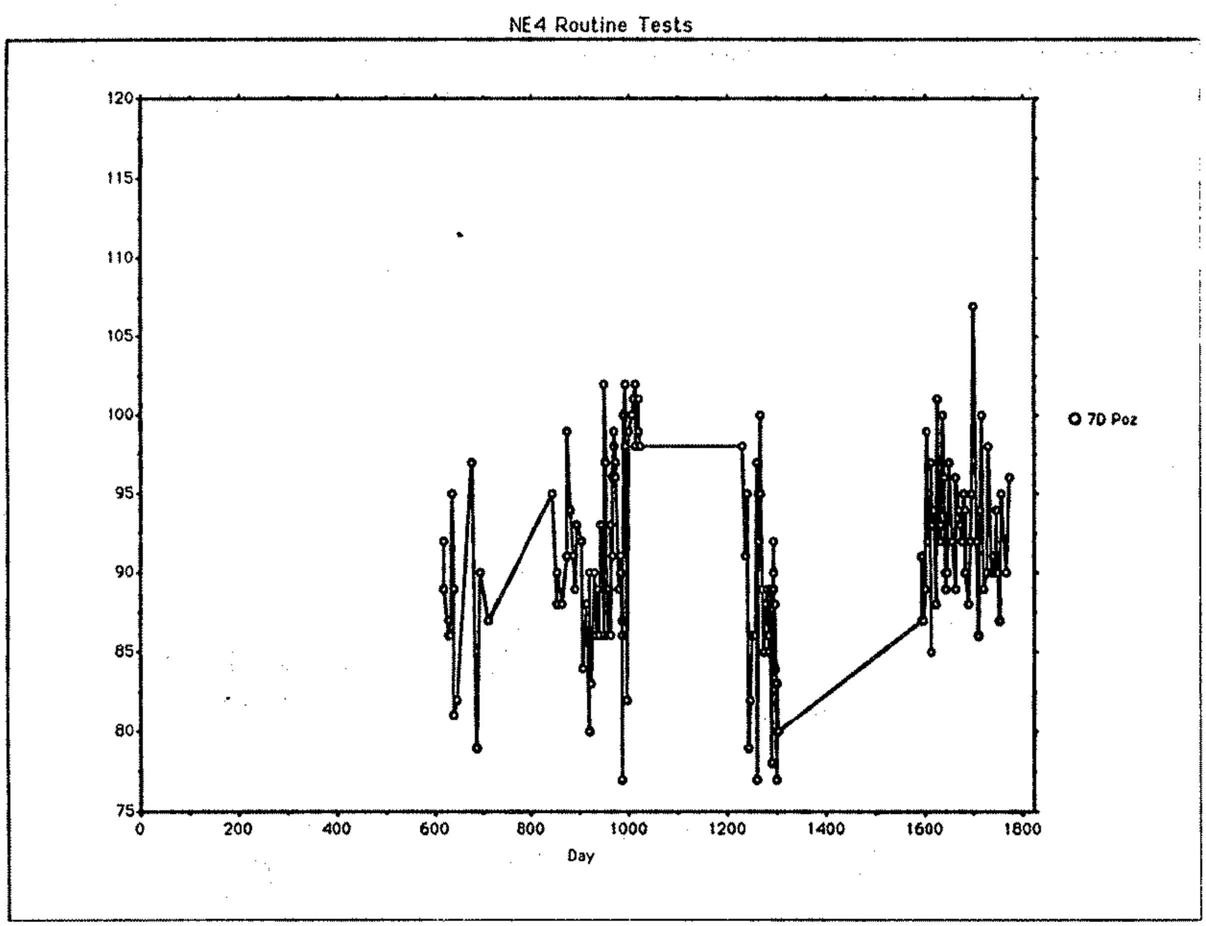

Figure 62, Appendix C

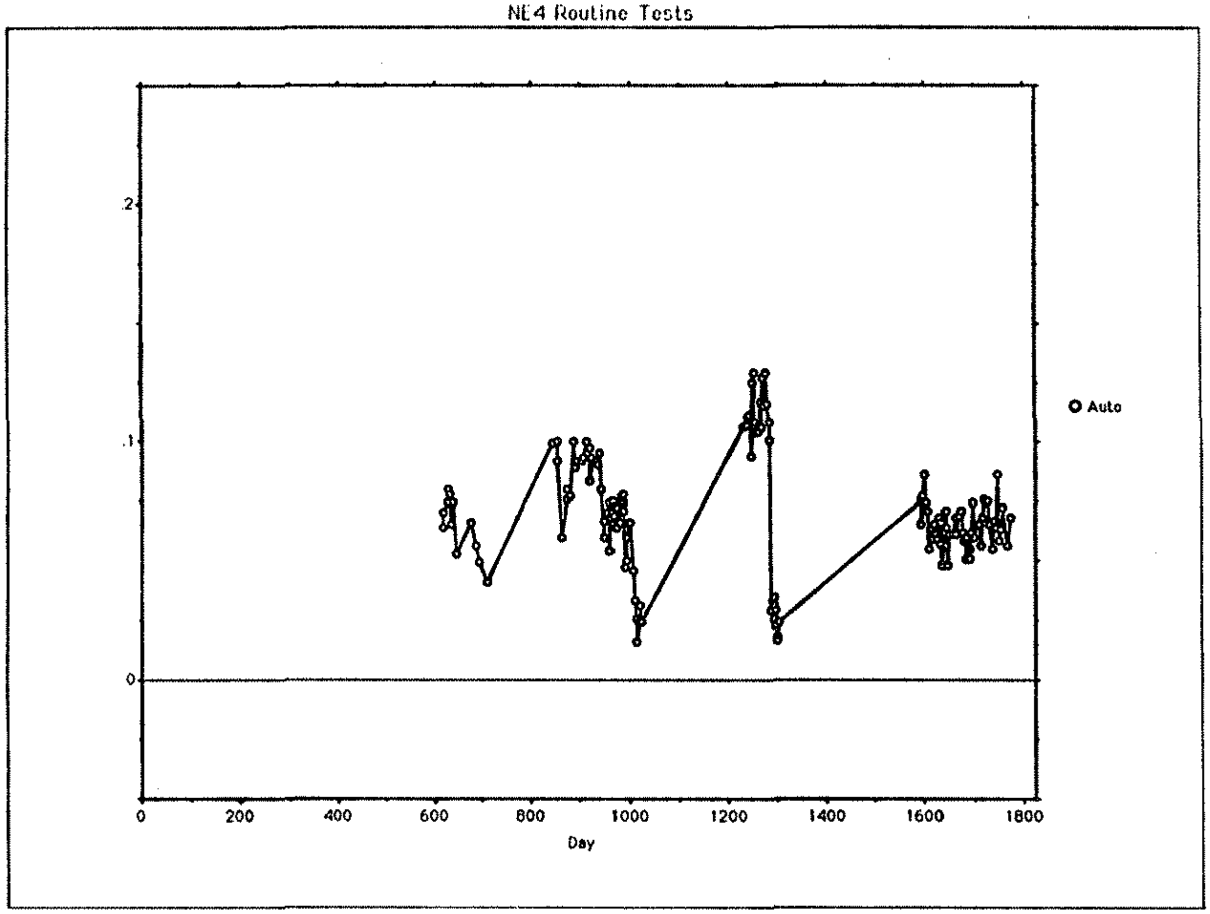

Figure 63, Appendix C

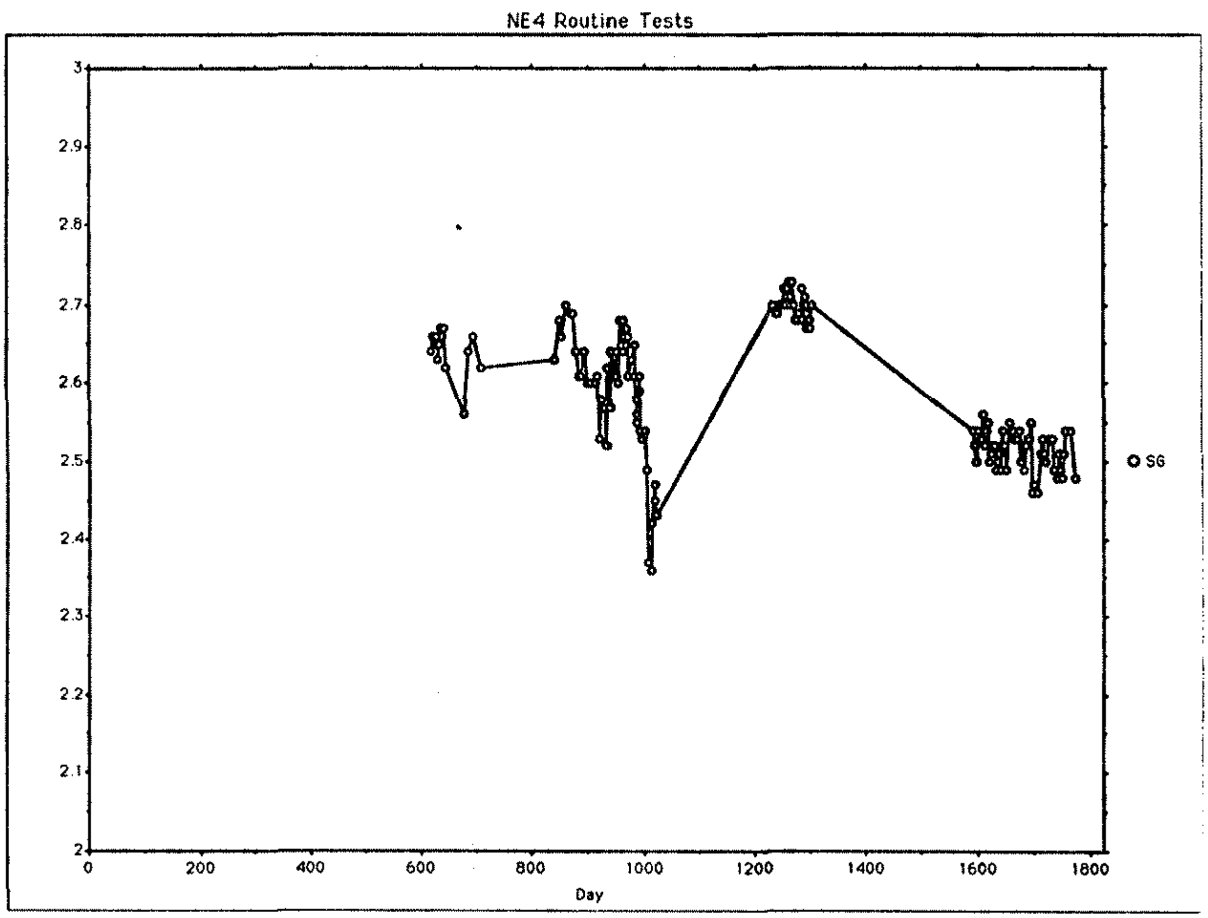

Figure 64, Appendix C

Table I, Appendix D
Paste Test Data

Table I, Appendix D

Sample Name	Day No. (1/1/83)	4 hour	1 day	3 day	7 day	14 day	28 day	56 day	%exp air	%exp humid	Initial set	Final set	Onset time	Final time	ΔTemp	Peak Temp
OTT011385	0744	336	613	646	770	928	955	•	-0.026	-0.009	21.0	37.0		49.5	3.8	27.8
OTT022085	0782	392	614	656	823	891	1126	•	-0.034	-0.010	21.0	44.0		74.0	3.8	26.8
OTT022585	0787	448	550	584	700	890	950	•	-0.013	-0.043	12.0	18.5		57.0	7.5	29.8
OTT031585	0805	490	695	772	801	773	862	•	-0.003	-0.014	18.0	41.0		75.0	4.5	28.5
OTT032685	0816	176	282	351	360	448	578	•	-0.026	0.007	27.0	37.0		38.0	4.9	29.9
CBF040285	0823	1271	1521	•	1735	1436	•	•	•	•	•	•		•	•	•
OTT040385	0824	411	339	478	634	674	671	•	0.118	0.001	9.0	25.0		32.0	5.9	28.9
OTT041085	0831	290	376	499	481	557	665	•	-0.037	0.004	11.0	24.0		38.0	5.8	28.4
OTT041285	0833	305	315	417	591	751	689	•	-0.027	-0.007	16.0	33.0		43.0	5.1	29.1
OTT041685	0837	82	410	502	314	477	579	•	-0.029	•	36.0	107.0		82.5	3.9	27.5
OTT041985	0840	429	554	512	648	547	752	•	-0.029	-0.003	12.0	25.0		36.0	5.5	28.5
OTT042485	0845	218	393	529	490	518	467	•	0.049	-0.001	22.0	32.0		36.0	3.8	25.8
CBF042585	0846	978	1362	•	2127	2085	3089	•	-0.033	0.009	7.0	12.0		46.5	10.6	32.6
LAN043085	0851	2514	3158	2697	3742	3689	4159	•	-0.055	0.014	6.0	11.0		24.0	14.8	37.8
OTT050185	0852	223	301	•	703	906	892	•	-0.013	-0.014	31.0	40.0		44.0	3.5	26.0
OTT050285	0853	119	186	1060	2078	2186	2692	•	•	•	18.0	33.0		33.0	3.1	25.5
OTT050385	0854	151	247	479	834	785	1079	•	-0.009	•	26.0	39.0		51.0	3.2	25.7
OTT050785	0858	333	530	1002	2677	3301	3312	•	-0.080	0.026	34.0	47.0		52.0	4.4	25.9
OTT050885	0859	325	520	1016	3250	2725	2778	•	-0.029	-0.016	32.0	41.0		57.0	5.6	28.6
CBF051085	0861	1053	1153	•	1167	1192	921	•	-0.029	-0.010	9.0	16.0		53.0	8.8	29.8
OTT051085	0861	•	2375	3047	3267	4417	3990	•	•	0.024	20.0	32.0		41.0	5.4	28.9
LAN051385	0864	2682	3696	5228	4359	6250	6861	•	-0.106	0.036	2.0	8.0		•	•	•
OTT051485	0865	366	1633	3082	4721	4054	5081	•	-0.034	0.053	32.0	36.0		42.0	6.0	29.0
OTT051685	0867	357	1359	3411	4126	2417	6038	•	-0.086	0.060	25.0	30.0		52.0	4.4	25.9
OTT052085	0871	341	1438	2600	4198	5190	4875	•	•	0.013	29.0	33.0		40.0	5.3	28.8
OTT052185	0872	364	1319	3123	3157	2824	4485	•	-0.071	0.026	25.0	28.0		37.0	6.3	28.5
OTT052385	0874	385	1596	3881	3519	4648	5448	•	-0.084	0.094	22.0	27.0		29.0	6.8	29.3
CBF052485	0875	748	765	•	1010	1011	1025	•	-0.031	-0.013	12.0	17.0		31.0	7.8	28.8
OTT052885	0879	388	798	2245	2979	3017	3116	•	-0.141	0.012	26.0	31.0		36.0	6.0	30.0
OTT053085	0881	366	974	2470	2550	2507	2856	•	•	•	22.0	26.0		32.5	6.9	32.5
OTT060185	0883	396	889	1505	1886	4434	4219	•	-0.078	0.040	26.0	34.0		32.0	5.5	28.0
CBF060785	0889	707	1084	•	1230	1337	1182	•	-0.035	-0.020	11.0	17.0		25.0	9.0	31.5
OTT060785	0889	353	2017	3285	3897	5221	5273	•	-0.057	0.069	8.0	13.0		27.0	6.1	30.0
OTT061085	0892	247	330	742	1394	2718	2486	•	-0.050	0.013	24.0	34.0		38.0	4.1	26.1
OTT061285	0894	208	•	1409	1761	1875	2870	•	-0.046	0.000	23.0	28.0		30.0	5.0	27.0
CBF061385	0895	693	1154	•	1551	1584	1660	•	-0.040	-0.031	•	•		•	•	•
OTT061785	0899	305	1462	2630	3135	3530	3900	•	-0.055	0.036	11.0	13.0		36.0	6.0	28.5
LAN061985	0901	2239	3262	3477	4281	3704	4949	•	-0.047	0.015	6.0	9.0		24.0	14.8	38.3
OTT061985	0901	302	984	2172	3102	2577	4300	•	-0.048	0.021	8.0	12.0		41.0	5.5	28.5
CBF062585	0907	853	1467	•	5669	3599	6681	•	-0.045	0.009	10.0	14.0		25.8	8.5	31.5
LAN062585	0907	1973	3571	2994	3472	3941	4700	•	-0.039	0.029	•	•		•	•	•
OTT062585	0907	414	656	1107	1181	1453	1667	•	-0.046	-0.010	26.0	42.0		58.0	6.5	28.5
OTT062885	0910	430	419	957	1760	3425	3221	•	•	•	11.0	16.0		20.0	5.9	28.9
CBF070185	0913	530	580	•	820	•	1209	•	-0.009	-0.006	5.0	14.0		•	•	•
OTT070185	0913	407	523	863	1527	2657	2944	•	-0.017	0.016	10.0	14.0		22.0	6.0	27.7
LAN070685	0918	1357	2417	2520	2457	2795	3312	•	-0.030	-0.001	9.0	11.0		•	•	•
CBF070885	0920	805	1208	•	1659	1689	1940	•	-0.029	-0.017	•	•		•	•	•
OTT070885	0920	613	1065	1863	2770	2627	3592	•	-0.037	0.001	10.0	14.0		56.0	7.0	29.0

Table I, Appendix D

Sample Name	Day No. (1/1/83)	4 hour	1 day	3 day	7 day	14 day	28 day	56 day	%exp air	%exp humid	Initial set	Final set	Onset time	Final time	ΔTemp	Peak Temp
OTT071285	0924	491	825	1169	1135	1377	1709	•	-0.047	-0.021	36.0	57.0		67.0	6.3	28.8
LAN071385	0925	2206	2662	3490	3934	4247	5623	•	-0.046	0.003	•	•		17.0	14.3	38.3
OTT071985	0931	538	798	1170	1310	1449	1105	•	-0.040	-0.021	•	•		40.0	7.2	29.8
LAN072085	0932	2246	4106	4959	5316	5496	5752	•	-0.052	0.096	•	•		•	•	•
CBF072385	0935	1034	1173	•	1265	1182	1724	•	-0.026	-0.020	7.0	11.0		44.0	8.5	31.5
OTT072685	0938	460	674	958	985	911	1316	•	-0.033	-0.010	31.0	51.0		65.0	4.5	26.5
LAN072785	0939	1843	3002	3474	3808	3449	4909	•	-0.050	0.021	6.0	9.0		22.0	17.8	40.8
CBF072985	0941	1193	1142	•	1379	1559	1426	•	-0.040	-0.028	11.0	19.0		44.0	7.8	28.3
OTT080185	0944	381	469	670	798	973	1120	•	-0.038	-0.008	17.0	21.0		30.0	5.6	30.8
LAN080285	0945	2300	4235	3584	5229	6737	7130	•	-0.104	0.033	4.0	6.0		•	•	•
OTT080585	0948	357	643	905	711	952	1106	•	-0.038	-0.017	31.0	50.0		60.0	6.6	28.1
CBF080685	0949	1146	1255	1473	1519	1625	1878	•	-0.063	-0.019	4.0	11.0		•	•	•
OTT080985	0952	390	690	1153	1244	1288	1709	•	-0.056	-0.021	24.0	27.0		40.0	5.0	28.3
LAN081085	0953	1297	1506	1624	2373	1771	1940	•	•	•	7.0	11.0		40.0	12.3	34.3
OTT081285	0955	270	718	1291	1424	1211	1875	•	-0.040	-0.005	31.0	39.0		43.0	5.3	26.5
OTT081585	0958	348	342	692	896	890	1041	•	-0.054	-0.006	19.0	25.0		35.0	6.3	28.8
OTT082085	0963	428	581	701	1047	1003	1020	•	-0.033	-0.005	•	•		37.0	5.0	29.0
LAN082485	0967	2396	3462	4123	4567	5196	6204	•	-0.068	0.050	5.0	9.5		•	•	•
OTT082685	0969	432	•	1249	1679	1189	1894	•	-0.043	-0.019	21.0	32.0		48.0	7.4	29.4
CBF082785	0970	734	1232	1728	2030	2221	2502	•	-0.049	-0.014	10.0	16.0		29.0	11.0	34.0
OTT083085	0973	442	538	693	1019	965	1021	•	-0.067	-0.017	25.0	42.0		63.5	6.5	27.5
OTT090585	0979	577	•	1052	1048	1539	1438	•	-0.041	-0.020	28.0	43.0		70.0	6.8	28.5
CBF090685	0980	475	759	1128	1298	1293	1910	•	-0.041	-0.021	14.0	26.0		42.0	8.5	30.5
CBF091185	0985	1122	1538	1484	2083	3300	4716	•	-0.063	-0.004	12.0	17.0		36.0	10.5	32.5
OTT091285	0986	574	645	1038	1061	1229	1493	•	-0.062	-0.008	20.0	28.0		•	•	•
CBF091685	0990	1057	1407	1737	2324	3883	4542	•	-0.061	0.003	12.0	18.0		48.0	10.5	32.5
CBF092085	0994	1114	964	1240	1388	1893	2327	•	-0.030	0.009	10.0	20.0		58.0	10.3	31.3
OTT092085	0994	492	•	900	789	1156	1041	•	-0.034	-0.008	16.0	23.0		31.0	8.3	30.3
LAN092185	0995	1684	2251	2784	3814	3612	4391	•	-0.043	0.015	10.0	13.0		26.0	12.5	34.5
OTT092585	0999	333	•	672	698	1259	1328	•	-0.060	-0.023	23.0	39.0		51.0	5.0	27.8
CBF093085	1004	802	1118	•	1442	1434	2308	•	-0.030	-0.023	13.0	19.0		37.0	10.5	32.5
OTT100485	1008	302	•	808	704	1025	1077	•	-0.048	-0.018	18.0	52.0		59.0	4.0	26.0
OTT100885	1012	494	538	689	1205	1382	1128	•	-0.053	-0.015	15.0	42.0		71.0	4.5	26.6
CBF101185	1015	870	1062	•	1477	2086	3239	•	-0.046	-0.018	16.0	21.0		34.0	12.0	34.0
LAN101185	1015	78	316	706	792	772	787	•	•	•	7.0	50.0		28.0	4.3	25.8
OTT101285	1016	356	567	641	1013	1332	1067	•	-0.053	-0.033	19.0	29.0		55.0	5.0	26.0
OTT101785	1021	301	416	699	896	860	1047	•	-0.062	-0.012	14.0	27.0		55.0	3.9	24.9
OTT102285	1026	232	387	791	829	966	1224	•	-0.050	-0.014	19.0	31.0		48.0	4.9	27.4
OTT102885	• 1032	226	280	586	642	805	920	•	-0.020	0.011	13.0	52.0		22.0	5.5	28.5
OTT110485	1039	216	342	638	792	867	•	•	-0.034	-0.016	14.0	29.0		29.0	5.0	27.4
OTT112285	1057	205	416	284	546	495	607	•	-0.007	-0.003	12.0	23.0		46.0	2.8	25.3
CBF021986	1146	1555	1878	2981	4330	5325	5918	•	0.008	0.309	6.0	8.0		17.0	17.0	41.5
LAN030786	1162	1118	1374	•	2942	2526	2731	•	•	0.019	8.0	15.0		•	•	•
OTT031386	1168	217	230	•	438	566	605	•	-0.021	-0.015	19.0	26.0		30.5	5.8	30.8
OTT040386	1189	215	296	•	487	597	595	•	-0.023	-0.014	20.0	26.0		43.0	5.6	30.1
LAN040786	1193	1596	1622	•	2574	3956	4050	•	-0.018	0.066	•	•		20.5	16.6	39.6
OTT041286	1198	210	329	317	357	363	525	•	-0.013	0.005	24.0	42.0		39.0	6.6	28.6
CBF041886	1204	887	1567	3602	4672	4699	5361	•	-0.013	0.134	5.0	7.0		13.0	11.3	35.8
OTT042186	1207	285	539	480	548	653	756	•	-0.017	-0.005	13.0	23.0		40.0	7.5	29.5
LAN042586	1211	1647	1727	•	2418	3543	3959	•	-0.027	-0.013	•	•		56.5	12.1	35.1

Table I, Appendix D (continued)

Table I, Appendix D

Sample Name	Day No. (1/1/83)	4 hour	1 day	3 day	7 day	14 day	28 day	56 day	%exp air	%exp humid	Initial set	Final set	Onset time	Final time	ΔTemp	Peak Temp
LAN081186	1319	•	3199	•	•	•	6935	•	-0.099	0.099	13.0	15.0		22.5	15.9	37.9
OTT081186	1319	189	588	•	644	951	•	•	•	•	32.0	47.0		48.0	4.0	26.0
CBF081286	1320	1802	1937	•	2866	5046	5631	6933	-0.030	0.075	16.5	18.5		31.0	16.1	40.6
OTT081486	1322	•	374	•	575	430	571	•	-0.040	-0.004	50.0	60.0		69.0	2.5	27.0
LAN081886	1326	1743	2462	•	3115	4254	5035	4207	-0.074	0.074	9.5	12.0		25.0	14.9	39.9
OTT081886	1326	•	400	•	490	542	604	•	•	-0.007	44.0	55.0		59.0	2.2	25.7
CBF081986	1327	1913	2328	•	2863	4534	6406	5805	•	•	16.0	18.5		32.0	13.5	39.5
CBF082286	1330	1930	2490	•	2881	3957	4301	5225	•	•	13.0	14.5		23.0	15.0	41.0
OTT082286	1330	•	367	•	505	785	827	•	-0.040	-0.003	31.0	38.0		•	•	•
LAN082586	1333	2401	3155	•	5354	4778	6551	5753	-0.095	0.073	13.0	17.0		27.0	16.5	41.0
CBF082686	1334	1671	1752	•	2455	•	3811	4530	-0.043	0.032	15.0	16.0		29.0	11.5	36.5
OTT082886	1336	•	312	•	588	742	727	•	•	•	34.0	41.0		52.5	3.6	27.6
CBF082986	1337	1517	1653	•	1974	•	3708	4388	-0.055	0.054	13.0	15.0		27.0	12.8	38.8
OTT090286	1341	•	481	•	851	809	906	•	-0.033	-0.002	17.0	21.0		30.0	5.9	27.9
CBF090486	1343	1138	1436	•	1900	1992	3688	4509	-0.042	0.109	•	11.0		31.0	11.0	36.5
CBF090586	1344	984	1011	•	1671	1597	2256	4177	-0.052	•	11.5	13.8		31.0	9.8	34.8
CBF090686	1345	812	868	•	1564	1761	2159	3402	-0.076	0.079	18.8	20.8		31.0	10.5	35.5
OTT090686	1345	•	300	•	487	516	631	•	•	0.002	25.0	32.0		42.5	4.5	26.5
CBF090886	1347	962	1066	•	1768	1858	2825	3626	-0.043	0.015	13.0	15.0		41.0	8.2	33.7
LAN090886	1347	1567	2073	•	2899	3761	4253	4319	-0.084	-0.010	8.0	9.0		25.0	15.0	41.0
OTT090986	1348	•	501	•	603	568	720	•	-0.040	0.009	25.0	33.0		44.0	5.3	27.3
CBF091086	1349	1068	1617	•	1985	2325	4001	3666	•	0.057	11.7	13.2		29.0	11.7	37.7
OTT091586	1354	•	469	•	699	838	885	•	-0.051	-0.012	29.0	36.0		40.0	4.0	26.0
CBF091686	1355	1143	•	•	2221	3193	4010	4332	-0.051	0.056	10.5	12.5		28.0	10.2	36.7
OTT091986	1358	•	540	•	688	888	737	•	-0.029	-0.003	23.0	29.0		38.0	5.1	28.1
LAN092386	1362	1787	2249	•	3445	4657	4461	4827	-0.111	0.158	5.6	7.0		35.0	12.0	37.0
OTT092486	1363	•	423	•	614	890	775	•	-0.035	0.000	22.0	30.0		32.0	5.6	27.6
LAN092986	1368	1780	1525	•	2001	2828	3197	3936	-0.124	-0.007	5.0	6.5		44.0	12.7	37.7
OTT092986	1368	•	512	•	599	605	905	•	-0.028	0.001	20.0	26.0		•	•	•
LAN100686	1375	2319	3159	•	4063	5429	4565	5552	-0.109	0.073	10.7	12.2		23.0	19.0	43.5
OTT100686	1375	•	349	•	•	608	722	•	-0.030	0.003	20.8	26.0		22.5	6.4	27.4
OTT101086	1379	•	463	•	560	717	747	•	-0.037	0.025	36.0	52.0		70.0	3.5	24.5
LAN101586	1384	1890	2265	•	2773	4061	4761	4749	-0.070	0.089	12.3	13.3		21.0	17.3	42.3
OTT101786	1386	•	289	•	452	464	504	•	-0.026	0.010	33.0	43.0		33.0	5.0	27.0
LAN102286	1391	1575	2281	•	3228	3402	4042	3228	-0.064	0.028	10.0	12.0		33.0	11.8	36.8
OTT102386	1392	•	509	•	755	603	895	•	-0.015	0.006	18.0	25.0		29.0	4.3	26.3
LAN102786	1396	1929	2515	•	4067	4397	5127	4496	-0.051	0.043	8.0	9.5		25.0	15.3	42.3
OTT103186	1400	•	489	•	641	640	962	•	-0.013	-0.003	15.0	22.0		•	•	•
LAN110386	1403	1749	1965	•	3534	4674	4800	4344	-0.069	0.094	8.0	9.0		22.0	14.2	40.7
OTT111086	1410	•	467	•	2219	•	2688	•	•	0.133	19.0	24.0		29.0	2.8	25.8
CBF120886	1438	1284	1602	•	3514	4732	6102	4896	-0.053	0.060	6.0	7.2		29.0	10.7	36.7
OTT121586	1445	•	2467	•	2827	•	4526	•	-0.028	0.123	12.0	14.0		20.0	4.7	27.2
OTT011587	1476	402	605		692	899	696	637	-0.038	-0.004	12.0	17.0		34.0	4.8	30.8
OTT021587	1507	293	452		671	644	639	753	-0.037	-0.014	15.0	22.0		39.0	4.8	29.8
OTT031687	1536	305	541		645	659	560	515	-0.029	-0.009	13.0	18.0		34.0	4.6	29.6
OTT040287	1553	298	416		489	538	359	459		0.007	10.0	17.0		36.0	3.7	28.7
OTT040887	1559	306	361		560	553	422	485	-0.025	0.014	9.0	19.0		32.0	5.5	30.5
OTT041587	1566	250	542		721	709	646	514	-0.045	0.008	9.0	36.0		17.0	3.0	27.0
OTT041787	1568	301	546		691	658	690	625	-0.041	0.019	10.0	31.0		33.0	4.8	28.8
LAN042087	1571	2610	4232		5587	5184	6638	6681	-0.060	0.007	6.0	8.5				

Table I, Appendix D

Sample Name	Day No. (1/1/83)	4 hour	1 day	3 day	7 day	14 day	28 day	56 day	%exp air	%exp humid	Initial set	Final set	Onset time	Final time	ΔTemp	Peak Temp
OTT042886	1214	278	326	339	376	510	439	•	-0.011	-0.001	12.0	22.0		44.0	5.8	28.3
CBF043086	1216	914	1265	1586	2901	4829	5238	•	-0.024	0.112	7.0	8.0		17.0	12.5	36.5
OTT050186	1217	412	715	880	959	1056	1229	•	-0.034	-0.021	24.0	35.0		58.0	6.9	28.9
CBF050686	1222	1130	1709	•	2528	3438	3838	•	-0.020	0.039	8.0	10.0		17.0	16.0	39.0
OTT050786	1223	273	449	•	767	969	1176	•	-0.037	-0.016	28.0	34.0		44.0	4.4	26.4
CBF050986	1225	1715	2154	•	3626	5162	3732	•	-0.032	0.075	7.0	9.0		19.0	17.8	40.8
OTT050986	1225	201	598	•	2497	2298	2728	•	-0.024	0.017	14.0	19.0		22.0	5.0	27.5
OTT051386	1229	283	605	•	1168	1244	1791	•	-0.033	-0.007	23.0	27.0		34.0	5.8	26.8
OTT051686	1232	203	423	•	1897	1723	2026	•	-0.022	0.003	13.0	19.0		23.0	5.3	28.3
CBF051986	1235	2057	2597	•	3262	4625	4908	•	-0.043	0.039	7.0	9.0		19.0	14.8	36.8
LAN052086	1236	1979	2368	•	3916	5018	4967	•	-0.039	0.050	5.0	7.0		25.0	15.0	38.0
OTT052186	1237	176	321	751	1088	1357	1655	•	-0.024	-0.002	17.0	25.0		26.0	4.4	27.4
OTT052386	1239	87	191	514	966	1342	1213	•	-0.015	0.001	27.0	39.0		30.0	3.5	27.0
CBF052786	1243	1245	2624	•	4158	5036	5943	•	-0.066	0.027	8.0	10.0		19.0	10.5	32.0
OTT052886	1244	212	348	775	1481	1483	2061	•	-0.025	-0.002	17.0	22.0		23.5	4.5	27.5
CBF053086	1246	998	1929	1524	2958	3943	4487	•	-0.035	0.097	•	•		19.5	13.2	35.2
OTT053186	1247	274	415	•	881	1058	1333	•	-0.048	-0.019	20.0	29.0		38.0	4.3	28.3
OTT060486	1251	229	360	414	569	741	858	•	-0.035	-0.005	17.0	23.0		24.0	5.0	29.0
CBF060586	1252	937	1398	•	4139	4737	6086	•	-0.032	0.173	8.0	9.0		17.0	12.3	35.3
OTT060686	1253	241	325	426	689	536	827	•	-0.026	-0.013	28.0	36.0		41.0	5.0	29.0
CBF060986	1256	998	1354	•	4239	4768	6056	•	-0.047	0.107	10.0	11.0		20.0	10.0	33.0
OTT061286	1259	258	319	761	1759	1783	1898	•	-0.011	-0.009	11.0	28.0		37.0	3.8	26.8
OTT061386	1260	132	266	242	417	442	521	•	•	-0.001	34.0	77.0		75.0	3.8	27.8
CBF061686	1263	867	1392	•	2035	3569	4991	•	-0.047	0.026	9.0	12.0		20.0	11.8	37.8
OTT061786	1264	216	262	•	395	510	587	•	-0.013	-0.004	13.0	25.0		37.0	4.0	27.0
OTT061986	1266	351	426	400	571	644	664	•	-0.021	-0.006	15.0	26.0		35.0	6.3	32.3
CBF062386	1270	1065	1563	1952	3124	3742	3717	•	-0.082	0.004	8.0	10.0		19.0	9.5	34.5
OTT062386	1270	357	525	575	698	1032	812	•	-0.031	-0.021	21.0	33.0		48.0	6.0	31.5
OTT062486	1271	342	557	688	1035	1082	1328	•	•	-0.003	22.0	37.0		48.0	6.3	31.3
CBF062686	1273	811	1447	1591	1712	2767	3435	•	-0.089	-0.004	8.0	10.0		20.0	9.8	34.3
OTT062686	1273	357	490	697	1034	1172	1331	•	-0.035	-0.029	22.0	34.0		52.0	6.5	30.5
CBF070186	1278	1174	1701	1821	2452	2809	3713	•	-0.092	0.038	7.0	10.0		18.0	8.8	33.8
OTT070186	1278	398	751	696	991	908	1298	•	-0.031	-0.022	22.0	40.0		58.0	4.5	29.5
LAN070286	1279	2010	4123	4048	5340	4451	5596	•	-0.067	0.042	6.0	7.0		18.0	16.5	42.0
OTT070386	1280	349	605	619	899	796	744	•	-0.030	-0.018	18.0	29.0		48.0	6.4	31.4
OTT070786	1284	462	524	569	608	662	625	•	•	-0.008	12.0	27.0		46.0	5.9	30.9
CBF071086	1287	1057	1845	•	3443	3809	4897	3938	-0.068	-0.025	11.5	12.5		21.0	8.5	33.5
OTT071086	1287	329	465	440	571	677	520	•	-0.021	-0.008	12.0	22.0		39.0	5.1	29.1
LAN071486	1291	1707	2696	3106	3238	3097	5576	•	-0.064	0.095	7.0	8.0		18.0	15.8	40.8
OTT071686	1293	289	384	472	574	629	546	•	-0.025	-0.010	18.0	27.0		47.0	4.8	29.8
CBF071886	1295	1013	1624	•	2299	3305	3951	4706	-0.099	0.014	16.5	19.0		31.0	9.2	33.2
OTT072186	1298	315	455	482	535	685	928	•	-0.014	0.003	14.0	22.0		32.0	6.3	31.3
CBF072486	1301	1325	1452	•	2308	2649	5526	6398	-0.081	0.048	16.7	20.2		33.5	14.0	39.0
OTT072486	1301	•	450	550	732	682	695	•	-0.043	-0.003	15.0	21.0		36.0	5.8	28.8
LAN073086	1307	•	•	•	•	•	7536	•	-0.111	0.072	10.0	13.0		22.0	16.6	38.6
OTT073186	1308	340	453	•	642	770	717	•	•	•	23.0	29.0		•	•	•
CBF080186	1309	1411	1642	•	2357	3709	4677	5543	-0.078	0.087	18.5	21.5		31.0	14.7	39.7
OTT080486	1312	•	•	•	703	707	800	•	-0.046	-0.033	29.0	37.0		•	•	•
OTT080786	1315	300	•	•	632	772	•	•	•	•	37.0	50.0		61.0	3.6	26.6
CBF080886	1316	1788	1808	•	2862	4220	4819	5642	-0.034	0.090	18.0	20.5		35.5	16.2	41.7

Table I, Appendix D (continued)

Table I, Appendix D

Sample Name	Day No. (1/1/83)	4 hour	1 day	3 day	7 day	14 day	28 day	56 day	%exp air	%exp humid	Initial set	Final set	Onset time	Final time	ΔTemp	Peak Temp
OGS092587	1729	328	406		670	762	738	807	-0.037	-0.007	10.0	14.0	21.0	26.0	4.5	27.5
LGS092687	1730	829	1625		3458	3559	4701	4832		0.000	12.0	19.0	14.0	47.0	5.2	29.2
OGS100687	1740	33	173		347	265	240	532	-0.026	-0.005	94.0	178.0	9.0	15.0	0.5	22.5
OGS100787	1741										97.0	198.0	6.0	12.0	0.3	22.8
OGS100887	1742	237	360		613	1577	2277	2591	-0.034		23.0	27.0	19.0	42.0	3.0	26.0
OGS100987	1743	199	298		1793	1996	2169	3342	-0.029		35.0	41.0	9.0	20.0	0.5	23.5
OGS101287	1746	207	621		2273	2508	2030	2991	-0.035		11.0	15.0	7.0	14.0	1.3	24.8
LAN102387	1757	1403	1560		2267	2563	2790	3772	-0.079	0.069	9.5	10.5	24.0	28.0	12.0	34.5
LGS103087	1764	280	1103		2242	2834	3239	3752	-0.061	0.128	6.0	8.0	9.0	18.0	3.8	27.3
LGS110187	1766	300	646		1985	1593	2944	3288		0.088	7.0	11.0	14.0	19.0	3.5	26.5
LGS110387	1768	259	862		2767	1940	3526	3853		0.111	7.0	10.0	15.0	20.0	3.4	26.4
LGS110587	1770	230	832		2738	1817	3253	3471		0.107	9.0	14.0	25.0	21.0	2.3	25.3
OTT111687	1781	218	417		1786	1600	1930	2229		0.050	11.0			22.0	3.1	27.1
OTT112587	1790		357		514	571	790	1193			49.0			23.0	0.6	24.6
OTT121587	1810	275	420		2006	2731	3382	4022	-0.032	0.006	12.0	19.0		23.0	4.3	27.3
LAN121887	1813	1402	1282		1910	2213	2272	3024	-0.066	0.027	4.0	5.5	28.0	36.0	9.0	31.5
Samples	264	239	253	106	260	256	259	98	216	236	250	249	40	242	242	241
Min	0744	33	112	242	132	173	148	156	-0.186	-0.043	2.0	4.5	6.0	11.0	0.3	22.5
Max	1813	2824	5074	5228	6869	8196	8180	9335	0.118	0.309	97.0	198.0	40.0	82.5	19.0	43.5
Range	1069	2791	4962	4986	6737	8023	8032	9179	0.304	0.352	95.0	193.5	34.0	71.5	18.7	21.0
Average	1273	782	1152	1457	1926	2211	2620	3329	-0.050	0.021	16.5	24.8	18.0	35.1	7.2	30.6
St Deviation	0303	687	1009	1164	1501	1742	2024	2409	0.037	0.046	11.4	20.1	8.5	13.8	4.1	4.6

Table I, Appendix D

Sample Name	Day No. (1/1/83)	4 hour	1 day	3 day	7 day	14 day	28 day	56 day	%exp air	%exp humid	Initial set	Final set	Onset time	Final time	ΔTemp	Peak Temp
OTT042187	1572	63	112		132	173	148	156			21.0	32.0		38.0	5.0	30.0
OTT042487	1575	423	557		689	592	558	643	-0.037	0.019	8.0	16.0		28.0	5.5	28.5
OTT042887	1579	505	674		710	844	676	943	-0.032	0.102	8.0	24.0		29.0	4.8	29.8
LAN050487	1585	2824	3471		5474	6026	5827	7256	-0.150	0.015	8.0	10.0				
OTT050587	1586	306	425		575	465	467	653		0.026	14.0	27.0		24.0	4.5	28.5
OTT050887	1589	387	497		791	1009	862	1021	-0.042	-0.012	17.0	29.0		36.0	4.4	27.4
LAN051087	1591	2494	3823		6043	6555	6925	8323	-0.167	0.010	6.0	9.0				
LAN052687	1607	2489	4374		5524	6562	7600	9335	-0.156	0.009	9.0	11.5	26.0	31.0	10.2	33.2
LAN053187	1612	2423	4741		6078	8196	7348	8611	-0.141	0.019	9.5	12.0				
OTT060987	1621	152	202		321	343	479	406		0.003	14.0	22.0		19.0	2.8	25.8
OTT061187	1623	101	148		197	220	365	352	-0.017					11.0	1.0	25.0
OTT061587	1627	113	251		354	347	512	375	-0.021	0.004				25.0	3.2	26.7
OTT061787	1629	284	293		372	374	380	305		0.007	16.0	22.0		30.0	3.9	27.4
OTT062287	1634	246	370		443	412	477	349	-0.033	0.000	15.0	21.0		35.0	3.2	27.2
OTT062487	1636	310	511		785	736	1033	•	-0.065	-0.005	20.0	28.0		37.0	4.9	28.4
OTT062787	1639	235	518		565	561	625	•	-0.047	-0.013	27.0	33.0		44.0	3.3	27.3
LAN062987	1641	2561	3977		6533	6712	8180	7889	-0.135	-0.004	17.0	20.5	29.0	30.0	12.2	34.2
LAN070287	1644	2336	5074		6869	7801	8140	8884	-0.149	0.035	12.5	14.5	18.0	19.0	14.5	35.5
OTT070287	1644	269	370		894	830	902	1169	-0.070	-0.016	28.0	33.0		41.0	3.3	28.3
OGS070687	1650	280	423		914	970	1395	1483	-0.061	-0.017	23.0	27.0		25.0	4.5	29.5
LGS070987	1651	318	988		2517	2538	4289	3110			9.0	13.0	15.0	39.0	2.5	
LAN071387	1655	2415	3440		6400	6709	7802	8595	-0.156	0.041	14.5	18.0	15.0	17.0	10.5	32.5
LGS071587	1657	931	1417		3259	4108	3410	4196	-0.120	0.067	7.0	9.0	21.0	35.0	6.5	31.5
OGS071587	1657	399	793		1087	1571	1408	2076		-0.011	24.0	29.0		34.0	4.3	28.3
LGS072187	1663	476	1139		3737	3853	3202	3812	-0.122	0.056	10.0	12.0	23.0	35.0	4.8	29.8
OGS072287	1664	566	628		895	919	1112	1256	-0.048	0.009	10.0	14.0	20.0	28.0	6.8	29.8
LAN072887	1670	1587	2123		4687	4490	5484	6705	-0.140	0.069	13.0	14.0	17.0	20.0	10.5	33.0
LGS072987	1671	702	1796		2955	4094	3849	3900		0.098	7.0	10.0	13.0	37.0	4.0	28.5
OGS072987	1671	305	490		818	876	1014	1211	-0.036	-0.020	11.0	15.0		23.0	4.3	28.3
LAN080387	1676	2013	3074		5245	4962	5137	9056	-0.129	0.073	3.5	4.5	13.0	15.0	10.8	33.8
LGS080487	1677	624	1554		2105	4322	3897	4094		0.094	6.0	12.0	15.0	36.0	3.0	26.0
OGS080587	1678	364	512		779	893	806	972	-0.038	0.002	19.0	38.0		24.0	5.0	29.0
LGS081287	1685	232	368		1267	2348	2241	2364	-0.055	0.070	7.0	10.0	9.0	20.0	2.8	27.8
OGS081287	1685	249	363		520	590	696	796			43.0	57.0	40.0	48.0	3.8	26.8
OGS081987	1692	290	394		483	497	704	743	-0.042		22.0	36.0		30.0	4.0	28.0
LGS082087	1693	327	730		1747	2578	3459	2978		0.150	4.5	5.5	7.0	19.0	4.5	28.5
LGS082687	1699	648	1392		3088	3928	4458	4068		0.073	7.0	10.0	13.0	34.0	6.3	31.3
OGS082687	1699	550	723		886	1004	984	1161	-0.076	-0.011	12.0	30.0		46.0	3.8	26.8
OGS090287	• 1706	498	558		730	770	777	1076	-0.074	0.002	9.0	21.0	26.0	38.0	6.5	27.5
LGS090487	1708	531	1430		3523	3596	2999	4121		0.085	7.0	10.0	14.0	30.0	4.3	28.3
OGS090987	1713	434	577		666	691	809	1041			11.0	16.0		28.0	6.5	29.5
LGS091087	1714	524	755		2720	3653	3369	2862		0.010	10.0	14.0	12.0	28.0	3.3	26.8
OGS091487	1718	390	496		600	788	902	956	-0.064	0.009	10.0	16.0	23.0	34.0	6.2	27.2
LGS091687	1720	661	822		3515	3844	3545	4408	-0.156	0.028	12.0	17.0	13.0	35.0	2.8	29.8
OGS091687	1720	115	247		384	406	412	435			19.0	27.0	34.0	47.0	3.5	26.5
OGS091887	1722	79	158		238	258	236	229			33.0	51.0	31.0	52.0	2.5	24.2
LGS092087	1724	671	1001		3540	4499	3510	4066	-0.186	0.018	8.0	11.0	10.0	23.0	6.3	30.3
OGS092187	1725	316	501		735	863	675	1095	-0.057	0.010	15.0	21.0	36.0	56.0	1.8	24.8
OGS092387	1727	306	356		552	597	692	845		-0.001	14.0	23.0	18.0	27.0	7.3	30.2
LGS092487	1728	936	1746		3893	4337	3362	4368		0.037	8.0	11.0	10.0	27.0	7.8	31.3

Table II (Appendix D)

1985-86 COUNCIL BLUFFS FLYASH CORRELATION MATRIX

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	H4	D1	D7	D14	D28	D56	ACE	HCE	IS	FS	PKT	TIM	DT
H4	1.00000	0.79516	0.33773	0.55686	0.47624	0.72055	-0.01532	0.38985	0.19534	-0.08591	0.67845	-0.12637	0.54653
	0.0000	0.0001	0.0165	0.0001	0.0005	0.0011	0.9195	0.0074	0.1985	0.5703	0.0001	0.4081	0.0001
	50	49	50	47	49	17	46	46	45	46	45	45	45
D1	0.79516	1.00000	0.60390	0.73714	0.66452	0.53826	-0.15497	0.36935	-0.00789	-0.33781	0.57799	-0.48691	0.50379
	0.0001	0.0000	0.0001	0.0001	0.0001	0.0315	0.3094	0.0125	0.9595	0.0232	0.0001	0.0008	0.0005
	49	49	49	46	48	16	45	45	44	45	44	44	44
D7	0.33773	0.60390	1.00000	0.83652	0.84010	0.46224	0.05708	0.58252	-0.22540	-0.50103	0.32929	-0.61288	0.30857
	0.0165	0.0001	0.0000	0.0001	0.0001	0.0617	0.7063	0.0001	0.1366	0.0004	0.0272	0.0001	0.0392
	50	49	50	47	49	17	46	46	45	46	45	45	45
D14	0.55686	0.73714	0.83652	1.00000	0.88576	0.67112	0.05656	0.64965	-0.16050	-0.45329	0.60689	-0.61705	0.50726
	0.0001	0.0001	0.0001	0.0000	0.0001	0.0062	0.7187	0.0001	0.3099	0.0023	0.0001	0.0001	0.0005
	47	46	47	47	46	15	43	43	42	43	43	43	43
D28	0.47624	0.66452	0.84010	0.88576	1.00000	0.74128	-0.11987	0.60595	0.03792	-0.32342	0.54105	-0.52273	0.35833
	0.0005	0.0001	0.0001	0.0001	0.0000	0.0007	0.4275	0.0001	0.8047	0.0283	0.0001	0.0002	0.0156
	49	48	49	46	49	17	46	46	45	46	45	45	45
D56	0.72055	0.53826	0.46224	0.67112	0.74128	1.00000	0.12762	0.32807	0.36417	0.41111	0.71440	0.11288	0.41591
	0.0011	0.0315	0.0617	0.0062	0.0007	0.0000	0.6637	0.2522	0.1655	0.1011	0.0013	0.6662	0.0968
	17	16	17	15	17	17	14	14	16	17	17	17	17
ACE	-0.01532	-0.15497	0.05708	0.05656	-0.11987	0.12762	1.00000	0.30602	-0.34019	-0.17818	0.10052	0.05166	0.41461
	0.9195	0.3094	0.7063	0.7187	0.4275	0.6637	0.0000	0.0409	0.0275	0.2530	0.5265	0.7453	0.0063
	46	45	46	43	46	14	46	45	42	43	42	42	42
HCE	0.38985	0.36935	0.58252	0.64965	0.60595	0.32807	0.30602	1.00000	-0.10238	-0.39037	0.63974	-0.47459	0.46323
	0.0074	0.0125	0.0001	0.0001	0.0001	0.2522	0.0409	0.0000	0.5188	0.0097	0.0001	0.0015	0.0020
	46	45	46	43	46	14	45	46	42	43	42	42	42
IS	0.19534	-0.00789	-0.22540	-0.16050	0.03792	0.36417	-0.34019	-0.10238	1.00000	0.82370	0.18146	0.33200	-0.10450
	0.1985	0.9595	0.1366	0.3099	0.8047	0.1655	0.0275	0.5188	0.0000	0.0001	0.2442	0.0296	0.5048
	45	44	45	42	45	16	42	42	45	45	43	43	43
FS	-0.08591	-0.33781	-0.50103	-0.45329	-0.32342	0.41111	-0.17818	-0.39037	0.82370	1.00000	-0.18116	0.63226	-0.25366
	0.5703	0.0232	0.0004	0.0023	0.0283	0.1011	0.2530	0.0097	0.0001	0.0000	0.2392	0.0001	0.0966
	46	45	46	43	46	17	43	43	45	46	44	44	44
PKT	0.67845	0.57799	0.32929	0.60689	0.54105	0.71440	0.10052	0.63974	0.18146	-0.18116	1.00000	-0.43619	0.65468
	0.0001	0.0001	0.0272	0.0001	0.0001	0.0013	0.5265	0.0001	0.2442	0.2392	0.0000	0.0027	0.0001
	45	44	45	43	45	17	42	42	43	44	45	45	45
TIM	-0.12637	-0.48691	-0.61288	-0.61705	-0.52273	0.11288	0.05166	-0.47459	0.33200	0.63226	-0.43619	1.00000	-0.32232
	0.4081	0.0008	0.0001	0.0001	0.0002	0.6662	0.7453	0.0015	0.0296	0.0001	0.0027	0.0000	0.0308
	45	44	45	43	45	17	42	42	43	44	45	45	45
DT	0.54653	0.50379	0.30857	0.50726	0.35833	0.41591	0.41461	0.46323	-0.10450	-0.25366	0.65468	-0.32232	1.00000
	0.0001	0.0005	0.0392	0.0005	0.0156	0.0968	0.0063	0.0020	0.5048	0.0966	0.0001	0.0308	0.0000
	45	44	45	43	45	17	42	42	43	44	45	45	45

Table II (Appendix D)

1985-86 LANSING FLYASH CORRELATION MATRIX

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	H4	D1	D7	D14	D28	D56	ACE	HCE	IS	FS	PKT	TIM	DT
H4	1.00000	0.82218	0.80196	0.81858	0.84535	0.88306	-0.34114	0.12402	-0.18327	-0.68966	0.73837	-0.25088	0.78112
	0.0000	0.0001	0.0001	0.0001	0.0001	0.0007	0.0881	0.5377	0.3913	0.0002	0.0001	0.2601	0.0001
	29	29	29	29	29	10	26	27	24	24	22	22	22
D1	0.82218	1.00000	0.88661	0.75855	0.82421	0.72546	-0.18382	0.14491	-0.16512	-0.55683	0.67035	-0.47509	0.72483
	0.0001	0.0000	0.0001	0.0001	0.0001	0.0176	0.3587	0.4619	0.4303	0.0039	0.0005	0.0220	0.0001
	29	30	29	29	30	10	27	28	25	25	23	23	23
D7	0.80196	0.88661	1.00000	0.79580	0.85576	0.68696	-0.18744	0.23728	-0.11141	-0.53770	0.63491	-0.44758	0.65151
	0.0001	0.0001	0.0000	0.0001	0.0001	0.0282	0.3592	0.2334	0.6043	0.0067	0.0015	0.0367	0.0010
	29	29	29	29	29	10	26	27	24	24	22	22	22
D14	0.81858	0.75855	0.79580	1.00000	0.88191	0.78373	-0.39569	0.38106	-0.20541	-0.55991	0.76467	-0.32984	0.73467
	0.0001	0.0001	0.0001	0.0000	0.0001	0.0073	0.0454	0.0499	0.3356	0.0045	0.0001	0.1338	0.0001
	29	29	29	29	29	10	26	27	24	24	22	22	22
D28	0.84535	0.82421	0.85576	0.88191	1.00000	0.65810	-0.40609	0.37050	0.04585	-0.48449	0.64019	-0.46774	0.71319
	0.0001	0.0001	0.0001	0.0001	0.0000	0.0386	0.0320	0.0479	0.8240	0.0121	0.0008	0.0212	0.0001
	29	30	29	29	31	10	28	29	26	26	24	24	24
D56	0.88306	0.72546	0.68696	0.78373	0.65810	1.00000	-0.17987	0.44959	0.44201	0.46478	0.61244	-0.39605	0.72833
	0.0007	0.0176	0.0282	0.0073	0.0386	0.0000	0.6190	0.1924	0.2009	0.1759	0.0598	0.2572	0.0169
	10	10	10	10	10	10	10	10	10	10	10	10	10
ACE	-0.34114	-0.18382	-0.18744	-0.39569	-0.40609	-0.17987	1.00000	-0.32171	0.00748	-0.01435	-0.17085	-0.09599	-0.02426
	0.0881	0.3587	0.3592	0.0454	0.0320	0.6190	0.0000	0.0950	0.9730	0.9482	0.4471	0.6709	0.9146
	26	27	26	26	28	10	28	28	23	23	22	22	22
HCE	0.12402	0.14491	0.23728	0.38106	0.37050	0.44959	-0.32171	1.00000	0.27308	0.10972	0.27571	-0.29583	0.23634
	0.5377	0.4619	0.2334	0.0499	0.0479	0.1924	0.0950	0.0000	0.1967	0.6098	0.2143	0.1813	0.2896
	27	28	27	27	29	10	28	29	24	24	22	22	22
IS	-0.18327	-0.16512	-0.11141	-0.20541	0.04585	0.44201	0.00748	0.27308	1.00000	0.24091	0.21369	-0.25460	0.27194
	0.3913	0.4303	0.6043	0.3356	0.8240	0.2009	0.9730	0.1967	0.0000	0.2358	0.3523	0.2654	0.2331
	24	25	24	24	26	10	23	24	26	26	21	21	21
FS	-0.68966	-0.55683	-0.53770	-0.55991	-0.48449	0.46478	-0.01435	0.10972	0.24091	1.00000	-0.72662	0.01198	-0.68626
	0.0002	0.0039	0.0067	0.0045	0.0121	0.1759	0.9482	0.6098	0.2358	0.0000	0.0002	0.9589	0.0006
	24	25	24	24	26	10	23	24	26	26	21	21	21
PKT	0.73837	0.67035	0.63491	0.76467	0.64019	0.61244	-0.17085	0.27571	0.21369	-0.72662	1.00000	-0.42838	0.90813
	0.0001	0.0005	0.0015	0.0001	0.0008	0.0598	0.4471	0.2143	0.3523	0.0002	0.0000	0.0367	0.0001
	22	23	22	22	24	10	22	22	21	21	24	24	24
TIM	-0.25088	-0.47509	-0.44758	-0.32984	-0.46774	-0.39605	-0.09599	-0.29583	-0.25460	0.01198	-0.42838	1.00000	-0.46949
	0.2601	0.0220	0.0367	0.1338	0.0212	0.2572	0.6709	0.1813	0.2654	0.9589	0.0367	0.0000	0.0206
	22	23	22	22	24	10	22	22	21	21	24	24	24
DT	0.78112	0.72483	0.65151	0.73467	0.71319	0.72833	-0.02426	0.23634	0.27194	-0.68626	0.90813	-0.46949	1.00000
	0.0001	0.0001	0.0010	0.0001	0.0001	0.0169	0.9146	0.2896	0.2331	0.0006	0.0001	0.0206	0.0000
	22	23	22	22	24	10	22	22	21	21	24	24	24

Table II (Appendix D)

1985-86 OTTUMWA FLYASH CORRELATION MATRIX

PEARSON CORRELATION COEFFICIENTS / PROB > |R| UNDER HO:RHO=0 / NUMBER OF OBSERVATIONS

	H4	D1	D3	D7	D14	D28	ACE	HCE	IS	FS	PKT	TIM	DT
H4	1.00000	0.43193	0.22793	0.18024	0.20144	0.15580	-0.22076	-0.09611	-0.12512	-0.19741	0.34480	0.27244	0.58892
	0.0000	0.0001	0.0477	0.0929	0.0598	0.1545	0.0521	0.3964	0.2510	0.0685	0.0012	0.0112	0.0001
	88	81	76	88	88	85	78	80	86	86	86	86	86
D1	0.43193	1.00000	0.90259	0.76609	0.77599	0.78123	-0.34708	0.59430	-0.08484	-0.20470	0.15874	-0.07179	0.27305
	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0010	0.0001	0.4037	0.0421	0.1224	0.4870	0.0071
	81	101	72	100	99	99	87	93	99	99	96	96	96
D3	0.22793	0.90259	1.00000	0.91647	0.83810	0.91845	-0.49996	0.75509	0.11093	-0.20407	0.08237	-0.16207	0.23345
	0.0477	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.0001	0.3401	0.0770	0.4763	0.1591	0.0410
	76	72	78	78	78	77	70	73	76	76	77	77	77
D7	0.18024	0.76609	0.91647	1.00000	0.90593	0.95621	-0.42702	0.60487	-0.06813	-0.26153	0.05976	-0.20649	0.17839
	0.0929	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.0001	0.4878	0.0068	0.5508	0.0373	0.0728
	88	100	78	108	106	105	93	99	106	106	102	102	102
D14	0.20144	0.77599	0.83810	0.90593	1.00000	0.93137	-0.46576	0.67111	-0.07307	-0.23162	0.09985	-0.22891	0.21584
	0.0598	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.0001	0.4588	0.0174	0.3205	0.0213	0.0302
	88	99	78	106	107	104	93	98	105	105	101	101	101
D28	0.15580	0.78123	0.91845	0.95621	0.93137	1.00000	-0.45373	0.66846	-0.08040	-0.26609	0.00672	-0.24100	0.14947
	0.1545	0.0001	0.0001	0.0001	0.0001	0.0000	0.0001	0.0001	0.4172	0.0063	0.9471	0.0157	0.1377
	85	99	77	105	104	106	93	99	104	104	100	100	100
ACE	-0.22076	-0.34708	-0.49996	-0.42702	-0.46576	-0.45373	1.00000	-0.19219	-0.26413	-0.07538	0.02448	-0.12550	-0.11348
	0.0521	0.0010	0.0001	0.0001	0.0001	0.0001	0.0000	0.0664	0.0110	0.4751	0.8199	0.2412	0.2897
	78	87	70	93	93	93	94	92	92	92	89	89	89
HCE	-0.09611	0.59430	0.75509	0.60487	0.67111	0.66846	-0.19219	1.00000	-0.08427	-0.23945	-0.15013	-0.37810	-0.12149
	0.3964	0.0001	0.0001	0.0001	0.0001	0.0001	0.0664	0.0000	0.4094	0.0176	0.1465	0.0002	0.2409
	80	93	73	99	98	99	92	100	98	98	95	95	95
IS	-0.12512	-0.08484	0.11093	-0.06813	-0.07307	-0.08040	-0.26413	-0.08427	1.00000	0.74173	-0.29774	0.50165	-0.34810
	0.2510	0.4037	0.3401	0.4878	0.4588	0.4172	0.0110	0.4094	0.0000	0.0001	0.0025	0.0001	0.0004
	86	99	76	106	105	104	92	98	107	107	101	101	101
FS	-0.19741	-0.20470	-0.20407	-0.26153	-0.23162	-0.26609	-0.07538	-0.23945	0.74173	1.00000	-0.26834	0.69496	-0.35881
	0.0685	0.0421	0.0770	0.0068	0.0174	0.0063	0.4751	0.0176	0.0001	0.0000	0.0067	0.0001	0.0002
	86	99	76	106	105	104	92	98	107	107	101	101	101
PKT	0.34480	0.15874	0.08237	0.05976	0.09985	0.00672	0.02448	-0.15013	-0.29774	-0.26834	1.00000	-0.18226	0.71196
	0.0012	0.1224	0.4763	0.5508	0.3205	0.9471	0.8199	0.1465	0.0025	0.0067	0.0000	0.0654	0.0001
	86	96	77	102	101	100	89	95	101	101	103	103	103
TIM	0.27244	-0.07179	-0.16207	-0.20649	-0.22891	-0.24100	-0.12550	-0.37810	0.50165	0.69496	-0.18226	1.00000	-0.19243
	0.0112	0.4870	0.1591	0.0373	0.0213	0.0157	0.2412	0.0002	0.0001	0.0001	0.0654	0.0000	0.0515
	86	96	77	102	101	100	89	95	101	101	103	103	103
DT	0.58892	0.27305	0.23345	0.17839	0.21584	0.14947	-0.11348	-0.12149	-0.34810	-0.35881	0.71196	-0.19243	1.00000
	0.0001	0.0071	0.0410	0.0728	0.0302	0.1377	0.2897	0.2409	0.0004	0.0002	0.0001	0.0515	0.0000
	86	96	77	102	101	100	89	95	101	101	103	103	103

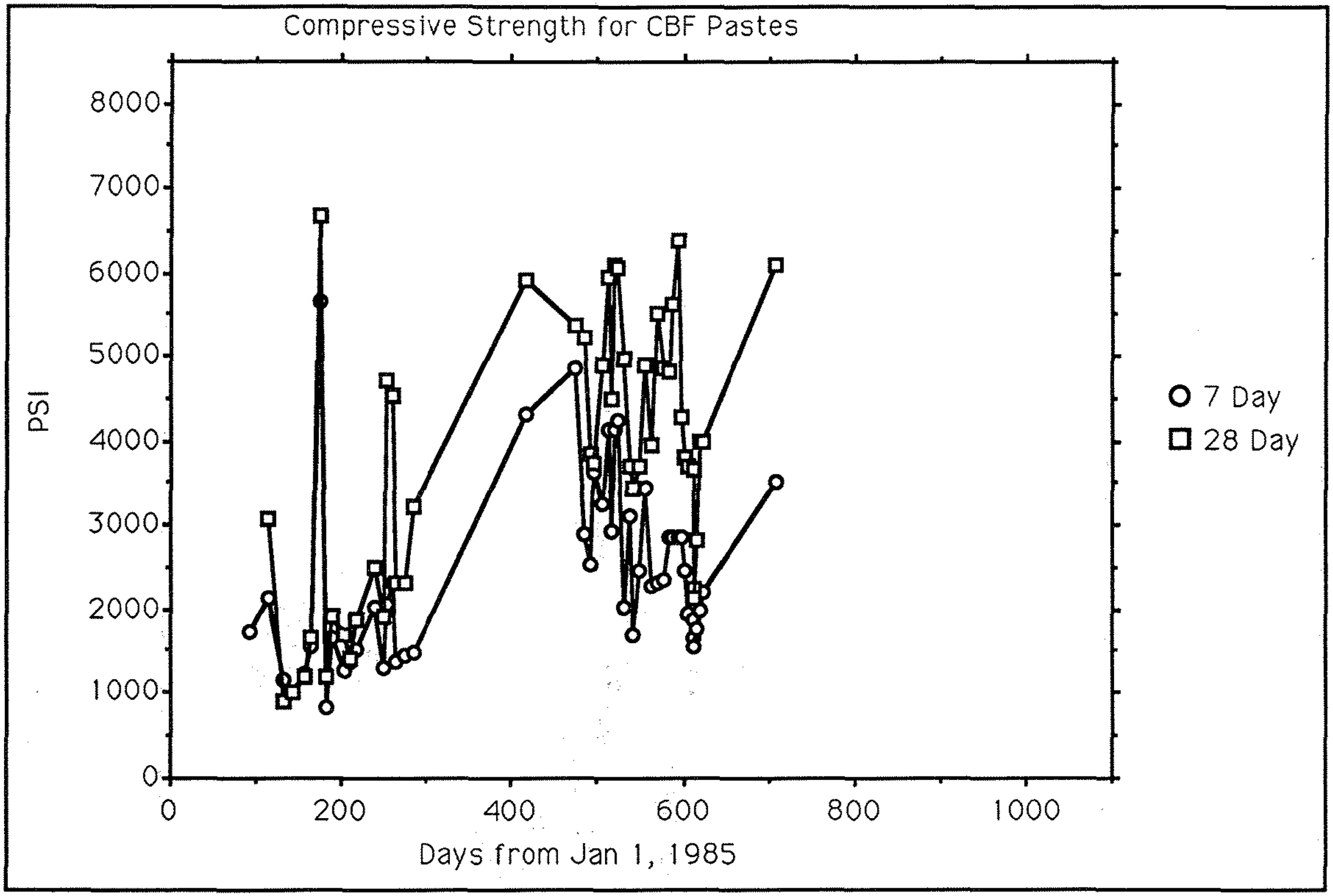

Figure 1, Appendix D

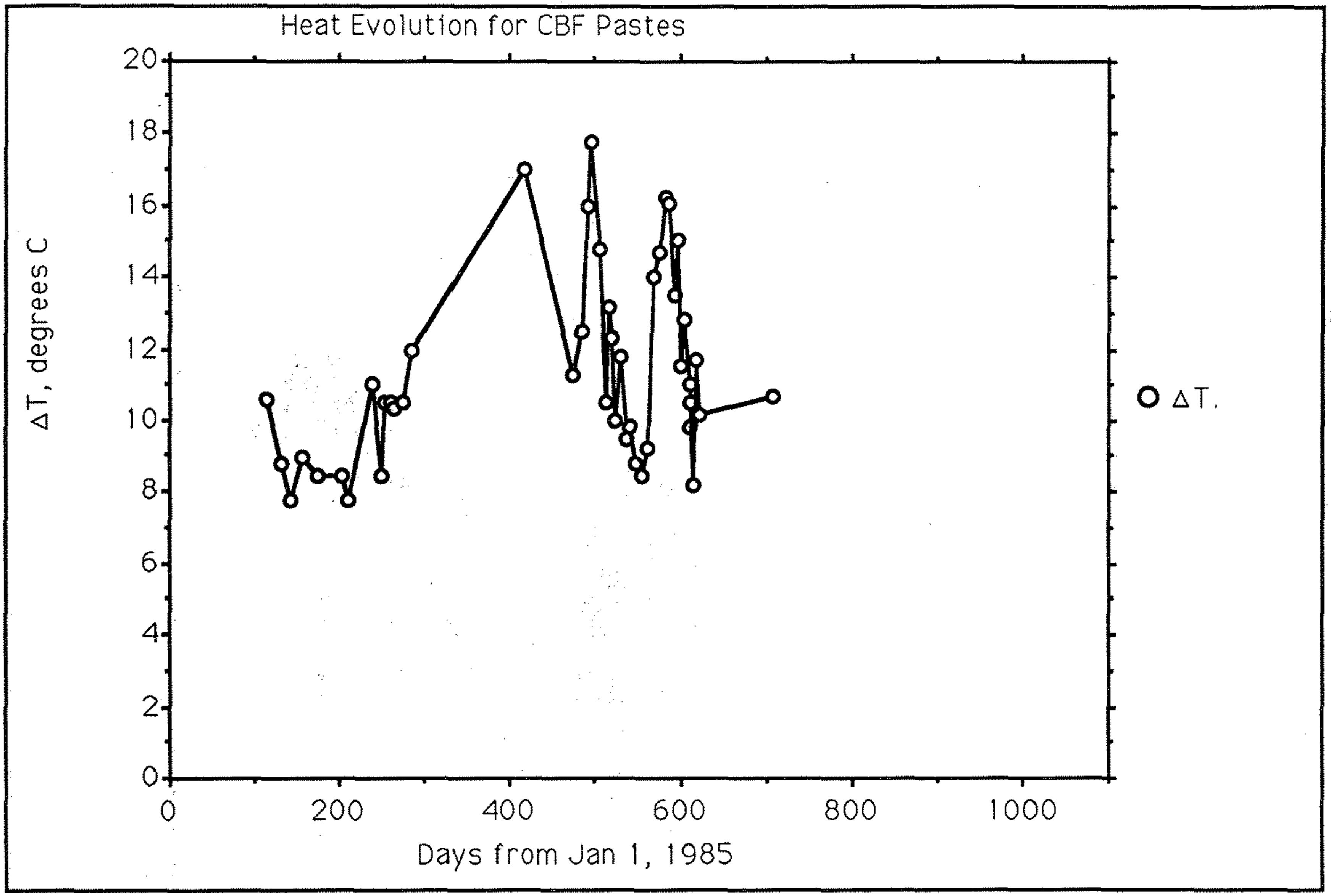

Figure 2, Appendix D

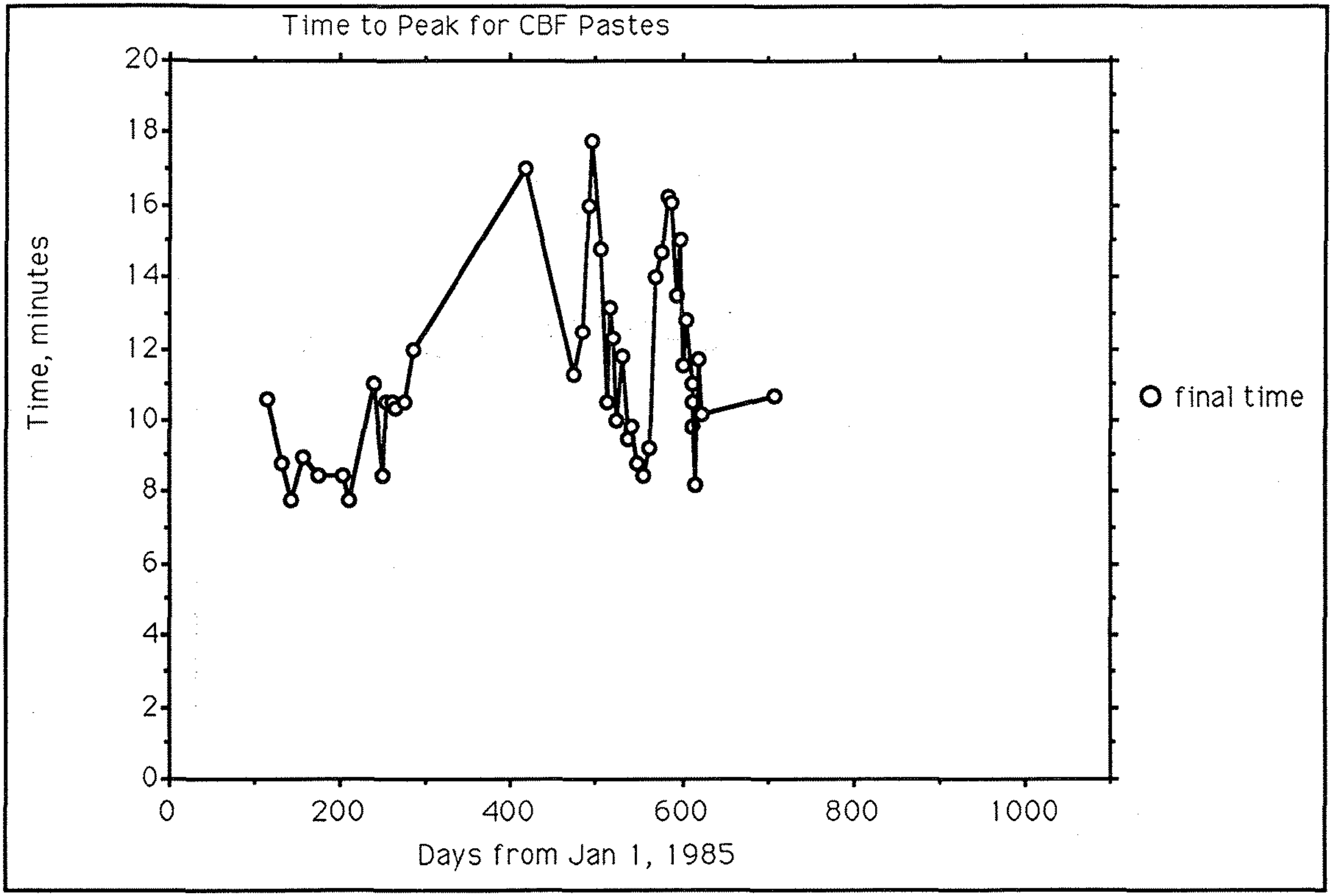

Figure 3, Appendix D

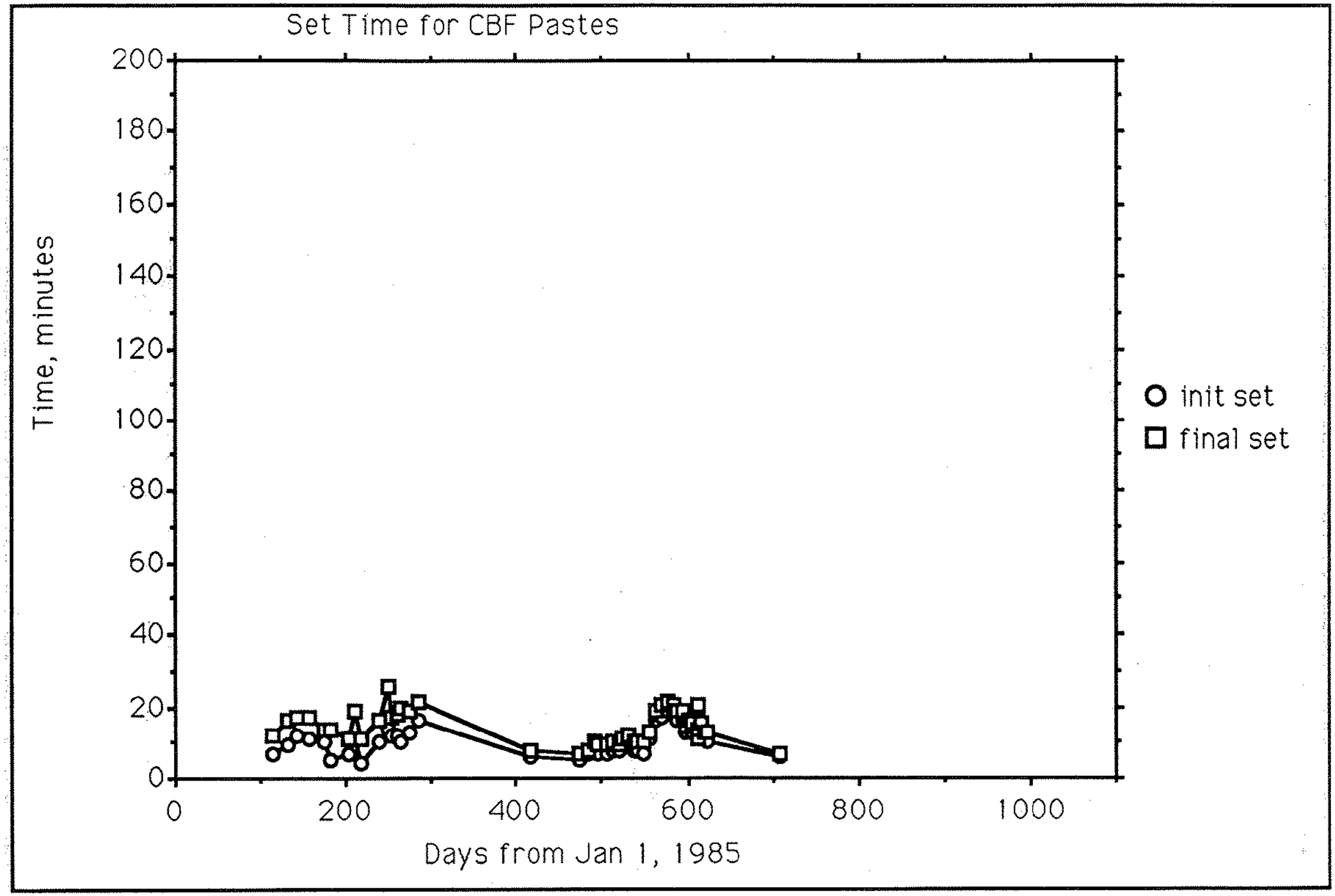

Figure 4, Appendix D

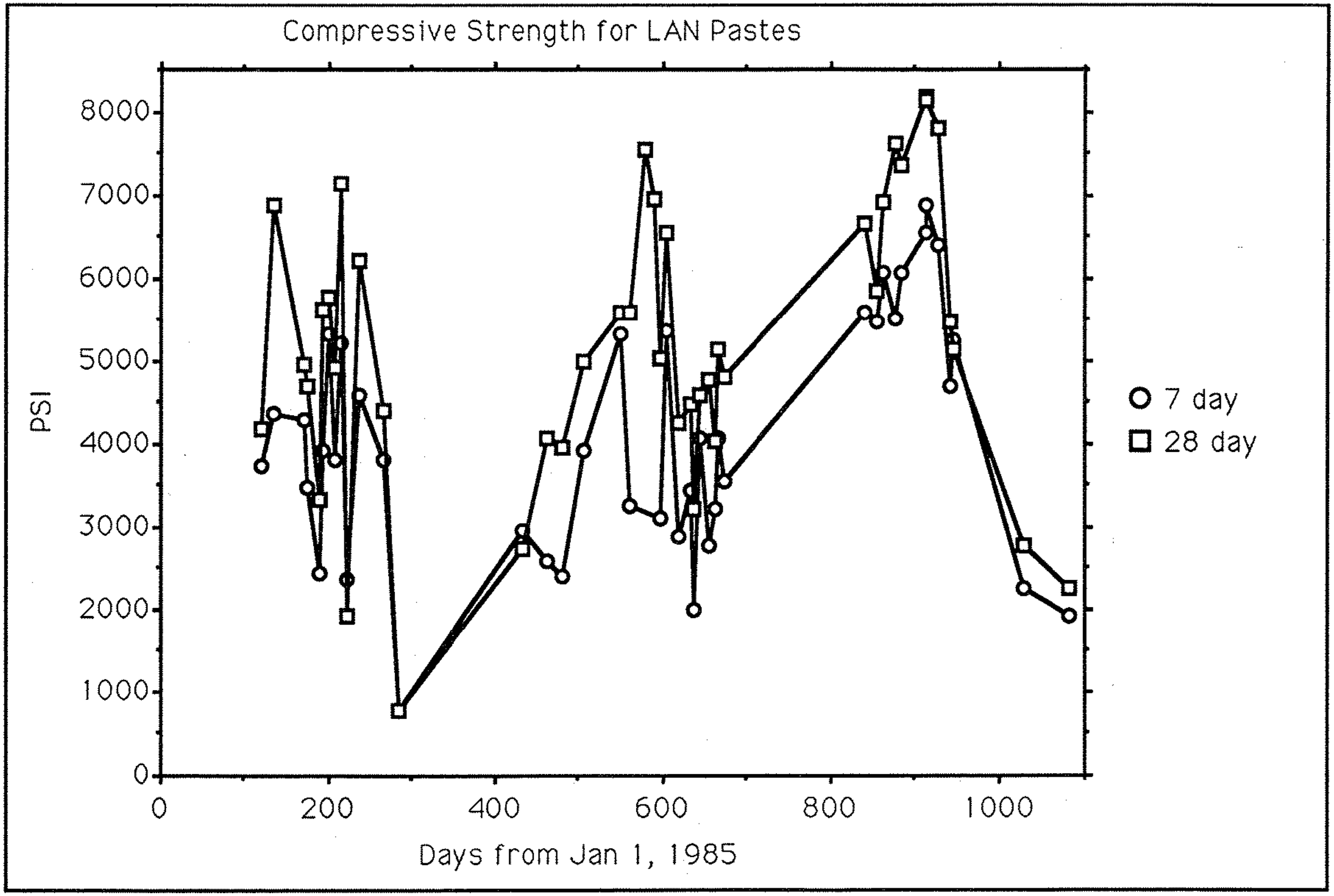

Figure 5. Appendix D

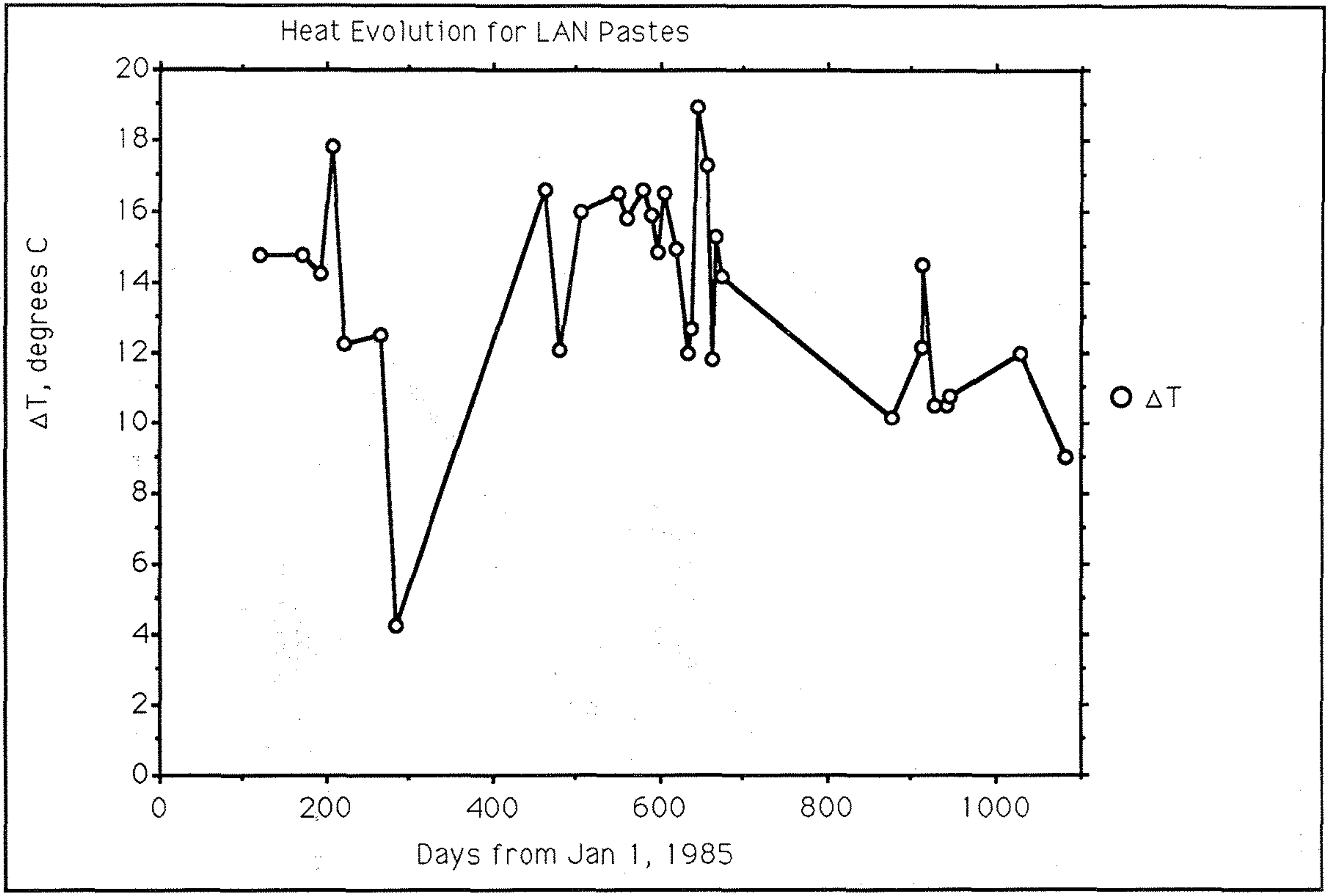

Figure 6, Appendix D

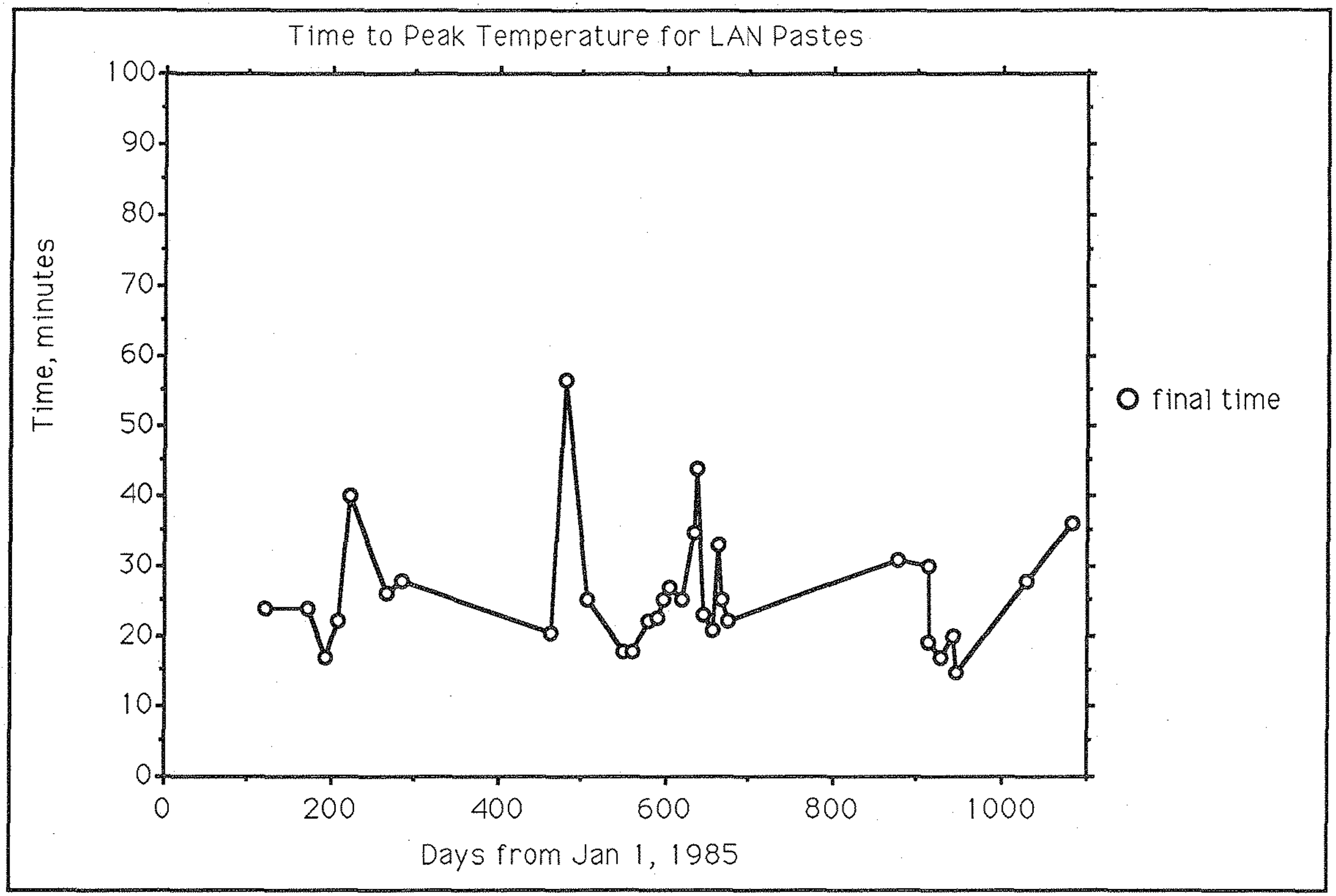

Figure 7, Appendix D

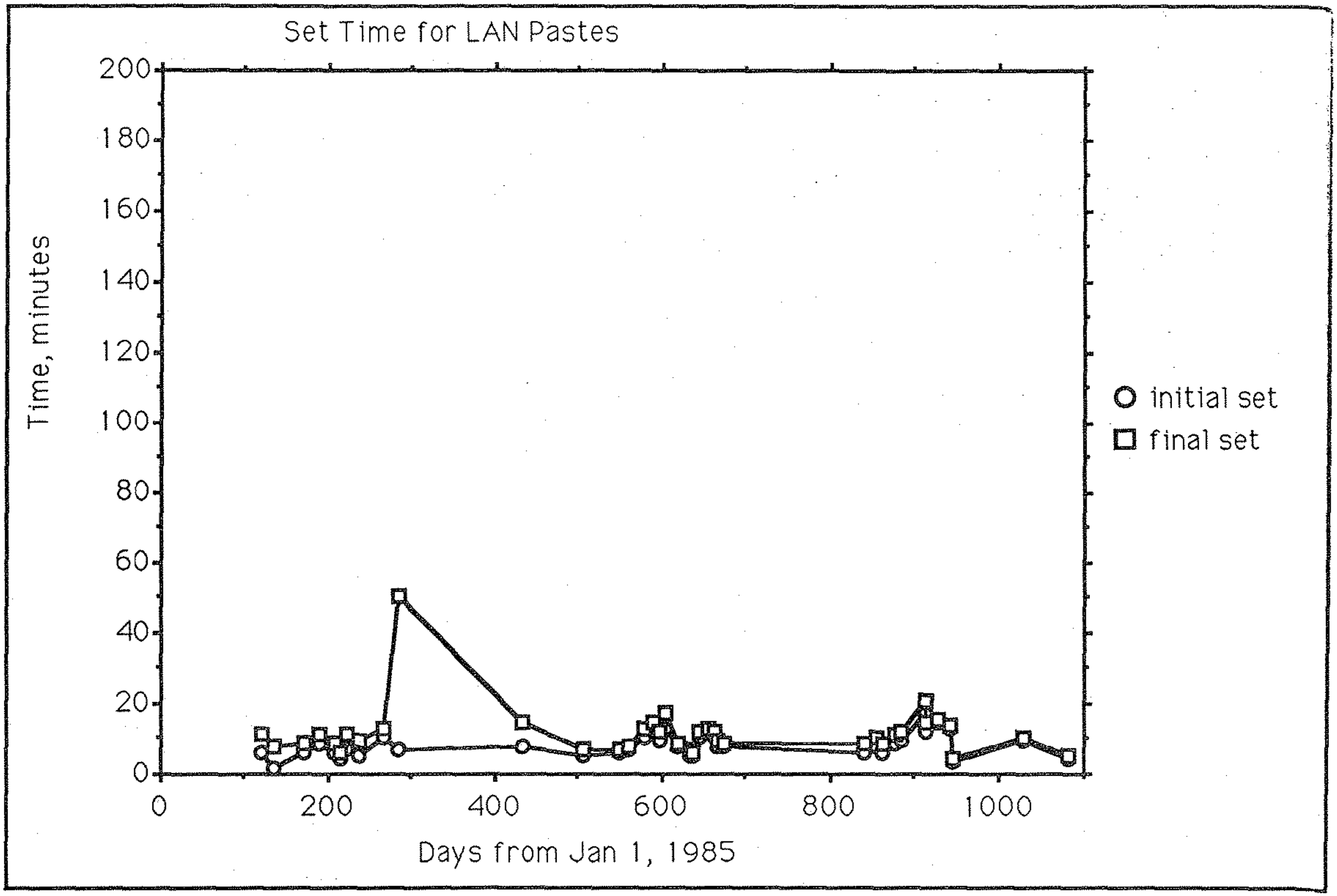

Figure 8, Appendix D

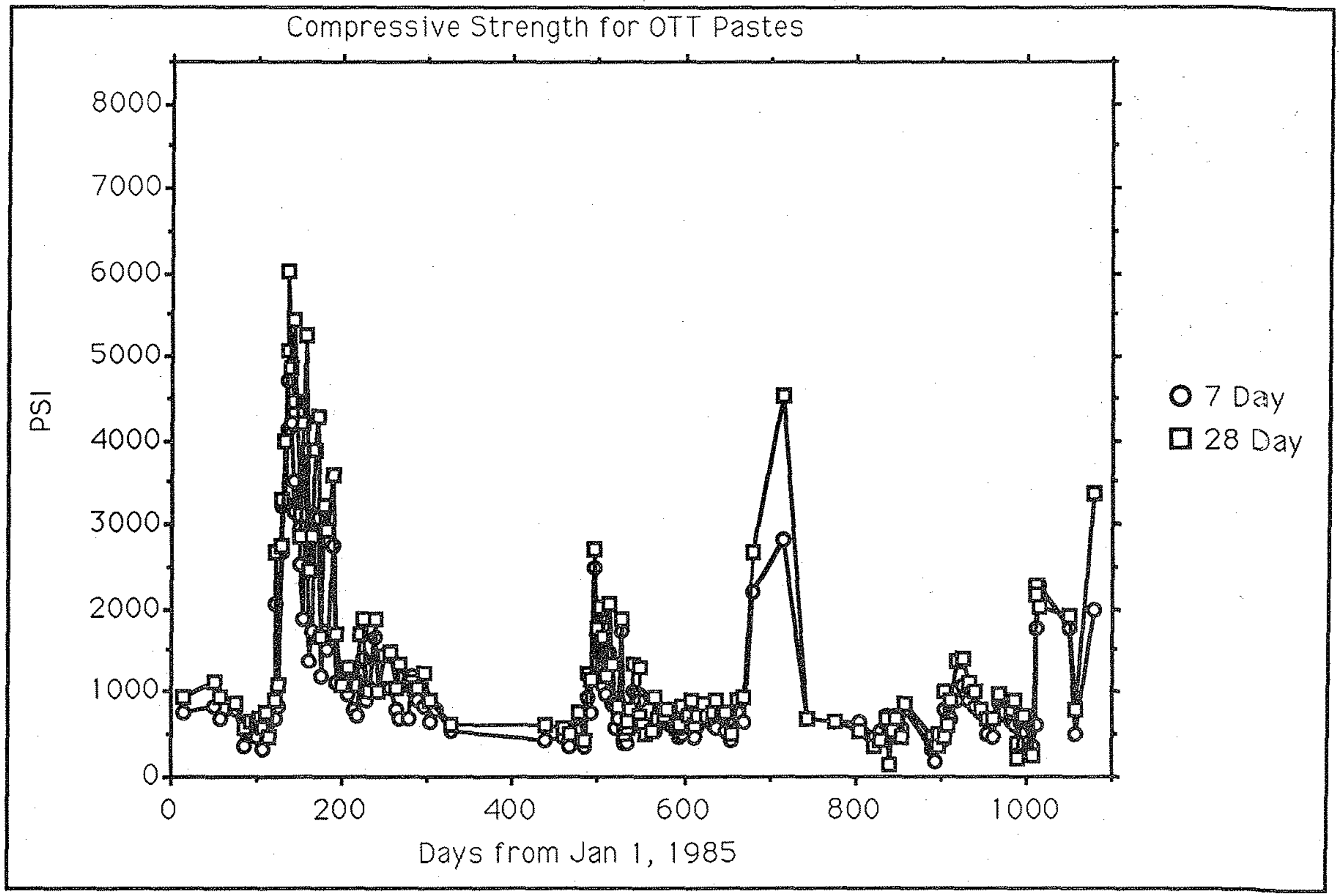

Figure 9, Appendix D

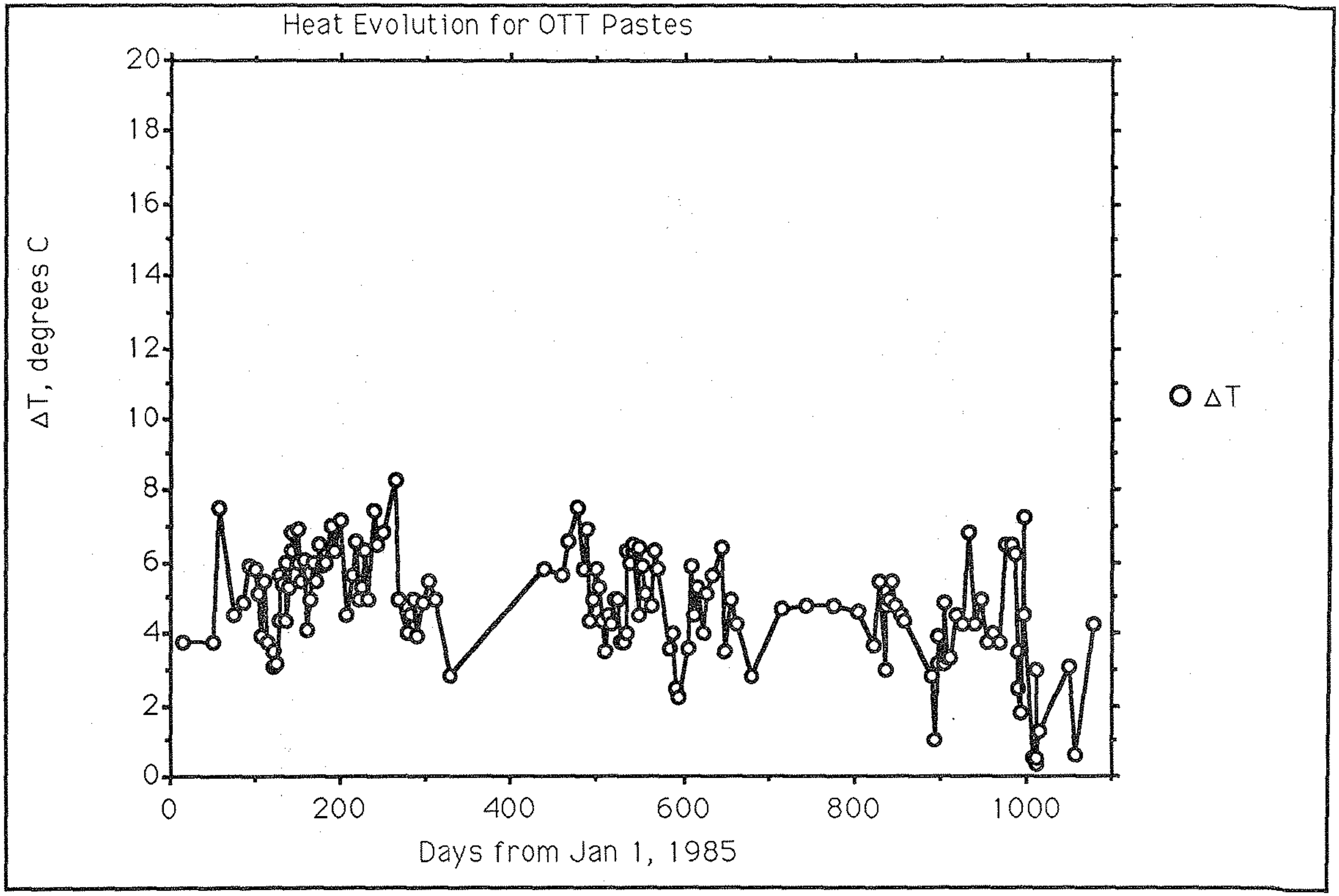

Figure 10, Appendix D

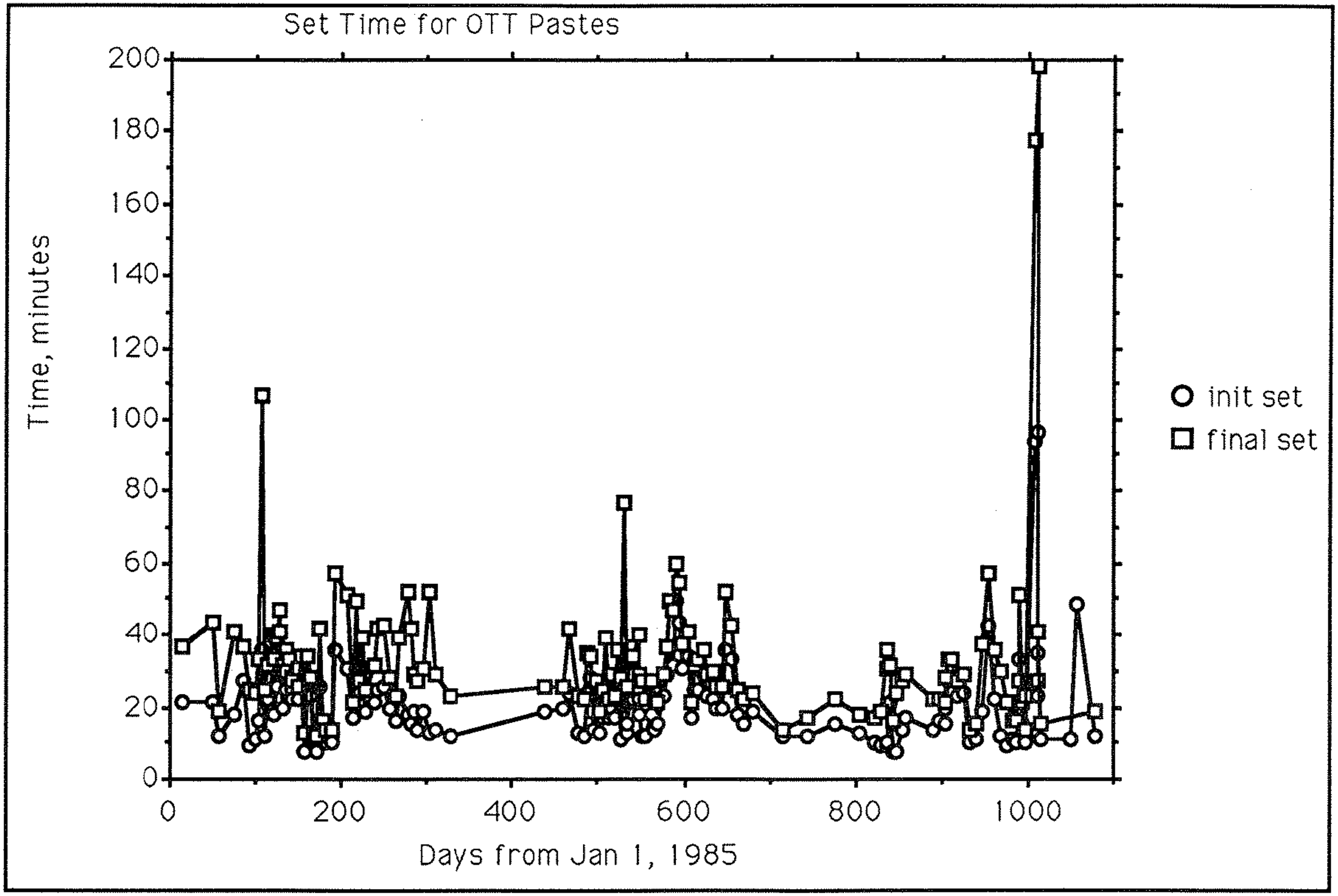

Figure 11, Appendix D

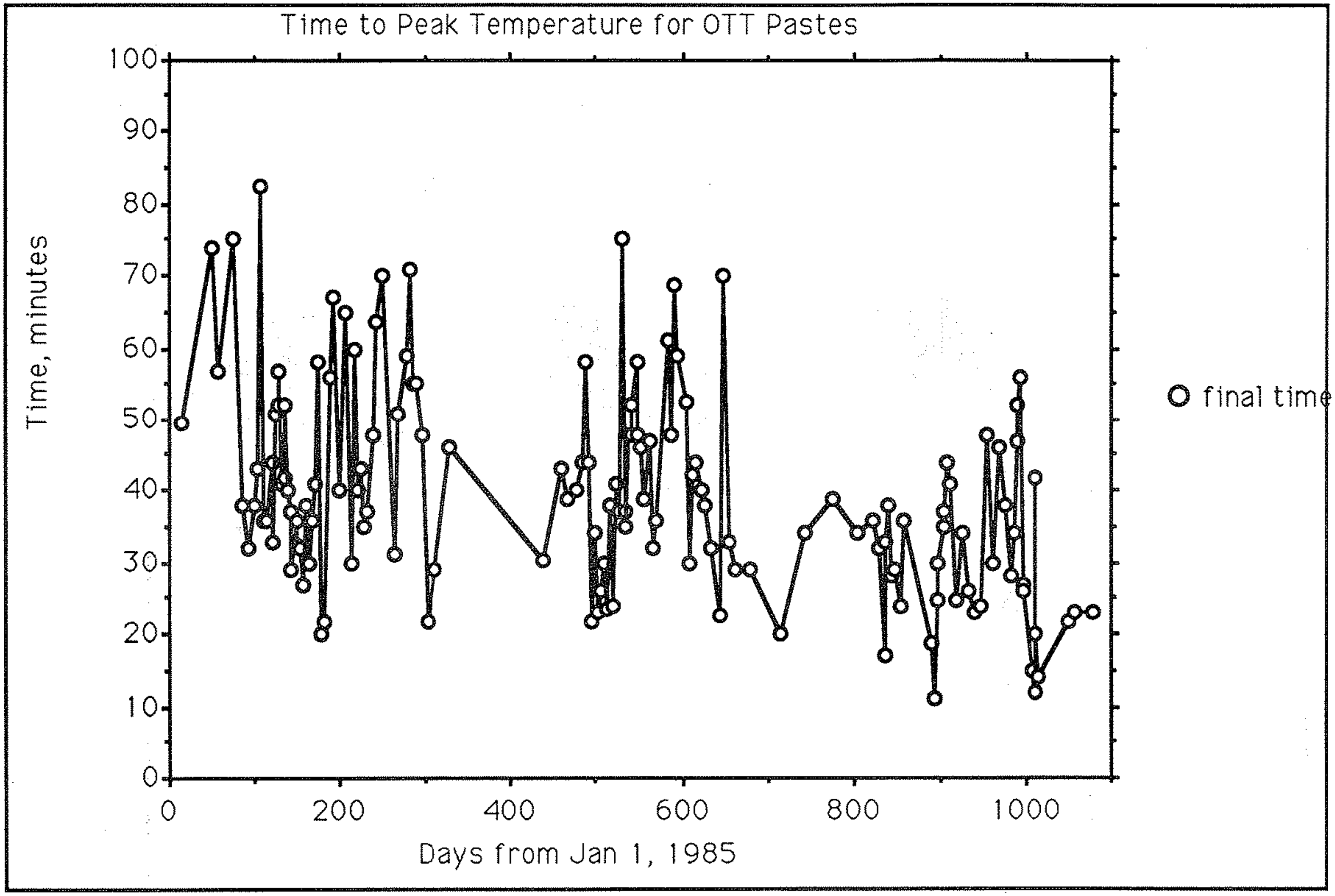

Figure 12, Appendix D

Table I (Appendix E)
Raw Data for LGS-OGS

Sample Name	Day No. (7/1/87)	Day No. (1/1/83)	4 hour	1 day	3 day	7 day	14 day	28 day	56 day	%exp air	%exp humid	Initial set	Final set	Onset time	Final time	ΔTemp	Peak Temp
LGS070987	0009	1651	318	988	•	2517	2538	4289	3110	•	•	9.000	13.0	15.0	39.0	2.5	•
LGS071587	0015	1657	931	1417	•	3259	4108	3410	4196	-0.12	0.087	7.000	9.0	21.0	35.0	6.5	31.5
LGS072187	0021	1663	476	1139	•	3737	3853	3202	3812	-0.122	0.056	10.000	12.0	23.0	35.0	4.8	29.8
LGS072987	0029	1671	702	1796	•	2955	4094	3849	3900	•	0.098	7.000	10.0	13.0	37.0	4.0	28.5
LGS080487	0035	1677	624	1554	•	2105	4322	3897	4094	•	0.094	8.000	12.0	15.0	36.0	3.0	26.0
LGS081287	0043	1685	232	368	•	1267	2348	2241	2364	-0.055	0.070	7.000	10.0	9.0	20.0	2.8	27.8
LGS082087	0051	1693	327	730	•	1747	2578	3459	2978	•	0.150	4.500	5.5	7.0	19.0	4.5	28.5
LGS082687	0057	1699	648	1392	•	3088	3928	4458	4088	•	0.073	7.000	10.0	13.0	34.0	6.3	31.3
LGS090487	0066	1708	531	1430	•	3523	3596	2999	4121	•	0.085	7.000	10.0	14.0	30.0	4.3	28.3
LGS091087	0072	1714	524	755	•	2720	3653	3369	2862	•	0.010	10.000	14.0	12.0	26.0	3.3	26.8
LGS091687	0078	1720	661	822	•	3515	3844	3545	4408	-0.156	0.028	12.000	17.0	13.0	35.0	2.8	29.8
LGS092087	0082	1724	671	1001	•	3540	4499	3510	4066	-0.186	0.018	8.000	11.0	10.0	23.0	6.3	30.3
LGS092487	0086	1728	936	1746	•	3893	4337	3362	4368	•	0.037	8.000	11.0	10.0	27.0	7.8	31.3
LGS092687	0088	1730	829	1625	•	3458	3559	4701	4832	•	0.000	12.000	19.0	14.0	47.0	5.2	29.2
LGS103087	0122	1764	280	1103	•	2242	2834	3239	3752	-0.061	0.128	6.000	8.0	9.0	18.0	3.8	27.3
LGS110187	0124	1766	300	646	•	1985	1593	2944	3288	•	0.088	7.000	11.0	14.0	19.0	3.5	26.5
LGS110387	0126	1768	259	862	•	2767	1940	3526	3853	•	0.111	7.000	10.0	15.0	20.0	3.4	26.4
LGS110587	0128	1770	230	832	•	2738	1817	3253	3471	•	0.107	9.000	14.0	25.0	21.0	2.3	25.3
OGS070887	0008	1650	280	423	•	914	970	1395	1483	-0.061	-0.017	23	27	•	25	4.5	29.5
OGS071587	0015	1657	399	793	•	1087	1571	1408	2076	•	-0.011	24	29	•	34	4.3	28.3
OGS072287	0022	1664	566	628	•	895	919	1112	1256	-0.046	0.009	10	14	20	26	6.8	29.8
OGS072987	0029	1671	305	490	•	818	876	1014	1211	-0.036	-0.020	11.0	15.0	•	23.0	4.3	28.3
OGS080587	0036	1678	364	512	•	778	893	806	972	-0.038	0.002	19.0	38.0	•	24.0	5.0	29.0
OGS081287	0043	1685	249	363	•	520	590	696	796	•	•	43.0	57.0	40.0	48.0	3.8	26.8
OGS081987	0050	1692	290	394	•	483	497	704	743	-0.042	•	22.0	36.0	•	30.0	4.0	28.0
OGS082687	0057	1699	550	723	•	886	1004	984	1161	-0.076	-0.011	12.000	30.0	•	46.0	3.8	26.8
OGS090287	0064	1706	498	558	•	730	770	777	1076	-0.074	0.002	9.000	21.0	26.0	38.0	6.5	27.5
OGS090987	0071	1713	434	577	•	666	691	809	1041	•	•	11.000	16.0	•	28.0	6.5	29.5
OGS091487	0076	1718	390	496	•	600	788	902	956	-0.064	0.009	10.000	16.0	23.0	34.0	6.2	27.2
OGS091687	0078	1720	115	247	•	384	406	412	435	•	•	19.000	27.0	34.0	47.0	3.5	26.5
OGS091887	0080	1722	79	158	•	238	258	236	229	•	•	33.000	51.0	31.0	52.0	2.5	24.2
OGS092187	0083	1725	316	501	•	735	863	675	1095	-0.057	0.010	15.000	21.0	36.0	56.0	1.8	24.8
OGS092387	0085	1727	306	356	•	552	597	692	845	•	-0.001	14.000	23.0	18.0	27.0	7.3	30.2
OGS092587	0087	1729	328	408	•	670	762	738	807	-0.037	-0.007	10.000	14.0	21.0	26.0	4.5	27.5
OGS100687	0098	1740	33	173	•	347	265	240	532	-0.026	-0.005	94.000	178.0	9.0	15.0	0.5	22.5
OGS100787	0099	1741	•	•	•	•	•	•	•	•	•	97.000	198.0	6.0	12.0	0.3	22.8
OGS100887	0100	1742	237	360	•	613	1577	2277	2591	-0.034	•	23.000	27.0	19.0	42.0	3.0	26.0
OGS100987	0101	1743	199	298	•	1793	1996	2169	3342	-0.029	•	35.000	41.0	9.0	20.0	0.5	23.5
OGS101287	0104	1746	207	621	•	2273	2508	2030	2991	-0.035	•	11.000	15.0	7.0	14.0	1.3	24.8

Table I (Appendix E)
Raw Data for LGS-OGS

Sample Name	SrO	MgO	Na2O	Fe2O3	SO3	BaO	MnO	SiO2	CaO	K2O	P2O5	Al2O3	Peak Intensity*							
													Q	UNK	CAS	AN	C3A-1	L	P	TA
LGS070987	0.458	4.381	1.136	5.848	1.552	0.628	0.026	37.753	24.136	0.419	1.434	17.822	117	23	25	48	132	51	46	29
LGS071587	0.432	4.577	1.346	6.093	2.333	0.607	0.030	33.334	26.628	0.310	1.277	18.593	96	19	30	67	170	104	78	32
LGS072187	0.440	4.435	1.706	5.952	1.898	0.660	0.035	32.525	25.618	0.388	1.337	19.443	49	14	24	52	174	55	52	40
LGS072987	0.440	4.228	1.728	5.841	1.880	0.637	0.030	33.451	25.503	0.392	1.257	19.000	58	20	27	64	172	59	51	40
LGS080487	0.441	4.561	1.359	6.124	1.881	0.656	0.030	33.009	26.016	0.341	1.384	19.063	56	20	29	60	160	64	60	34
LGS081287	0.439	3.981	1.404	6.169	1.473	0.656	0.029	34.529	23.258	0.434	1.442	19.355	60	30	17	58	140	25	44	21
LGS082087	0.418	4.299	1.669	5.828	1.859	0.616	0.030	33.968	25.214	0.364	1.148	18.728	65	13	33	71	188	61	79	32
LGS082687	0.410	5.043	1.569	5.662	2.085	0.635	0.028	35.465	25.870	0.296	0.950	17.047	62	17	29	78	194	88	99	18
LGS090487	0.396	5.237	1.619	6.144	2.093	0.629	0.030	36.503	25.542	0.284	0.775	16.004	80	17	23	77	136	73	95	27
LGS091087	0.389	5.305	1.594	6.386	2.236	0.677	0.036	36.085	25.891	0.286	0.860	15.549	85	18	23	77	168	64	104	32
LGS091687	0.376	5.319	1.508	7.025	2.610	0.662	0.035	35.298	26.584	0.230	0.768	14.852	62	17	25	87	140	101	113	32
LGS092087	0.409	5.870	1.631	6.641	2.639	0.680	0.032	35.142	26.748	0.240	0.892	15.022	53	12	25	85	161	79	125	19
LGS092487	0.399	5.368	1.691	6.662	2.701	0.642	0.035	33.410	27.127	0.215	0.778	15.332	55	18	23	91	172	99	125	36
LGS092687	0.405	5.380	1.590	6.954	3.180	0.645	0.034	33.023	27.779	0.239	0.829	15.827	44	21	31	111	159	97	126	28
LGS103087	0.494	4.975	1.375	6.312	2.041	0.731	0.028	34.254	26.148	0.316	1.571	17.005	48	20	22	72	142	73	74	29
LGS110187	0.470	4.303	1.351	6.030	1.560	0.708	0.028	35.752	24.198	0.404	1.420	18.658	63	20	17	48	146	44	72	15
LGS110387	0.455	4.890	1.398	6.877	1.874	0.678	0.029	35.012	25.495	0.319	1.302	16.851	60	17	22	60	171	45	86	13
LGS110587	0.446	4.514	1.373	6.249	1.617	0.664	0.027	34.976	24.766	0.364	1.247	18.484	54	17	25	50	150	52	59	24
OGS070887	0.477	4.461	1.958	5.637	2.321	0.727	0.028	32.202	25.953	0.357	1.666	18.459	39	•	24	79	129	62	54	28
OGS071587	0.461	4.750	1.936	5.533	2.294	0.665	0.029	32.193	26.458	0.342	1.485	18.466	•	•	32	87	146	59	65	30
OGS072287	0.424	4.586	2.797	6.249	3.394	0.638	0.032	29.34	27.032	0.295	1.379	18.154	•	•	•	•	•	•	•	•
OGS072987	0.522	4.349	2.108	5.682	2.309	0.766	0.027	31.912	25.884	0.322	1.955	17.863	37	•	•	67	123	43	64	25
OGS080587	0.539	4.486	2.609	5.704	2.864	0.814	0.026	30.223	25.723	0.341	2.299	18.293	23	•	•	87	138	58	62	33
OGS081287	0.497	4.274	2.331	5.936	2.589	0.752	0.028	31.297	24.561	0.381	2.077	18.644	•	•	•	82	118	49	43	27
OGS081987	0.466	4.379	2.917	5.675	2.673	0.685	0.030	30.884	24.993	0.372	1.665	18.564	•	20	•	77	133	48	55	30
OGS082687	0.418	4.596	3.228	5.532	3.075	0.617	0.029	31.549	26.199	0.291	1.085	17.662	•	•	•	•	•	•	•	•
OGS090287	0.412	4.651	3.181	5.485	3.235	0.637	0.026	30.510	26.142	0.293	0.991	18.172	29	•	•	98	158	48	59	27
OGS090987	0.400	4.657	3.369	5.530	3.504	0.625	0.028	30.245	26.025	0.279	0.839	18.142	•	•	•	•	•	•	•	•
OGS091487	0.398	4.448	3.321	5.615	3.486	0.637	0.026	29.502	26.667	0.236	0.791	17.830	•	•	•	88	146	72	71	28
OGS091687	0.405	4.522	3.390	5.581	4.530	0.662	0.029	28.923	26.330	0.247	0.931	17.706	31	•	•	176	150	77	56	40
OGS091887	0.414	4.424	3.348	5.606	3.627	0.648	0.026	30.520	26.086	0.277	0.970	17.738	50	22	•	170	140	49	44	18
OGS092187	0.436	4.274	3.062	5.536	4.136	0.661	0.026	31.038	24.834	0.310	1.260	17.280	30	•	26	153	143	45	46	31
OGS092387	0.414	4.544	2.790	5.540	3.008	0.645	0.027	31.575	25.684	0.315	1.039	18.011	39	•	29	81	138	53	61	31
OGS092587	0.477	4.457	1.958	5.543	2.321	0.724	0.028	33.303	25.164	0.381	1.692	17.881	61	•	•	71	94	46	54	27
OGS100687	0.573	4.047	2.089	5.780	1.546	0.824	0.025	33.288	22.611	0.448	2.251	19.777	•	23	•	56	69	31	37	24
OGS100787	0.561	4.254	2.222	5.675	1.501	0.843	0.026	33.001	23.009	0.463	2.231	20.019	•	•	•	•	•	•	•	•
OGS100887	0.494	4.462	2.278	5.718	1.981	0.768	0.026	31.588	25.355	0.371	1.695	19.041	•	•	•	52	109	35	39	23
OGS100987	0.530	4.252	2.213	5.797	1.841	0.791	0.026	32.486	24.244	0.407	1.946	19.389	28	•	•	55	108	38	50	14
OGS101287	0.443	4.207	2.114	5.554	1.764	0.677	0.026	33.903	23.418	0.455	1.287	19.866	33	•	•	68	96	32	32	24

*Q=quartz; UNK=unknown; CAS=tetracalcium trialuminate sulfate; AN=anhydrite; C3A-1=tricalcium aluminate; L=lime; P=periclase; TA=tricalcium aluminate