Applied Technology Division
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TRW

Healy Clean Coal Project
Healy Coal Firing at TRW Cleveland Test Facility

Final Report

SN 58175

August 1991

Prepared for:
Alaska Industrial Development and Export Authority
480 West Tudor
Anchorage, Alaska

Professional Service Agreement No. HCP-003

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30 August 1991

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Subject: Contract No. HCP-003
Final Report - S/N 058175
Healy Coal Firing at TRW Cleveland Facility

Dear John:

The final report was approved by DOE on August 16, 1991. The work was performed pursuant to Cooperative Agreement DE-FC22-91PC900544. Please find enclosed (5) copies of the subject report. Copies (1) each, have also been submitted to the attached list of recipients.

If you have any questions, please don't hesitate to contact me at (213) 813-4916 or mail station R4/2058.

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The comments made on the draft report entitled "Healy Coal Firing at the TRW Cleveland Facility" are addressed below.

Usibelli Coal Mine, Inc., Steve W. Denton, July 26, 1991

1. "Out of curiosity, I plotted carbon conversion figures in this section against grind figures reported in the parametric test summaries (copy of plot attached). It is interesting to note that the larger grind runs showed equal, if not better, carbon burn out than for the finer grind runs. Perhaps we should look more closely at increasing grinder output through a coarser grind."

Response: The carbon conversion versus coal grind plot is indeed interesting and shows a definite trend. The trend shows that carbon conversion increases as the coal grind is made coarser. In order to better understand the reason for the observed variation, and its consequences, it is important to recall how carbon conversion is calculated from experimental data. Carbon conversion is calculated (see page 48) from carbon losses to the slag and fly ash. The data also shows (see table 5-7, page 51 for example) that the carbon losses to the slag are much larger than carbon losses to the fly ash and accordingly, the observed trends can be understood by analysis of carbon losses to the slag only. These losses were calculated for every test by multiplying the amount of slag recovered (in pounds) by the carbon fraction in the slag.

The carbon fraction in the slag results from chemical analysis of slag samples. For the performance coal, (where most of the data is available), slag samples and coal sieve analyses are available simultaneously for only three tests (H23, H36, H40). The measured carbon content is plotted, for these tests as a function of coal grind in Figure 5-3 page 53. It is observed that as the coal is made finer, the average carbon content of the slag actually increases. This by itself would contribute to an increase in carbon losses as the coal is made finer.

The slag recovered also varies with coal grind. The variations are shown for the performance coal, in Figure 5-9, page 65. Here it is seen that the slag recovery increases as the coal grind is made finer. Furthermore a 70% through 200 mesh grind or finer yields slag recovery numbers in excess of 75%. This is the second reason for the observed increase in carbon losses as the coal size is decreased.

These trends are consistent with our understanding of slag recovery. A finer coal results in better particle combustion in the combustor and hence slag recovery is increased. As the coal is made coarser, the very large char particles are not captured which yields a decrease in slag recovery. However, these large particles are oxidized in the furnace so that although the carbon conversion in the combustor decreases, the overall carbon conversion is increased as observed.

It can be concluded that for the 34 inch combustor a 70% through 200 mesh coal grind or finer is required to achieve the desired slag recovery levels. For this coal size, carbon losses were of the order of 1% which is an acceptable level. A coarser grind would result in a significant decrease in slag recovery with a minor increase in overall carbon conversion (slag recovery 60% and 99.5% carbon conversion).

2. "Limestone was added to the coal as a fluxing agent in test TBR 12 and resulted in a marked improvement in slag capture. The nature of this test needs to be discussed in more detail in the text and the potential application of the results to fly ash injection in the HCCP should be addressed."

Response: Test TBR 12 did result in improved slag recovery due to fluxing with limestone. However, the slag recovery number for this test may be artificially high due to the release of slag/ash accumulations (from previous tests) in the combustor on injection of the limestone. The results are thus inconclusive.

<u>Department of Energy, Pittsburgh Energy Technology Center, Steven J. Heintz, August 16, 1991</u>

1. "Much of the description of the modifications to the Test Facility, in order to handle and fire Healy coals, is marked proprietary information. TRW needs to review if all marked information is properly proprietary and delete any truly proprietary data. The final report must not contain any proprietary data."

Response: Proprietary information has been removed from the report.

2. "On page 4, "Loads as high as 3800 lb/hr were demonstrated using Healy performance coal." The corresponding Btu/hr and the percent of designed combustor heat release rate should also be included, since the combustor is rated in MMBtu/hr"

Response: This corresponds to a heat input of 30.1 MMBtu/hr assuming a coal HHV of 7932 Btu/lb. System steam production was near 25300 lb/hr which included 2100 lb/hr generated by the flash tank (7% heat loss).

3. "At the bottom line of page 4, NOx emissions ranged from 131 to 270 ppm corrected to 3% stack oxygen (.20-.41 lbs/MMBtu). In the series tests reported, NOx emissions in ppm is used and there is no conversion to lb/MMBtu carried out in the text of the report."

Response: The equation to convert NOx from ppm to lbs/MMBtu is in Appendix C, Equation 20. Furthermore, summary tables have been modified to include NOx values in ppm as well as in lb/MMBtu.

4. "On page 7 and throughout the report, "TRW entrained coal combustion system", "TRW slagging coal combustion technology", and "TRW coal combustion system" were interchangeably used. To be consistent, it is better to use only one."

Response: "TRW Coal Combustion System" has been selected and is used throughout the report.

5. "Page 15 is not properly located"

Response: Page 15 is now properly located.

6. "On page 17, "Note that no NOx ports, as shown, are installed." NOx ports should be defined in the report because other terms are normally used such as overfire air ports, etc."

Response: To avoid confusion, this statement has been removed from the text as well as in the corresponding figure.

7. "On page 21, "..., the combustion gas is rich in CO and H2." CO may be because of incomplete combustion, why H2? What was the percentage in the combustion gas?"

Response: Combustion gases contain CO and H2 because under substoichiometric or fuel rich conditions, no oxygen is available for further oxidation. CO and H2 measurements were not made in the combustor during the tests.

8. "On page 30, "The coal was dried to a moisture level of 10-12%, ..." What was the original moisture content in the coal? Will the moisture content always be required to be reduced to 10-12% before firing in the TRW combustor for the designed boiler in the Healy project?"

Response: The original moisture content of the coal was 23%. The 10-12% moisture content was limited by the air flow capacity of the system and the maximum allowable inlet temperature of the mill. The 10-12% moisture content presented no signicant problems during the Cleveland testing. SO2 monitoring may have been affected. At this time, it is not known whether the moisture content will be required to be reduced to 10-12% in the Healy project. The higher moisture contents may affect coal preparation, grinding, and feeding, as well as combustion performance, baghouse operation, and emissions monitoring.

9. "On page 33, "As fed" coal is referred throughout this report. What is the difference between the term "As fed" used in this report and "As fired" commonly used?"

Response: The terms "As fed" and "As fired" are the same. "As fed" has been exchanged for "As fired" in the report.

10. "On page 33, "Usibelli Coal Mine, Inc., who also funded transportion of the coals to the test facility." The cost of coal, limestone, and transportation were Healy Clean Coal project

funded."

Response: Appropriate changes have been made in the report.

11. "On page 34, Table 5-1, why the totals of three out of four proximate and ultimate analyses are not 100 percent?"

Response: The numbers were checked and the Healy performance coal average proximate analysis was found to be a little off. The corrections have been made. For the TBR coal proximate analysis, the sum is 100.01 because of round off. The same is true for the TBR ash analysis.

12. "On page 55, carbon conversion. Although a formula was given for carbon conversion, several questions relating the test procedure and data acquisition must be asked. How were these slag and flyash samples collected. How can it be ensured that these samples were collected at the same time during the test, not the slag or fly ash generated during earlier boiler tests or operation? Was there any bottom ash? Was the slag weighed in wet or dry?"

Response: Generally, four samples were taken per test at roughly 30 minute intervals. Slag samples were taken from buckets (wet). The buckets were used for temporary storage prior to being dumped into the slag dumpster. The fly ash was taken from drums used for storage of the baghouse catch. The samples are assumed to reflect the given test, and not previous tests, due to the good overall solids balances obtained per test.

13. "On page 64, what is the meaning of "The FCM tests ranged in slag recovery from 62 to 101%"?"

Response: Slag recovery values greater than 100% can be obtained due to randon fluctuations in the slag layer. In addition, determination errors in the coal weight or slag weight may also result in values greater than 100%.

14. "On page 101, NOx Emissions. Referring back to page 4, what is the corresponding NOx emissions in lb/MMBtu?"

Response: The NOx values in lb/MMBtu have been included in the summary tables for each test.

15. "On page 106, is there any physical meaning for calcination? How is this quantitatively related to limestone utilization? How were [CaO], [CaSO4], and [CaCO3] chemically determined?"

Response: The physical meaning of calcination is the degree to which calcium in the limestone reacts to form calcium oxide. Calcium in the form of calcium sulfate is also counted since calcium oxide is the precursor to calcium sulfate. Limestone utilization, however, is the degree to which calcium in the limestone is converted to calcium sulfate.

$$\text{Calcination} = \frac{[CaO]/56 + [CaSO4]/136}{[CaO]/56 + [CaSO4]/136 + [CaCO3]/100}$$

$$\text{Limestone Utilization} = \frac{[CaSO4]/136}{[CaO]/56 + [CaSO4]/136 + [CaCO3]/100}$$

The method of determination of [CaO], [CaSO4], and [CaCO3] in the FCM has been included in the report as Appendix E.

16. "On page 12, "Sulfur mass balance did not close while other mass balance closed well." Is this because of not enough measurements or wrong kind of measurements?"

Response: Moisture in the stack may have interfered with the SO2 measurements. A coating of condensate may have formed on the in-situ probe, which scrubbed SO2 from the flue gas sample as it passed through the probe to the analyzer. This is why SO2 values measured in tests where no sorbent was injected may have been lower than calculated values based on sulfur in the coal.

17. "On page 112, the conclusion on SO2 emissions is not given."

Response: SO2 emissions were suspect, and thus this section has been removed.

18. "On page 113, the TCLP regulatory limit for cadmium is 1.0 MG/L."

Response: The change has been made in the table.

<u>Stone & Webster Engineering Corporation, Brent Crowder, August 28, 1991</u>

1. "Please refer to the "Test Procedures for Healy Clean Coal Project Test Burn at TRW's Entrained Combustion Facility in Cleveland, Ohio", Rev. 1, February 20, 1991 and address whether the objectives (a through h) as stated in Section 1.1 therein were met.

Response: The current objectives were discussed in presentations made to Stone & Webster the first quarter of 1991. The objectives concluded at the end of these presentations are reflected in this final report.

2. "What percent (by weight) carbon was in the slag resulting from the Two Bull Ridge coal?"

Response: The average carbon content in the slag for TBR tests was 2.76%. The average carbon content in the flyash for the TBR tests was 0.79%. The values are given in Table 5-8 of the report.

3. "Per page 112, add the paragraph following the last bullet under "SO2 Emissions and Sulfur Balance" to the "Conclusions", Section 2.5."

Response: SO2 measurements were suspect, and thus not included in this section.

4. "Please define the term "Equivalence Ratio"."

Response: Equivalence ratio is the amount of air entering the combustor relative to the amount of air required to oxidize the coal stoichiometrically.

5. "Change: "Load 20 Btu/hr" to "Load 20 MMBtu/hr""

Response: The correction has been made in report.

6. "In the first line under "Cooling Loads", change: "heating value" to "higher heating value" if correct to do so."

Response: The correction has been made in the report.

7. "According to the Cleveland Test Logic Diagram, Table 1 of the 2/20/91 Cleveland test procedure, TRW was going to determine whether fluxing was necessary. Please describe how this determination was made for the Two Bull Ridge Coal. The first paragraph on page 64 states that fluxing was tried after accumulations had formed and that it had little influence on reducing slag thickness, but if fluxing is introduced from the start, slag accumulation should be preventable. Please provide the following additional information:

1. Describe the nature (location(s), quantity, and consistency) of the slag accumulation in the combustor just before fluxing.

2. Provide the limestone injection rate (if different than 5 percent of the coal flowrate), the coal flow rate while fluxing, and the duration of the two fluxing tests.

3. Why was fluxing not introduced before a large accumulation of slag build up occurred?"

Response: Fluxing was to be initiated if slag tap plugging was a problem. This was not a problem during the period of performance coal testing. Fluxing was used during some TBR coal tests because of indications of slag tap plugging due to high slag viscosity and low phi. Slag tap plugging did not occur with the TBR coal at higher loads and higher phi. Fluxing was also initiated to see what would happen to the slag/ash accumulations in the slagging stage. Results were inconclusive because of short test duration.

8. "Page 95, Section 5.4.3, Main Combustor Operation, second bullet: Could this be changed to read as follows? The difference in exit section heat fluxes between the Healy coal and the Ohio

coal is believed to be primarily due to a difference in the slag T250 values because the slag layers were observed to be "completely" melted (glassy), and must have reached the slag T250 values. Assuming the combined convection-radiation heat transfer coefficient between the combustion gas and the slag fluid surface would be approximately equal for either coal's combustion gas, the lower heat flux for the Healy coal might be attributed to a smaller temperature difference between the combustion gas and the higher liquid slag surface temperature due to its higher T250."

Response: Appropriate changes have been made in the report.

9. "Third bullet, last sentence: Could this be addended as follows? This is because of the large ash accumulations observed post test for the Healy coals. These accumulations created a large resistance to conduction between the slag-gas surface and the tube outer surfaces."

Response: Appropriate changes have been made in the report.

10. "Page 112, Section 5.4.3.,..., at end of section there is the following: "In conclustion on SO2 emissions:, complete the statement or delete."

Response: The words "In conclusion on SO2 emissions:" have been removed.

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Professional Service Agreement No. HCP-003

TRW Space & Defense Sector

One Space Park
Redondo Beach, CA 90278

TITLE

Healy Coal Firing at TRW Cleveland Facility - Final Report

AUGUST 1991

PREPARED BY: T. Koyama, E. Petrill, D. Sheppard — Sept 3, 1991 DATE

APPROVAL SIGNATURES:

S. Ubhayakar, Area Leader, Combustion and Energy Technology — DATE: September 4, '91

A. Solbes, Department Manager, Combustion and Energy Technology — DATE: Sept 4, 1991

Acknowledgements

TRW acknowledges the contributions and support given by the following personnel during the course of this project:

- Steve Denton, Usibelli Coal Mine, Inc. for giving guidelines to safely store and monitor the Healy coals.
- Bob Follett, Stone & Webster Engineering Corporation, for providing temperature measurements in the furnace, and also collecting flyash and slag samples.
- Helene Bjerre-Nielson, NIRO Atomizer, for providing support at Cleveland and analysis of the FCM on a timely basis, which helped in determining the calcination of the limestone injected.

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1. ABSTRACT

A test burn of two Alaskan coals was conducted at TRW's Cleveland test facility in support of the Healy Clean Coal Project, as part of Clean Coal Technology III Program in which a new power plant will be constructed using a TRW Coal Combustion System. This system features ash slagging technology combined with NO_x and SO_x control. The tests, funded by the Alaska Industrial Development and Export Authority (AIDEA) and TRW, were conducted to verify that the candidate Healy station coals could be successfully fired in the TRW coal combustor, to provide data required for scale-up to the utility project size requirements, and to produce sufficient flash-calcined material (FCM) for spray dryer tests to be conducted by Joy/NIRO. The tests demonstrated that both coals are viable candidates for the project, provided the data required for scale-up, and produced the FCM material.

This report describes the modifications to the test facility which were required for the test burn, the tests run, and the results of the tests.

2. EXECUTIVE SUMMARY

TRW conducted a test burn of two Alaskan coals in support of the Healy Clean Coal Project, as part of a DOE Clean Coal Technology III Program in which a new power plant will be constructed using a TRW Coal Combustion System. The TRW system will meter and fire the coal under conditions which suppress NOx emissions. It will also function in conjunction with the furnace as a limestone calciner. A back-end spray dryer will utilize the calcined limestone to reduce sulfur emissions to the required limit.

The tests, funded by the Alaska Industrial Development and Export Authority (AIDEA), and TRW, were conducted between March 29 and June 7, 1991 at the TRW coal combustion test facility in Cleveland, Ohio. This test facility consists of a TRW Model 35 coal combustion system integrated with a 29,000 lb steam/hr Keeler boiler. The coal firing capacity of the facility was increased specifically for these tests to accommodate the lower heating value of the Alaskan coals. Improvements in technology and equipment were also incorporated.

The tests were designed to provide data that will form the basis of the scale-up and design of the combustor and other systems for the Healy Clean Coal Project. The tests also provided calcined material to enable Joy/NIRO to perform pilot plant tests, planned for September, for design of the spray dryer system.

2.1 Objectives

The objectives of the tests were to:

1. Evaluate combustion system operation and performance using selected Alaskan (Usibelli) coals.

2. Collect a 5-ton lot of flash-calcined baghouse catch material (FCM) from the flue gas stream and prepare for shipment to NIRO in Denmark for spray dryer tests. Limestone from Alaska was injected into the combustor/furnace interface.

2.2 Approach

The approach to this project required making necessary modifications to the test facility, then to conduct a series of tests on the Healy coals.

Facility modifications were required to handle higher coal flow rates necessitated by the low heating value of the coals, and to address safety concerns arising from the high volatility of the coal. Modifications were also made to prevent pulverized coal agglomeration and/or accumulation during transfer. This applied to both the pulverizer sweep air system and to the coal feed transport and recycle systems. System lightoff methods and precombustor design were modified to obtain operability and performance consistent with safe boiler firing practices.

2.3 Accomplishments

The test series:

1. Established facility operations for the Healy coals (coal preparation system operation and mill capacity)

2. Evaluated the coals in terms of grinding and handling characteristics, and combustion and slagging characteristics.

3. Produced 5 tons of FCM for the Joy/NIRO spray dryer tests.

Specifically under this program, TRW accomplished the following:

1. Achieved safe and stable operation of the coal feed system.

2. Established successful coal preparation, handling, and feed systems operation on the Alaska coals.

3. Achieved successful precombustor operation.

4. Conducted 10 parametric tests using Healy Performance coal.

5. Collected 5 tons of FCM in 42 separate runs. The lot was shipped to NIRO in Copenhagen, Denmark.

6. Conducted 10 parametric tests using Healy performance coal, and Two Bull Ridge (TBR) coal.

2.4 Results

2.4.1 Facility Operations

During the test program, over 350 tons of Healy coal were handled by the Cleveland test facility without any indication of coal smoldering or fires. The coal preparation and feed systems were operated without any adverse incidents throughout the 10-week period of using Healy coal. The CO2 inverting system was used only when the system was idle. Use of the CO2 deluge system to quench smoldering or burning coal was never required.

The capacity of the Kennedy Van Saun (KVS) ball mill was found to be limited to 0.8 ton/hr, necessitating that tests be of short duration and/or be conducted at reduced loads. This indicated a Hardgrove Grindibility Index of 25 according to KVS. High erosion characteristics during transport were observed for the Healy coal as compared to Ohio coal.

Coal flow rates as high as 3800 lbs/hr were demonstrated using Healy performance coal. This corresponds to a heat input of 30.1 MMBtu/hr (million Btu/hr) assuming a coal HHV of 7932 Btu/lb. System steam production was near 25,300 lbs/hr which included 2,100 lbs/hr generated by the flash tank (7% heat loss). Operation during the test program demonstrated safe and stable operation of the coal feed system including:

- Safe storage of pulverized coal in the surge bin which was used as an accumulator
- Controllable coal flow rate and split
- Smooth, repeatable light-offs during all of over 80 tests
- Prevention of coal agglomeration and accumulation in the coal transport lines.

2.4.2 Precombustor and Main Combustor Operation and Performance

The tests with the Healy performance coal established the operational characteristics of the precombustor and combustor. Stable precombustor operation was achieved with a precombustor coal flow rate of up to 1500 lb/hr. Slag recovery efficiency was excellent, with most of the tests falling in the range of 80 to 90%. The slag tap remained open and free-flowing under all combustor conditions tested, down to as low as 12.5 MMBtu/hr (3 to 1 turndown). There was evidence of ash accumulations at the head end of the main combustor and in the exit of the precombustor. Although the accumulations were cleaned out after intervals of six or seven tests to reduce pressure drop, the accumulations did not appear to adversely affect combustion performance. There were also accumulations of slag in the slag recovery section exit and accumulations of ash in the furnace. These accumulations can be expected to be greatly reduced at Healy due to higher preheat temperatures, larger combustor size, and higher load operation without frequent shutdown.

Carbon losses were low (averaging 1.14% of the total input carbon), with 0.07% lost out the baghouse and 1.07% lost out the slag tap. NOx emissions ranged from 131 to 270 ppm corrected to 3% stack oxygen (0.20 - 0.41 lb/MMBtu).

Solids balances measured on the FCM collection tests were excellent and repeatable to within 10% of closure, giving increased confidence in the slag recovery efficiency and carbon loss results.

The heat absorbed by the combustor was 6 to 13% of the heat input, dependent primarily upon combustor load.

The temperature of the combustion gas exiting the furnace was measured with a high velocity thermocouple (HVT) probe. Furnace exit temperature ranged from 1900 to 2200°F over a load range of 25 to 31 MMBtu/hr.

The flash-calcined material collected for the Joy/NIRO tests was analyzed for level of calcination (percentage of calcium carbonate that oxidized to calcium oxide). Calcination ranged from 50 to 90%. Calcination for the first 11 FCM collection tests was lower (50 to 60%) than for the last 31 FCM tests (80 to 90%).

The tests with the Two Bull Ridge coal showed slightly decreased combustor performance as with the Healy Performance coal. Carbon losses were similar, as well as NOx emissions. CO levels were higher. Slag recovery was less due to the higher T_{250} of the TBR coal.

2.5 Conclusions

The Healy coal test burn demonstrated that the Healy performance coal and the Two Bull Ridge coal can be effectively burned in TRW's coal combustion system. The coal was handled, pulverized, and fed safely and reliably in the Cleveland test facility coal preparation and feed systems. Good to excellent combustion performance was achieved with both coals as inferred by carbon losses. Slag capture was excellent with the performance coal (85%). Slag capture with the TBR coal was less (45%). This is attributed directly to the higher T_{250} (2900 vs 2750°F) of the TBR coal. The larger combustor size and higher preheat temperature (650 vs 400°F) which will be present at Healy will accommodate the TBR coal. Low NOx emissions was also demonstrated. Finally, the tests demonstrated that FCM for the Joy/NIRO spray dryer SOx capture system can be produced by the TRW Coal Combustion System using Alaska coal and limestone.

3. INTRODUCTION

The Healy Clean Coal Project (HCCP) is a joint project of the Alaska Industrial Development and Export Authority (AIDEA) and of the U. S. Department of Energy (DOE). An advanced coal-fired power plant will be constructed in Healy, Alaska. In this project, TRW Coal Combustion System will interface with a Foster Wheeler boiler, and a back-end spray dryer supplied by Joy/NIRO will utilize flash-calcined limestone to control sulfur emissions.

Technical issues associated with the design and operation of the coal combustion system include:

- Effects of coal properties
- Two-phase flow cooling of the combustor shell
- Scale-up from Model 35 combustion system

An approach has been taken which mitigates the risks associated with each of these issues. In particular, for the issues which relate to the effects of coal properties and scale-up, the decision was made to conduct a series of tests at TRW's Cleveland test facility using Healy coals.

The properties of Healy coals are typically low in sulfur, high in volatiles, high moisture, high ash content, and high ash T_{250}. Coals with this combination of properties, and the ensuing low heating value, had not been tested before in the TRW Coal Combustion System. Accordingly, the first goal of the test series was to obtain operational data.

- The high volatile content is advantageous from a combustion view point, but it increases the hazards associated with handling, preparation, and feeding.
- The high ash content and high T_{250} affect primarily the slagging and slag tapping characteristics of the combustor and the heat rejection to the cooling system. The operating conditions are also affected, in particular, the required coal flow split between the precombustor and the main combustor as well as the main combustor equivalence ratio.

The second goal was to conduct a series of tests with representative Healy coals to establish a database to be used for scaling to 350 MMBtu/hr during the design phase of the Healy Clean Coal Project.

At the same time, flash-calcined material (FCM) would also be produced using an Alaskan limestone. The FCM sample would be later used by Joy/NIRO during pilot plant tests. The results of these tests would be used by Joy/NIRO during the design of the Healy back-end clean-up system.

The project team participating in the Healy Clean Coal Project includes AIDEA; DOE; Golden Valley Electric Association, the Healy power plant owner; Usibelli Coal Mine, Inc., the coal supplier; TRW, the coal combustion system supplier; Foster Wheeler Energy Corporation, the boiler supplier; Joy/NIRO, the spray dryer system supplier; and Stone and Webster Engineering Corporation, the project architect/engineer. The project team participated in the test burn by reviewing test plans and procedures, supplying coal and providing storage advice (Usibelli), being on-site during tests (Stone and Webster, Joy/NIRO), and receiving test data and solid samples.

3.1 OBJECTIVES

The objectives of the Cleveland tests were to:

1. Evaluate TRW Coal Combustion System performance at reduced scale using selected Alaskan coals. Data obtained were:

   - Coal grindability
   - Pulverized coal handling/safety
   - Coal feed system operations
   - Combustion efficiency
   - Slag removal efficiency
   - Combustor cooling loads
   - NO_x emissions
   - Furnace temperatures
   - Flyash characteristics
   - Limestone calcination

2. Collect 5 tons of flash-calcined material (FCM) from the flue gas stream by injecting limestone from Alaska into the combustion/furnace interface. The FCM collected by the baghouse would be packaged for the Joy/NIRO spray dryer test work at NIRO's test facility in Copenhagen.

3.2 APPROACH

The overall approach for the test burn was to test the selected Healy coals at TRW's Coal Combustion System Test Facility in Cleveland, Ohio.

The steps taken to conduct this test burn were to:

1. Procure the Healy coals from Usibelli Mine, Inc. in Alaska and transport to a store near the test facility.

2. Modify the Cleveland Coal Combustion System Test Facility as required to perform tests on Healy coals.

3. Perform tests designed to provide the data and the FCM sample as described in the objectives.

4. Analyze the test data and prepare the final report.

4. CLEVELAND FACILITY

4.1 Description of Cleveland Facility

The TRW Coal Combustion System Test Facility is located in the Argo-Tech manufacturing plant in Euclid, Ohio. The facility was originally owned by TRW, and then sold to Argo-Tech. The test facility is currently leased and operated by TRW. The test facility is a commercial application of the combustion system, instrumented for testing. It provides process steam to the manufacturing plant during operation.

The manufacturing plant originally received steam from three stoker-fired watertube Keeler boilers. These boilers were converted to oil and gas operation in the late 1960's, then mothballed in the 1970's. In 1985, Unit No. 3 was converted to fire pulverized coal using the TRW coal combustion system. The combustor/boiler unit, rated at 29,000 lb/hr, produces saturated steam at 100 psig. It presently operates under an Ohio EPA permit for sulfur dioxide and nitrogen oxide and has burned a wide range of coals; low, medium, and high-sulfur bituminous, low-volatile low-sulfur anthracite, and low-sulfur, high-volatile, high-ash subbituminous coal. These coals have featured a T_{250} range of 2300 to 2850°F.

The facility consists of the coal preparation and feed, limestone feed, combustor, boiler, and auxiliary systems. Figure 4-1 is a plan view of the Cleveland facility.

4.1.1 Coal Preparation and Feed Systems

Coal up to 1 1/4 inch x 0 inch size was received by the TRW test facility and pulverized to a nominal 70 to 80% through 200 mesh, transported to a surge bin, and fed to the combustor system. Figure 4-2 shows a schematic of the system.

The coal preparation system includes a KVS ball mill with gas-fired sweep air to dry and carry the coal to the surge bin. The as-received coal moisture content was 23%. The coal was dried to a level of 10-12%. The drying process was limited by the air flow capacity of the system and the maximum allowable inlet temperature of the mill. A classifier with a return leg to the mill allows control of coal particle size distribution. A baghouse separates fines from the sweep air stream; the fines are continuously added back to the coal in the surge bin. For the Healy coal tests, the existing CO2

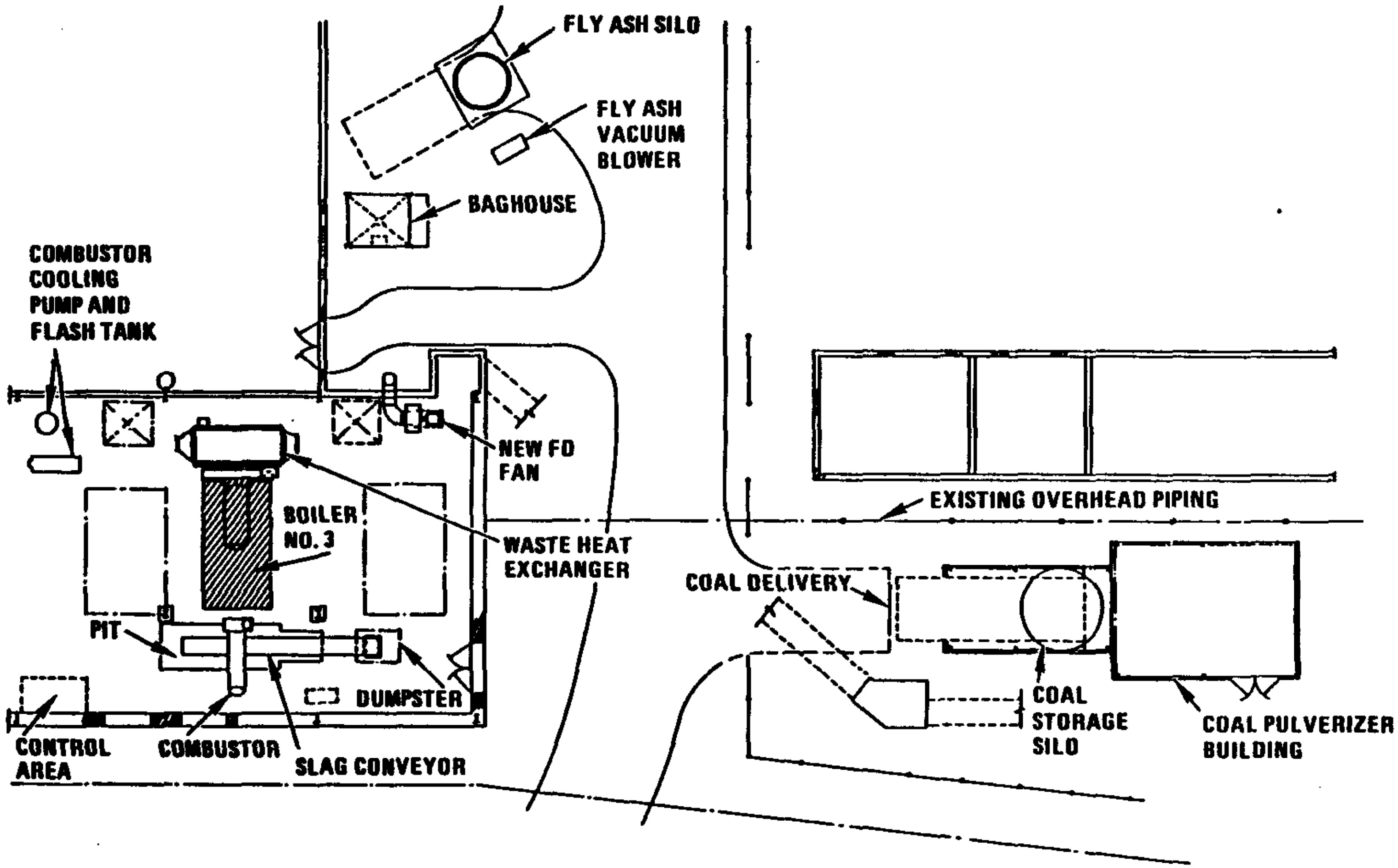


FIGURE 4-1. PLAN VIEW OF THE CLEVELAND TEST FACILITY

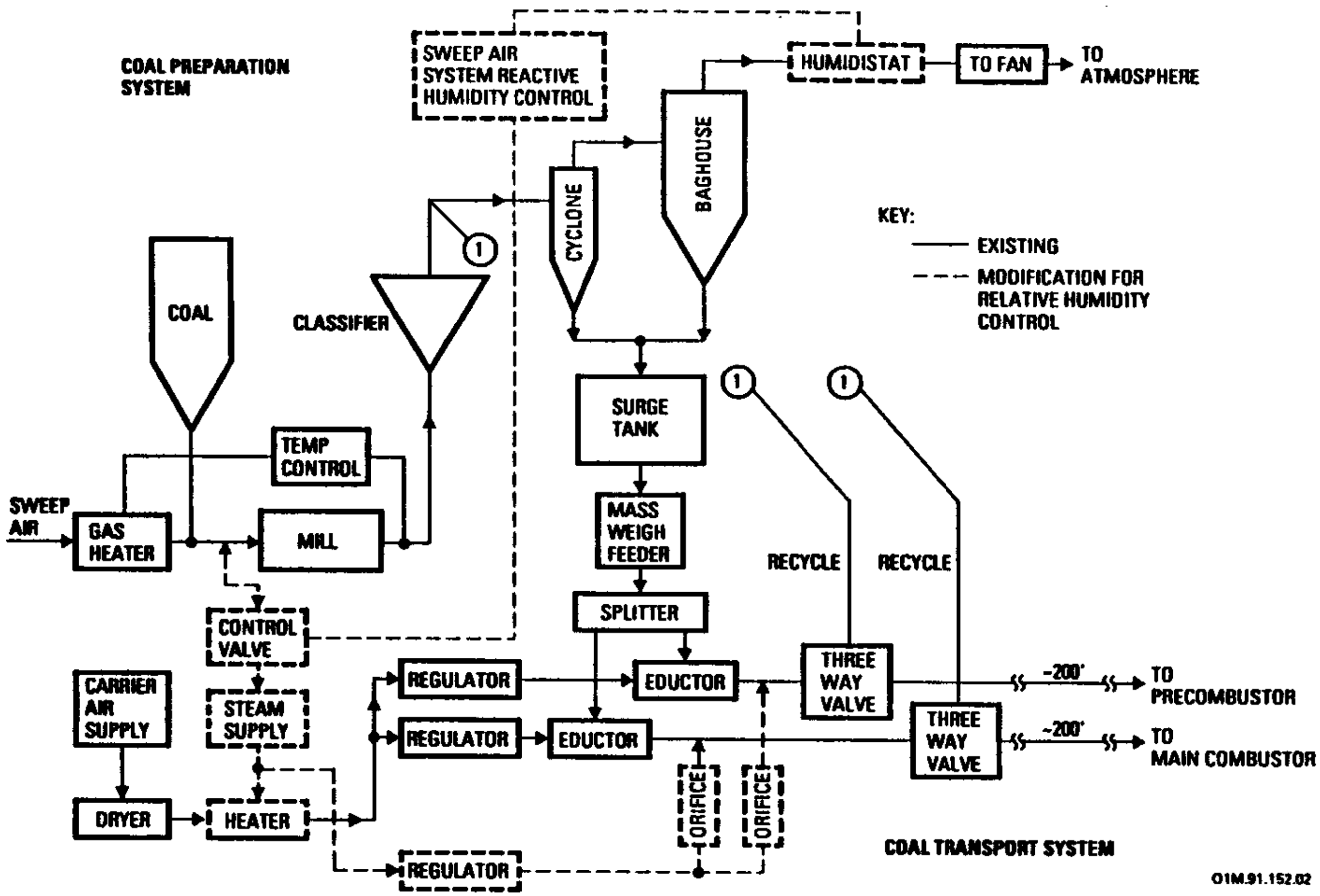


FIGURE 4-2. COAL FEED SYSTEM AND MODIFICATIONS OVERVIEW

inverting system was upgraded and a deluge system installed for fire prevention and quenching. A CO monitoring system was implemented at the baghouse exit to indicate presence of coal smoldering or fires.

The coal feed system includes a surge bin with vibrating bin bottom to assure coal availability from the bin. The surge bin collects pulverized coal from the coal preparation system. It provides the capacity which allows for separate control of pulverizer output and coal feed to the combustor system. The surge bin was also used as an accumulator on the Healy coals.

The surge bin supplies coal to a drag-chain-type feeder which controls and meters the coal flow. An adjustable splitter divides the coal flow into two streams, one to the precombustor, the other to the main combustor. The coal is transported to the combustor, located 200 feet away, via carrier air at an air-to-fuel ratio ranging from 0.5 at light-off to 1.5 for the Healy tests.

4.1.2 Limestone Feed System

Pulverized limestone was used in the TRW Coal Combustion System for sulfur capture or fluxing to control the T250 of the ash. Limestone is received at the plant preground to the size required (at least 70% through 200 mesh). Limestone is stored on site in bags or in 30-ton tanker trucks. In operation, the limestone is transported pneumatically to a 4-ton storage tank with a vibrating bin-bottom which supplies the drag-chain-type weigh feeder with a smooth, steady supply of limestone (Figure 4-3). The weigh feeder monitors and controls the limestone flow rate. The flow stream can be split with an adjustable splitter. The limestone drops through the splitter into two eductors. Carrier air transports the limestone through 1-1/2 inch lines to the limestone injectors and/or the fluxing line. This system is very similar to the coal feed arrangement.

Figure 4-4 shows two injection locations available for sulfur capture: the centerline injector and/or the peripheral nozzles. The centerline injector is installed in the back wall of the combustor exit duct leading to the boiler, on the centerline of the duct. The peripheral nozzles are eight equally-spaced nozzles located around the periphery of the secondary burner. For the Healy tests, the FCM collection tests were conducted with the limestone injected through the centerline injector, except for one test in which the limestone was injected through the nozzles. Previous tests on bituminous coal with sulfur content ranging from 1 to 3% demonstrated that for high-sulfur coal, splitting the limestone flow equally between the two injection options gave the optimum sulfur capture.

Limestone was used to flux the ash in two tests on the Two Bull Ridge coal. During these tests, limestone was not used for sulfur capture. To that effect, limestone was injected into the main combustor coal feed line upstream of the coal injector. The limestone flow rate for fluxing was about 5% of the coal flow rate. No problems were encountered with the operation of the fluxing system nor the combustion system during fluxing.

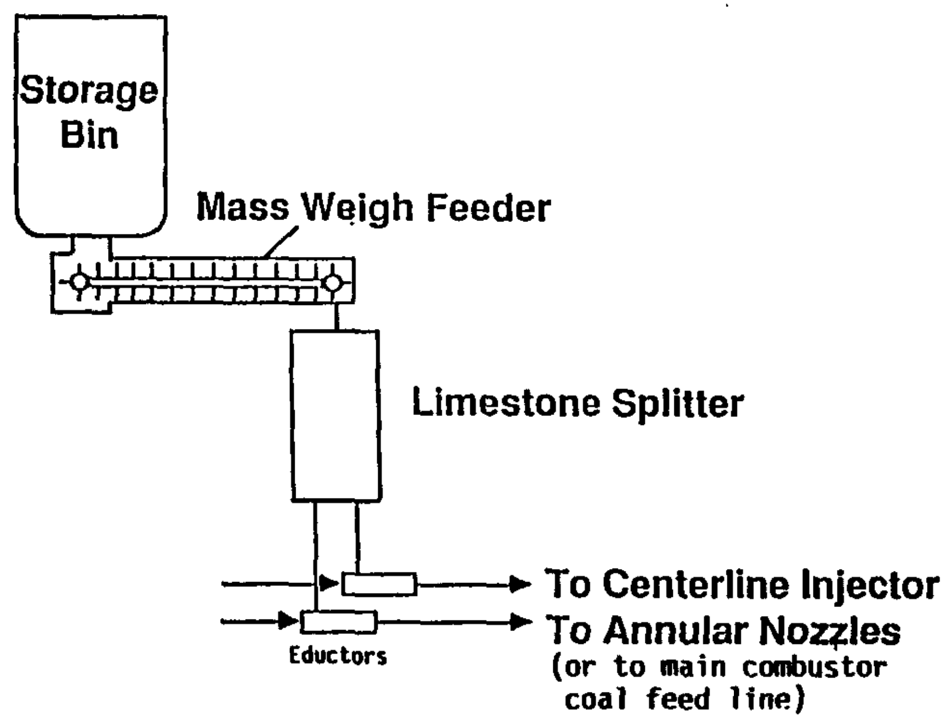


FIGURE 4-3. LIMESTONE FEED SYSTEM

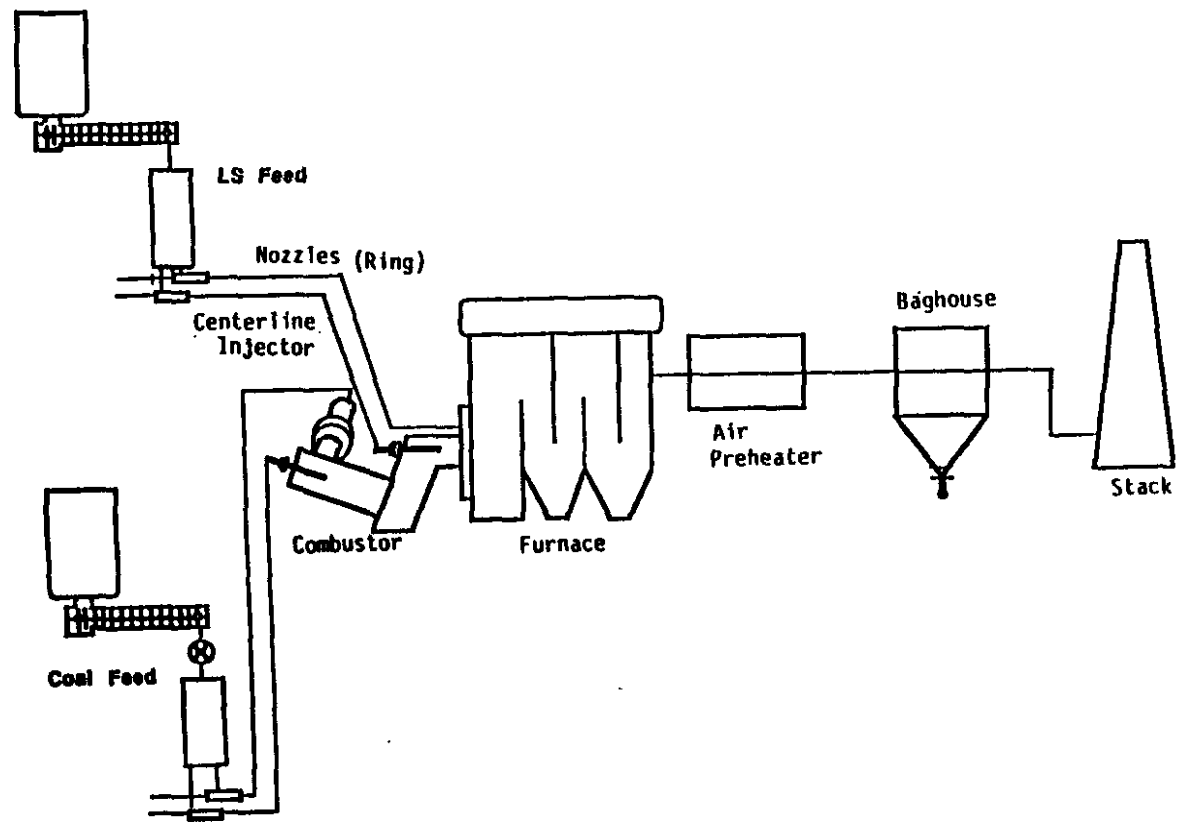


FIGURE 4-4. COAL AND LIMESTONE INJECTION LOCATIONS

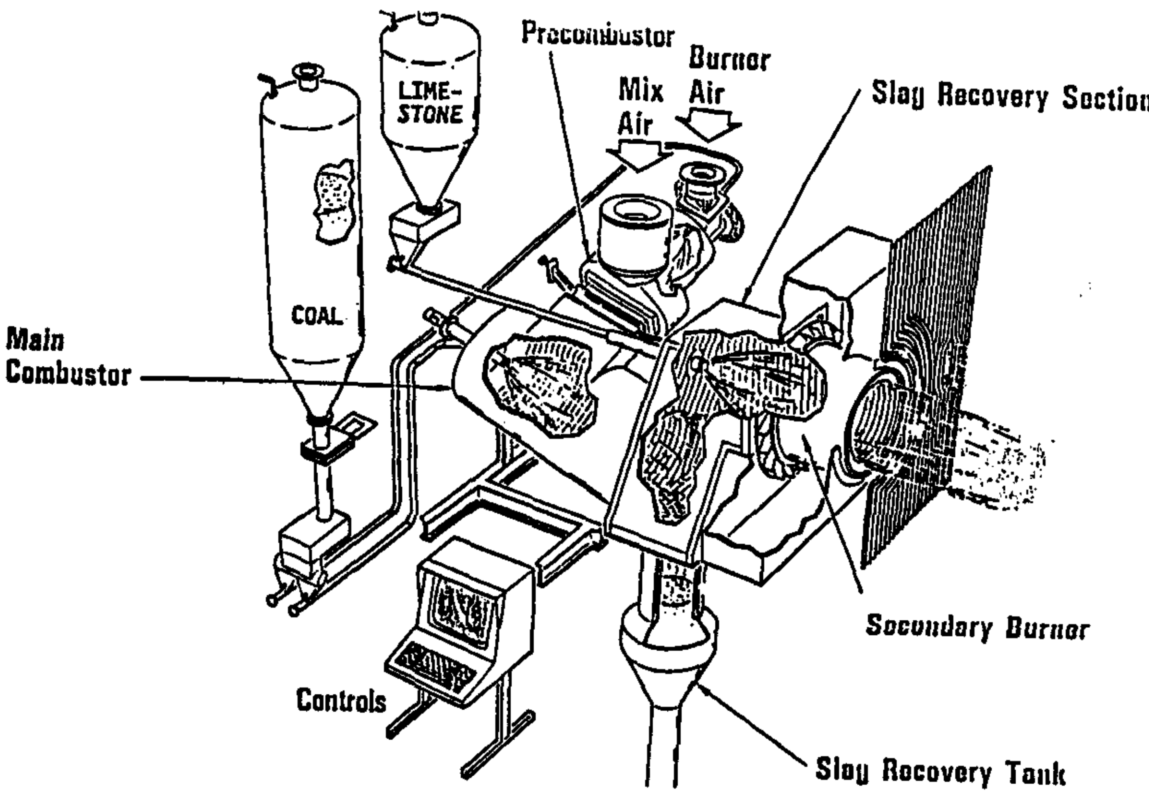
4.1.3 TRW Coal Combustion System

The TRW Coal Combustion System includes a precombustor and a main combustor as shown in Figure 4-5. A photograph of the installation is included.

The precombustor provides high-temperature air to the main combustor for ignition by burning 25 to 50% of the coal stoichiometrically, then mixing with the remaining first stage air. Mounted tangentially on the main combustor, the precombustor is a water-cooled refractory lined cylinder approximately one-fourth the size of the main combustor. Coal is injected axially along the precombustor centerline. The remaining first stage combustion air is added to the precombustor exhaust gases. These hot gases then enter the main combustor, forming a swirling flow pattern.

With the hot gases from the precombustor, the balance of the coal is injected into the main combustor which operates in a substoichiometric, slagging mode. Combustion stoichiometries from deeply sub to complete can be used. The main combustor is a water-cooled cylinder inclined at a 15° angle towards the slag tap with a tangential air inlet and a centered exit baffle. The tangential air inlet and the baffle promote proper mixing and an internal vortex flow pattern for rapid combustion (Figure 4-6). The coal injector, located at the head end, injects coal in a conical pattern axially along the main combustor centerline. Multiport injectors have also been successfully used.

Fifty to seventy-five percent of the coal is injected into the main combustor where it is entrained by the hot, swirling combustion air from the precombustor and burned in flight. Ash contained in the coal is converted to molten slag and centrifuged to the combustor walls, forming an insulating slag layer. The fluid slag flows by gravity down the main combustor to the slag tap, and then into the water-filled slag tank where it is quenched, and fractured into pebble-sized particles. The slag is removed from the slag tank with a drag chain conveyor and dropped into a bin for disposal (Figure 4-7).



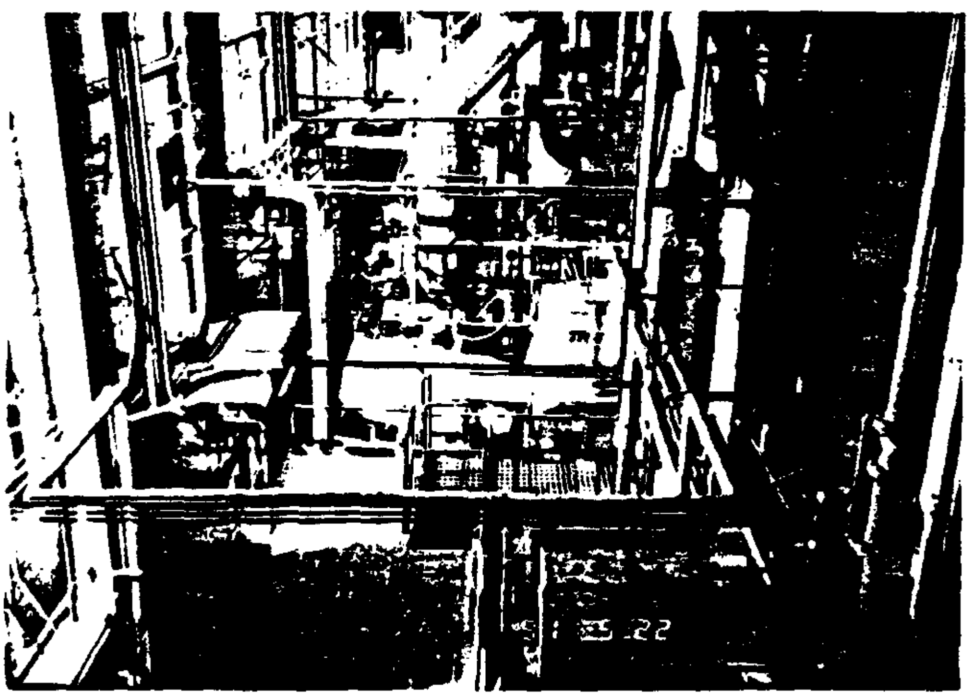


FIGURE 4-5. TRW COAL COMBUSTION SYSTEM

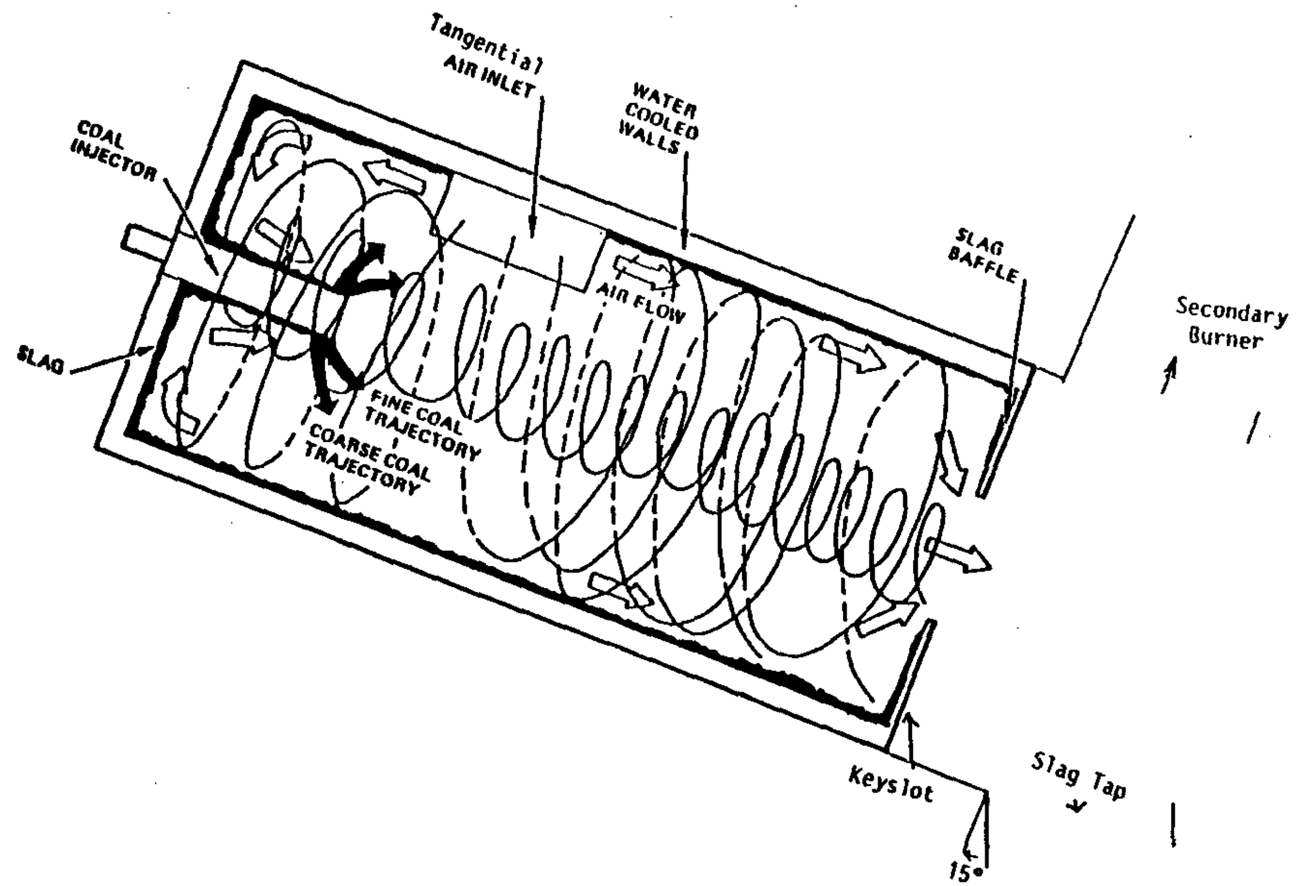


FIGURE 4-6. MIXING, COMBUSTION, AND INTERNAL VORTEX FLOW PATTERN IN MAIN COMBUSTOR

FIGURE 4-7. SLAG REMOVAL WITH DRAG CHAIN CONVEYOR

The hot combustion gases enter the slag recovery section which provides additional residence time for combustion and additional slag recovery. When the main combustor operates at substoichiometric (fuel-rich) conditions, the combustion gas contains CO and H2. The gases are ducted to the furnace via a water-cooled duct. Secondary air is added at the interface of the furnace so as to yield a stoichiometry in the range 1.1 to 1.4. The secondary air is introduced through an annulus in the windbox surrounding the combustor hot gas duct. Combustion is completed in the boiler's furnace.

4.1.4 Boiler System

The Keeler boiler is divided into furnace and convective sections as shown in Figure 4-8. The exit of the TRW combustor interfaces with the boiler at the front face of the furnace section. The furnace section of the boiler (only 40% water-cooled) is refractory-lined, providing a hot combustion zone. The convective passes of the boiler cool the gases to 500 to 700°F prior to entering a tubular air preheater, which preheats the combustion air to a maximum of 430°F.

The boiler is a balanced-draft system with forced and induced draft fans. The balance point is located inside the boiler. A baghouse with Gortex bags removes particulates from the gas stream before exhausting out the stack. Emissions (sulfur dioxide (SO_2), nitrogen oxide (NO), carbon monoxide (CO), and oxygen (O_2)) are monitored continuously at the stack using in-situ analyzers. SO_2 and NOx are measured by a Lear-Siegler instrument using second derivative spectroscopy. A zirconium oxide analyzer measures O_2, and an infra-red absorption analyzer measures CO.

4.1.5 Auxiliary Systems

The combustor is cooled by pressurized sub-cooled water which is flashed to steam in a flash tank. The pressure in the cooling jackets is near 650 psig. The flow rate of the combustor cooling water and its temperature rise is measured to determine combustor heat absorption.

The operation of the combustor and boiler systems are controlled and monitored by a computerized distributed control system. The control room contains two computer modules and a printer. The system is customized for the

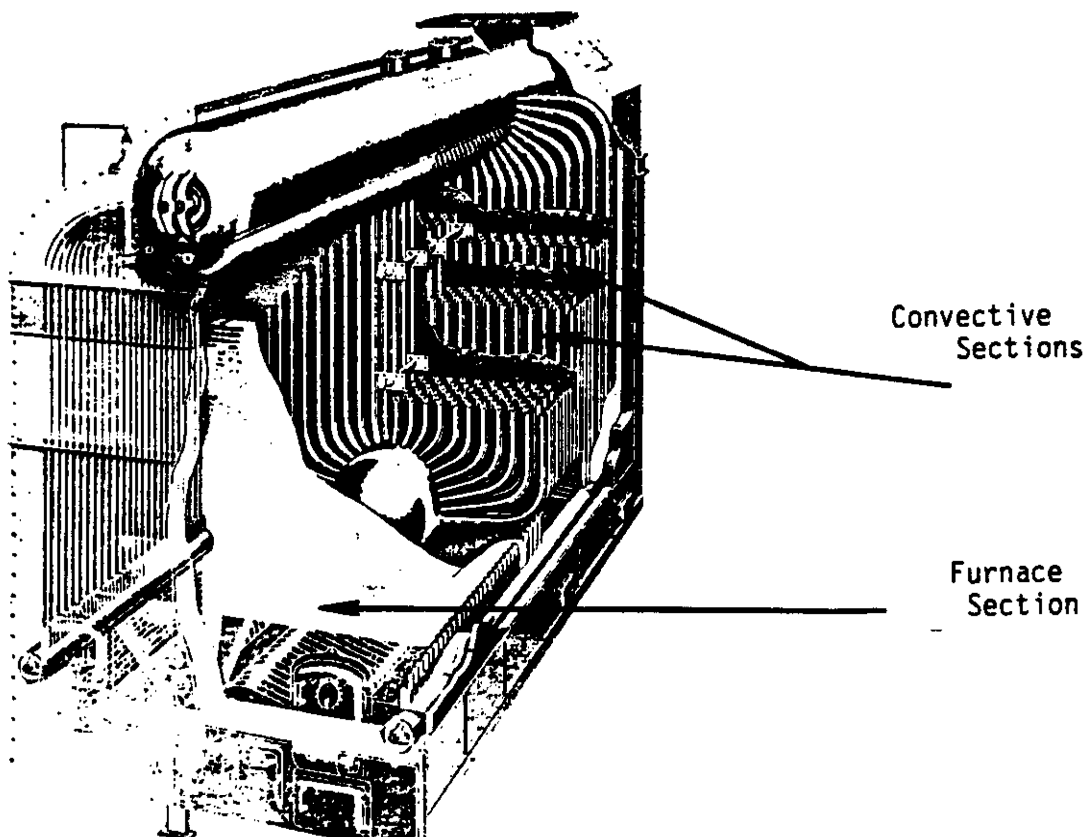


FIGURE 4-8. CUTAWAY VIEW OF KEELER BOILER

TRW combustor and includes alarms as well as automatic main fuel trips to shut down the combustor in the case of potentially hazardous conditions.

Three types of data can be retrieved from the system:

1. Instantaneous conditions of the system.

2. Current trends of up to six measurements.

3. Historical trends of measurements.

4.2 Facility Modifications for the Healy Test Burn

The Healy test program could not have been conducted without making a number of facility and equipment changes to the Cleveland Test Site. Many of these modifications were required to deal with the large change in Healy coal properties compared to other coals which the facility had been recently handling. Modifications were needed to:

- handle higher coal flow rates necessitated by the low heating value of the coal.

- address safety concerns arising from the high volatility of the coal.

A number of issues pertaining to system operation and performance had been carried over from previous test activities. Additional modifications were required to:

- resolve coal feed control problems.

- provide a high level of system lightoff reliability.

- improve system performance.

The installation of a new coal feed system had been undertaken prior to the implementation of the Healy test burn. Upgrading of the system was required to meet Healy requirements.

A brief description of each of the modifications at Cleveland prior to the Healy test burn and the reason for their implementation is presented in the following sections.

4.2.1 COAL PREPARATION SYSTEM

4.2.1.1 System Safety

Because of the high volatility of the Healy coals, provisions for fire prevention and fire fighting were installed in the coal preparation plant. CO_2 was used for inverting and was available for suppressing smoldering or fires if required. Water was available for use as a last resort. CO and temperature levels were monitored to determine system status. Steps taken to improve coal feed control and to control relative humidity also improved safety.

- CO_2 inverting

Additional lines for flowing CO_2 gas from the existing CO_2 dewar system were installed in strategic locations for inverting the system after shutdown.

- CO_2 deluge

An emergency high pressure CO_2 deluge system was installed for immediately backfilling the entire system. Activation required pulling a single handle outside the building in the event of an emergency.

- Water lines

Water lines with connections for attaching a flexible water hose were installed to strategic equipment in case of need for fighting a fire and/or coal smoldering.

- Sample system

Sample lines and a continuous monitoring system were installed for constant monitoring of CO and CO_2 in the system.

4.2.2 Coal Feed System

4.2.2.1 Pulverized Coal Surge Bin

Increased coal storage capacity was needed in the surge bin. A larger (3000-lb capacity) surge bin was installed. A vibrating bin-bottom (provided by Vibrascrew) was also installed to assure a stable flow of coal to the weigh feeder. The bin-bottom was enclosed inside the tank providing a unit meeting the NFPA 50-psig design pressure requirement. CO_2 inverting was continuously maintained in the dead space between the bin-bottom and tank walls. The tank interior was inverted only when the system was off for more than several hours. Coal was left in the surge bin only when necessary.

- Structure modification

The existing mounting structure was changed to contain and support the larger/heavier surge bin. Personnel access grating, etc., was modified as required.

- Indicators

A new vertical mounting arrangement for the indicators used to monitor the coal level in the surge bin was installed. The existing electrical wiring/DCS logic arrangement was used.

- Bin-bottom vibrator

A second vibrator was added to the bin bottom. The bin-bottom vibrators required removal for adjustment. Setting the new and or original vibrators at different outputs provided three available vibration levels by switching one, the other, or both units on, without the need to remove the vibrators for adjustment. The lowest available level of vibration provided the best coal flow stability and was used during the test series.

- Atmospheric vent

The existing vent to the sweep air system was removed. A new atmospheric vent to ground level outside the coal preparation building was installed. This vent was open during most of the testing.

4.2.2.2 Weigh Feeder/Splitter/Transport/System

A Vibrascrew mass weigh system enclosed in a safety vessel meeting the NFPA requirements had been installed prior to Healy. It provided sufficient output to meet Healy requirements. CO2 inverting was continuously maintained within the safety vessel. Changes to the feeder were made to improve its performance. A new enlarged splitter assembly was required.

- Coal sample port

A pipe and valve was installed for sampling pulverized coal immediately below the isolation gate valve positioned between the surge bin and feeder.

- Exit transitions

New upper and lower feeder exit transitions were made with steeper sides to prevent coal accumulations on their surfaces. Small coal accumulations had affected the weigh feeder load cell reading. This reading provided system stability as well as coal density data.

- Feeder drag chain

Metal drags of larger cross section were installed on the drag chain to increase the area of the feed channel swept by the drags. Drag chain speeds up to 25 ft/min appeared to provide stable coal flow without this modification. Incorporating the change provided stable flow at the maximum speeds of 40 ft/min required during the Healy test program.

- Feeder inlet box

Shrouds previously employed within the feeder inlet box to help assure coal supply to the drag chain were eliminated.

- Splitter/eductor assembly

A larger splitter/eductor assembly was designed, fabricated, and installed. The assembly included new three-inch and four-inch Fox Eductor Assemblies. Three sets of different-sized nozzles were available. Changing nozzles had little effect.

- Transport Lines

New carbon steel schedule 80 three and four inch lines were installed for conveying precombustor and main combustor coal, respectively. The transport lines required about 5.5 equivalent 90 degree bends and over 200 feet of length. Approximately the last 30 feet of both lines was stainless steel. All bends were short radius flanged at both ends for quick access for line inspection and/or clean out. Coal coating in the lines never exceeded a very light dusting after relative humidity control and grounding was provided.

The end of the main combustor line was initially installed at a 45 degree angle from plant ceiling to floor. This was changed to vertical after a large deposit of coal was found at ground level in the line.

A connection was provided in the main combustor recycle line for discharging coal to a guppy storage system. A return line was installed for returning coal from the guppy to the surge tank. The need for these lines was later negated by a decision not to use the guppy system.

- Diverter Valves

Special three-way air-operated ball valves were installed to divert coal flow from recycle to firing. The valves were returned to the recycle position after shutdown. These valves retain constant flow area at all ball orientations. The air operators were modified to require only a few seconds transition time from the recycle to the firing position. This minimized coal accumulation at the valve during the transition period. The shortened time provided very smooth lightoffs.

- Fire Valves

Special two-way air-operated ball valves were installed as fire valves. Each valve was opened prior to cycling its corresponding diverter valve. This technique assured that carrier air flow was never intermittently combined with coal. This avoided intermittent flame failure at light-off which had previously been a problem.

- Back Purge

An enlarged back purge air supply system was required to supply sufficient flow to adequately clean the transport and recycle lines during back purging. Back purge operations were carried out first through the precombustor transport line, splitter assembly, and the main combustor recycle line. Both diverter valve positions were then reversed and the procedure performed through the main combustion transport line, splitter assembly, and precombustion recycle line.

4.2.3 Limestone Feed System

The Vibrascrew limestone feed system already installed did not require any modification for this program. Catch and weigh calibrations were run to assure the accuracy of the limestone flow at the low flow rates required (less than 1 pound per minute). This system has delivered rates as high as 25 pounds per minute.

- Limestone centerline injector

A new water-cooled limestone centerline injector with a thermal expansion compensation joint was installed. The previous injector, designed without compensation, had distorted and failed.

- Limestone fluxing

A Y-joint connection for injecting limestone into the main combustor coal transport line for fluxing was installed downstream of the fire valve. Connecting plumbing from the existing system to the fluxing line shutoff valve was added. A two-way splitter and eductor system was already available. This permitted injecting limestone into the burner throat and fluxing at the same time. Fluxing was not used while making baghouse catch product for NIRO.

4.2.4 Flue Gas/Fly Ash Systems

The fly ash from the Healy test burn was handled without making major modifications to the system. A method for dumping all the sorbent collected from each test into barrels was devised. A special attachment for conducting the material from the fly ash silo into the barrel was installed. The barrels were sealed after filling and shipped to NIRO.

The water content of the flue gas was higher than previously experienced. The coal was dried to a moisture level of 10 to 12%, not the normal operating level near 2%. No baghouse operating problems were experienced as a result of the higher moisture content of the flue gas. Problems with deposits in the stack emissions monitoring equipment did require attention. The equipment was checked out and cleaned by Spectrum Systems during the program.

At the outset of the Healy test burn, an unusually high pulse rate was accidently imposed on the baghouse. This cleaned the bags to where some of the very fine fly ash bled through creating a stack plume. Reducing the pulse frequency by adjusting/repairing the timer control system resolved the problem. Each row of bags was pulsed at a uniform period of one minute between rows. A similar practice is also used by NIRO to maximize cake uniformity on the bags.

4.2.5 Combustor System

A number of modifications were made to the head-end of both the precombustor and main combustor in order to accommodate the larger-sized coal injectors required. Centerline coal injection was used at both locations. Provisions were incorporated to allow changing the depth of the location of coal injection relative to the head-end.

- Precombustor injector

The precombustor injector was a pipe of the same diameter as the precombustor coal transport line. Windbox equipment within the precombustor surrounding the injector had to be modified to accommodate the larger pipe. Various flame holding arrangements were tried until a system was found which could adequately attach the coal flame despite a nearly two-fold increase in cold carrier air present.

The coal flame scanner was relocated so that readjustment by the operator during lightoff was never required. Prior positioning had occasionally resulted in the generation of an erroneous coal flame signal if the flame scanner picked up the gas ignitor flame.

The ignitor acted as an excellent source of stabilization, however, the goal was to operate with the ignitor off. Flame-holding without the ignitor was verified, however, much of the test program was conducted with the ignitor on.

The injector was mounted so that different length sleeves mounted and sealed between bolted flanges could be used to change the depth of the location of coal injection. The location of injection relative to the plane of the precombustor throat proved to be important. The coal supply pipe was extended about six feet straight out in front of the injector.

- Main combustor injector

A pintle-type injector was used for the main combustor. The existing hot sleeve was used as the outer sleeve within which the coal/carrier air flowed. The end of the sleeve required a redesign and repair of cracks which would have resulted in cooling water leakage. The hot sleeve was freed from the headend plate prior to the start of testing.

The pintle deflector, or wear ring, used to divert coal flow outward was replaceable. Replacement of this piece was necessary during the program because of the very high rate of erosion noted with the Healy coal.

The injector arrangement was also designed so that sleeve extensions mounted and sealed between bolted flanges could be used to alter the depth of the location of the coal injector. The injector was moved from a two-inch depth to as much as eight inches during the test program.

The coal entrance to the injector was changed at the start of the program from vertical down to sloped upward.

- Slag tap

A special plate containing a restrictive slag tap had been removed during earlier testing. A special dipper skirt arrangement incorporating tiles extending from below the water to the bottom side of the plate had been installed at the same time as the plate. These tiles had deteriorated and required replacement to prevent dipper skirt overheating. It was noted that the tiles contained numerous vertical cracks which allowed the tiles to crumble and fall inward.

New tiles were installed in two sections with a sawbreak two inches below the normal level of water on the dipper skirt. Retaining bands were welded in place in locations where contact with slag could be avoided. The saw cuts reduced the stress levels in the tiles. No case of dipper skirt overheating due to tile failure was noted during the program.

4.2.6 Distributed Control System

The recycle, lightoff, and back purge system changes required that logic revisions be programmed into the Westinghouse DCS. New control and data display stations were created. A ramping station was added for control of the coal feeder speed. A fully automatic system for controlling air and fuel changes over the load range from lightoff to full load was programmed but not implemented.

5. TECHNICAL DISCUSSION

5.1 Coal Types and Properties/Implications

The Healy coals are subbituminous coals with high moisture, high ash content, and high volatility. The ash also has a high T_{250}, the temperature at which the ash flows with a viscosity of 250 poise.

Coals with this combination of properties had not been tested before in a TRW coal combustion system. The high moisture was a concern for handling, drying/pulverization, and feeding the coal as well as combustor performance, baghouse operation, and emissions monitoring at the stack. The high ash and high T_{250} was a concern for slagging characteristics and slag recovery efficiency. The high volatility is beneficial for combustion, but posed safety concerns in storing and pulverizing the coals, and feeding the pulverized coals to the combustor.

Two coals were selected for this test burn series: the Healy performance blend and Two Bull Ridge coal. The coals, both candidate station coals for the utility project, were supplied by Usibelli Coal Mine, Inc.. Two other coals were also supplied to the test burn project by Usibelli but were not tested. These were waste coal and run-of-mine coal.

The Healy performance coal is a 50-50 blend of run-of-mine coal, and waste coal. The run-of-mine coal has a lower T_{250} and is currently sold to overseas customers. The waste coal has a higher T_{250} and currently has no market. The reason for blending these coals is to yield a technically viable coal at a reasonable price. The Two Bull Ridge (TBR) coal is a low-grade seam coal, from a seam from which Usibelli is not currently producing. This coal is another potentially low-priced fuel for the Healy power plant.

As fired analyses of the two coals are given in the following table. The analyses are averages of a number of samples taken after pulverizing, from a sample port in the surge bin of the coal feed system. The performance coal analysis is an average of 22 samples, the TBR analysis is an average of 8 samples. The ultimate and proximate analysis and the mineral analysis of the ash of each coal sample are presented in Appendix A, Tables A1 & A2.

The summary table shows that the performance coal was dried to about 11% moisture for these tests. The as-fired ash content was 20%, heating value about 8000 Btu/lb, and the

Table 5-1. Average Analysis of As-Fired Coal

	Average of Healy Performance Coal Analyses	Average of Two Bull Ridge Coal Analyses
PROXIMATE		
% Moisture	11.00	9.82
% Ash	20.63	27.32
% Volatile	39.24	38.20
% Fixed Carbon	29.13	24.67
Btu/lb	8047	7358
ULTIMATE		
% Moisture	11.00	9.82
% Carbon	47.81	43.50
% Hydrogen	3.62	3.41
% Nitrogen	0.77	0.76
% Sulfur	0.33	0.36
% Ash	20.61	27.32
% Oxygen	15.86	14.83
ASH ANALYSIS		
% SiO2	61.62	58.05
% Al2O3	14.46	21.71
% TiO2	0.64	0.95
% Fe2O3	4.53	3.78
% CaO	9.92	6.28
% MgO	1.76	1.62
% K2O	1.74	1.96
% Na2O	0.70	0.14
% SO3	3.31	3.16
% P4O5	0.17	0.14
% SrO	0.10	0.07
% BaO	0.23	0.27
% MnO	0.16	0.15
Undetermined	0.64	1.73
T250 (Calculated)	2692	2876

T_{250} was about 2700°F. The TBR coal was dried with the same mill conditions to a lower moisture content at about 10%. The as-fired ash content was higher at 27%, heating value lower at about 7400 Btu/hr, and the T_{250} was higher at about 2900°F, due to different constituents in the ash. The volatile content and sulfur content were comparable for both coals.

As will be discussed subsequently, the coal preparation system (mill) also imposed limitations as a result of the low grindability of the coal. Consequently, performance data as well as FCM collection data were acquired during tests of limited duration. The maximum duration for these tests was about 3 hours as limited by the capacity of the coal feed system surge bin which was used as an accumulator.

5.2 Limestone Types and Properties

Two Alaska limestones were available for use during Healy testing. They were Cantwell limestone which came from a previously unmined quarry, and Cantwell dolomite limestone which came from a previously mined quarry. Chemical and physical properties for each limestone are given in the following table. It indicates that the Cantwell limestone is much richer in calcium carbonate (90%) than the dolomite limestone (60%). For Healy testing, only the Cantwell limestone was utilized. This was because it was thought that the Cantwell limestone would generate a more suitable type flyash material for NIRO's pilot plant tests.

5.3 Test Description

The tests for the Healy test burn were conducted between March 29 and June 7, 1991 at the TRW Coal Combustion System Test Facility in Cleveland, Ohio. Over 350 tons of Alaska coal were burned during these tests.

Three types of tests were conducted: coal grindability tests, parametric tests, and FCM sample collection tests. The test series was designed to:

1. Establish facility operations (coal preparation system operation and mill capacity).

2. Evaluate the coals in terms of grinding and handling characteristics, and combustion and slagging characteristics.

3. Collect 5 tons of FCM for the Joy/NIRO spray dryer tests.

Table 5-2. Sorbent Types and Properties

o Type	Cantwell Limestone	Limestone Dolomite
o Chemical, wt. %		
CaCO3	90.71	57.14
MgCO3	5.04	36.69
Insolubles	4.71	5.90
o Physical, % passing *		
Mesh		
50	95.16	98.71
100	92.55	95.73
140	89.81	93.51
200	79.34	80.29
270	69.85	73.97
325	48.16	68.92
400	N/A	61.92
500	0.00	0.00

** - the size analysis was determined by the wet sieve process*

5.3.1 Grinding Tests

Several tests were conducted using the performance coal to determine coal grindability and maximum capacity of the Cleveland facility ball mill. The following parameters were varied:

- Ball level in mill
- Classifier setting
- Mill outlet temperature

For these tests, less than one ton of coal was pulverized, then fired in the combustor. A sieve analysis on pulverized coal samples taken from the surge bin during each run was performed to determine coal particle size distribution.

With the database established for the performance coal, only a few tests were needed for the TBR coal to determine grindability and mill capacity. The results showed similar behavior for the two coals. The results are discussed in section 5.4.

5.3.2 Parametric Tests

<u>Test Procedures</u>

Since the minimum test load selected for parametric tests was higher than the maximum capacity of the mill, the surge bin was used as an accumulator and the test duration was limited to a few hours. The tests were performed as follows:

1. Coal was pulverized and stored in the surge bin until the surge bin level indicators read 100% full.

2. The precombustor and main combustor were started at light-off conditions, then ramped up to the selected load as quickly as possible. This ramp-up averaged 20 minutes. Once load was reached, the test began and data was recorded.

3. A set of distributed control system (DCS) diagrams were printed every 30 minutes after the test started detailing the combustor operating conditions.

4. Gas samples were monitored continuously during each test.

5. Coal samples were taken during each test for analysis. The samples were taken at the bottom of

the coal surge bin as shown in Figure 5-1. Four samples were taken for each test.

6. Slag flowing from the combustor was removed by the drag chain conveyor and dumped into buckets for temporary storage prior to being emptied into the slag dumpster. Slag samples were taken from the buckets (wet) during each test for analysis. A weigh scale was located under the dumpster.

7. Flyash material was continuously trapped in the baghouse. It was transferred to a flyash silo as shown in Figure 5-1. The flyash material was then dropped into 55 gallon drums for storage. Flyash samples were taken from the drums for analysis. Four samples were taken for each test. Total flyash weight for each test was the net weight of the filled drum.

8. The test continued until the surge bin accumulator emptied of coal and a main fuel trip (MFT) occurred. The test ended on the MFT.

9. The raw test data was copied and sent to project team members (Stone and Webster, Golden Valley Electrical Association (GVEA), and NIRO). The test data originals were sent to the TRW project office in California for analysis.

10. Samples were sent to Commercial Testing & Engineering for analysis: ultimate and proximate analyses, and mineral analysis of ash. Duplicate samples were sent to NIRO and GVEA.

Performance Coal.

Ten parametric tests were conducted using the Healy performance coal (tests H13 through H18). The conditions and results of these tests are summarized in Table 5-3. Complete data is presented for each individual test in Appendix B.

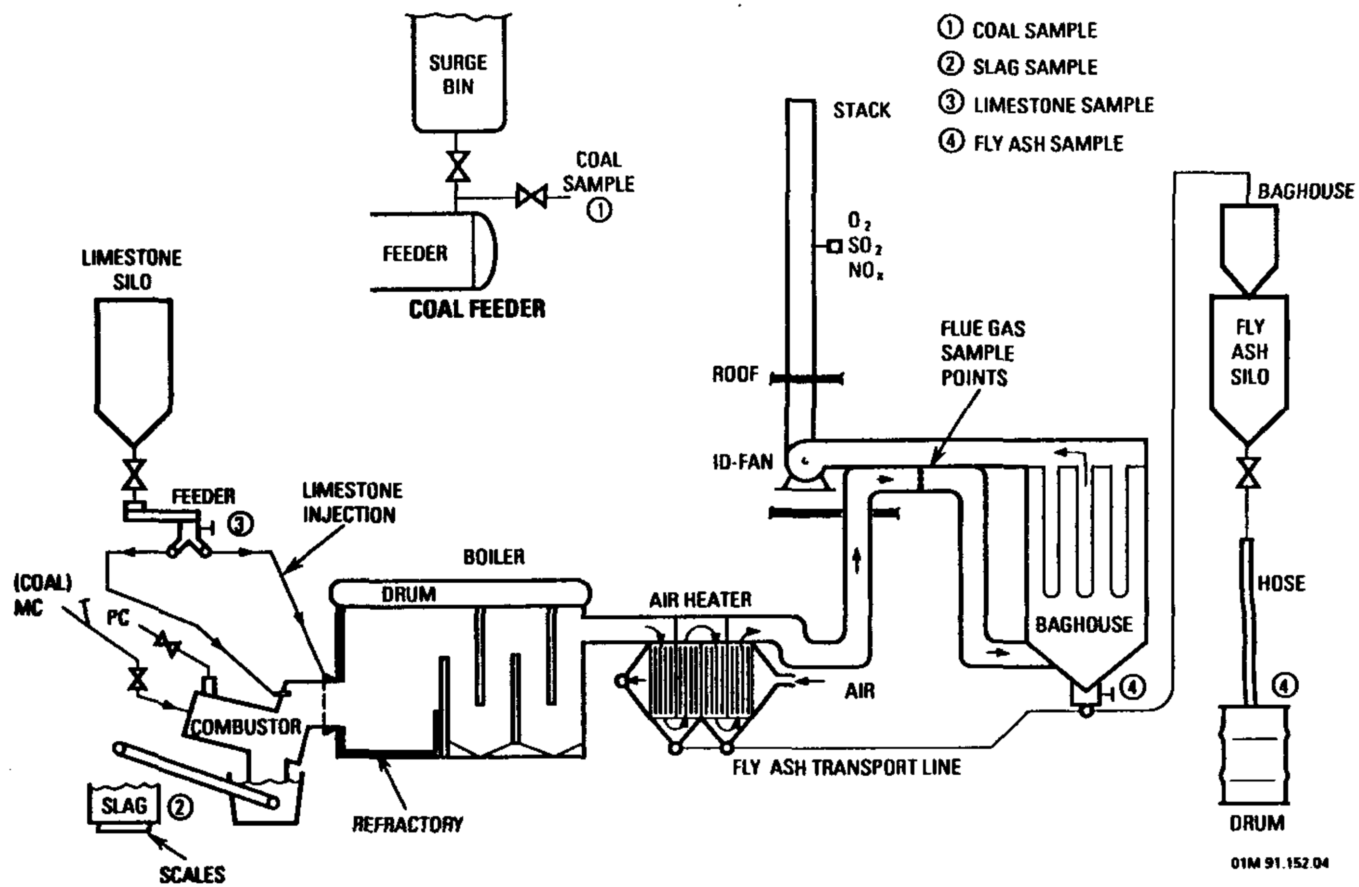


Figure 5-1. Solid Sample Locations

Table 5-3. Summary of Healy Performance Coal Parametric Tests

HEALY TESTS	SLAG RECVRY %	COAL GRIND %*	DAMPER POS. A/B,%	PC EXIT FT/S	COAL INJ. DEPTH IN.	PCC PHI	PC PHI	NC PHI	SB PHI	LOAD MMBTU /HR	COAL PC #/HR	COAL NC #/HR	COAL SPLIT %	PCCA KPPH	PCMB KPPH	SBCA KPPH	INTR. AIR #/HR	O2 SB %	O2 STACK %	CO @3% PPM	NOX @3% PPM	NOX #/MMBTU
300-H13		76	25/25	327	2	0.93	1.70	0.76	1.15	20.1	959	1550	38.1	4.30	4.45	5.87	4401	2.55	6.13	126	148	0.233
309-H13-1	70	83	50/50	253	2	1.02	2.11	0.92	1.22	19.7	938	1522	38.1	4.80	6.11	4.43	3481	3.55	6.27	0	213	0.321
400-H13-2	94	83	65/65	253	2	1.03	2.21	1.00	1.20	20.2	1013	1513	40.1	5.28	7.17	3.14	3868	3.34	6.31	0	180	0.272
401-H14	87	77	90/90	255	2	1.01	2.37	1.00	1.29	24.9	1200	1913	38.5	6.30	9.75	5.39	1502	4.47	5.40	109	180	0.270
402-H14-1	62	81	85/85	257	2	1.01	2.29	0.98	1.42	24.7	1200	1888	38.9	6.20	9.21	8.05	-110	5.86	5.80	65	215	0.321
404-H14-2			65/65	262	2	1.04	2.23	0.91	1.35	25.9	1200	2048	36.9	6.54	8.53	8.65	1630	5.27	6.10	0	219	0.320
405-H15			60/60	302	2	1.09	2.07	0.88	1.21	24.9	1192	1920	38.3	6.00	7.01	6.16	4491	3.45	6.25	4	183	0.276
406-H16	97		90/90	306	2	0.81	2.07	0.91	1.22	29.7	1492	2220	40.1	6.29	11.25	6.94	5384	3.51	6.30	15	233	0.351
407-H17	63	79	80/80	303	2	0.89	2.01	0.88	1.21	30.1	1368	2399	36.3	6.37	9.16	9.06	4795	3.37	5.90	105	239	0.360
408-H18	85	78	80/88	308	2	0.95	2.45	0.89	1.20	30.6	1272	2561	33.2	6.28	11.43	7.15	7455	3.25	6.90	2	271	0.400
AVG	80	80		283		0.98	2.15	0.90	1.25	25.1	1183	1955	37.9	5.93	8.41	6.48	3890	3.85	6.14	52	208	0.314

Table 5-3. Summary of Healy Performance Coal Parametric Tests (continued)

HEALY TESTS	SO2 @3% PPM	SO2 W/O LS	LS #/HR	CA/S RATIO	S %	SO2 REDUC %	PC EXIT DEG F	TOT STM KPPH	COOL LOAD %	BLR EFF %	FUEL /STM CORR	HEAT LOSS Bt/s	FLX 1 Btu/ f2-s	FLX 2 Btu/ f2-s	FLX 3 Btu/ f2-s	FLX 4 Btu/ f2-s	FLX 5 Btu/ f2-s	FLX 6 Btu/ f2-s	FLX 7 Btu/ f2-s	FLX 9 Btu/ f2-s	COMMENTS:
308-H13	348	405	____	N/A	0.34	13.9	3000	17.8	10.4	81.9	0.93	584	1.36	1.77	2.03	2.19	4.00	2.70	1.00	0.77	MEDIUM LOAD AT PHI=.8
309-H13-1	336	405	____	N/A	0.34	17.3	2820	17.5	9.4	81.9	0.92	511	0.87	1.33	1.63	2.01	1.63	1.27	0.96	1.50	MEDIUM LOAD AT PHI=.9, SWIRL VELOCITY AT 250 FT/S
400-H13-2	357	405	____	N/A	0.34	12.0	2896	18.3	11.0	81.5	0.90	617	0.83	1.26	2.64	3.32	3.12	2.27	1.42	1.36	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 250 FT/S
401-H14	364	405	____	N/A	0.34	10.4	2545	22.4	8.4	80.9	0.90	584	0.58	0.94	3.03	3.27	2.70	2.22	1.39	0.45	MAXIMUM LOAD AT PHI=.9, SWIRL VELOCITY AT 250 FT/S
402-H14-1	322	405	____	N/A	0.34	21.3	2597	23.2	9.6	82.4	0.87	661	0.44	0.94	3.27	4.00	4.20	2.06	1.39	1.36	MAXIMUM LOAD AT PHI=.9, SWIRL VELOCITY AT 250 FT/S
404-H14-2	331	405	____	N/A	0.34	10.0	2631	23.5	7.9	82.9	0.91	567	0.58	1.10	2.80	3.43	2.30	1.74	1.28	0.00	MAXIMUM LOAD AT PHI=.8, SWIRL VELOCITY AT 300 FT/S
405-H15	319	405	____	N/A	0.34	21.5	2784	20.7													MAXIMUM LOAD AT PHI=.9, SWIRL VELOCITY AT 300 FT/S
406-H16	336	405	____	N/A	0.34	17.1	2796	23.2	7.8	82.5	1.05	581	0.22	0.77	4.28	5.72	3.89	1.82	1.49	0.23	MAXIMUM LOAD AT PHI=.9, SWIRL VELOCITY AT 300 FT/S
407-H17	336	405	____	N/A	0.34	17.1	2878	23.6	6.5	82.7	1.05	547	0.36	0.71	2.92	3.19	2.54	1.35	1.07	0.45	MAXIMUM LOAD AT PHI=.8, SWIRL VELOCITY AT 300 FT/S
408-H18	341	405	____	N/A	0.34	15.8	2412	22.2													MAXIMUM LOAD AT PHI=.9, SWIRL VELOCITY AT 300 FT/S
AVG	339	405			0.34	16.5	2715	21.2	8.8	82.1	0.94	581	0.66	1.11	2.81	3.39	3.07	1.93	1.25	0.77	

The conditions for these tests ranged as follows:

Load	20 - 31 MMBtu/hr
Coal Grind	76 - 83% through 200 mesh
Coal Flow Split	33 - 40% to precombustor, remaining to main combustor
Main Combustor Equivalence Ratio	0.76 - 1.00
Secondary Burner Equivalence Ratio	1.20 - 1.42
Stack O2	5.9 - 6.9%
Combustion Air Preheat	355 - 415°F
Ca/S Ratio	0

Two Bull Ridge Coal.

Ten parametric tests were conducted using the Two Bull Ridge coal (tests TBR3 through TBR12). The conditions and results of these tests are summarized in Table 5-4. Complete data is given for each individual test in Appendix B.

The conditions for these tests ranged as follows:

Load	13 - 25 MMBtu/hr
Coal Grind	82 - 96% through 200 mesh
Coal Flow Split	39 - 47% to precombustor, remaining to main combustor
Main Combustor Equivalence Ratio	0.74 - 1.10
Secondary Burner Equivalence Ratio	0.91 - 1.43
Stack O2	5.5 - 8.8%
Combustion Air Preheat	249 - 393°F
Ca/S Ratio	0

Table 5-4. Summary of Two Bull Ridge Coal Parametric Tests

HEALY TESTS	SLAG RECVRY %	COAL GRIND	DAMPER POS. A/B%	PC EXIT FT/S	COAL INJ. DEPTH IN.	PCC PHI	PC PHI	NC PHI	SB PHI	LOAD MMBTU /HR	COAL PC #/HR	COAL NC #/HR	COAL SPLIT %	PCCA KPPH	PCNB KPPH	SBCA KPPH	INTR. AIR #/HR	O2 SB %	O2 STACK %	CO @3% PPM	NOX @3% PPM	NOX #/MMBTU
553-TBR1			0/50	154	6	1.33	1.96	0.94	1.05	12.0	679	1060	39.0	4.02	2.37	1.02	6167	2.12	8.80	19	193	0.292
554-TBR2			0/50	254	6	0.98	2.05	0.91	1.05	20.0	1060	1658	39.0	4.79	6.23	2.03	6549	0.84	6.53	111	174	0.264
555-TBR3			0/50	343	6	0.79	1.42	0.74	0.91	25.4	1600	1055	46.3	6.00	5.55	3.15	9032	-1.05	5.88	31	207	0.310
556-TBR4		95	0/50	347	6	0.90	2.06	1.06	1.31	23.2	1480	1674	46.9	6.39	9.47	4.33	1048	4.71	5.89	82	241	0.361
557-TBR5	54	97	0/75	313	6	0.88	2.06	1.06	1.43	23.1	1474	1666	46.9	6.16	9.60	6.45	-148	6.06	5.97	156	242	0.361
558-TBR6	40		0/75	321	6	0.85	2.03	1.04	1.32	23.9	1523	1720	47.0	6.21	9.04	4.93	1096	4.81	5.50	138	343	0.514
559-TBR7	43	96	100/100	180	6	0.87	2.08	1.07	1.40	23.3	1489	1683	46.9	6.22	9.91	5.78	455	5.73	6.00	126	224	0.336
560-TBR8		82	100/100	180	6	0.91	2.09	1.08	1.42	23.2	1482	1675	46.9	6.49	9.66	6.03	-288	5.96	5.79	234	211	0.315
561-TBR9	49		100/100	182	6	0.90	2.07	1.07	1.27	23.6	1504	1700	46.9	6.52	9.71	3.53	2350	4.16	5.70	344	253	0.300
562-TBR10	30		0/50	279	6	1.04	1.94	1.03	1.23	18.7	1192	1347	46.9	5.87	5.91	2.79	2755	3.66	5.96	202	236	0.355
563-TBR11		92	0/50	270	6	1.13	2.09	1.10	1.43	17.8	1135	1282	47.0	6.12	5.90	4.34	-590	6.54	6.11	186	231	0.345
564-TBR12	73	88	0/50	274	6	1.10	2.07	1.09	1.35	17.8	1134	1281	47.0	5.95	6.01	3.47	1103	5.70	6.60	30	226	0.340
AVG	48			259		0.97	1.99	1.02	1.26	21.1	1313	1550	45.6	5.89	7.52	3.99	2527	4.11	6.23	138	232	0.348

Table 5-4. Summary of Two Bull Ridge Parametric Tests (Continued)

HEALY TESTS	SO2 @3% PPM	SO2 W/O LS	LS #/HR	CA/S RATIO	S %	SO2 REDUC %	PC EXIT DEG F	TOT STM KPPH	COOL LOAD %	BLR EFF %	FUEL /STM CORR	HEAT LOSS Bt/s	FLX 1 Btu/ f2-s	FLX 2 Btu/ f2-s	FLX 3 Btu/ f2-s	FLX 4 Btu/ f2-s	FLX 5 Btu/ f2-s	FLX 6 Btu/ f2-s	FLX 7 Btu/ f2-s	FLX 9 Btu/ f2-s	COMMENTS:
553-TBR1	240	465	48.0	2.22	0.36	48.2	2000	8.8	14.9	82.7	1.21	529	0.87	1.29	2.57	3.60	2.06	1.74	2.56	0.00	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
554-TBR2	289	464			0.36	37.7	1950	15.9	7.1	83.0	1.03	394	0.58	1.06	1.63	2.61	1.59	1.27	2.24	0.00	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
555-TBR3	371	461	553.0	12.89	0.36	18.7	2450	16.9	6.2	82.2	1.21	435	1.02	0.82	1.17	1.00	1.74	1.59	3.20	1.36	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
556-TBR4	331	466			0.36	29.2	1950	19.1	7.2	83.2	1.00	463	1.02	1.06	0.95	1.63	2.38	2.06	2.13	0.91	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
557-TBR5	346	466			0.36	26.4	1950	21.1	6.0	82.7	0.89	383	0.87	0.71	1.17	2.29	1.27	1.27	2.13	0.91	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
558-TBR6	242	464			0.36	48.4	1950	18.5	4.8	84.1	1.07	317	0.73	1.06	0.93	1.63	1.11	1.27	1.71	0.91	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
559-TBR7	382	464			0.36	18.7	1950	19.6	5.7	82.3	0.97	370	0.44	1.06	1.17	2.61	1.43	0.95	1.92	0.00	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
560-TBR8	340	466			0.36	25.9	1950	19.6	5.3	82.3	0.96	339	0.50	1.06	1.63	2.61	1.59	1.11	2.03	-0.45	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
561-TBR9	313	466			0.36	33.0	1950	16.0	6.9	86.8	1.21	452	0.44	0.82	1.17	2.29	2.54	1.90	1.17	0.91	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
562-TBR10	365	466			0.36	21.8	2000	15.1	6.6	83.9	1.02	342	0.58	0.82	0.70	1.63	1.59	1.59	1.17	1.36	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
563-TBR11	310	465	82.0	2.73	0.36	32.3	1950	16.1	6.2	83.9	0.91	309	0.58	0.82	0.70	1.31	0.95	1.11	1.07	1.36	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
564-TBR12	324	464	166.0	5.53	0.36	30.7	1950	14.5	4.7	83.1	0.99	230	0.29	0.82	0.93	1.31	0.79	0.63	1.07	0.45	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
AVG	322	465	212.3	5.84	0.36	30.9	2000	16.8	6.8	83.3	1.04	380	0.67	0.95	1.22	2.11	1.59	1.37	1.87	0.64	

5.3.3 FCM Collection Tests

Forty-two tests were run using the performance coal in which the baghouse catch was collected as the FCM sample for NIRO's pilot plant tests. The tests were run at 20 MMBtu/hr, selected to promote acceptable slagging and to allow reasonable test durations for sample collection. Since these tests were run at a load higher than the maximum capacity of the mill, the test duration was limited to about three hours per test.

These tests were conducted using the same procedures as the parametric tests with the additional steps of injecting limestone in the combustor exit and collecting the FCM. The baghouse catch was collected in 55-gallon drums, marked and weighed for each test.

The conditions and results of these tests are given in Table 5-5. Complete data is given for each individual test in Appendix B.

Average test conditions for the FCM collection tests were:

Load	20 MMBtu/hr
Coal Grind	75% through 200 mesh
Coal Flow Split	45% to precombustor, remaining to main combustor
Main Combustor Equivalence Ratio	0.98
Secondary Burner Equivalence Ratio	1.04
Stack O2	6.15%
Combustion Air Preheat	385°F
Ca/S Ratio	1.6 (ranged from 1.02 to 2.05)

Table 5-5. Summary of Healy Performance Coal FCM Tests

HEALY TESTS	SLAG RECVRY %	COAL GRIND %*	DAMPER POS. A/B,%	PC EXIT FT/S	COAL INJ. DEPTH IN.	PCC PHI	PC PHI	NC PHI	SB PHI	LOAD MMBTU /HR	COAL PC #/HR	COAL NC #/HR	COAL SPLIT %	PCCA KPPH	PCMA KPPH	SBCA KPPH	ENTR. AIR #/HR	O2 SB %	O2 STACK %	CO 03% PPM	NOX 03% PPM	NOX #/MMBTU
500-H20			60/60	164	2	1.00	1.94	0.89	1.17	19.9	1000	1496	40.1	5.84	5.39	4.18	3882	3.48	6.45	24	164	0.247
501-H21		77	75/75	181	2	0.95	2.05	0.92	1.11	22.1	1105	1667	39.9	5.34	7.26	3.19	5581	2.60	6.59	4	154	0.232
502-H22		78	65/65	183	2	0.99	2.24	1.01	1.10	19.5	971	1465	39.9	4.79	7.25	1.37	5017	2.55	6.63	14		
503-H23	63	51	65/65	184	2	1.06	2.34	1.04	1.11	19.6	977	1472	39.9	5.25	7.45	1.00	4300	2.74	6.27	8	199	0.381
504-H24	65	62	35/35	244	2	1.06	2.35	1.61	1.00	20.0	954	1547	38.1	5.10	7.30	1.02	5226	2.10	6.45	7	232	0.351
505-H25	82	77	25/25	246	2	1.27	2.84	1.02	1.10	19.8	799	1684	32.2	5.13	7.48	1.19	4920	2.61	6.55	4	225	0.340
507-H27	77	70	0/50	296	2	1.05	1.83	0.96	1.02	19.9	1160	1331	46.6	6.30	5.45	0.85	5510	1.26	6.10	78	220	0.333
508-H28	86	77	0/50	309	2	1.02	1.84	0.97	1.06	19.9	1162	1332	46.6	6.12	5.72	1.31	4742	1.05	5.93	14	197	0.290
509-H29	81	78	0/50	318	2	1.06	1.91	1.00	1.07	20.0	1160	1330	46.6	6.45	5.83	1.02	5313	2.03	6.41	1	233	0.353
510-H30		77	0/50	310	2	1.06	1.94	1.02	1.00	19.9	1162	1332	46.6	6.40	6.16	0.94	5405	2.22	6.60	3	250	0.391
511-H31	76	75	0/50	300	2	1.00	1.83	0.96	1.14	20.0	1167	1342	46.5	6.06	5.78	2.63	4104	3.08	6.30	29	252	0.380
512-H32	90	78	0/50	302	2	0.97	1.70	0.94	1.00	19.8	1152	1325	46.5	5.74	5.56	0.92	5814	0.92	6.13	20	215	0.327
513-H33	82	77	0/50	305	2	0.87	1.78	0.94	1.04	19.9	1155	1330	46.5	5.74	5.61	1.56	5449	1.65	6.30	17	210	0.330
523-H34		80	0/50	301	2	0.99	1.77	0.93	1.09	20.1	1167	1344	46.5	5.94	5.49	2.27	4919	2.31	6.32	19	195	0.295
524-H35		75	0/50	307	2	1.05	1.89	0.99	1.02	20.2	1177	1356	46.5	6.45	5.90	0.52	4817	1.26	5.56	21	174	0.264
525-H36	91	78	0/50	309	2	1.01	1.05	0.97	0.97	19.9	1160	1337	46.5	6.05	5.82	0.00	6324	0.34	6.12	8	172	0.261
526-H37			0/50	302	2	1.05	2.00	0.99	0.99	20.1	1160	1344	46.5	6.37	5.84	0.00	7134	0.65	6.77	7	201	0.305
527-H38	83		0/50	311	2	1.06	1.94	1.01	1.01	19.9	1156	1331	46.5	6.38	6.10	0.00	5290	1.15	5.89	9	160	0.255
528-H39	72		0/50	307	2	1.02	1.80	0.98	1.07	20.2	1173	1352	46.5	6.19	6.02	1.29	4259	2.00	5.66	15	149	0.225
529-H40	81	76	40/70	239	2	1.01	1.86	0.98	1.05	20.0	1165	1342	46.5	6.10	5.93	1.09	4501	1.72	5.67	99	135	0.204
530-H41	70	80	0/50	370	6	1.02	1.87	0.98	1.03	20.3	1179	1357	46.5	6.23	6.00	0.00	4775	1.42	5.63	24	130	0.210
531-H42	101		0/50	310	6	1.03	1.87	0.98	1.00	20.1	1168	1345	46.5	6.22	5.88	0.34	5704	0.91	6.05	41	152	0.230
532-H43	90		0/50	304	6	1.06	1.94	1.01	1.02	19.8	1154	1320	46.5	6.36	6.07	0.18	5776	1.33	6.33	21	178	0.270
533-H44	90		0/55	304	6	1.02	1.87	0.98	1.00	19.8	1154	1330	46.5	6.08	5.88	0.35	5966	0.97	6.25	27	172	0.261
534-H45	91	77	30/70	274	6	0.99	1.83	0.96	0.97	20.1	1171	1348	46.5	6.00	5.85	0.22	6137	0.43	6.01	37	157	0.238
535-H46			60/100	176	6	0.96	1.74	0.92	0.96	20.0	1165	1342	46.5	5.75	5.44	0.61	6184	0.10	5.92	34	141	0.214
536-H47			0/80	259	6	1.04	1.91	1.00	1.00	19.8	1158	1323	46.5	6.17	6.01	0.00	6108	0.90	6.32	16	151	0.229
537-H48		78	0/90	250	6	1.06	1.95	1.02	1.02	19.7	1147	1322	46.5	6.34	6.10	0.00	5662	1.24	6.22	27	164	0.249
539-H50			20/100	213	6	1.04	1.86	0.98	1.03	19.9	1159	1334	46.5	6.26	5.72	0.85	5334	1.50	6.12	28	152	0.231
540-H51	83		100/100	153	6	1.01	1.87	0.98	0.98	20.1	1169	1346	46.5	6.11	6.05	0.00	6656	0.56	6.42	8	223	0.339
541-H52	88	78	100/100	152	6	1.01	1.87	0.98	0.98	20.1	1171	1350	46.4	6.11	6.02	0.00	5553	0.48	5.63	71	136	0.206
542-H53	74		60/60	215	6	1.06	1.94	1.01	1.10	19.9	1160	1337	46.5	6.38	6.17	1.28	4436	2.46	6.12	17	139	0.210
543-H54	89		50/50	217	6	1.04	1.86	0.98	0.98	19.6	1143	1317	46.5	6.15	5.65	0.00	7023	0.64	6.79	14	163	0.248
544-H55	73		70/70	182	6	1.05	1.93	1.01	1.00	19.7	1147	1320	46.5	6.28	5.98	1.05	4850	2.21	6.27	67	151	0.220
545-H56	92	73	0/75	250	6	1.04	1.90	0.99	1.04	20.1	1167	1345	46.5	6.28	6.06	0.75	4542	1.66	5.65	30	133	0.201
546-H57	80		0/50	309	8	0.99	1.82	0.96	0.96	20.2	1173	1352	46.5	5.98	5.85	0.00	5843	0.00	5.60	56	131	0.199
547-H58			0/50	309	8	1.04	1.91	1.00	1.00	19.9	1156	1333	46.5	6.23	6.02	0.00	5991	0.87	6.20	19	167	0.253
548-H59		78	0/50	304	8	1.04	1.89	0.99	0.99	19.8	1154	1329	46.5	6.20	5.93	0.00	5701	0.77	6.01	11	187	0.284
549-H60			0/55	294	8	1.01	1.86	0.98	0.98	19.6	1140	1314	46.5	5.96	5.80	0.00	5510	0.54	5.74	32	153	0.233
550-H61	103		0/50	323	8	1.04	1.93	1.01	1.01	20.1	1168	1344	46.5	6.28	6.20	0.00	5466	1.06	5.92	40	158	0.239
551-H62	94		0/50	305	8	1.03	1.90	1.00	1.11	19.8	1153	1327	46.5	6.14	6.05	1.69	4238	2.71	6.17	30	160	0.242
552-H63	100	70	10/50	280	8	1.00	2.01	1.05	1.17	19.5	1134	1306	46.5	6.44	6.23	1.78	3599	3.52	6.35	102	175	0.264
AVG	84			266		1.03	1.94	0.98	1.04	20.0	1133	1367	45.3	6.02	6.07	0.86	5327	1.55	6.15	28	177	0.267

* - PERCENT THRU 200 MESH

Table 5-5. Summary of Healy Performance Coal FCM Tests (Continued)

HEALY TESTS	SO2 03% PPM	SO2 W/O LS	LS #/HR	CA/S RATIO	S %	SO2 REDUC %	PC EXIT DEG F	TOT STM KPPH	COOL LOAD %	BLR EFF %	FUEL /STM CORR	HEAT LOSS Bt/s	FLX 1 Btu/ f2-s	FLX 2 Btu/ f2-s	FLX 3 Btu/ f2-s	FLX 4 Btu/ f2-s	FLX 5 Btu/ f2-s	FLX 6 Btu/ f2-s	FLX 7 Btu/ f2-s	FLX 9 Btu/ f2-s	COMMENTS:
500-H20	259	404	60.0	2.05	0.34	36.2	2120	18.0	19.0	82.7	0.93	1052	3.19	4.94	6.07	4.74	4.76	6.82	3.31	1.36	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 250 FT/S, NIRO COLLECT'N
501-H21	200	405	55.5	1.71	0.34	30.8	2050	18.3	9.3	82.0	1.00	572	1.02	2.12	2.57	3.27	2.54	2.22	2.56	1.36	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 250 FT/S, NIRO COLLECT'N
502-H22		405	50.0	1.75	0.34		1920	16.8													MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 250 FT/S, NIRO COLLECT'N
503-H23	330	405	36.0	1.25	0.34	10.4	1850	18.1													MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 250 FT/S, NIRO COLLECT'N
504-H24	369	405	30.6	1.02	0.34	8.7	1850	17.6	11.4	82.6	0.94	631	1.30	1.77	2.08	2.86	2.30	1.98	1.17	1.13	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 330 FT/S, NIRO COLLECT'N
505-H25	325	405	33.0	1.13	0.34	19.6	1620	17.7	11.0	81.6	0.92	606	0.87	1.65	3.27	3.27	2.54	3.01	1.71	0.91	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 330 FT/S, NIRO COLLECT'N
507-H27	352	406	34.0	1.16	0.34	12.6	2200	16.7													MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 375 FT/S, NIRO COLLECT'N
508-H28	321	405	36.0	1.23	0.34	20.6	2200	18.2													MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 380 FT/S, NIRO COLLECT'N
509-H29	365	405	18.0	0.61	0.34	9.6	2150	17.8	10.2	81.7	0.96	570	0.50	1.06	3.27	3.76	3.17	2.30	1.71	0.91	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 380 FT/S, NIRO COLLECT'N
510-H30	336	405	17.8	0.58	0.34	16.8	2150	17.8	12.7	78.9	0.90	704	0.73	1.29	3.97	4.09	4.12	2.54	2.03	1.36	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 440 FT/S, NIRO COLLECT'N
511-H31	328	405	17.3	0.59	0.34	18.9	2200	18.4	10.1	80.2	0.87	561	0.51	1.47	3.27	3.04	3.01	2.22	1.01	0.23	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 440 FT/S, NIRO COLLECT'N
512-H32	328	405	17.0	0.59	0.34	19.2	2250	17.8													MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 440 FT/S, NIRO COLLECT'N
513-H33	355	405	18.0	0.62	0.34	12.0	2250	18.0	10.3	80.3	0.89	570	0.44	1.18	2.33	3.10	2.30	2.06	1.71	0.91	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 440 FT/S, NIRO COLLECT'N
523-H34	252	405	47.7	1.62	0.34	37.6	2250	17.5	9.8	81.9	0.94	547	1.28	0.92	2.29	3.24	2.03	2.19	2.54	0.82	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
524-H35	249	405	48.0	1.62	0.34	30.3	2150	18.1	10.2	81.3	0.91	575	0.87	1.06	2.22	3.27	2.22	2.22	2.24	1.27	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
525-H36	169	405	49.6	1.09	0.34	50.0	2200	17.0	8.8	81.4	0.95	489	0.65	1.08	2.15	2.01	2.30	2.03	2.22	0.54	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
526-H37	182	405	50.4	1.71	0.34	54.7	2150	15.6	10.2	81.3	1.05	570	0.58	1.29	2.08	3.76	3.33	2.06	2.56	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
527-H38	193	405	48.0	1.65	0.34	52.1	2150	16.9	10.8	81.0	0.95	550	0.32	1.80	2.92	3.60	2.05	2.06	2.51	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
528-H39	201	405	49.0	1.65	0.34	50.3	2200	17.6	9.3	81.2	0.93	522	0.22	0.82	2.33	3.19	2.30	2.14	2.24	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
529-H40	221	405	50.3	1.71	0.34	45.3	2200	18.9	10.4	81.4	0.90	570	0.32	0.74	2.60	4.09	2.82	2.65	2.40	-0.77	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
530-H41	220	405	48.0	1.61	0.34	45.4	2200	17.5	10.8	82.2	0.95	609	0.44	1.10	3.03	3.92	3.01	2.06	2.24	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
531-H42	213	405	40.0	1.36	0.34	47.1	2200	17.7	11.2	80.7	0.92	626	0.44	1.41	3.27	4.09	2.85	2.22	2.35	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
532-H43	177	405	50.0	1.72	0.34	56.2	2150	17.2	11.1	80.6	0.93	609	0.29	1.29	2.00	4.09	2.70	2.54	2.24	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
533-H44	185	405	42.5	1.46	0.34	51.5	2200	16.9	9.6	80.7	0.95	527	0.51	1.12	2.33	3.43	2.06	2.54	2.24	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
534-H45	189	405	47.0	1.59	0.34	52.9	2200	17.0	9.4	80.5	0.91	525	0.44	1.06	2.57	3.27	2.22	2.38	2.24	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
535-H46	197	405	51.0	1.73	0.34	51.0	2250	17.6	9.1	81.6	0.92	500	0.29	1.24	2.80	3.19	2.14	1.98	2.08	0.23	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
536-H47	186	405	52.0	1.79	0.34	53.7	2150	16.7	9.6	81.4	0.96	521	0.91	0.98	2.52	3.32	3.22	1.95	2.38	0.14	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
537-H48	196	405	51.0	1.76	0.34	51.4	2150	17.1	11.5	80.9	0.94	631	0.50	1.10	3.27	3.92	3.33	3.01	2.67	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
539-H50	172	405	50.0	1.71	0.34	57.4	2200	17.3	9.8	81.3	0.93	542	0.57	1.17	2.78	3.91	3.47	2.68	2.61	0.41	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
540-H51	175	405	52.5	1.78	0.34	56.4	2200	16.5	8.8	83.3	1.01	491	0.44	1.29	3.27	4.09	2.85	2.38	2.24	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
541-H52	218	406	47.0	1.59	0.34	47.9	2200	17.5	11.4	80.8	0.93	640	0.44	1.18	3.27	4.50	3.17	2.78	3.31	-0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
542-H53	198	405	51.6	1.76	0.34	52.9	2150	18.4	12.0	80.6	0.88	665	1.02	1.29	3.50	4.90	3.01	3.01	2.99	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
543-H54	197	405	51.8	1.77	0.34	51.1	2200	15.9	10.4	80.5	1.00	566	0.50	1.06	2.80	4.25	3.65	2.54	2.67	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
544-H55	194	405	40.9	1.69	0.34	51.9	2150	17.9	10.5	80.9	0.89	575	0.55	1.04	3.45	4.30	3.77	2.82	2.75	-0.54	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
545-H56	181	405	48.0	1.63	0.34	55.2	2150	19.4	11.8	81.3	0.84	614	0.73	1.41	4.43	4.09	3.96	2.64	2.45	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
546-H57	208	405	47.6	1.61	0.34	48.4	2200	17.4	9.9	81.4	0.94	553	1.10	1.06	3.73	3.86	2.85	2.35	2.19	0.23	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
547-H58	181	405	48.5	1.66	0.34	55.1	2150	16.5	9.5	80.9	0.98	523	0.76	1.58	2.74	3.72	2.50	2.58	2.21	1.25	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
548-H59	186	405	50.0	1.72	0.34	53.8	2150	16.9	9.6	82.9	0.97	527	0.87	1.41	2.57	3.43	2.38	2.54	2.13	0.91	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
549-H60	199	405	50.5	1.75	0.34	50.5	2200	16.9	9.0	81.0	0.95	490	0.80	1.24	2.45	3.35	2.62	2.46	2.19	0.60	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
550-H61	223	406	50.0	1.70	0.34	44.7	2150	16.5	9.6	81.9	0.99	534	0.40	1.33	2.61	3.48	2.65	2.65	2.19	0.54	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
551-H62	266	405	49.5	1.70	0.34	34.1	2150	16.8	8.8	81.9	0.96	483	0.29	1.41	2.33	2.94	2.70	2.78	2.13	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
552-H63	183	405	48.8	1.71	0.34	54.8	2100	18.5	8.6	81.1	0.85	416	0.44	1.29	2.57	3.43	2.70	2.30	2.24	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
AVG	230	405	43.8	1.49	0.34	41.1	2143	17.4	10.4	81.4	0.94	577	0.70	1.34	2.97	3.69	2.92	2.53	2.31	0.44	

5.4 Test Results and Discussion

This section contains the findings of the tests and a discussion of the results.

5.4.1 Coal Handling, Preparation, and Feeding

Storage

The Healy coals were carefully stored in a local yard in 5-foot-high compacted piles instrumented with a grid of thermocouples at the bottom of the piles. Temperatures never rose above 95°F, demonstrating that attention given to coal storage was successful in avoiding problems. A temperature history record is shown in Figure 5-2.

Handling

The Healy performance coal did not present any significant handling difficulties. The coal was considerably more abrasive than other coals that have been handled in the Cleveland test facility.

The TBR coal was more difficult to handle at times than the performance coal, sticking in the transfer lines to the 25-ton silo upstream of the ball mill, as well as in the silo itself. The TBR coal varied in handling difficulty: one truckload was difficult to handle, the next was not.

Grindability

The Healy performance coal was more difficult to grind than coals previously tested in Cleveland. The maximum mill capacity was found to be 1 ton/hr, equivalent to 16 MMBtu/hr. According to KVS, the ball mill manufacturer, this corresponds to a Hardgrove Grindability Index of approximately 25.

Normal mill operation was to set mill feeder speed near 25% and to limit the mill inlet temperature to 400°F. The mill outlet temperature normally ran near 135°F. Raising the temperatue to 150°F did not increase the output measurably. The ball level in the mill was 2 inches below the inner edge of the mill exit liners. The sweep air flow rate was held constant near 5300 lbs/hr.

The TBR coal exhibited similar grindability characteristics.

Coal Preparation and Feed System Operation and Safety

During the test program, over 350 tons of Healy coal were handled by the Cleveland test facility without any indication of coal smoldering or fires anywhere in the facility. CO concentrations in the sweep air never reached

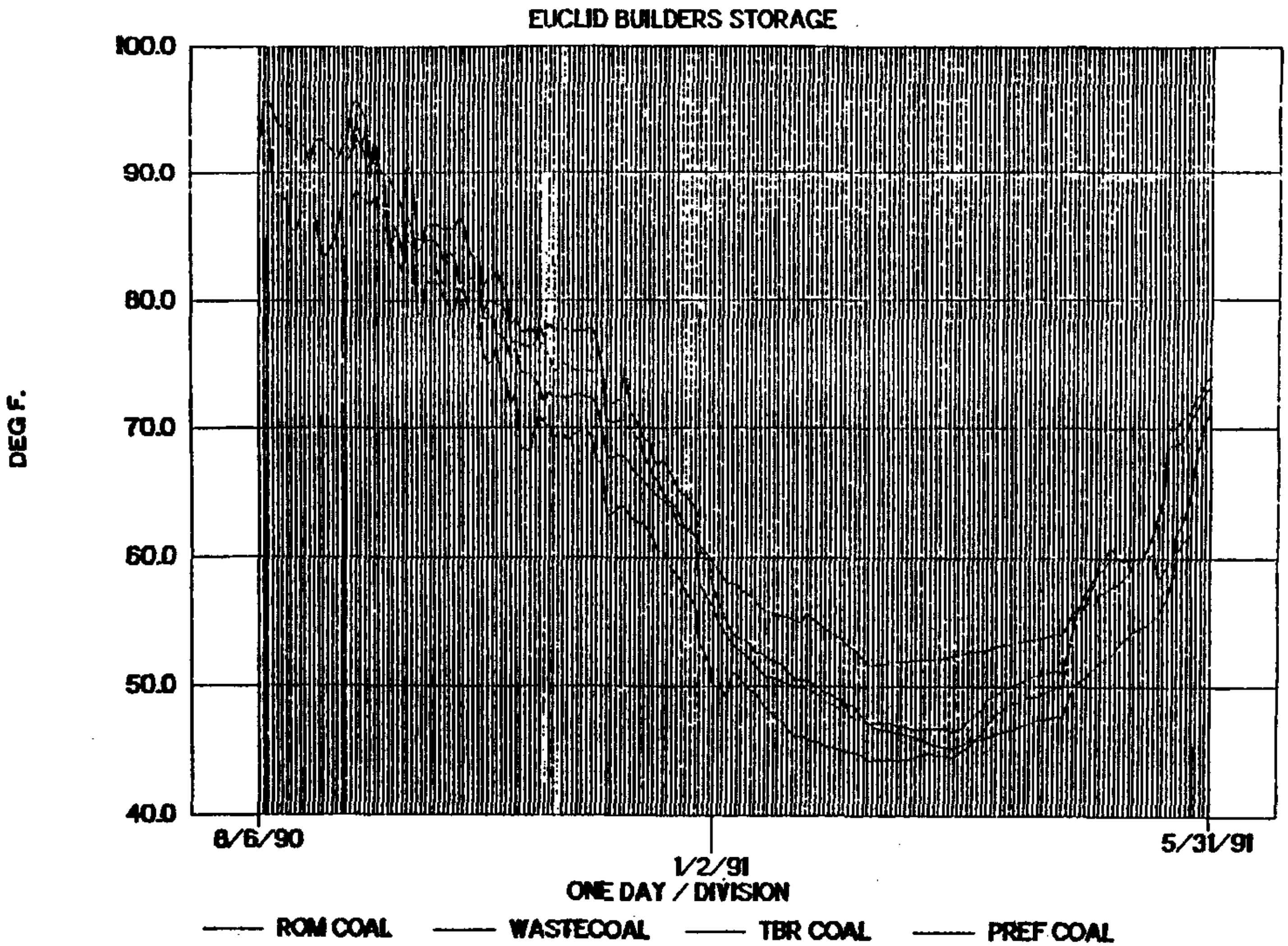


Figure 5-2. Historical Temperature Record of Healy Coal Piles in Storage

a level of concern. The coal preparation and feed systems were operated without incident during the 10-week period of using Healy coal. The CO_2 inerting system was successfully used during idle periods. Use of the CO_2 deluge system to quench smoldering or burning coal was not required.

The maximum coal flows demonstrated during the test program were 3800 lb/hr and 3455 lb/hr on the Healy performance coal and the TBR coals, respectively. Safe and stable coal feed operation was obtained. Furthermore, the high moisture content of the coals did not create any coal feed problem. In conclusion, the following was demonstrated:

- Safe storage of pulverized coal in the surge bin (surge bin capacity was approximately 1 ton)
- Controllable coal flow rate and split
- Smooth, repeatable light-offs during over 80 tests
- Prevention of coal agglomeration or accumulation in coal lines

5.4.2 Precombustor Operation

Prior to the Healy tests, the precombustor internal configuration was modified to accommodate the larger diameter injector (3 inch vs. 2 inch diameter) and the higher carrier and coal mass flow rates (factor of 3 to 4). Satisfactory precombustor operation was verified using an Ohio coal. Flame holding limited the combustion air flowrate to near 7000 pounds per hour.

The precombustor was operated successfully on both Healy coals for a total of over 80 tests. Light-offs were consistent and repeatable. While normal operation was to run the precombustor with the gas ignitor on, acceptable operation without the ignitor was verified.

Using the performance coal, the precombustor coal flow rate ranged from 800 to 1500 lb/hr. Using TBR coal, the coal flow rate ranged from 679 to 1523 lb/hr. Some evidence of slag growth was found at the exit of the precombustor, but these were less frequent and less troublesome when the precombustor was run at higher temperatures (higher coal flow rates).

In conclusion:

- The precombustor provided a reliable and stable source of high-temperature ignition air to the main combustor.

- The precombustor operated successfully over a wide range of conditions.
- Precombustor exit slag growths were reduced with higher precombustor exit temperatures.
- Flame holding diminished as flow was increased.

5.4.3 Main Combustor Operation

The main combustor lit off and operated acceptably on both Healy coals for a total of over 80 tests. As with the precombustor, light-offs were consistent and repeatable. Bright, intense head end combustion was observed, especially when the dampers, which control the velocity of the precombustor exit gases, were biased toward the head end (precombustor damper settings per test are given in Appendix D). The following sections give further details on combustor performance.

Carbon Conversion

Carbon conversion was calculated from the analyses of the solid samples taken during each test, to indicate the combustion performance of the system. Table 5-6 shows average slag and FCM analyses from the FCM collection tests. FCM is defined as the material caught in the baghouse and is also referred to as flyash in this report. Slag and flyash samples were taken during each test as described in the test procedure Section 5.3.2. Carbon content of the slag averaged 2.27%. For the FCM , the average was 0.7%. The carbon in the slag is relatively low, at about the same value or slightly higher than observed in previous tests with Ohio coal. The FCM carbon content is very low, significantly lower than observed in Ohio coal tests. The reduction in the FCM carbon content indicates that the combustion of the Healy performance coal is different from that of the Ohio coal.

Carbon conversion was calculated for the performance coal and TBR tests for which slag and FCM measurements were available. Carbon conversion was determined using the following equation:

$$\text{Carbon conversion} = (1 - \text{losses} / \text{input}) * 100$$

where

$$\text{Losses} = (\text{slag wt}) * (\text{slag carbon content}/100) + (\text{FCM wt}) * (\text{FCM carbon content}/100)$$

$$\text{Input} = (\text{coal wt}) * (\text{coal carbon content}/100)$$

The inputs to the calculations and the results are shown in

Table 5-6. FCM and Slag Characteristics

Slag Characteristics

PROXIMATE	
% Moisture	16.53
% Ash	80.89
% Volatile	1.09
% Fixed Carbon	1.50
Btu/lb	367
ULTIMATE	
% Moisture	16.53
% Carbon	2.27
% Hydrogen	0.03
% Nitrogen	0.12
% Sulfur	0.13
% Ash	80.89
% Oxygen	0.03

ASH ANALYSIS (dry)	
% SiO_2	66.81
% Al_2O_3	13.91
% TiO_2	0.63
% Fe_2O_3	4.33
% CaO	8.77
% MgO	1.66
% K_2O	1.72
% Na_2O	0.78
% SO_3	0.08
% P_4O_5	0.17
% SrO	0.10
% BaO	0.19
% MnO	0.17
Undetermined	0.72
T 250	2820

FCM Characteristics

PROXIMATE	
% Moisture	0.12
% Ash	98.04
% Volatile	1.75
% Fixed Carbon	0.09
Btu/lb	16.25
ULTIMATE	
% Moisture	0.12
% Carbon	0.70
% Hydrogen	0.04
% Nitrogen	0.21
% Sulfur	0.62
% Ash	98.05
% Oxygen	0.27

ASH ANALYSIS	
% SiO_2	48.60
% Al_2O_3	17.06
% TiO_2	0.72
% Fe_2O_3	6.06
% CaO	17.05
% MgO	2.57
% K_2O	2.32
% Na_2O	0.65
% SO_3	1.60
% P_4O_5	0.10
LOI	2.49
Undetermined	0.78
% Ca	12.02
% CO_2	2.08
% $CaCO_3$	4.72
% $CaSO_4$	2.79

Table 5-7 for the FCM collection tests. The average chemicalanalysis was used for tests for which the solid samples were not analyzed. The specific analysis was used for tests where the solid samples were analyzed. Where the carbon conversion results are not given, slag or flyash data were not available. Carbon conversion for the performance coal ranged from 97.0 to 99.5%, averaging 98.9%. These results show that combustion was very good during most tests.

Carbon losses are shown graphically in Figure 5-3. It shows the separate losses to the slag and FCM for each test. Carbon losses to the slag averaged 1.07% and to the flyash only 0.07% of the total carbon input. Since carbon losses to the flyash are small, the carbon conversion numbers above are thus mainly based upon carbon losses to the slag.

The effect of coal grind on carbon content of the slag is shown in Figure 5-4 for FCM tests where solid samples were analyzed. The figure indicates that the carbon content of the slag is less for a coarser grind. However, as will be shown in the next section, slag recovery is observed to decrease significantly with a coarser grind. Low values for slag carbon content and also slag recovery for a coarser grind results in a low level of carbon loss to the slag or a high level of carbon conversion. Although a coarser grind may appear advantageous from a carbon loss view point, 70% thru 200 mesh or finer is required to obtain high levels of slag recovery (greater than 75%).

Carbon conversion for the TBR tests for which data was available is shown in Table 5-8. Again, carbon losses to the slag were greater than to the flyash. The graphic representation is given in Figure 5-5. Carbon conversion ranged from 97.5 to 99.3%, averaging 98.5%. Carbon losses to the slag averaged 1.36% and to the flyash 0.07% of the total carbon input. Carbon losses using TBR coal were slightly higher than with the performance coal, indicating that the combustion was not quite as good with the TBR coal.

In conclusion:

- Carbon conversion for the Healy performance coal was very good, averaging 98.9%, indicating acceptable combustion of the performance coal
- Carbon conversion for the TBR coal as calculated was good, averaging 98.5%.
- Carbon losses to the flyash were extremely low, a phenomenon not previously observed for other coals (e.g. Ohio, W.VA.) in the past in Cleveland.

Table 5-7. Carbon Conversion for FCM Test

Carbon Conversion

TESTS	N22	N23	N24	N25	N27	N28	N29	N30	N31	N32	N33	N34	N35	N36	N37	N38	N39	N40	N41	N42	N43	N44	N45
INPUTS																							
COAL FLOW (#/HR)	2436	2449	2501	2483	2491	2494	2506	2494	2509	2477	2485	2511	2533	2497	2512	2487	2525	2507	2536	2513	2482	2484	2519
DURATION (MINS.)	206	196	134	163	142	163	141	183	159	176	165	164	151	212	165	169	133	151	209	163	194	153	180
CARBON IN COAL (%)	47.84	44.64	47.84	47.84	47.84	47.84	47.84	48.36	47.84	47.84	47.84	46.84	47.84	47.6	47.84	47.84	47.84	49.93	48.1	47.84	47.84	47.84	48.18
1. CARBON IN (#)	4001	3571	2672	3227	2820	3241	2817	3679	3181	3476	3269	3160	3050	4200	3305	3351	2670	3150	4249	3266	3839	3030	3801
TOTAL INPUT (#)		3571	2672	3227	2820	3241	2817		3181	3476	3269			4200		3351	2670	3150	4249	3266	3839	3030	3801
LOSSES																							
SLAG RECOVERED		1604	805	1356	1114	1428	1161		1220	1502	1369			2013		1413	981	1048	2020	1690	1773	1391	1835
CARBON IN SLAG (%)	2.20	1	2.20	2.20	2.20	2.20	2.20	0.5	2.20	2.20	2.20	1.65	2.20	3.23	2.20	2.20	2.20	1.84	5.92	2.20	2.20	2.20	1.76
1. SLAG CARBON LOST (#)		16	28	31	25	33	26		28	36	31			65		32	22	19	120	39	40	32	29
FLYASH RECOVERED	340	270	270	280	150	220	170	310	180	210	330	210	230	290	170	160	100	290	380	230	250	200	320
FLYASH CARBON (%)	0.74	0.52	0.74	0.74	0.74	0.74	0.74	1.27	0.74	0.74	0.74	0.31	0.74	0.37	0.74	0.74	0.74	0.52	0.97	0.74	0.74	0.74	0.94
2. FLYASH CARBON LOST (#)	3	1	2	2	1	2	1	4	1	2	2	1	2	1	1	1	1	2	4	2	2	1	3
TOTAL LOSSES (#)		17	22	33	27	34	28		29	38	34			66		33	24	21	123	40	42	33	32
(1-LOSSES/INPUT)*100 (%)		99.5	99.2	99.0	99.1	98.9	99.0		99.1	98.9	99.0			98.4		99.0	99.1	99.3	97.1	98.8	98.9	98.9	99.2

Table 5-7. Carbon Conversion for FCM Test (continued)

Carbon Conversion

TESTS	N46	N47	N48	N50	N51	N52	N53	N54	N55	N56	N57	N58	N59	N60	N61	N62	N63	AVERAGE
INPUTS																		
COAL FLOW (#/HR)	2507	2473	2469	2493	2515	2521	2497	2460	2467	2512	2525	2480	2403	2454	2512	1400	2440	2469
DURATION (MINS.)	151	141	179	256	50	191	151	137	162	149	211	175	113	170	284	100	113	6336
CARBON IN COAL (%)	47.84	47.84	46.86	47.84	47.84	47.01	47.84	47.84	47.84	50.38	47.84	47.84	46.66	47.84	47.84	47.84	50.33	47.84
1. CARBON IN (#)	3018	2780	3452	5089	1003	3773	3006	2687	3187	3143	4240	3472	2182	3326	4086	1274	2313	125871
TOTAL INPUT (#)				5089	1003	3773	3006	2687	3187	3143	4240				4086	1274	2313	93640
LOSSES																		
SLAG RECOVERED				2153	423	1758	1139	1221	1195	993	1736				2168	1027	1245	40758
CARBON IN SLAG (%)	2.20	2.20	1.04	2.20	2.20	1.73	2.20	2.20	2.20	0.83	2.20	2.20	2.55	2.20	2.20	2.20	5.25	2.20
1. SLAG CARBON LOST (#)				49	10	30	26	28	27	8	40				49	23	65	1001
FLYASH RECOVERED	150	200	220	270	80	300	230	120	360	170	350	50	500	290	290	424	330	9702
FLYASH CARBON (%)	0.74	0.74	0.71	0.74	0.74	0.82	0.74	0.74	0.74	0.74	0.74	0.74	0.75	0.74	0.74	0.74	0.96	0.74
2. FLYASH CARBON LOST (#)	1	2	2	2	1	2	2	1	3	1	3				2	3	3	66
TOTAL LOSSES (#)				51	10	33	28	29	30	9	42				51	27	69	1055
(1-LOSSES/INPUT)*100 (%)				99.0	99.0	99.1	99.1	98.9	99.1	99.7	99.0				98.7	97.9	97.0	98.9

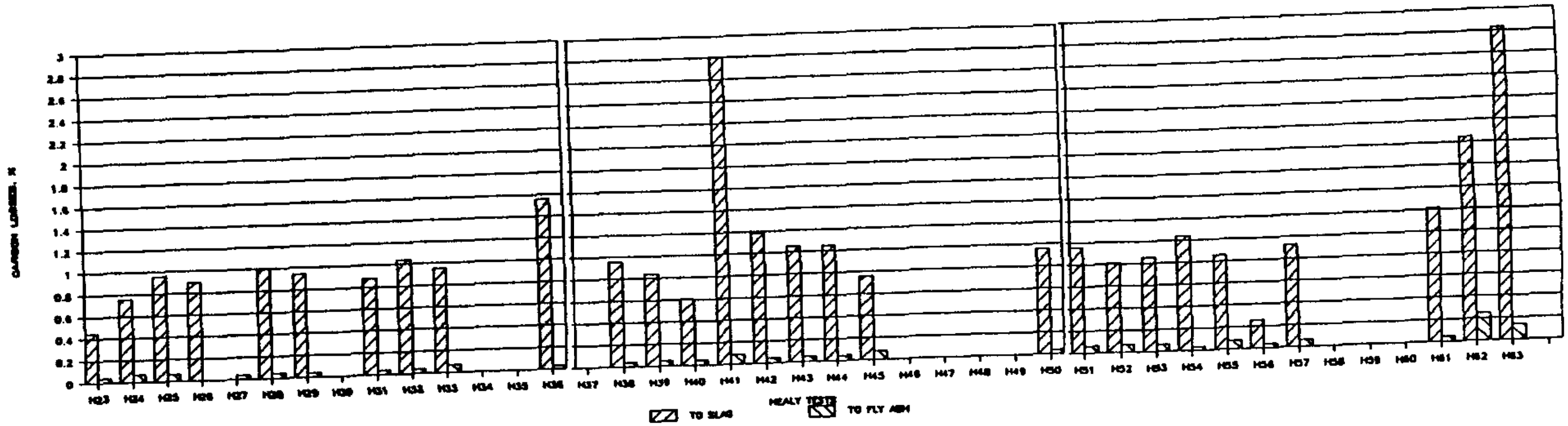


Figure 5-3. Carbon Losses to the Slag and Flyash for the FCM Performance Coal Tests

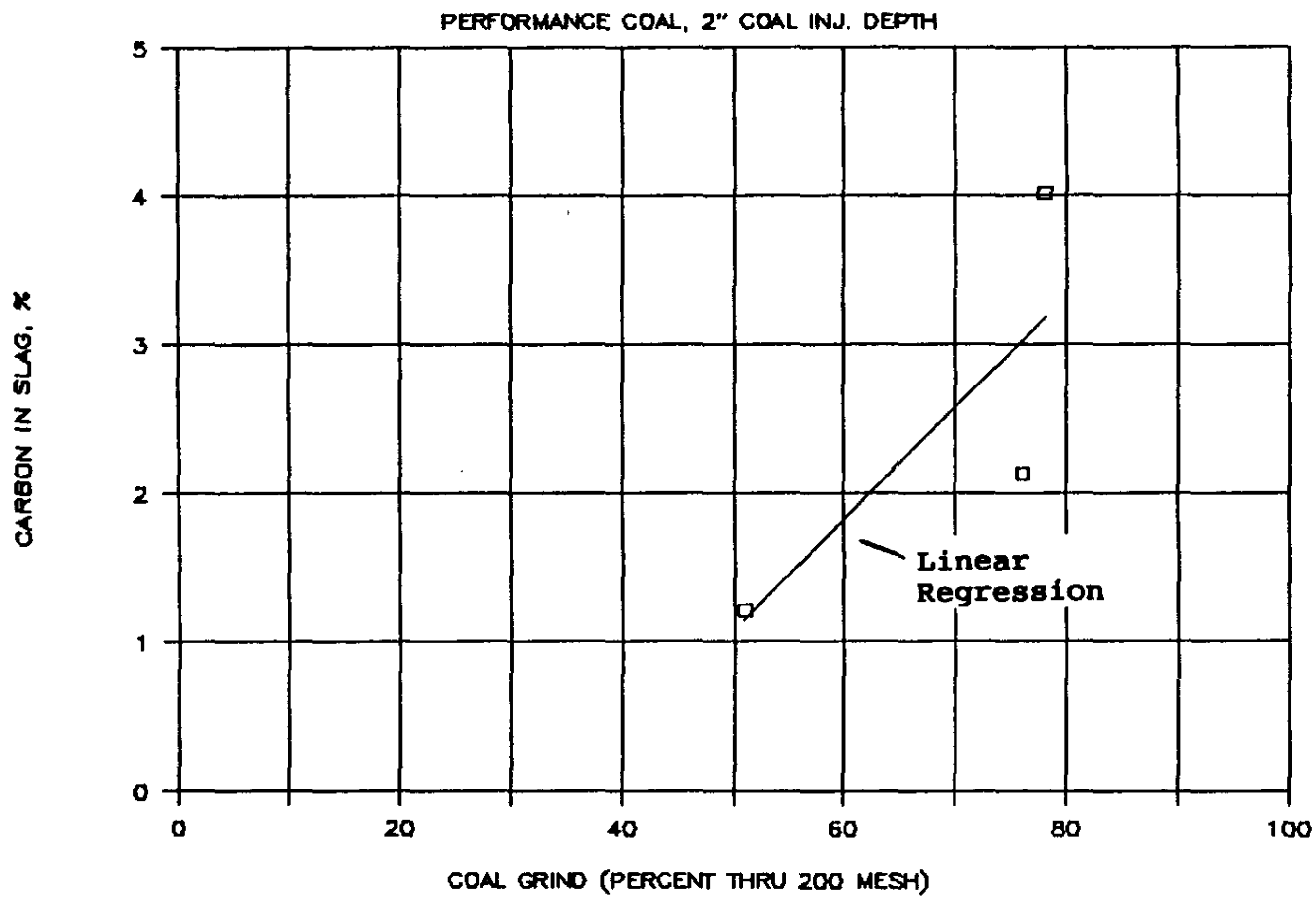


Figure 5-4. Effect of Coal Grind on Slag Carbon Content

Table 5-8. Carbon Conversion for Two Bull Ridge Tests

Carbon Conversion

TESTS	TBR1	TBR2	TBR3	TBR4	TBR5	TBR6	TBR7	TBR8	TBR9	TBR10	TBR11	TBR12	AVERAGE
INPUTS													
COAL FLOW (#/HR)	1730	2710	3455	3154	3140	3243	3172	3157	3204	2539	2417	2415	2863
DURATION (MINS.)	34	112	107	88	49	32	76	75	35	67	85	70	830
CARBON IN COAL (%)	43.5	43.5	43.5	43.5	43.5	43.5	43.5	43.5	43.5	43.5	43.5	43.5	43.5
1. CARBON IN (#)	429	2207	2680	2012	1115	752	1740	1717	813	1233	1489	1226	17422
TOTAL INPUT (#)					1115	752	1740	1717	813	1233	1489	1226	10094
LOSSES													
SLAG RECOVERED					495	304	766	583	402	503	656	767	4569
CARBON IN SLAG (%)	2.76	2.76	0.61	2.06	3.85	2.76	1.82	4.71	2.76	4.06	3.25	0.81	2.76
1. SLAG CARBON LOST (#)					19	8	14	28	11	20	21	6	137
FLYASH RECOVERED		274	600	430	210	130	200	330	170	200	240	170	2954
FLYASH CARBON (%)	0.79	0.79	0.52	0.76	0.92	0.79	0.29	0.40	0.79	1.04	1.29	1.10	0.79
2. FLYASH CARBON LOST (#)		2	3	3	2	1	0	1	1	2	3	2	22
TOTAL LOSSES (#)					21	9	14	29	12	31	24	8	150
(1-LOSSES/INPUT)*100 (%)					98.1	98.7	99.2	98.3	98.5	97.5	98.4	99.3	98.5

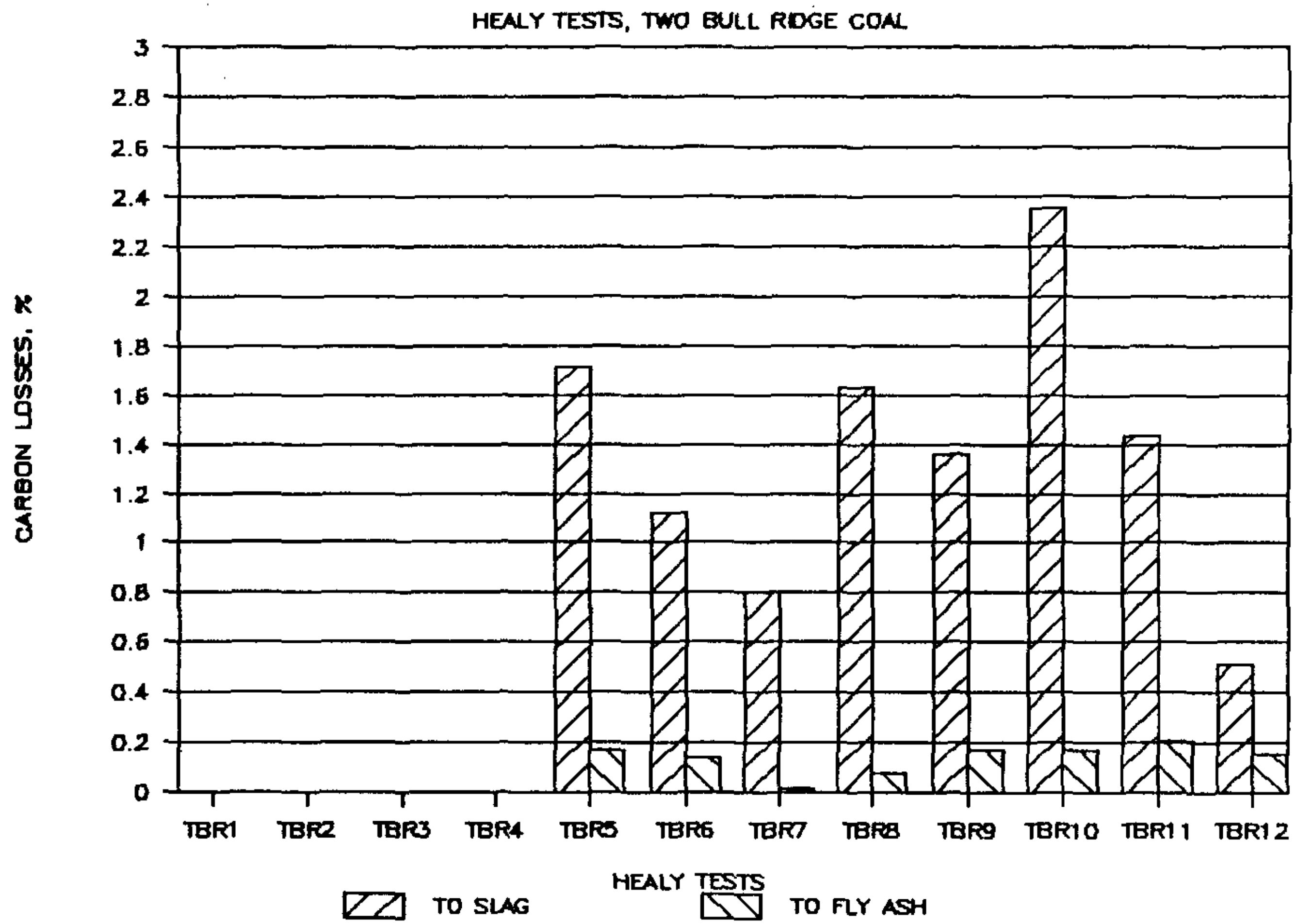


Figure 5-5. Carbon Losses to the Slag and to the Flyash for the Two Bull Ridge Coal Tests

- Carbon losses are expected to be lower in the Healy system because the combustion air preheat will be higher, the size and hence residence time will be longer and the system will generally run at higher load. All of these will improve combustion performance.

Slagging Characteristics

A drawing of the interior of the combustor is shown in Figure 5-6 as viewed post test by the test conductor. Some build up of slag was ovserved in the tap, however, slag flowed out of the slag tap in every performance coal test. Ash accumulations were observed in the head end which were removed after every 6 to 8 tests. This material appeared porous and sintered rather than molten. These accumulations were reduced by feeding more coal to the precombustor to increase the gas temperature in the head end. Downstream of the air inlet from the precombustor, the slag coating on the combustor walls was shiny and uniformly covered the walls, indicating higher temperatures and molten slag flow downstream of the air inlet. Conditions improved when the main combustor injector was moved inward by 4 inches after test No. H41.

Slag tapping was also achieved with the TBR coal which had a higher T_{250} than the performance coal. Ash accumulations occurred in the head end with this coal as well as with the performance coal. In early tests on the TBR coal, the slag tap plugged, but once the proper operating conditions were determined, the slag tap remained open for the rest of the tests. Slag accumulation was observed in the slag recovery section after some tests. This did not restrict the testing, but indicated that obtaining the proper conditions to make the slag flow was more difficult with the TBR coal than the performance coal. Limestone was mixed with the main combustor coal during the last two TBR tests in the series to act as a fluxing agent. Since ash accumulations had already formed in the combustor prior to fluxing, the net effect of the limestone could not be determined within the few hours of testing.

Neither slag nor ash accumulation is expected to occur in the Healy combustor because that system will operate under conditions more suitable for the Healy coals than the Cleveland system could offer. The Cleveland system was limited by the low air preheat, the reduced load, and the small diameter of the combustor. At Healy, slag surface temperatures will be higher than at Cleveland for the following reasons:

- The air preheat will be 200 to 300°F higher
- The nominal operating load will be the design load rather than 40% of the design load

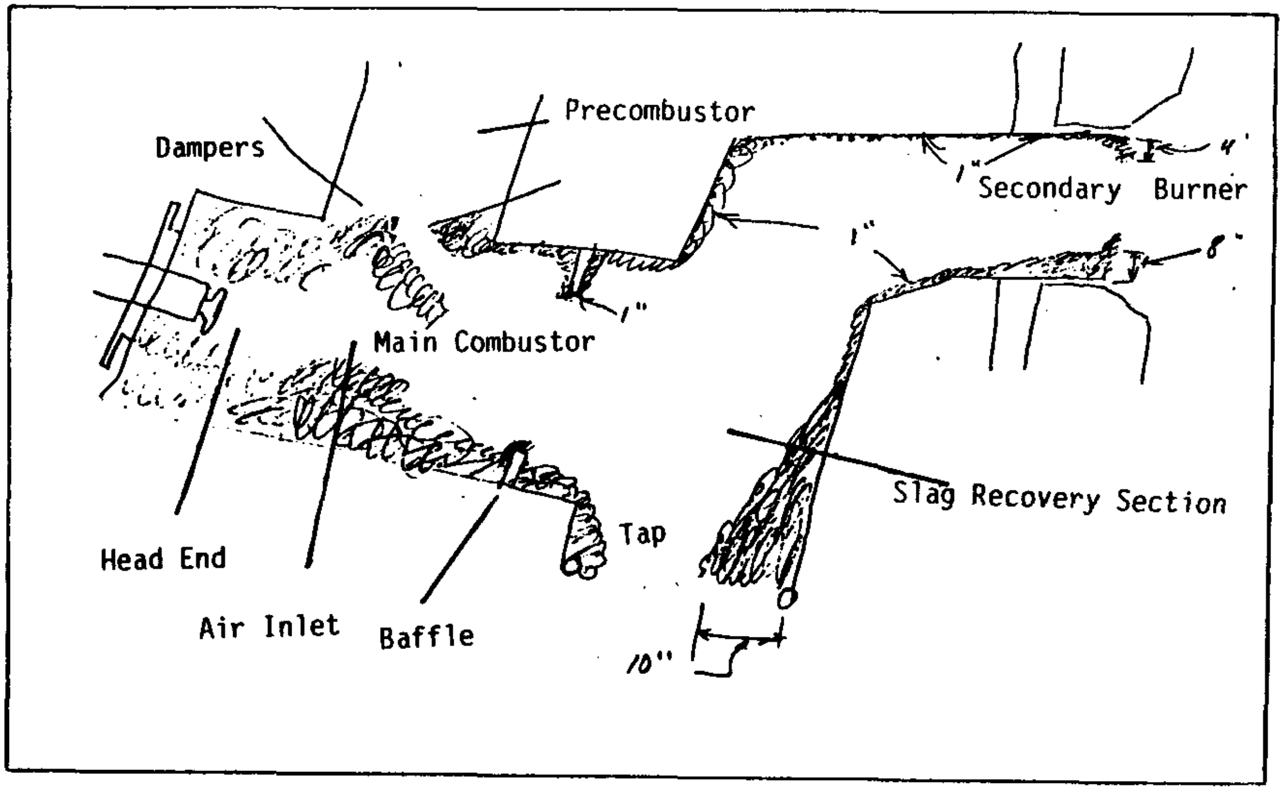


Figure 5-6. Operator's Drawing of Slag Accumulations in the Combustor During the Healy Performance Coal Test Burn

- The Healy combustor diameter will be almost three times larger, thus increasing the optical length. As optical length increases, more particles are available for radiation to the slag surface, thus increasing the heat flux available.

- Fluxing with limestone can be used to reduce the T_{250} of the slag. This should help prevent slag and/or ash accumulations as long as flux is introduced from the start with the coal. Fluxing after accumulations had formed did not cause any problems, however, little influence upon reducing the slag thickness was noted during the few hours of operation in which fluxing was used.

In conclusion:

- Slag tapping was successfully demonstrated for both the Performance blend and the Two Bull Ridge coal.

- Although ash accumulations were observed in the head end of the combustor for both performance and TBR coals, these accumulations are not expected to occur at Healy due to the higher air preheat, higher load operation, and longer optical length.

Slag Recovery

Slag recovery was determined for the Healy performance and TBR coal tests from which slag data was available. The equation used to determine the slag recovery is:

Slag recovery = (slag wt) * (slag ash content/100)*(1-slag ash SO3 content/100)/((coal wt) * (coal ash content/100)*(1-coal ash SO3 content/100))*100

The sulfur as SO3 is removed from the calculation because sulfur is released as a gas in the combustor zone and is not recoverable in the slag. This is clearly exhibited in the analyses of Tables 5-1 and 5-6.

Table 5-9 gives the inputs and results of the slag recovery calculations for the performance coal and TBR coal tests. Comments are given for the tests where the slag recovery could not be calculated. Figure 5-7 shows slag recovery where available for the performance coal tests along with combustor operating conditions. For the performance coal parametric tests, slag recovery ranged from 62 to 97%. The FCM tests ranged in slag recovery from 62 to 101%. Slag recovery values greater than 100% are possible due to random fluctuations in

Table 5-9. Slag Recovery Results for Healy Testing

Slag Recovery for Healy Tests

	COAL RUN TIME (MIN)	COAL FLOWRATE (#/HR)	ASH CONTENT (%)	SO3 CONTENT (%)	SLAG WEIGHT (LBS)	SLAG ASH (%)	SLAG SO3 (%)	SLAG RECOVERY (%)	COMMENTS
HEALY PERFORMANCE COAL PARAMETRIC TESTS									
H13									SLAG WEIGHT NOT RECORDED
H13-1	96	2460	22.22	2.57	709	84.81	0.03	78	
H13-2	120	2526	22.22	3.19	1201	84.59	0.09	94	
H14	111	3113	20.14	3.17	1144	85.20	0.04	87	
H14-1	102	3088	17.22	3.27	665	82.61	1.15	82	
H14-2									SLAG NOT WEIGHED
H15									SLAG NOT WEIGHED
H16	78	3720	18.14	2.81	985	83.74	0.12	97	
H17	68	3767	21.45	2.74	687	81.94	0.12	83	
H18	77	3833	20.78	3.45	1017	82.18	0.13	85	
H19									DCS OUT OF ORDER
TOTALS	651	3215	20.78	3.45	8408	82.18	0.13	75	
HEALY PERFORMANCE COAL FCM COLLECTION TESTS									
H20									SLAG NOT WEIGHED
H21									SLAG NOT WEIGHED
H22									SLAG NOT WEIGHED
H23	196	2449	26.30	1.86	1604	81.47	0.03	63	COARSE COAL GRIND (51% THRU 200 MESH)
H24	134	2501	20.78	3.45	885	82.18	0.13	65	COARSE COAL GRIND (62% THRU 200 MESH)
H25	183	2483	20.78	3.45	1356	82.18	0.13	82	
H26									TEST ABORTED
H27	142	2491	20.78	3.45	1114	82.18	0.13	77	
H28	183	2494	20.78	3.45	1428	82.18	0.13	86	
H29	141	2506	20.78	3.45	1161	82.18	0.13	81	
H30									SLAG SCALE MALFUNCTION
H31	159	2509	20.78	3.45	1228	82.18	0.13	76	
H32	176	2477	20.78	3.45	1582	82.18	0.13	90	
H33	165	2485	20.78	3.45	1369	82.18	0.13	82	
H34									FIRST TEST IN SERIES - SLAG MAY BE ACCUMULATING
H35									POOR COMBUSTION - WATER LEAK IN HOT SLEEVE
H36	207	2497	20.60	4.21	2013	76.77	0.14	91	
H37									FINAL SLAG WEIGHT NOT RECORDED
H38	168	2487	20.78	3.45	1413	82.18	0.13	83	
H39	133	2525	20.78	3.45	981	82.18	0.13	72	
H40	151	2507	18.23	4.58	1848	84.85	0.03	81	
H41	209	2536	21.76	4.41	2028	71.77	0.17	79	
H42	163	2513	20.78	3.45	1688	82.18	0.13	101	
H43	194	2482	20.78	3.45	1773	82.18	0.13	98	
H44	153	2484	20.78	3.45	1391	82.18	0.13	90	
H45	188	2519	20.38	3.56	1635	85.87	0.07	91	
H46									SLAG NOT COLLECTED COMPLETELY
H47									OPERATOR QUESTIONS WHETHER SLAG WAS COLLECTED

Table 5-9. Slag Recovery Results for Healy Testing (cont.)

Slag Recovery for Healy Tests

	COAL RUN TIME	COAL FLOWRATE	ASH CONTENT	SO3 CONTENT	SLAG WEIGHT	SLAG ASH	SLAG SO3	SLAG RECOVERY	COMMENTS
	(MIN)	(#/HR)	(%)	(%)	(LBS)	(%)	(%)	(%)	
H48									OPERATOR QUESTIONS WHETHER SLAG WAS COLLECTED
H49									TEST ABORTED
H50									MFT DURING MIDDLE OF TEST
H51	50	2515	20.78	3.45	423	82.18	0.13	83	
H52	191	2521	21.65	2.89	1758	84.71	0.03	88	
H53	151	2497	20.78	3.45	1139	82.18	0.13	74	
H54	137	2460	20.78	3.45	1221	82.18	0.13	89	
H55	162	2467	20.78	3.45	1185	82.18	0.13	73	
H56	149	2512	16.38	3.98	893	80.78	0.20	92	
H57	211	2525	20.78	3.45	1736	82.18	0.13	80	
H58									SLAG NOT COLLECTED
H59									SLAG CARRIED OVER FROM PREVIOUS TEST
H60									SLAG CARRIED OVER FROM PREVIOUS TEST
H61	204	2512	20.78	3.45	2160	82.18	0.13	103	
H62	108	2480	20.78	3.45	1027	82.18	0.13	94	
H63	113	2440	19.93	3.4	1245	78.78	0.22	108	
TOTALS	4480	2495	20.78	3.45	38597	82.18	0.13	85	
TWO BULL RIDGE COAL PARAMETRIC TESTS									
TBR1									SLAG WEIGHT NOT RECORDED
TBR2									SLAG TAP PLUGGED
TBR3									SLAG TAP PLUGGED, REMOVED 748# FROM TAP
TBR4									SLAG TAP PLUGGED
TBR5	49	3140	26.83	4.04	495	71.58	0.12	54	
TBR6	32	3243	27.32	3.16	304	60.26	0.13	40	
TBR7	76	3172	27.14	2.99	765	58.71	0.03	43	
TBR8									SLAG TAP PLUGGED, REMOVED 475# MOSTLY FROM TAP
TBR9	35	3204	27.32	3.16	482	60.26	0.13	49	
TBR10	67	2539	27.55	2.83	503	38.57	0.34	38	
TBR11									MFT DURING MIDDLE OF TEST
TBR12	70	2415	26.15	3.6	767	60.1	0.06	73	LIMESTONE ADDED WITH COAL AS FLUXING AGENT
TOTALS	329	2952	27.32	3.16	3328	60.26	0.13	47	

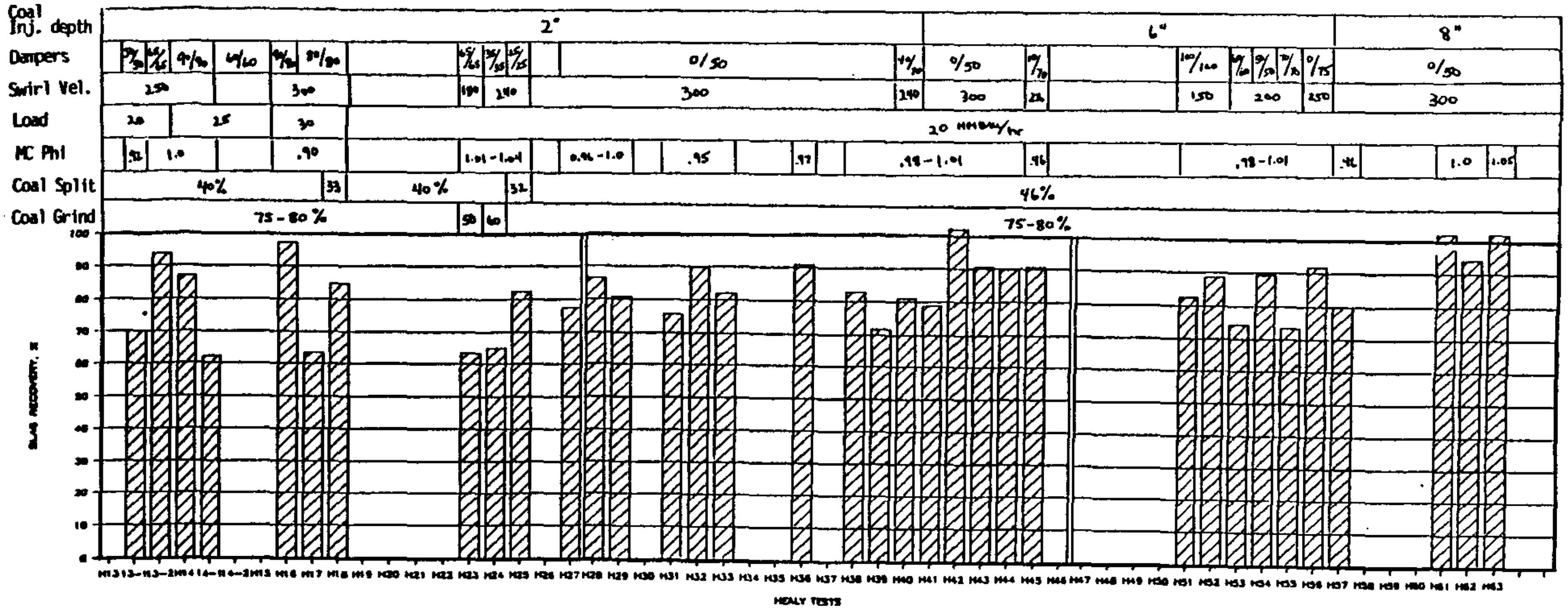


Figure 5-7. Slag Recovery for Performance Coal Tests. Included are Various Test Parameters

the slag/ash layers in the combustor. Errors in the determination process may also be a reason for slag recovery values greater than 100%. This topic will be covered later in this section.

A frequency distribution of slag recovery results for the all the Healy performance coal tests is shown in Figure 5-8. While there is scatter in the results, the distribution shows that the majority of the tests yielded 80 to 90% slag recovery.

Scatter in the slag recovery results for the performance coal parametric tests is consistent with the changing conditions of the parametric tests. Scatter in the results of the FCM collection tests was less pronounced, as would be expected since the tests were performed at similar operating conditions, except for two early tests. For these tests, the slag recovery dropped to near 65% because the coal grind was coarser. The effect of coal grind on slag recovery is shown in Figure 5-9. Slag recovery is observed to drop significantly with the coarser grind.

Figure 5-10 shows the frequency distribution of slag recovery results for the FCM collection tests only. Scatter in the FCM slag recovery is due to errors in the determination of slag recovery and/or changes in performance. Determination errors may be due to test duration or errors in either or both the coal flow measurement and the slag weight. Figure 5-11 shows cumulative slag weight with time during a typical FCM collection test. The figure shows that during the three-hour test, slag weight increased at a uniform rate beginning as soon as the load condition was reached. Thus, the duration of the test, although short, should not introduce significant errors provided that the wall coverage conditions are the same at the beginning and at the end of the test. Errors due to erroneous coal flow measurements can be compensated for by correcting the coal flow to correlate with steam flow to calculate a corrected slag recovery. This was done and the slag recovery results did not change significantly. However, by dividing slag recovery results by solids closure efficiency, which is discussed in the next section, the scatter in the slag recovery results was reduced. Figure 5-12 shows slag recovery corrected by solids closure. The majority of the slag recovery results fall between 86 and 90%, as shown in the frequency distribution for the corrected slag recovery, Figure 5-13. The solids closure correction accounts for errors in both coal flow and slag weight, and indicates that determination, not performance is believed to be main cause for the data scatter.

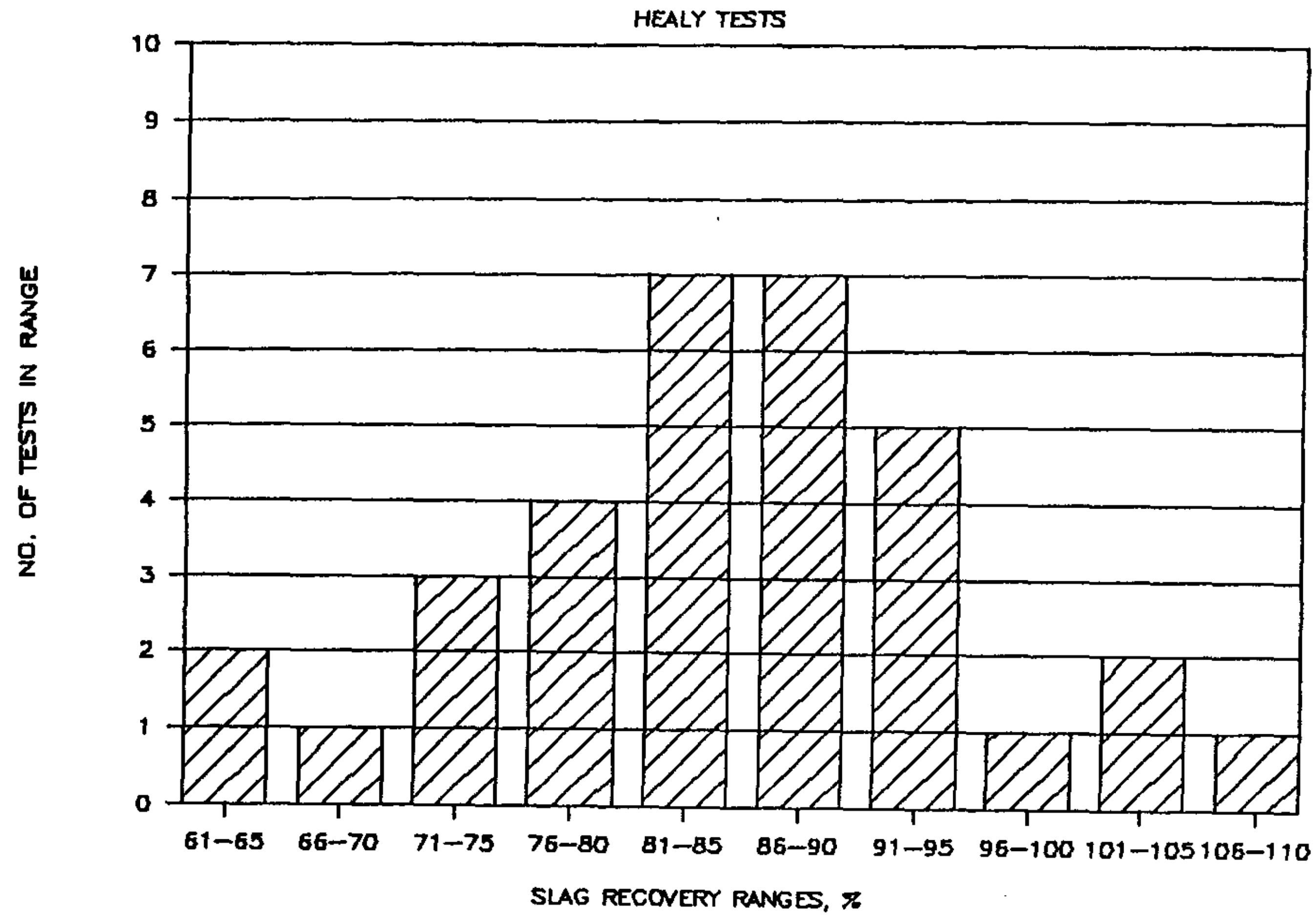


Figure 5-8. Slag Recovery Frequency for Performance Coal Tests

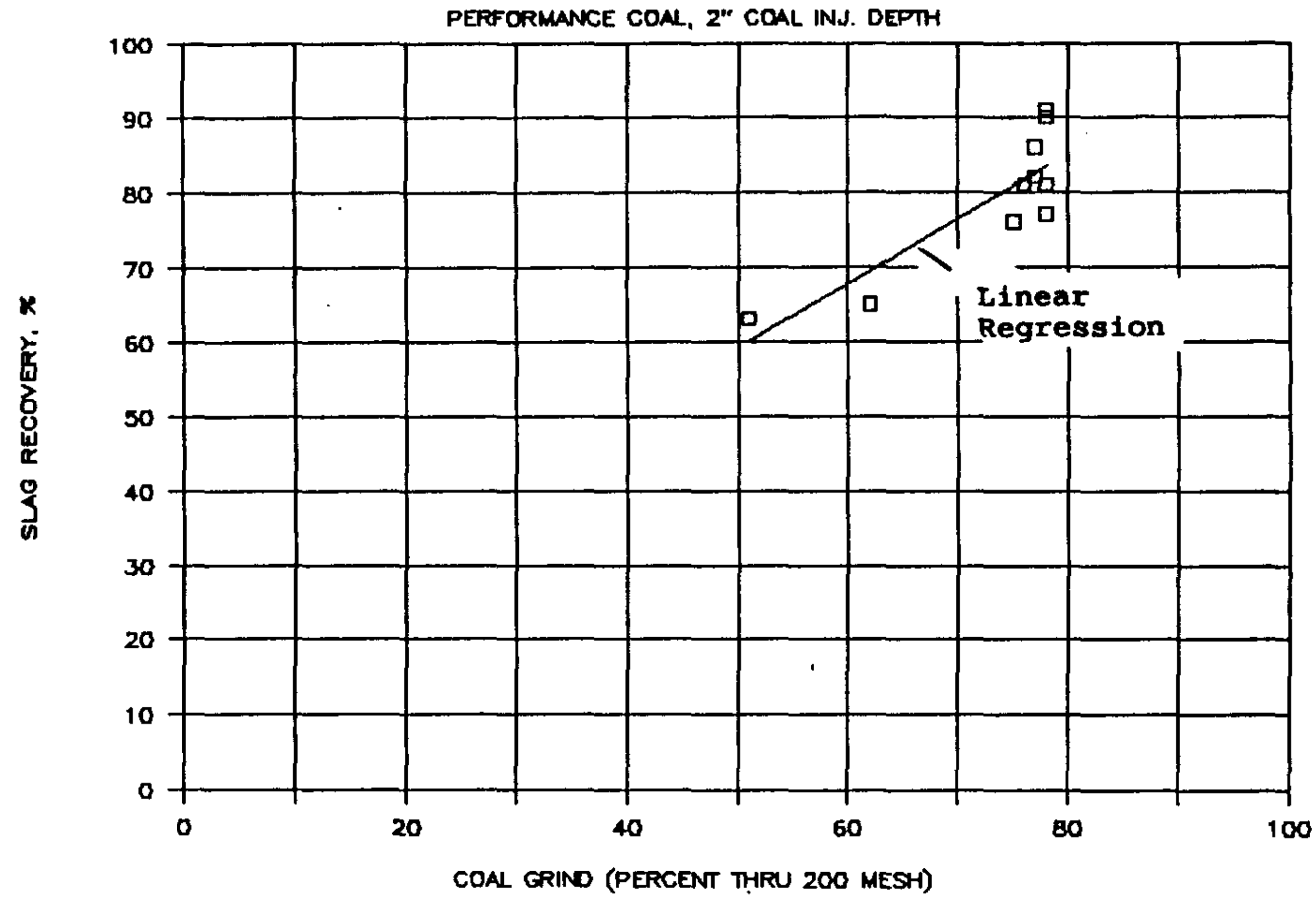


Figure 5-9. Effect of Coal Grind on Slag Recovery for Healy Performance Coal

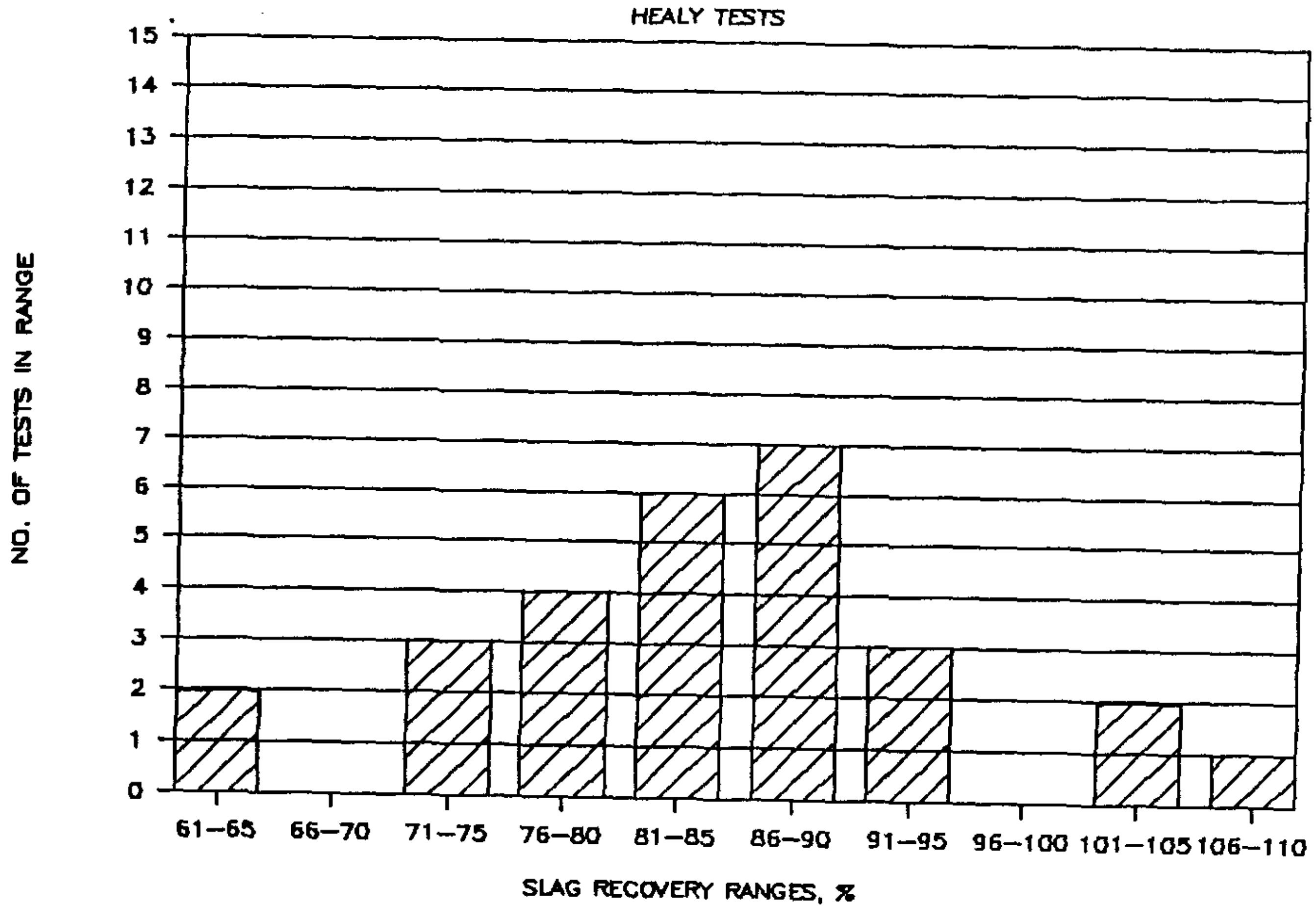


Figure 5-10. **Slag Recovery Frequency Distribution for FCM Tests Only**

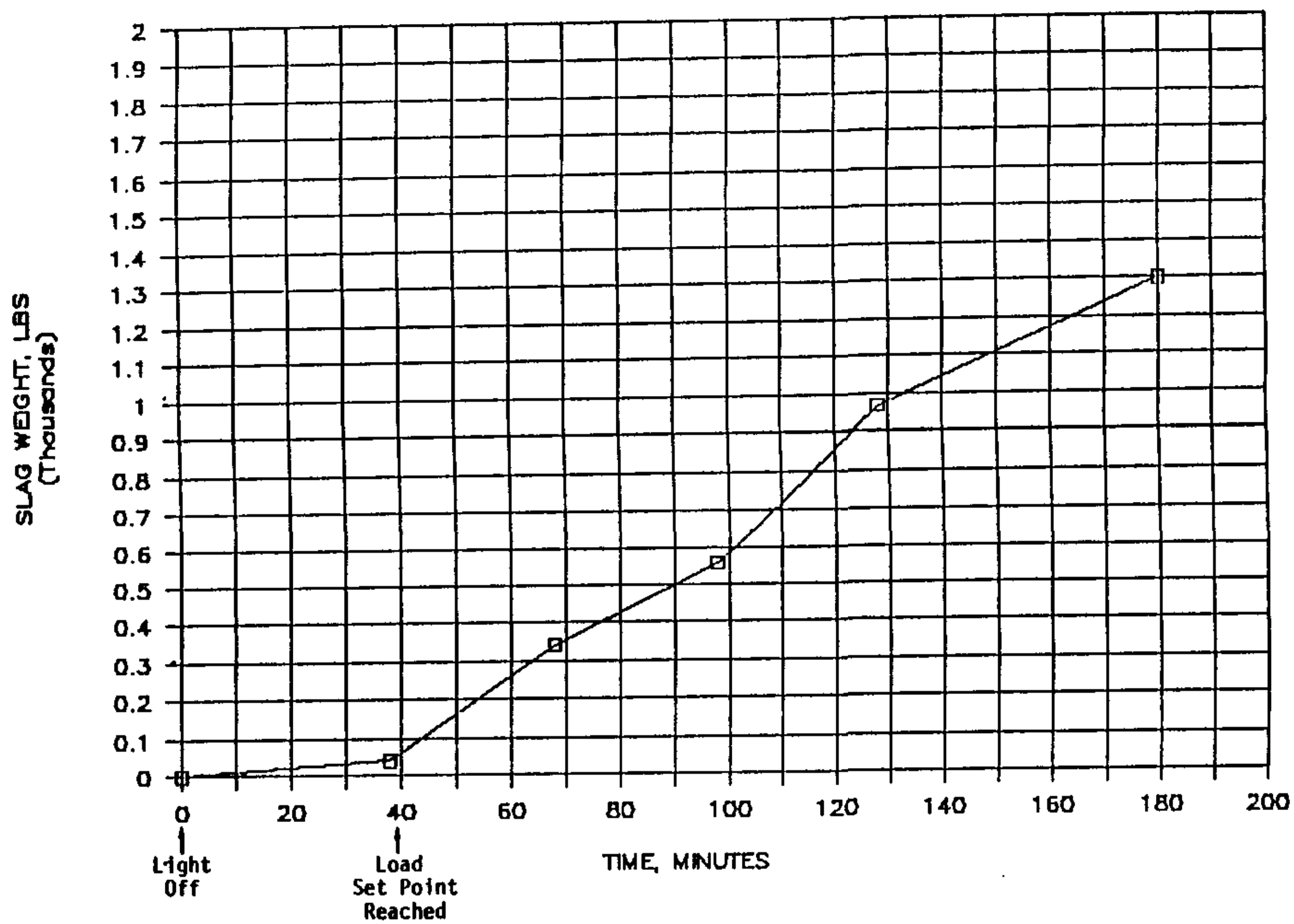


Figure 5-11. **Slag Weight Measured at Different Times During Healy Test H32**

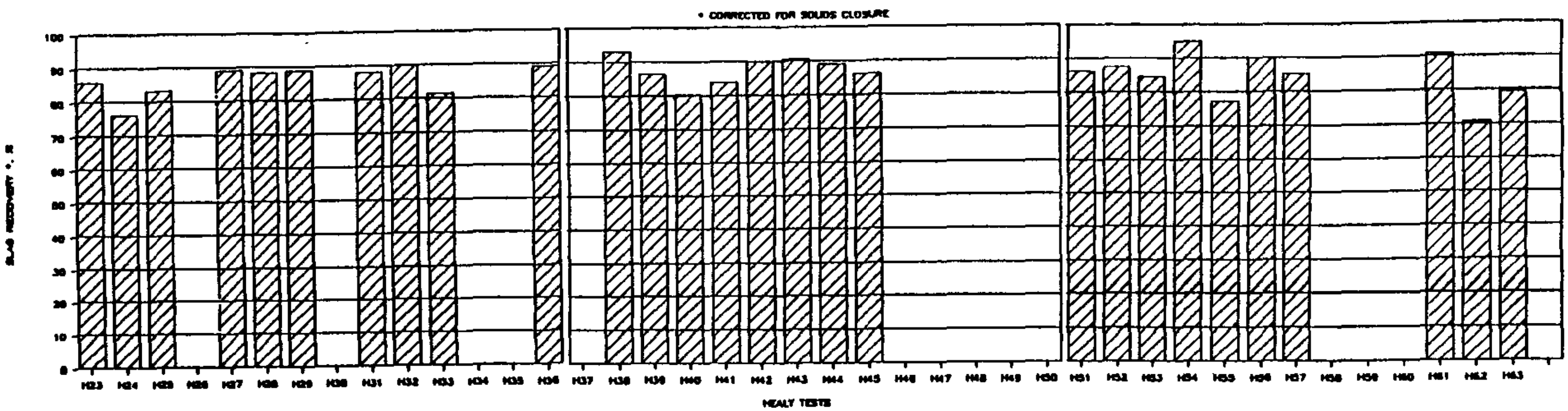


Figure 5-12. Slag Recovery Corrected for Solids Closure - FCM Tests

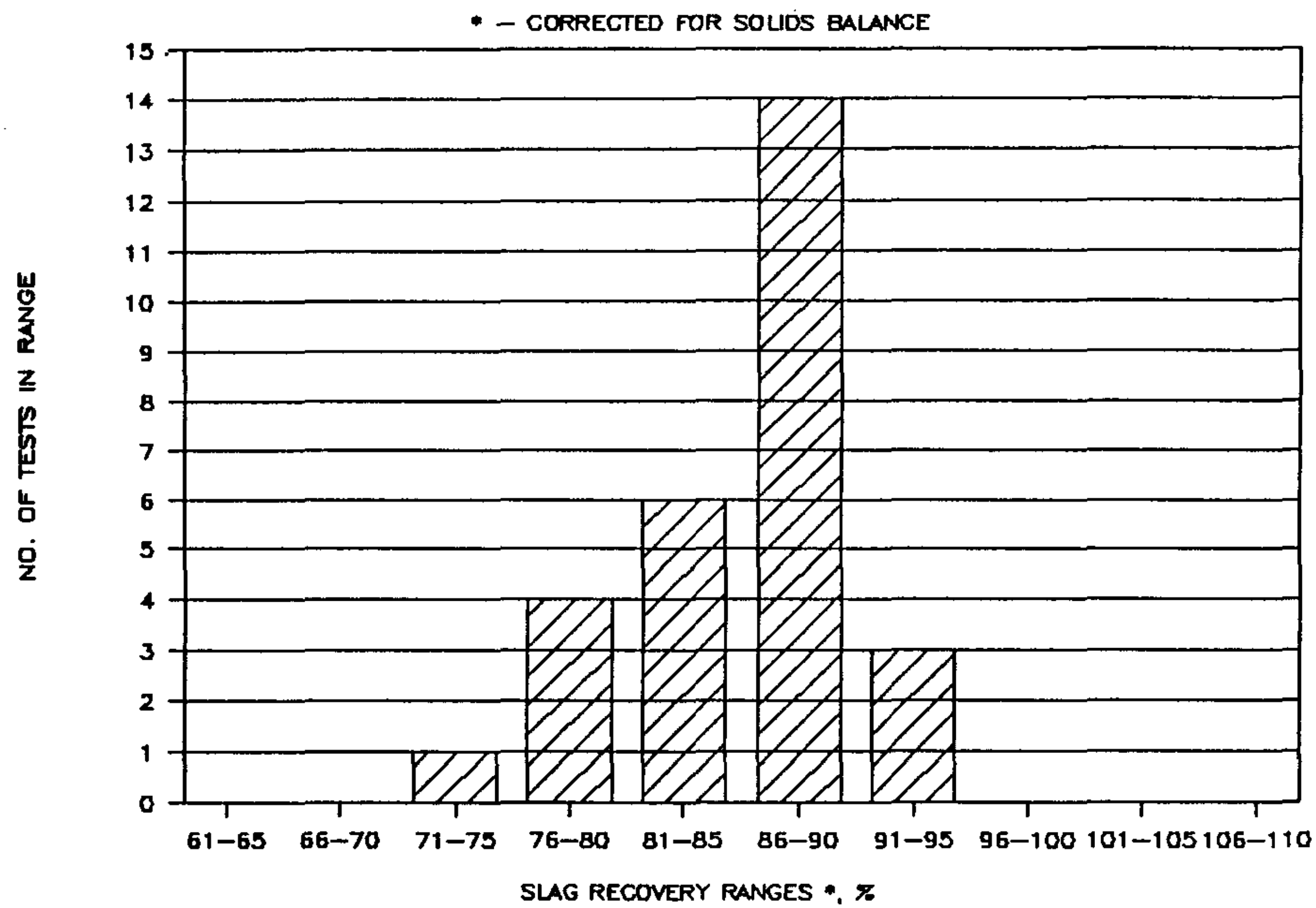


Figure 5-13. **Frequency Distribution for Slag Recovery Corrected for Solids closure - FCM Tests**

The TBR test slag recovery results are shown graphically in Figure 5-14. The TBR results are significantly lower than the performance coal results, ranging from 30 to 73%, with an average of 47%. The slag recovery frequency distribution in Figure 5-15 shows the scatter in the TBR results. Solids closures were also low for the TBR coal, which will be discussed in a later section. By correcting the TBR slag recovery for solids closure efficiency, shown in Figure 5-16, the scatter is reduced, as shown in Figure 5-17. However, even the corrected results are low, with the highest frequency at 51 to 60%. These results are consistent with the fact that the TBR coal has a higher T250 than the performance coal and that the observed combustion performance was not quite as good. Improved slag recovery was observed, however, in test TBR12 where limestone was added to the coal to act as a fluxing agent. This helped to lower the high T_{250} value of the slag. Slag recovery for this test was 73% (upper limit in scatter), which is a marked improvement over the other TBR tests. This slag recovery number may be artificially high, however, due to the release of some slag/ash accumulations previously existing in the combustor on the injection of limestone.

In conclusion on slag recovery:

- Slag recovery for the Healy performance coal was excellent, averaging 85% for tests at 20 MMBtu/hr, main combustor equivalence ratio of 1, coal split of 46%, and coal grinds of 70-80% thru 200 mesh.

- Slag recovery values dropped to near 65% for tests with coarser coal grinds (50-60% thru 200 mesh).

- The excellent slag recovery of 85% further corroborates that combustion performance was good with the performance coal.

- Correcting slag recovery by solids closure efficiency yields results with reduced scatter, indicating that the variations in slag recovery are primarily due to errors in slag weight measurements.

- The TBR slag recovery results were lower, as a result of the higher T_{250} and slightly reduced combustion performance.

- These results indicated that the combustion could be run within the limits of the operability window with the performance coal. Combustor running conditions were slightly outside the more restrictive operating window created by the TBR coal. This window will be wider at Healy because of the higher air preheat temperature and

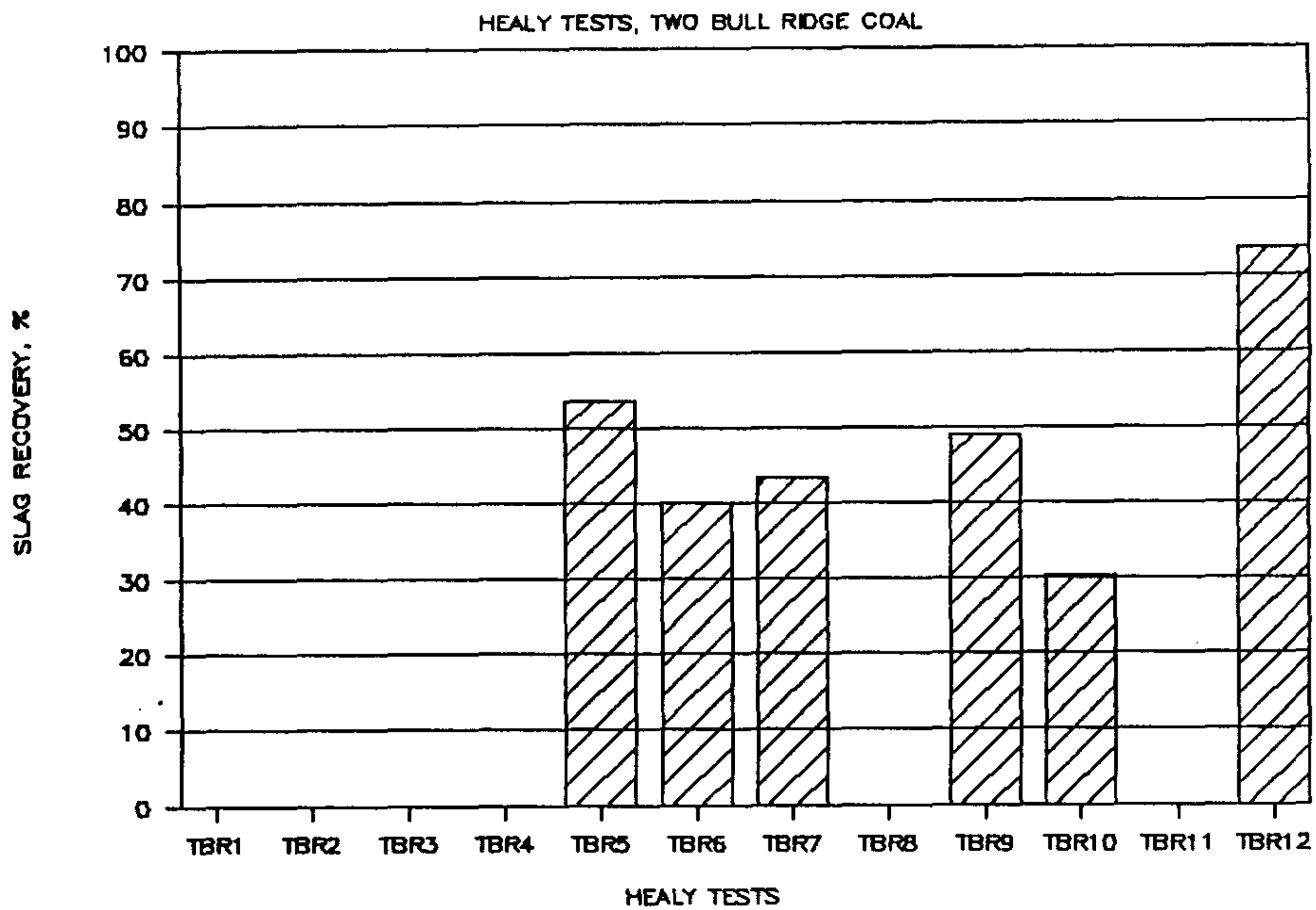


Figure 5-14. Slag Recovery for TBR Tests

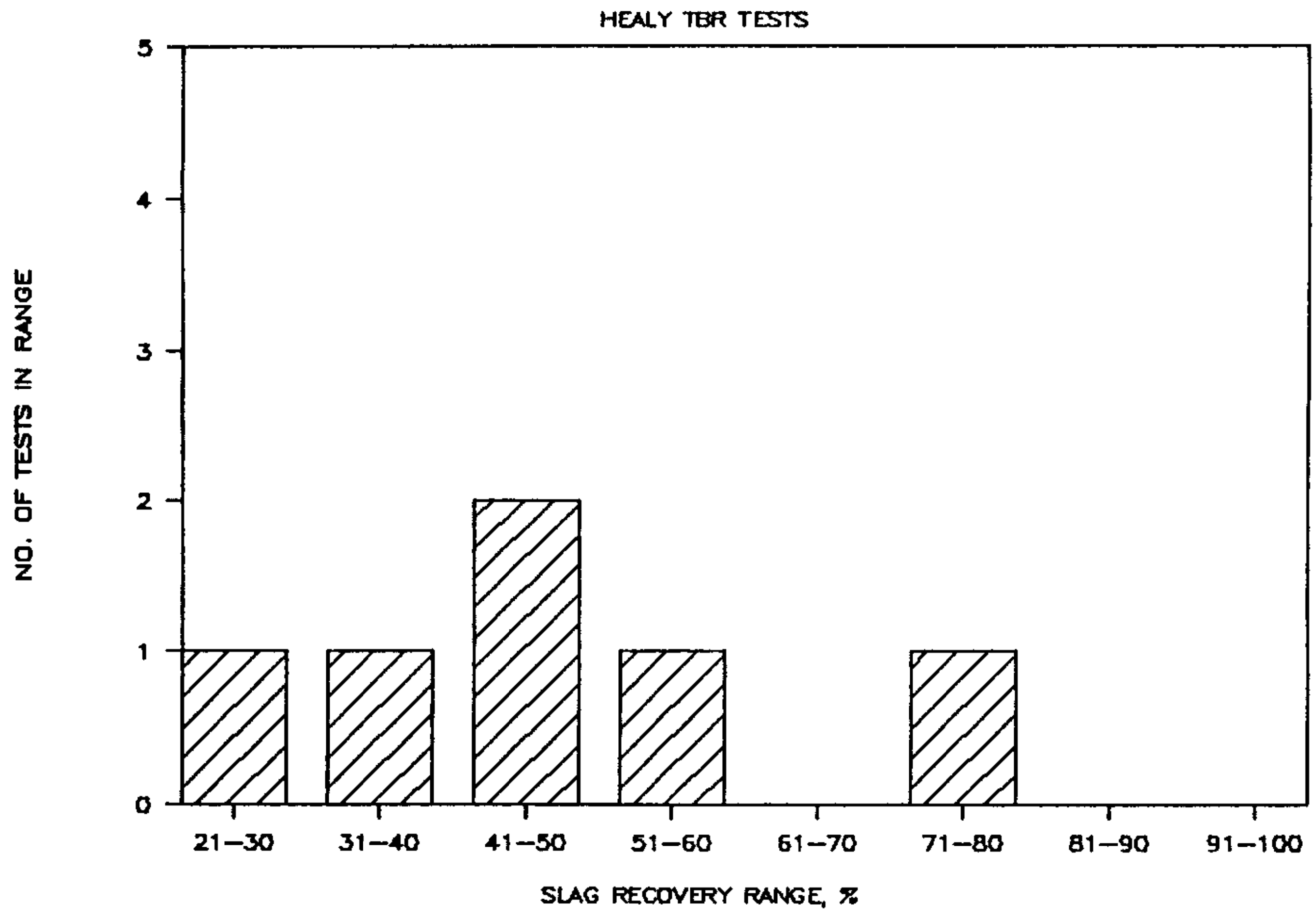


Figure 5-15. Slag Recovery Frequency Distribution for TBR Tests

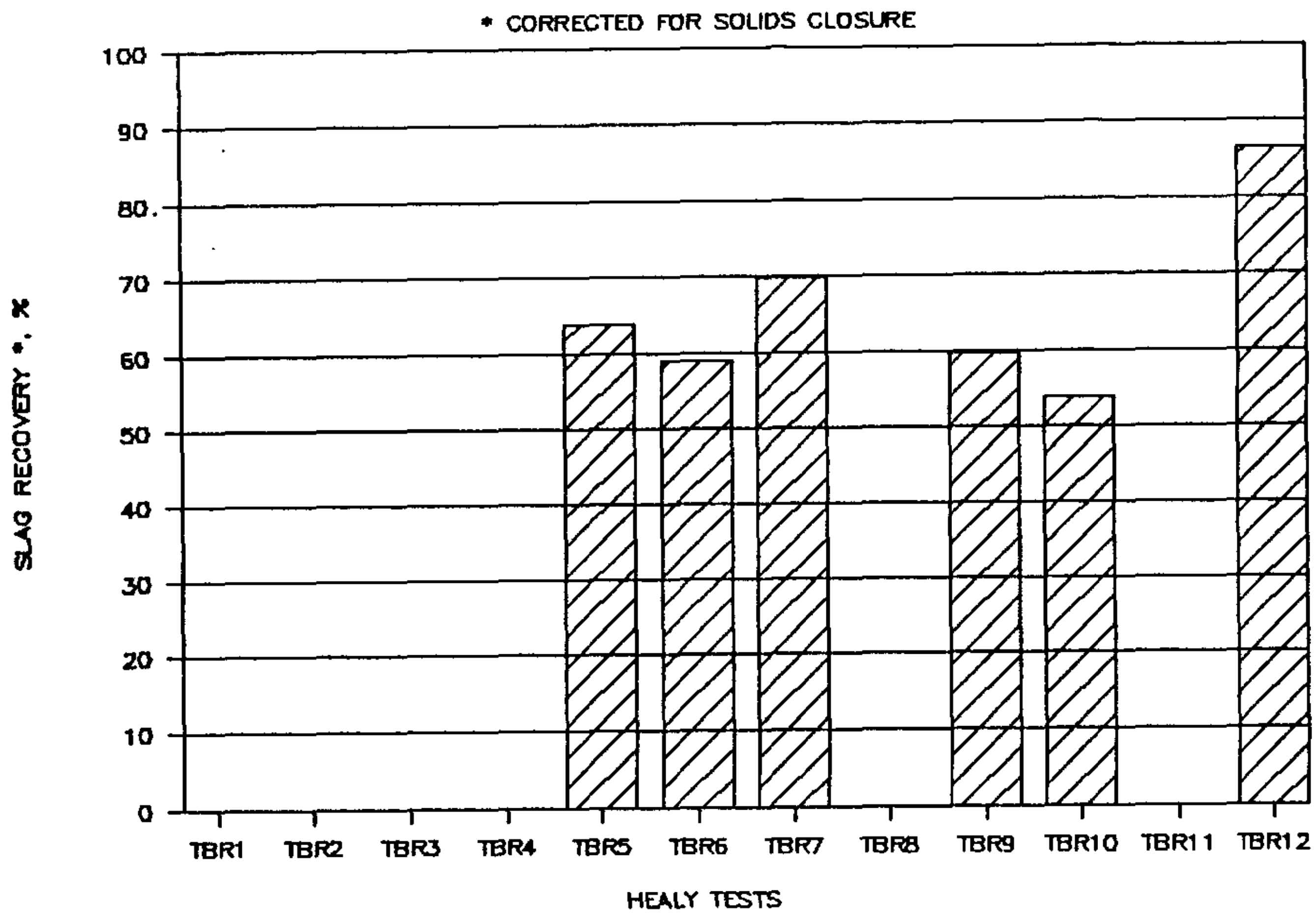


Figure 5-16. TBR Slag Recovery Results Corrected for Solids Closure

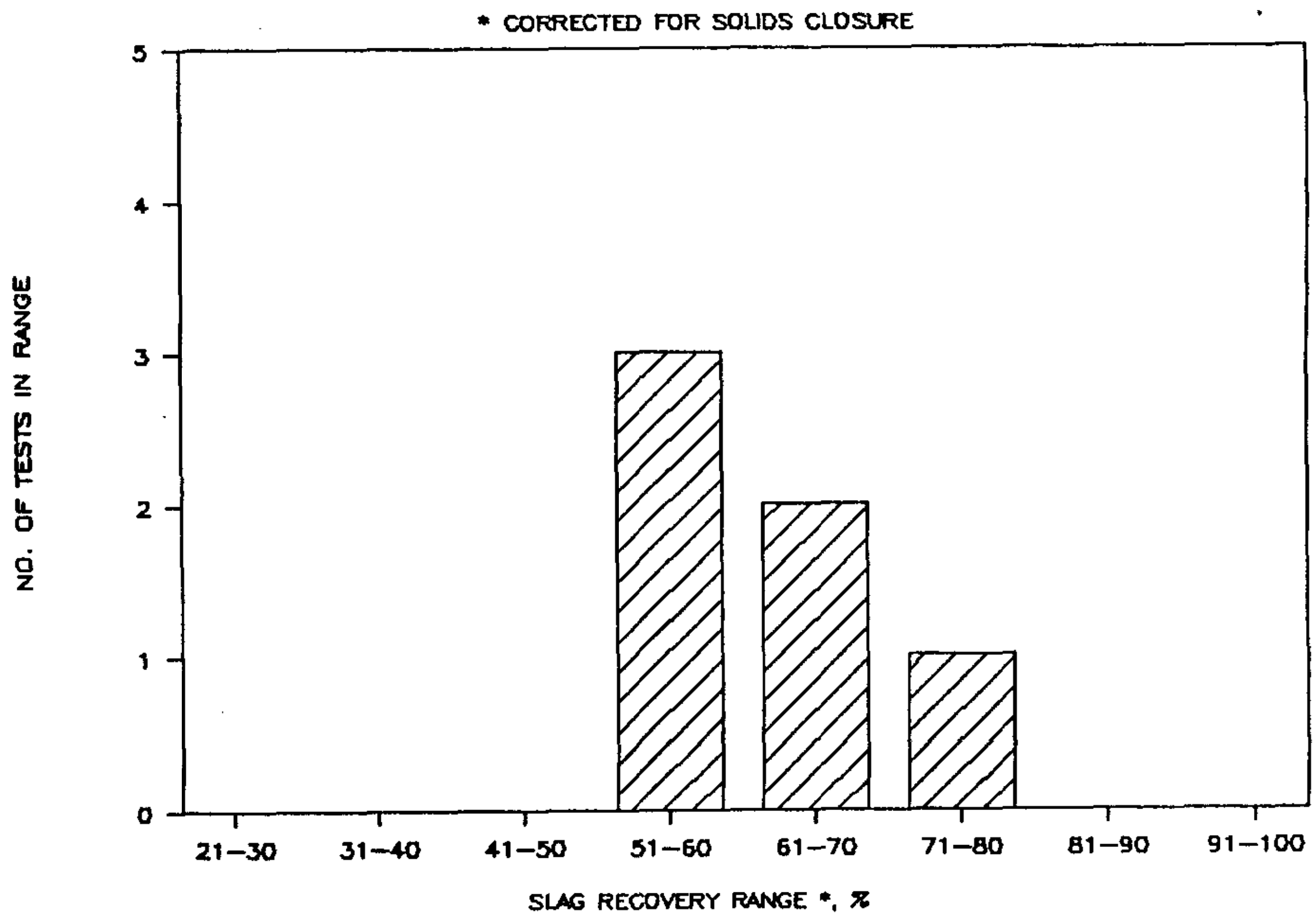


Figure 5-17. Slag Recovery Frequency Distribution for TBR Tests Corrected for Solids Closure

larger physical combustor size.

- An option with the TBR coal may be to mix limestone with the coal to act as a fluxing agent. Limestone injections with the coal lowers the high T_{250} value of the slag, which helps to facilitate slag recovery.

<u>Solids Closures</u>

Solids closure efficiency could be determined for the FCM collection tests and the TBR tests whenever both slag and flyash were weighed for these tests. In some of these tests, slag or flyash weights were not available, so the solids closure was not determined.

Solids Closure efficiency was calculated to determine how well the solids input (coal ash and limestone) matched the solids output (slag and flyash). The equation utilized to determine solids closure is:

Solids Closure = Output/Input *100

Output = (slag wt)*(slag ash content/100)*(1-slag ash SO3 content/100)+(FCM wt)*(FCM ash content/100)*(1-FCM ash SO3 content/100)

Input = (coal wt*(coal ash content/100)*(1-coal ash SO3 content/100)+(limestone flow)*test duration/60*((limestone CaCO3 content/100)*MW(CaO)/MW(CaCO3)+(1-limestone CaCO3 content/100)*MW(MgO)/MW(MgCO3))

Sulfur in the form of sulfur trioxide (SO3) was subtracted from the coal ash, slag, and flyash calculations, since sulfur is released as a gas and not available as a solid material. The solids input from the limestone was assumed to be all calcium oxide (90%) and magnesium oxide (10%).*

The results for the applicable performance coal FCM collection tests are shown in Table 5-10. and plotted in Figure 5-18. Solids closure was found to be excellent, in the range of 74 to 137% with an overall average closure of 97%. The frequency distribution for solid balances is shown in Figure 5-19 and shows that most tests fell within 85 to 105% solids closure.

Solids balances for applicable Two Bull Ridge coal tests have been calculated and are shown in Table 5-11 and plotted in Figure 5-20. Solids closure was found to be poor, in the

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* Inclusion of the actual calcination fractions, rather than the 100% value assumed here, changes the results very little.

Table 5-10. Solids Balance for FCM Tests

SOLIDS BALANCE

TESTS	M22	M23	M24	M25	M27	M28	M29	M30	M31	M32	M33
INPUTS											
COAL FLOW (#/HR)	2436	2449	2501	2483	2491	2494	2506	2494	2509	2477	2485
DURATION (HRS.)	206	196	134	163	142	163	141	183	159	176	165
ASH IN COAL (%)	20.78	26.3	20.78	20.78	20.78	20.78	20.78	19.32	20.78	20.78	20.78
SO3 IN COAL (%)	3.45	1.06	3.45	3.45	3.45	3.45	3.45	2.74	3.45	3.45	3.45
1. ASH IN (#)		2065	1121	1353	1103	1359	1102		1334	1458	1371
LS FLOW (#/HR)	50	36	30	33	34	36	36	34	34.5	34	36
CaCO3 IN LS (%)	90	90	90	90	90	90	90	90	90	90	90
2. LS ASH IN (#)	94.7	64.9	37.0	40.5	44.4	54.0	46.7	57.2	50.4	55.0	54.6
TOTAL INPUT (#)		2130	1158	1403	1227	1413	1228		1384	1513	1426
OUTPUTS											
SLAG RECOVERED		1604	806	1355	1114	1420	1161		1228	1592	1369
SLAG ASH (%)	82.10	81.47	82.10	82.10	82.10	82.10	82.10	87.2	82.10	82.10	82.10
SLAG SO3 (%)	0.13	0.03	0.13	0.13	0.13	0.13	0.13	0.03	0.13	0.13	0.13
1. SLAG OUT (#)		1306	726	1112	914	1172	953		1008	1307	1124
FLY ASH RECOVERED	340	270	270	280	150	220	170	310	180	210	330
FLY ASH ASH (%)	90	90.29	90	90	90	90	90	96.79	90	90	90
FLY ASH SO3 (%)	1.79	1.01	1.79	1.79	1.79	1.79	1.79	1.85	1.79	1.79	1.79
2. FLY ASH OUT (#)	327	263	260	260	144	212	164	294	173	202	310
TOTAL OUTPUT (#)		1569	986	1382	1059	1384	1116		1181	1509	1441
OUTPUT/INPUT (%)		74	85	98	86	98	91		85	100	101

TESTS	M34	M35	M36	M37	M38	M39	M40	M41	M42	M43	M44	M45
INPUTS												
COAL FLOW (#/HR)	2511	2533	2497	2512	2407	2525	2507	2536	2513	2482	2484	2519
DURATION (HRS.)	• 164	151	207	165	169	133	151	209	163	194	153	180
ASH IN COAL (%)	22.37	20.78	20.6	20.78	20.78	20.78	18.23	21.16	20.78	20.78	20.78	20.39
SO3 IN COAL (%)	3.53	3.45	4.21	3.45	3.45	3.45	4.58	4.41	3.45	3.45	3.45	3.56
1. ASH IN (#)			1700		1405	1123	1098	1837	1370	1610	1271	1552
LS FLOW (#/HR)	47.7	40	49.6	50.4	40	49	50.3	46	40	50	42.5	47
CaCO3 IN LS (%)	90	90	90	90	90	90	90	90	90	90	90	90
2. LS ASH IN (#)	71.9	66.7	94.4	76.5	74.6	59.9	69.9	92.3	60.0	89.2	59.0	81.3
TOTAL INPUT (#)			1794		1480	1183	1167	1930	1430	1699	1331	1633
OUTPUTS												
SLAG RECOVERED			2013		1413	981	1040	2020	1690	1773	1391	1636
SLAG ASH (%)	76.17	82.10	76.77	82.10	82.10	82.10	84.85	71.77	82.10	82.10	82.10	85.97
SLAG SO3 (%)	0.15	0.13	0.14	0.13	0.13	0.13	0.03	0.17	0.13	0.13	0.13	0.07
1. SLAG OUT (#)			1543		1160	805	889	1447	1387	1455	1142	1405
FLY ASH RECOVERED	210	230	290	170	160	180	298	380	230	250	200	320
FLY ASH ASH (%)	94.85	90	90.7	90	90	90	90.5	97.27	90	90	90	97.92
FLY ASH SO3 (%)	1.29	1.79	1.67	1.79	1.79	1.79	1.7	1.76	1.79	1.79	1.79	1.94
2. FLY ASH OUT (#)	205	221	281	164	154	173	281	363	221	241	192	307
TOTAL OUTPUT (#)			1825		1314	978	1170	1810	1608	1696	1334	1712
OUTPUT/INPUT (%)			102		89	83	100	94	113	100	100	105

Table 5-10. Solids Balance for FCM Tests (continued)

SOLIDS BALANCE

TESTS	H46	H47	H48	H50	H51	H52	H53	H54	H55	H56	H57	H58	H59	H60	H61	H62	H63	AVERAGE
INPUTS																		
COAL FLOW (#/HR)	2507	2473	2469	2493	2515	2521	2496.5	2459.5	2467	2511.5	2525	2488	2483	2454	2512	2480	2440	2495
DURATION (HRS.)	151	141	179	256	50	191	151	137	162	149	211	175	113	178	204	108	113	6330
ASH IN COAL (%)	20.70	20.70	21.19	20.70	20.70	21.65	20.70	20.70	20.70	16.30	20.70	20.70	21.33	20.70	20.70	20.70	19.83	20.70
SO3 IN COAL (%)	3.45	3.45	3.36	3.45	3.45	2.89	3.45	3.45	3.45	3.96	3.45	3.45	2.84	3.45	3.45	3.45	3.4	3.45
1. ASH IN (#)				2134	420	1607	1261	1127	1336	901	1702				1714	896	808	39609
LS FLOW (#/HR)	51	52	51	50	52.5	47	51.6	51	48.9	48	47.6	48.5	50	50.5	50	49.5	48.0	45
CaCO3 IN LS (%)	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
2. LS ASH IN (#)	70.0	67.4	84.0	117.7	24.1	82.6	71.7	64.3	72.9	65.0	92.4	70.1	52.0	79.0	93.0	49.2	50.7	2626
TOTAL INPUT (#)				2252	445	1770	1332	1191	1409	1047	1874				1807	945	831	41532
OUTPUTS																		
SLAG RECOVERED				2153	423	1750	1130	1221	1195	993	1736				2160	1027	1245	40750
SLAG ASH (%)	82.10	82.10	85.02	82.10	82.10	84.71	82.10	82.10	82.10	90.70	82.10	82.10	82.61	82.10	82.10	82.10	76.70	82.10
SLAG SO3 (%)	0.13	0.12	0.03	0.13	0.13	0.03	0.13	0.13	0.13	0.2	0.13	0.13	0.42	0.13	0.13	0.13	0.22	0.13
1. SLAG OUT (#)				1767	347	1409	935	1002	981	900	1425				1773	843	954	33269
FLY ASH RECOVERED	150	200	220	270	80	300	230	120	360	170	350	50	500	290	290	424	330	9702
FLY ASH ASH (%)	90	90	96.17	90	90	97.87	90	90	90	97.77	90	90	90.19	90	90	90	97.64	90
FLY ASH SO3 (%)	1.79	1.79	2.06	1.79	1.79	1.87	1.79	1.79	1.79	1.94	1.79	1.79	2.22	1.79	1.79	1.79	2.22	1.79
2. FLY ASH OUT (#)	144	250	212	260	77	280	229	115	346	163	337	48	480	279	279	408	315	9335
TOTAL OUTPUT (#)				2027	424	1777	1164	1118	1327	1063	1762				2052	1251	1269	40307
OUTPUT/INPUT (%)				90	95	100	87	94	94	102	94				114	132	130	97

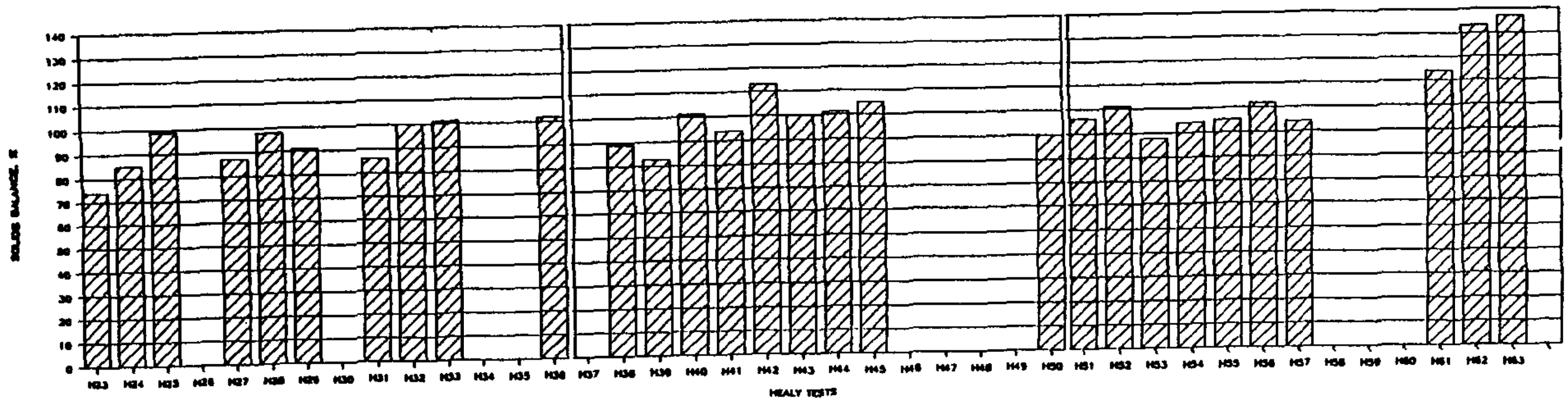

Figure 5-18. Solids Balance - FCM Tests on Performance Coal

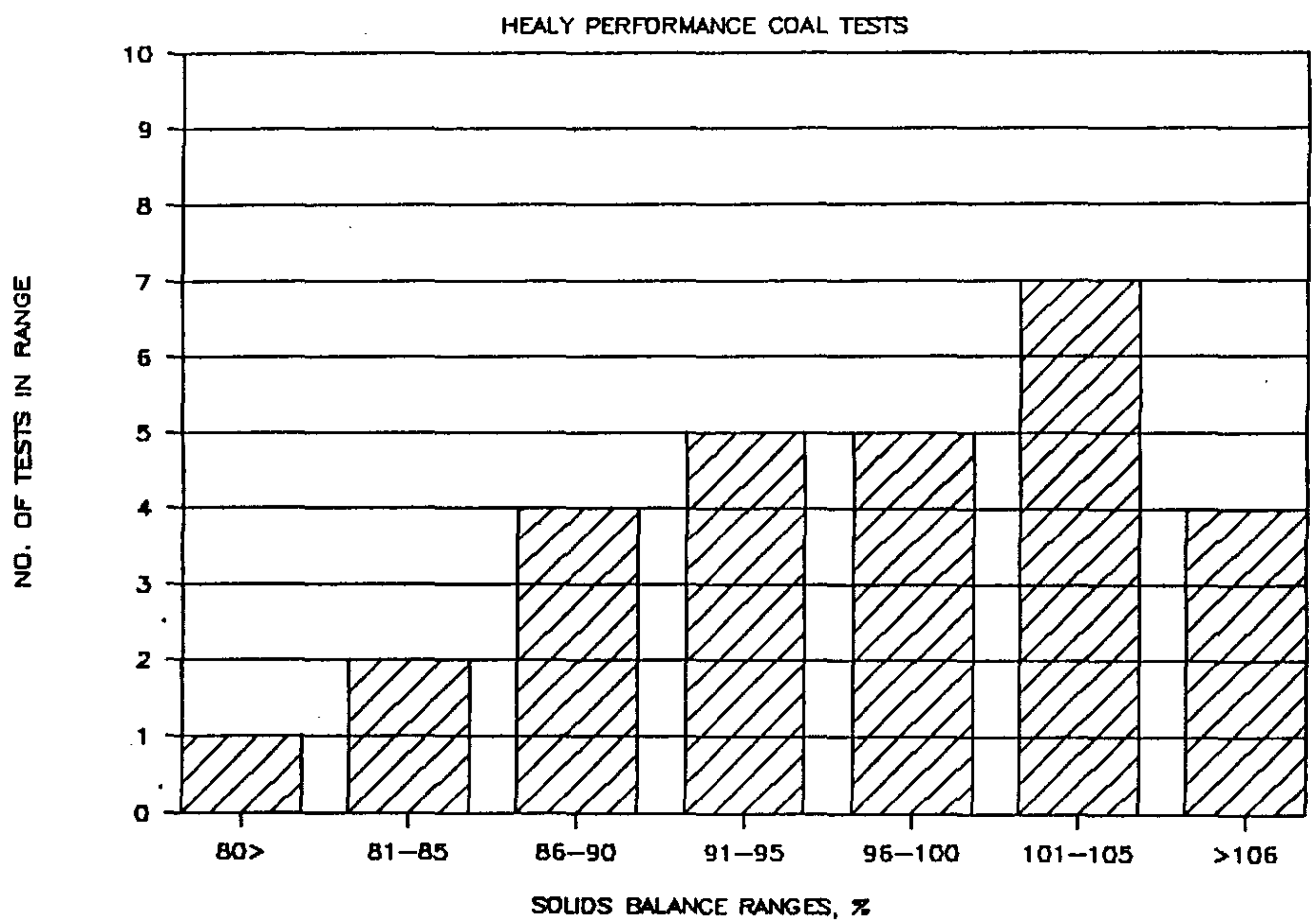

Figure 5-19. **Solids Balance Frequency Distribution for FCM Tests**

Table 5-11. Solids Balance for TBR Tests

SOLIDS BALANCE

TESTS	TBR1	TBR2	TBR3	TBR4	TBR5	TBR6	TBR7	TBR8	TBR9	TBR10	TBR11	TBR12	AVERAGE
INPUTS													
COAL FLOW (#/HR)	1739	2718	3455	3154	3140	3243	3172	3157	3204	2539	2417	2415	2863
DURATION (HRS.)	34	112	101	98	49	32	16	15	35	61	85	70	830
ASH IN COAL (%)	27.32	27.32	29.03	28.35	26.83	27.32	27.14	26.02	27.32	27.55	26.66	26.15	27.32
SO3 IN COAL (%)	3.16	3.16	2.25	3.46	4.04	3.16	2.99	3.3	3.16	2.03	2.0	3.6	3.16
1. ASH IN (#)					660	458	1050	1023	494	759	887	718	6050
LS FLOW (#/HR)	44										82	156	99
CaCO3 IN LS (%)	90	90	90	90	90	90	90	90	90	90	90	90	90
2. LS ASH IN (#)	14	0	0	0	0	0	0	0	0	0	59	90	170
TOTAL INPUT (#)					660	458	1050	1023	494	759	946	808	6206
OUTPUTS													
SLAG RECOVERED					495	304	765	593	402	593	650	767	4569
SLAG ASH (%)	60.26	60.26	83.27	61.13	11.58	60.26	59.71	63.96	60.26	38.51	45.75	60.1	60.26
SLAG SO3 (%)	0.13	0.13	0.1	0.1	0.12	0.13	0.03	0.00	0.13	0.34	0.21	0.06	0.13
1. SLAG OUT (#)					354	183	457	379	242	228	297	522	2661
FLY ASH RECOVERED		274	600	430	210	130	200	330	170	290	240	170	2954
FLY ASH ASH (%)	97.70	97.70	98.04	97.99	96.02	97.78	98.34	97.93	97.78	98.18	97.99	97.74	97.78
FLY ASH SO3 (%)	0.83	0.83	1.35	0.96	1	0.83	0.24	0.66	0.83	0.64	0.79	0.96	0.83
2. FLY ASH OUT (#)		266	588	417	200	126	196	321	165	195	233	165	2084
TOTAL OUTPUT (#)					554	309	651	700	407	423	530	687	4262
OUTPUT/INPUT (%)					84	68	62	68	82	56	56	85	69

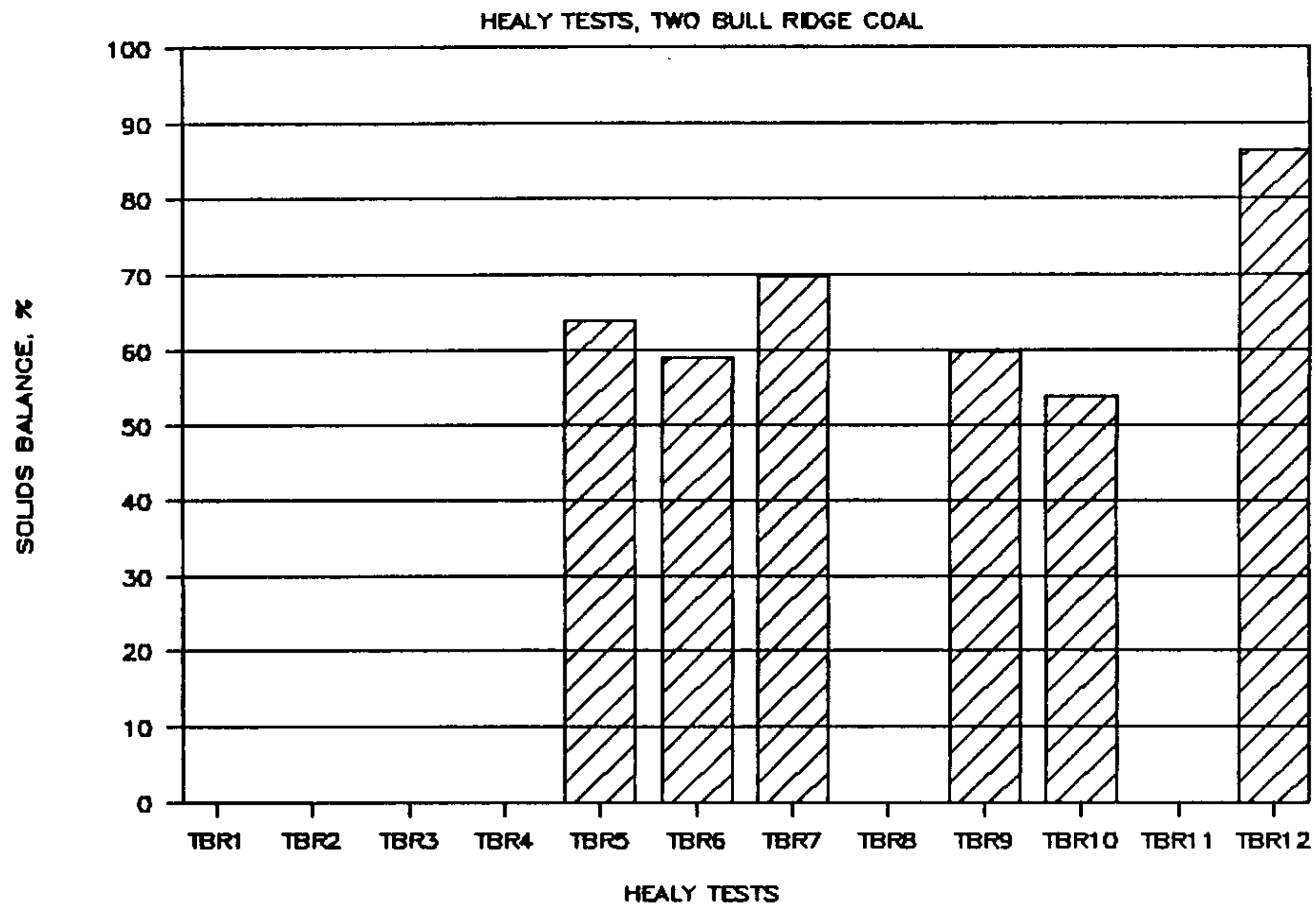

Figure 5-20. Solids Balance for TBR Tests

range of 56% to 85%, with an overall average of 69%. The solids closure was poor for these TBR coal tests primarily because of significant slag accumulation in the furnace section. The previous tests with the performance coal showed little slag accumulation in the furnace section. The reason why the performance coal had little slag accumulation in the furnace section is thought to be due to good combustion and an acceptable match between the active operating window and the performance coal. The combustion performance for the TBR coal tests was not quite as good as the Healy performance coal, and the higher T_{250} resulted in poorer slagging and more carryover into the furnace.

In conclusion on solids closure:

- FCM collection tests with the performance coal showed good solids closure.
- TBR tests showed poor solids closure. This was due to significant slag accumulation in the furnace section.

Calcium Balance

Calcium balances for FCM tests on performance coal have been determined with the results given in Table 5-12, and plotted in Figure 5-21. The calcium balances were found to range from 63% to 124% with an average of 78%. The calcium closure is thought to be reasonable in light of the large errors associated with the relatively small amounts of calcium present in the overall system (approximately 2% of entering solids).

Cooling Loads

Cooling load is the percentage of the higher heating value of the coal fired which is transferred to the combustor cooling water. Cooling load values were determined for the performance coal and Two Bull Ridge coal tests, and are plotted as a function of load in Figure 5-22. Also plotted in Figure 5-22 are cooling load results for Ohio coal tests performed previously under similar conditions as the Healy coal tests. The cooling loads for the Healy tests are observed to be much lower than for the Ohio coal tests. For a load of 20 MMBtu/hr, the cooling load for the Healy tests was approximately 10%, where as for the Ohio coal tests, the cooling load was 20-25%. The lower cooling loads for the Healy coal is due to the higher slag T_{250} values. The cooling loads for the Two Bull Ridge coal tests are slightly lower than those of the performance coal, consistent with the higher slag T_{250} values for the TBR coal above the performance coal.

Table 5-12. Calcium Balance for the FCM Tests on Perfomrance Coal

Calcium Balance — limestone duration (% of coal duration) 100 %

TESTS	N22	N23	N24	N25	N27	N28	N29	N30	N31	N32	N33	N34
INPUTS												
COAL FLOW (#/HR)	2436	2449	2501	2403	2491	2494	2506	2494	2509	2477	2485	2511
DURATION (MINS.)	206	196	134	163	142	163	141	183	159	176	165	164
ASH IN COAL (%)	20.70	26.3	20.70	20.70	20.70	20.70	20.70	19.32	20.70	20.70	20.70	22.31
CaO IN ASH (%)	9.89	7.16	9.89	9.89	9.89	9.89	9.89	10.36	9.89	9.89	9.89	9.13
1. CALCIUM IN (#)	123	106	82	99	87	99	86	109	98	107	100	100
LS FLOW (#/HR)	50	36	30	33	34	36	36	34	34.5	34	36	47.7
CaCO3 IN LS (%)	90	90	90	90	90	90	90	90	90	90	90	90
2. LS CALCIUM IN (#)	62	42	24	32	29	35	30	37	33	36	36	47
TOTAL INPUT (#)		150	106	131	116	135	117		131	143	136	
OUTPUTS												
SLAG RECOVERED		1604	885	1355	1114	1420	1161		1228	1502	1369	
ASH IN SLAG (%)	82.10	81.47	82.10	82.10	82.10	82.10	82.10	87.2	82.10	82.10	82.10	78.17
CaO IN SLAG ASH (%)	9.20	8	9.20	9.20	9.20	9.20	9.20	8.92	9.20	9.20	9.20	8.87
1. SLAG CALCIUM OUT (#)		75	48	74	61	78	63		67	67	75	
FLYASH RECOVERED	340	270	270	200	150	220	170	310	100	210	330	210
FLYASH ASH (%)	98	98.29	98	98	98	98	98	96.79	98	98	98	98
Ca IN FLYASH (%)	12.97	12.02	12.97	12.97	12.97	12.97	12.97	12.02	12.97	12.97	12.97	12.97
2. FLYASH CALCIUM OUT (#)	43	32	34	36	19	28	22	36	23	27	42	27
TOTAL OUTPUT (#)		107	83	109	80	106	85		90	113	117	
OUTPUT/INPUT (%)		71	78	83	69	79	73		69	80	86	

TESTS	N35	N36	N37	N38	N39	N40	N41	N42	N43	N44	N45
INPUTS											
COAL FLOW (#/HR)	2533	2497	2512	2487	2525	2507	2536	2513	2492	2484	2519
DURATION (MINS.)	151	207	165	169	133	151	209	163	194	153	108
ASH IN COAL (%)	20.70	20.6	20.70	20.70	20.70	18.23	21.76	20.70	20.70	20.70	20.39
CaO IN ASH (%)	9.89	10.09	9.89	9.89	9.89	11.06	8.63	9.89	9.89	9.89	11.44
1. CALCIUM IN (#)	94	120	101	103	82	91	118	100	118	93	132
LS FLOW (#/HR)	40	49.6	50.4	40	49	50.3	48	40	50	42.5	47
CaCO3 IN LS (%)	90	90	90	90	90	90	90	90	90	90	90
2. LS CALCIUM IN (#)	43	62	50	49	39	46	60	39	50	39	53
TOTAL INPUT (#)		190		152	121	136	179	139	176	132	105
OUTPUTS											
SLAG RECOVERED		2013		1413	981	1048	2020	1690	1773	1391	1635
ASH IN SLAG (%)	82.10	76.77	82.10	82.10	82.10	84.05	71.77	82.10	82.10	82.10	85.97
CaO IN SLAG ASH (%)	9.20	8.77	9.20	9.20	9.20	9.30	8.59	9.20	9.20	9.20	9.65
1. SLAG CALCIUM OUT (#)		97		77	53	60	89	92	97	76	97
FLYASH RECOVERED	230	290	170	160	100	290	380	230	250	200	320
FLYASH ASH (%)	98	98.7	98	98	98	98.5	97.27	98	98	98	97.92
Ca IN FLYASH (%)	12.97	16.8	12.97	12.97	12.97	18	17.6	12.97	12.97	12.97	17.12
2. FLYASH CALCIUM OUT (#)	29	48	22	20	23	51	65	29	32	25	56
TOTAL OUTPUT (#)		145		97	76	111	154	121	120	101	152
OUTPUT/INPUT (%)		76		64	63	81	86	87	73	77	83

Table 5-12. Calcium Balance for FCM Tests (continued)

Calcium Balance

TESTS	N46	N47	N48	N50	N51	N52	N53	N54	N55	N56	N57	N58	N59	N60	N61	N62	N63	AVERAGE
INPUTS																		
COAL FLOW (#/HR)	2507	2473	2468	2493	2515	2521	2497	2460	2467	2511	2525	2488	2483	2454	2512	2480	2440	2495
DURATION (MINS.)	151	141	170	256	50	101	151	137	162	149	211	175	113	170	204	108	113	6330
ASH IN COAL (%)	20.78	20.78	21.19	20.78	20.78	21.65	20.78	20.78	20.78	16.38	20.78	20.78	21.33	20.78	20.78	20.78	19.03	20.78
CaO IN ASH (%)	9.09	9.09	9.23	9.09	9.09	9.27	9.09	9.09	9.09	12.01	9.09	9.09	10.05	9.09	9.09	9.09	10.22	9.09
1. CALCIUM IN (#)	93	85	103	156	31	115	92	82	98	88	130	107	72	102	125	66	67	3045
LS FLOW (#/HR)	51	52	51	58	52.5	47	51.6	51	48.9	48	47.6	48.5	50	50.5	50	49.3	48.8	45
CaCO3 IN LS (%)	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90
2. LS CALCIUM IN (#)	46	44	55	77	16	54	47	42	48	43	60	51	34	52	61	32	33	1713
TOTAL INPUT (#)				233	41	169	139	124	145	131	191				187	98	100	4135
OUTPUTS																		
SLAG RECOVERED				2153	423	1758	1139	1221	1195	993	1736				2160	1027	1245	40750
ASH IN SLAG (%)	82.10	82.10	85.02	82.10	82.10	84.71	82.10	82.10	82.10	90.76	82.10	82.10	82.61	82.10	82.10	82.10	76.70	82.10
CaO IN SLAG ASH (%)	9.20	9.20	9.37	9.20	9.20	9.03	9.20	9.20	9.20	11.13	9.20	9.20	10.23	9.20	9.20	9.20	11.11	9.20
1. SLAG CALCIUM OUT (#)				117	23	96	62	67	65	72	95				110	56	76	2209
FLYASH RECOVERED	150	260	220	270	80	300	230	120	360	170	350	50	500	290	290	424	330	9702
FLYASH ASH (%)	98	98	98.17	98	98	97.07	96	98	98	97.77	98	98	98.19	98	98	98	97.64	98
Ca IN FLYASH (%)	12.97	12.97	12	12.97	12.97	15.06	12.97	12.97	12.97	14.52	12.97	12.97	13.15	12.97	12.97	12.97	14.86	12.97
2. FLYASH CALCIUM OUT (#)	19	33	26	34	10	44	30	15	46	24	44		65	37	37	54	40	1292
TOTAL OUTPUT (#)				152	33	140	92	82	111	96	139				155	118	124	3200
OUTPUT/INPUT (%)				65	71	83	66	66	76	73	73				83	113	124	78

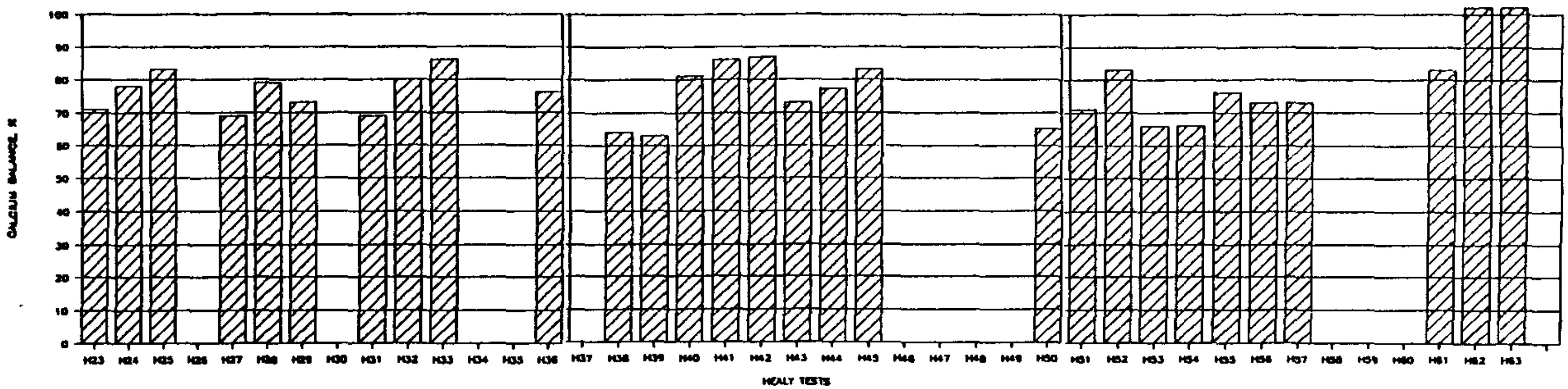

Figure 5-21. Calcium Balance for the Performance Coal FCM Tests

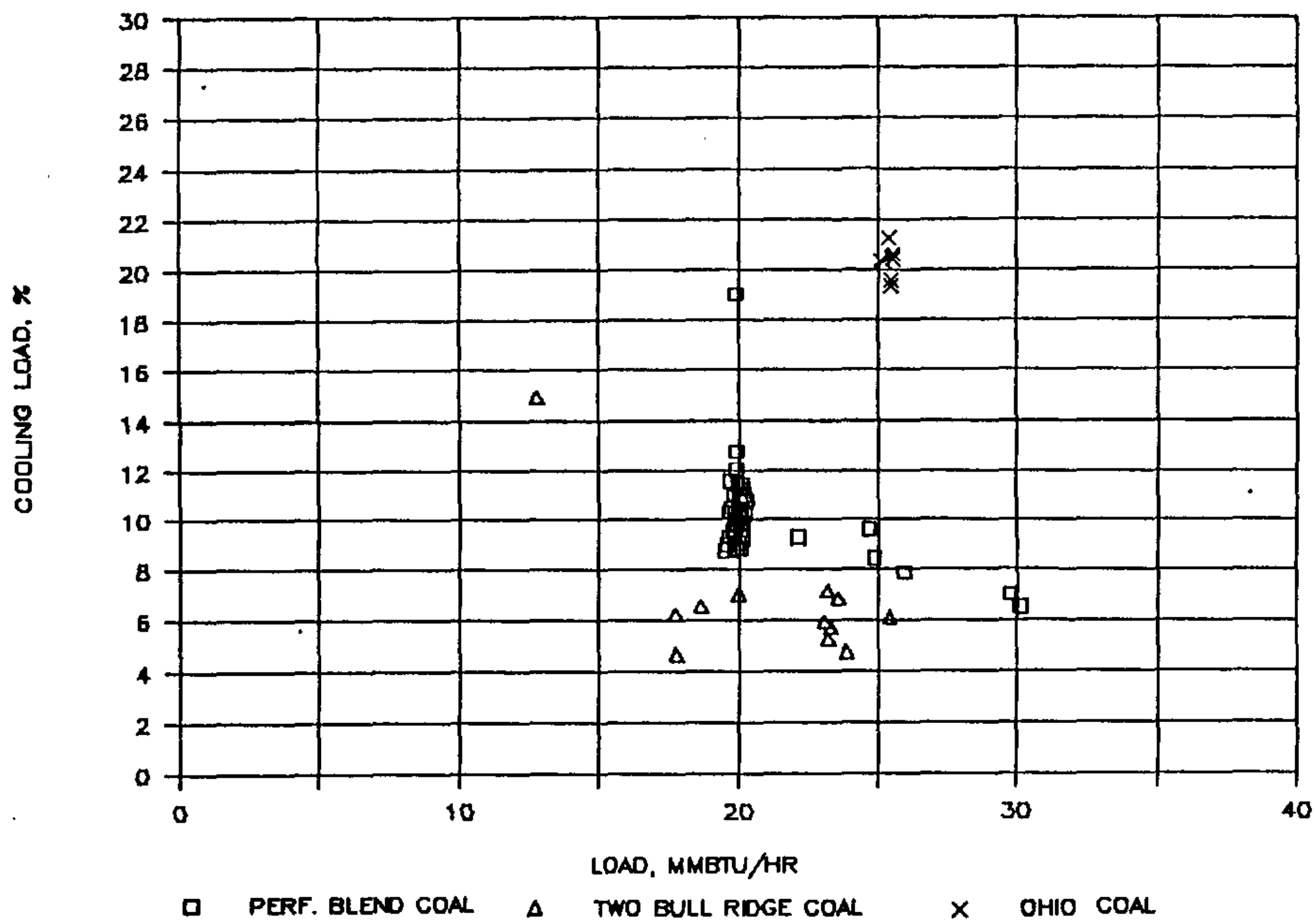

Figure 5-22. Effect of Load on Combustor Cooling Load for Different Coals During Healy Testing

Combustor heat fluxes making up the cooling loads observed above, are shown in Figure 5-23 for the performance coal, the TBR coal, and the Ohio coal, for similar loads and equivalence ratios. The difference in heat fluxes between the Ohio coal and the Healy coal tests in the slag recovery section of the combustor is primarily due to a difference in the slag T_{250} values. This is because the slag layers in the slag recovery section were observed to be melted, where the surface of the slag must have reached the T_{250} value. Heat fluxes in the slag recovery section for the Healy coal tests were roughly half the heat flux values for the Ohio coal tests. The difference in heat fluxes between the Ohio coal and Healy coal tests in the head end section of the combustor is due to more than just the difference in the slag T_{250} values. In this region, large ash accumulations were predominant for the Healy tests causing the heat fluxes to drop to values as low as 1 Btu/s/ft2. For the Healy combustor, ash accumulations are not expected because of higher air preheat temperatues and higher loadings. Heat fluxes for the head end region are thus expected to go up, but not as high as the Ohio coal, because of the higher slag T_{250} values for the Healy coal.

Calculations have been performed to show the relationship between heat flux, slag thickness, and gas temperature for the performance coal. The results of these calculations are shown in Figure 5-24. For the head end region, with heat fluxes of 1 Btu/s/ft2, calculated gas temperatures are observed to be only slightly higher than the T_{250} value of the slag. Calculated slag thicknesses are thus large, 3-4 inches, and potentially unstable if the gas temperature were to drop nearer the slag T_{250} value. This is consistent with the ash accumulations observed in the head end for the performance coal. For the exit section of the main combustor, heat fluxes were approximately 5 Btu/s/ft2. Calculated exit temperatures are observed to be much higher than the slag T_{250} value. This is assuming that no ash is in the gas, which is reasonable in this case for the performance coal which has good slag recovery. Calculated slag thicknesses are thus thinner and more stable, consistent with post test observations. To give more credence to the calculated results, the gas temperatures were compared against equilibrium gas temperatures determined from a thermal chemical equilibrium program, based upon stoichiometric conditions for the head end and exit regions. The equilibrium temperature results are shown in Figure 5-25, and are observed to agree well with the calculated temperatures in Figure 5-24.

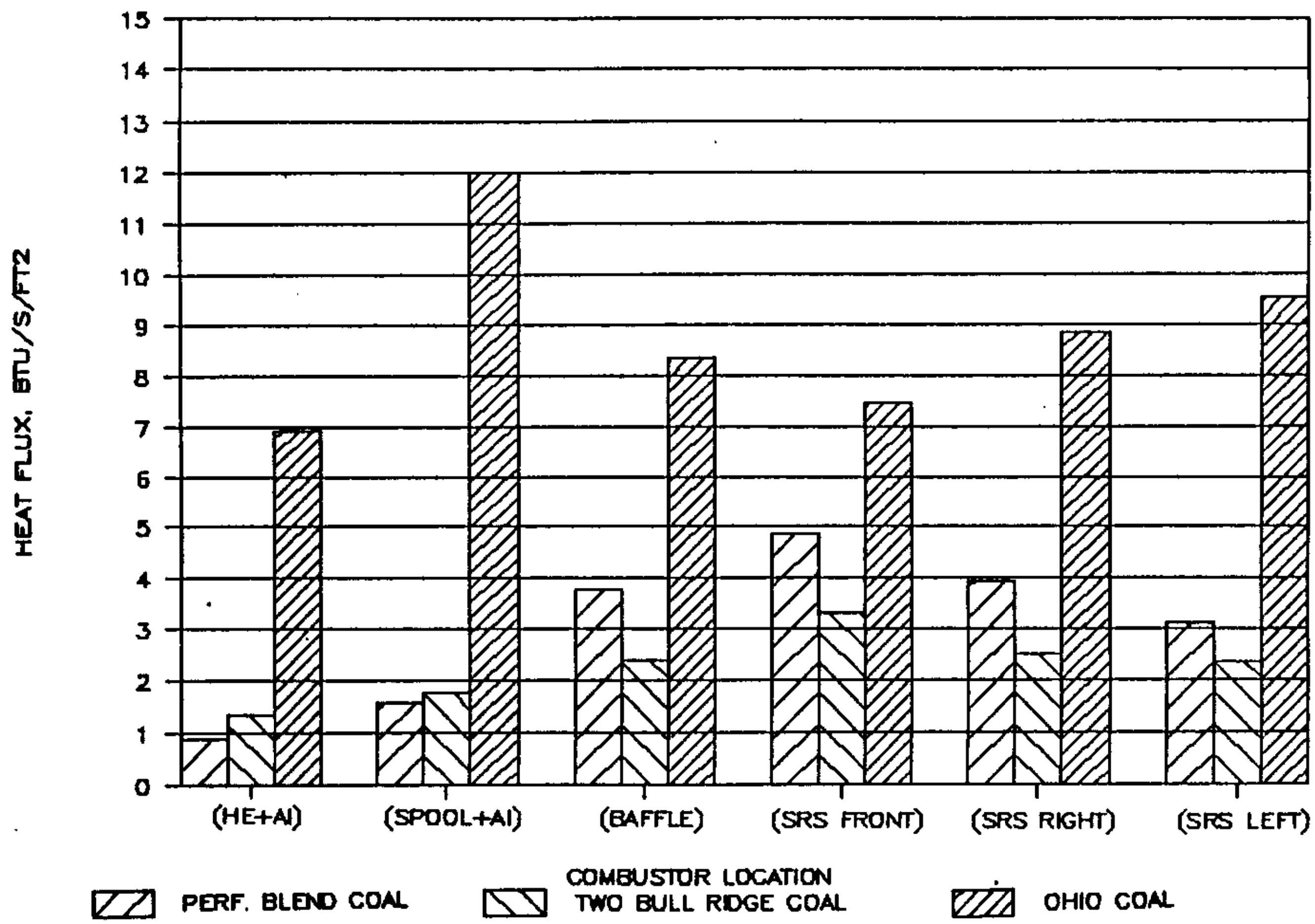

Figure 5-23. Combustor Heat Fluxes for Different Coals During Healy Testing

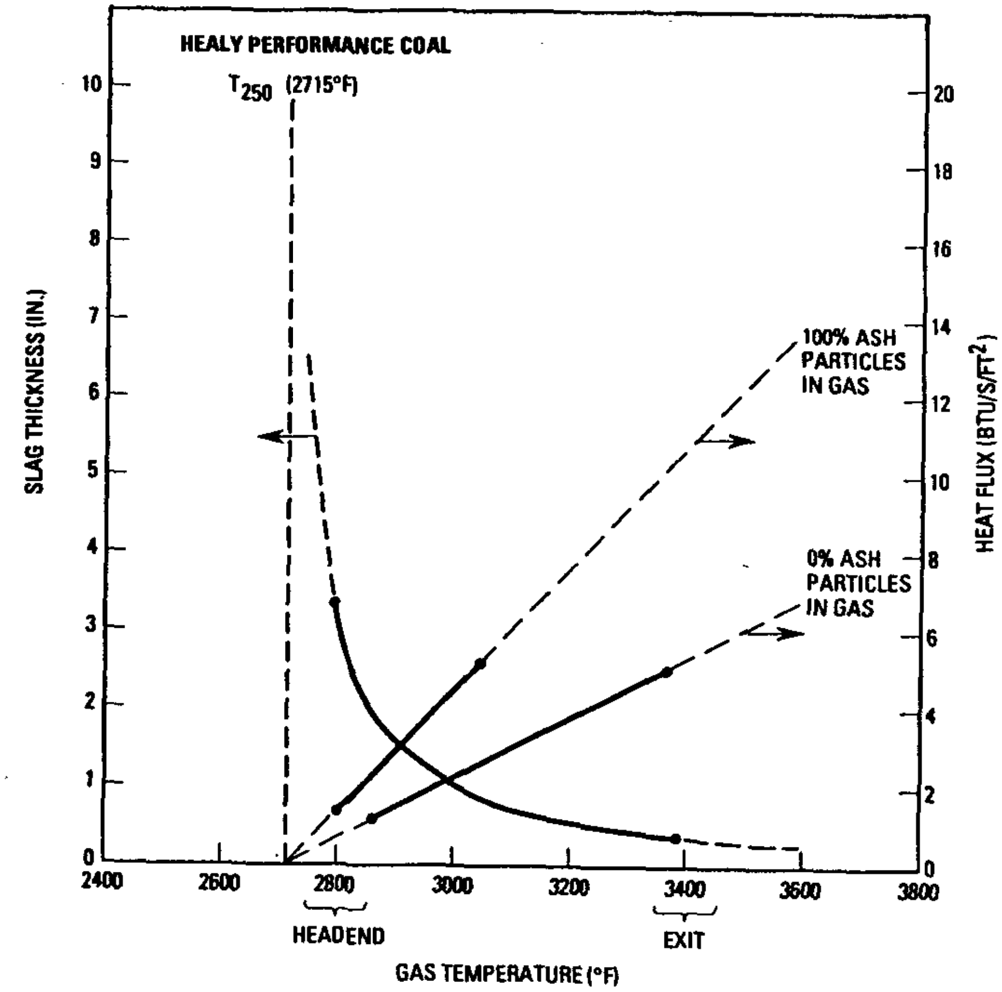

Figure 5-24. Calculated Relationship Between Heat Flux, Slag Thickness, and Gas Temperature for Performance Coal.

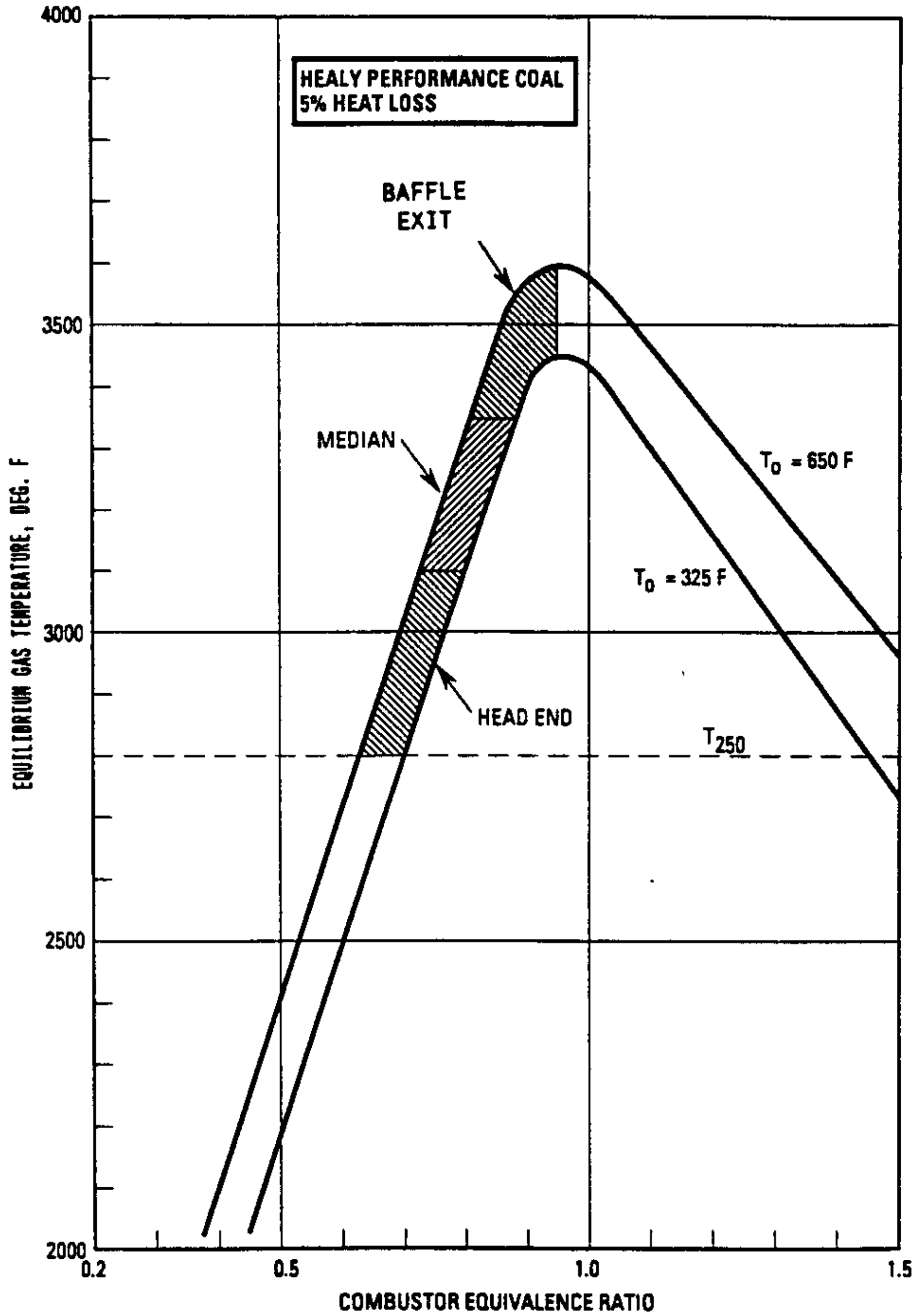

Figure 5-25. Equilibrium Gas Temperatures as a Function of Combustor Equivalence Ratio for Performance Coal

In conclusion on cooling loads:

- Cooling loads and heat fluxes were observed to be lower for the Healy tests compared to previous Cleveland experience with the Ohio coal.

- The difference in exit section heat fluxes between the Healy coal and the Ohio coal is believed to be primarily due to a difference in the slag T_{250} values. This is because the slag layers were observed to be completely melted and glassy, and must have reached the slag T_{250} values. The lower heat flux for the Healy coal tests is attributed to a smaller temperature difference between the combustion gas and the higher liquid surface temperature fo the slag (higher T_{250}). This result assumes that the convection-radiative heat transfer coefficient (between combustion gas and liquid slag surface) is the same for both coal types.

- The difference in head end region heat fluxes between the Healy coal and the Ohio coal is due to more than just a difference in slag T_{250} values. This is because of the large ash accumulations observed post test for the Healy coals. These accumulations created a large resistance to conduction between the slag-gas surface and the combustor wall.

- Slag accumulations are not expected to occur in the Healy combustor due to higher air preheat temperatures and higher loadings. Heat fluxes are expected to go up, but not as high as the Ohio coal tests due again to the higher slag T_{250} values of the Healy coals.

5.4.4 Furnace and Emissions

<u>Furnace Temperatures</u>

Temperatures were measured in the furnace during selected performance coal parametric tests using a Babcock & Wilcox high velocity thermocouple (HVT) probe. The tests for which these measurements were made were H13, H13-1, H14, H14-1, H16, H17, and H18. Traverses were made from two locations, both on a plane about 16 inches in front of the back wall of the furnace.

Figure 5-26 shows the measurement points. Access doors to the furnace were used for probe insertion. The upper measurements were taken on a diagonal traverse into the furnace. The location used to indicate furnace exit temperature was D-2. The lower measurements were taken on a horizontal traverse across the length of the furnace at a level just above the plane of the combustor exit.

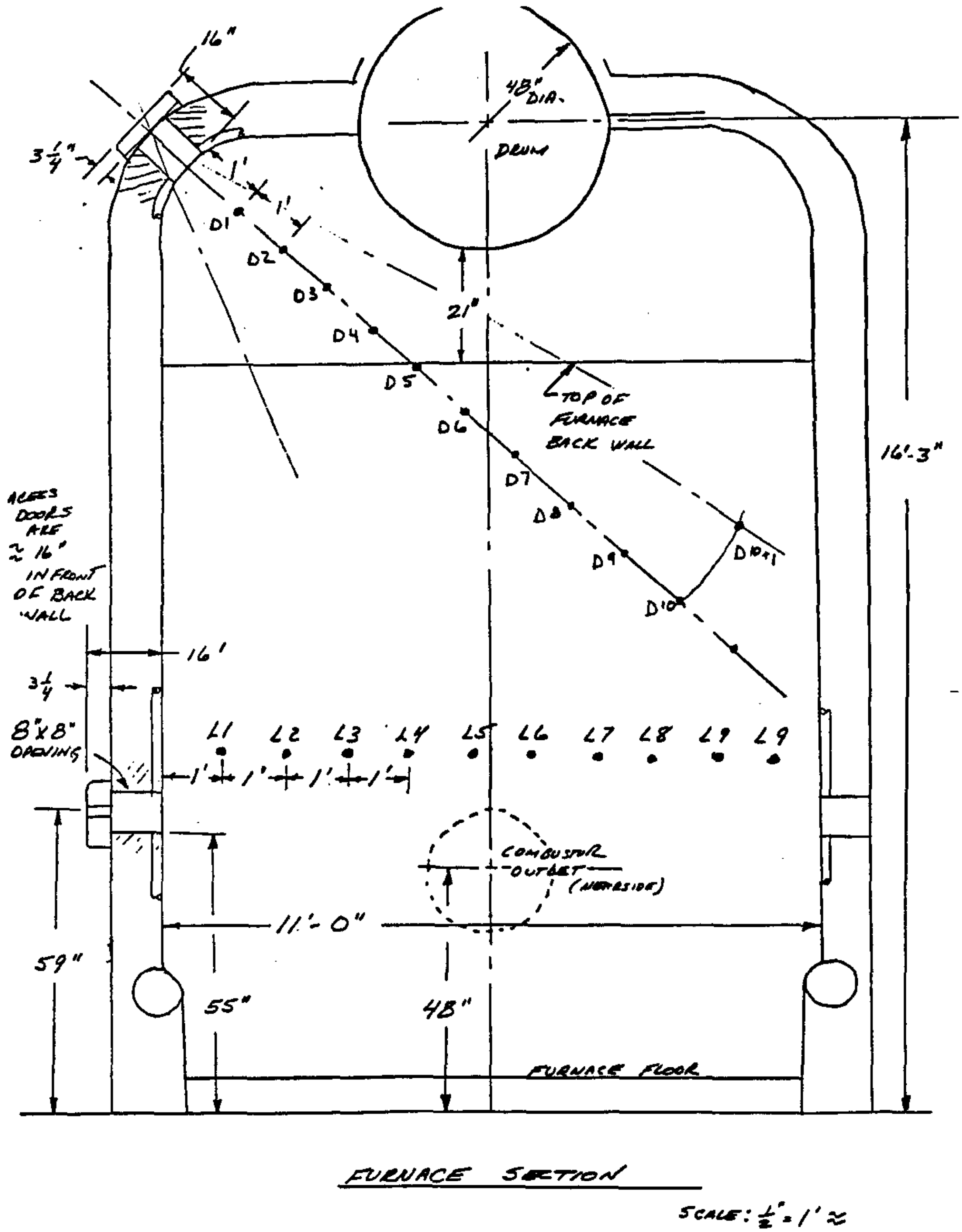

Figure 5-26. HVT Probe Test Locations (High Velocity Thermocouple)

The HVT furnace temperature measurements are given by test and measurement point in Table 5-13. The furnace exit temperature ranged from 1900 to 2180°F, depending on combustor load, as shown in Figure 5-27. Temperatures from an entire traverse for two tests (H14 & H14-1) are shown in Figure 5-28 for the diagonal traverse and in Figure 5-29 for the horizontal traverse.

NOx Emissions

Nitrogen oxide (NOx) emissions were measured in the stack using a Lear-Siegler in-situ monitor for SOx and NOx emissions. Figure 5-30 shows the NOx emissions corrected to 3% oxygen in the stack for all Healy performance coal and TBR coal tests. The figure gives the NOx levels in chronological order. NOx emissions ranged from a low of 130 ppm to a high of 340 ppm, with an average value of 183 ppm for the performance coal and 232 ppm for the TBR coal. NO_x levels can be determined in lbs/MMBtu using equation 20 in Appendix C. These values are, on the average, 0.271 lbs/MMBtu for the performance coal, and 0.348 lbs/MMBtu for the TBR coal.

Figure 5-31 shows that NOx emissions are a function of stack oxygen. NOx levels increased as stack oxygen increased as expected. The excess oxygen, however, could not be controlled to lower levels because of the large amount of intrusion air in the boiler. NOx emissions are also a function of combustor load, as shown in Figure 5-32, which shows that as load increases, NOx emissions increase. This is consistent with higher temperatures at higher loads.

While NOx emissions vary as oxygen and load vary, NOx emissions are not a strong function of combustor equivalence ratio, as shown in Figure 5-33. This suggests that the combustor can be operated for optimum slagging conditions without significantly compromising NOx emissions.

In conclusion on Nox Emissions:

- Low NOx emission levels were successfully demonstrated in concert with excellent combustion and slagging characteristics.

- NOx emission trend with excess O_2 indicates the potential for further reductions NOx emissions by better control of furnace conditions as will be available at Healy.

- NOx emissions appear to be mildly dependent on combustor stoichiometry thus providing operating flexibility.

Table 5-13. Furnace Temperature Readings Using the High Velocity Thermocouple (HVT) Probe

HORIZONTAL LOCATION	TEMPERATURES (DEGREES F)	
	H13-1	H13-2
L1	2264	2289
L2	2250	2210
L3	2264	2238
L4	2305	2256
L5	2340	2265
L6	2271	2246
L7	2220	2215
L8	2175	2186
L9	2146	2156
L10	2155	2153

DIAGONAL LOCATION	TEMPERATURES (DEGREES F)				
	H14	H14-1	H16	H17	H18
D1	1821	1830	1989	2132	*
D2	1892	1874	2013	2126	2167
D3	1915	1856	2023	*	2170
D4	1957	1856	1947	*	2119
D5	1991	1909	1910	*	2049
D6	2029	1968	1961	*	*
D7	2047	2008	1997	*	*
D8	2078	2050	2024	*	*
D9	2121	2129	2053	*	*
D10	2192	2224	*	*	*
D10+1	*	2099	*	*	*

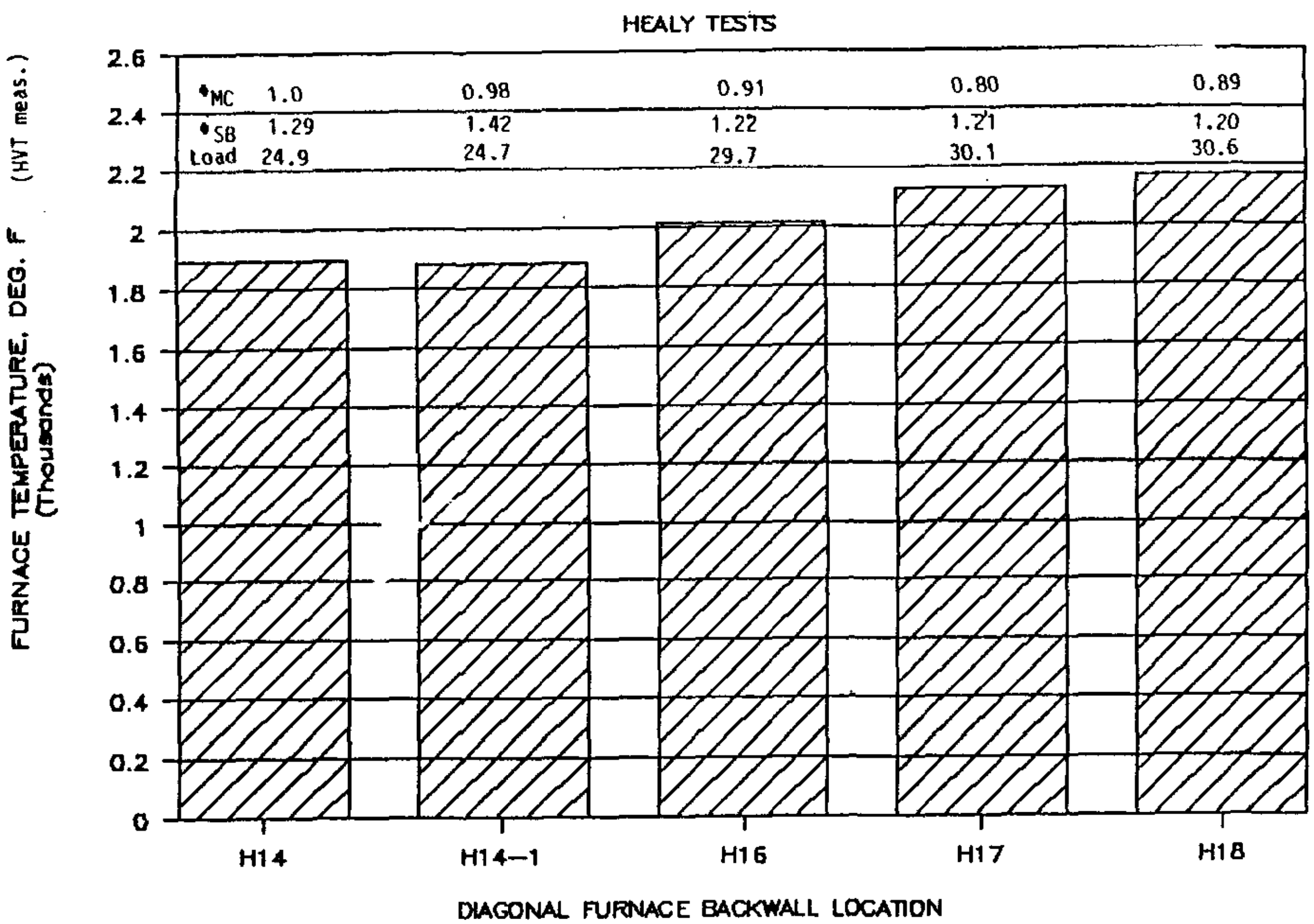

Figure 5-27. **Temperatures Measured by HVT Probe Near Furnace Exit (Loc. D2) Healy Performance Coal**

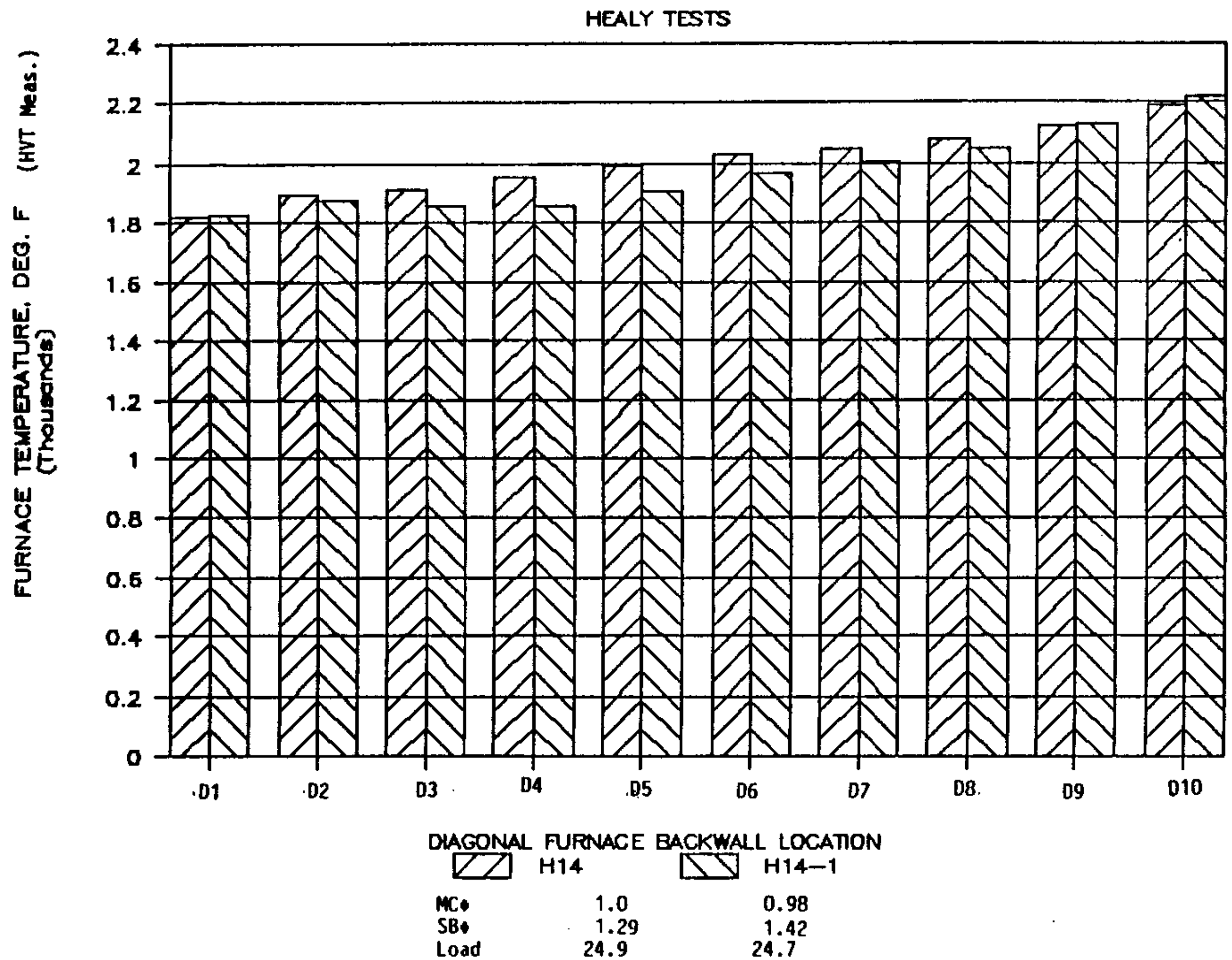

Figure 5-28. Temperatures Measured by HVT Probe Along Diagonal Backwall Location - Healy Performance Coal

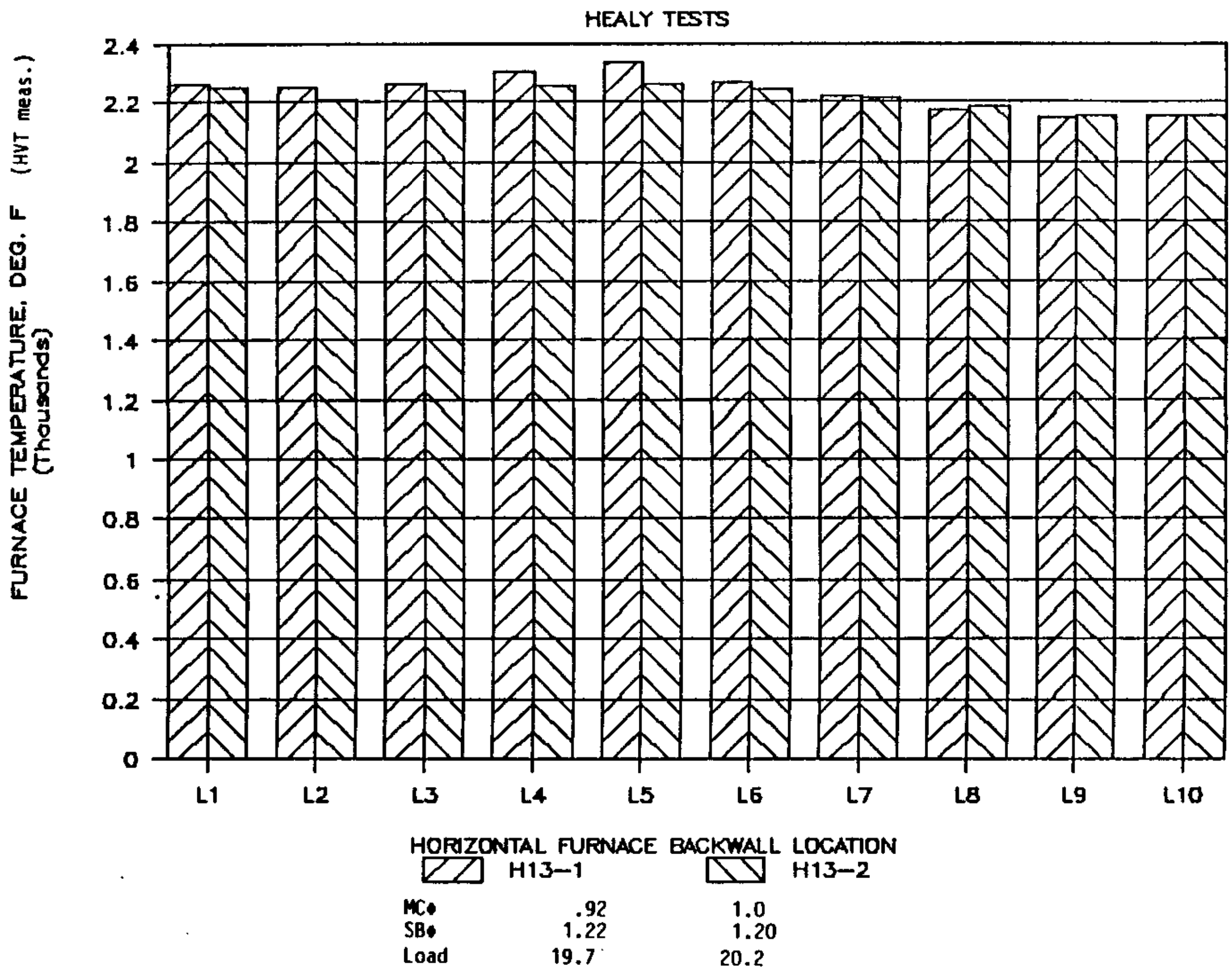

Figure 5-29. **Temperatures Measured by HVT Probe Along Horizontal Backwall Location - Healy Perfomance Coal**

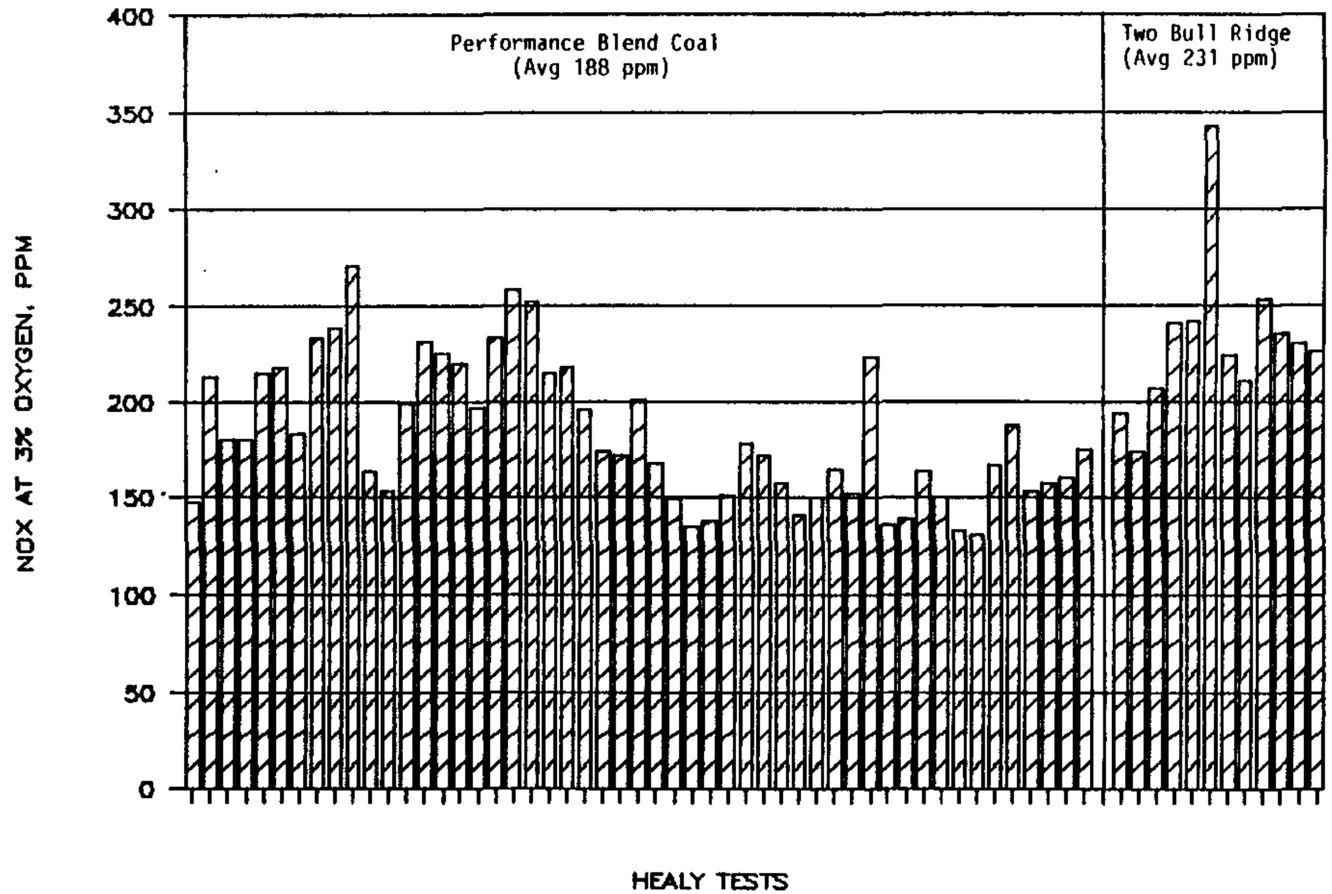

Figure 5-30. Average NOx Values During Healy Testing

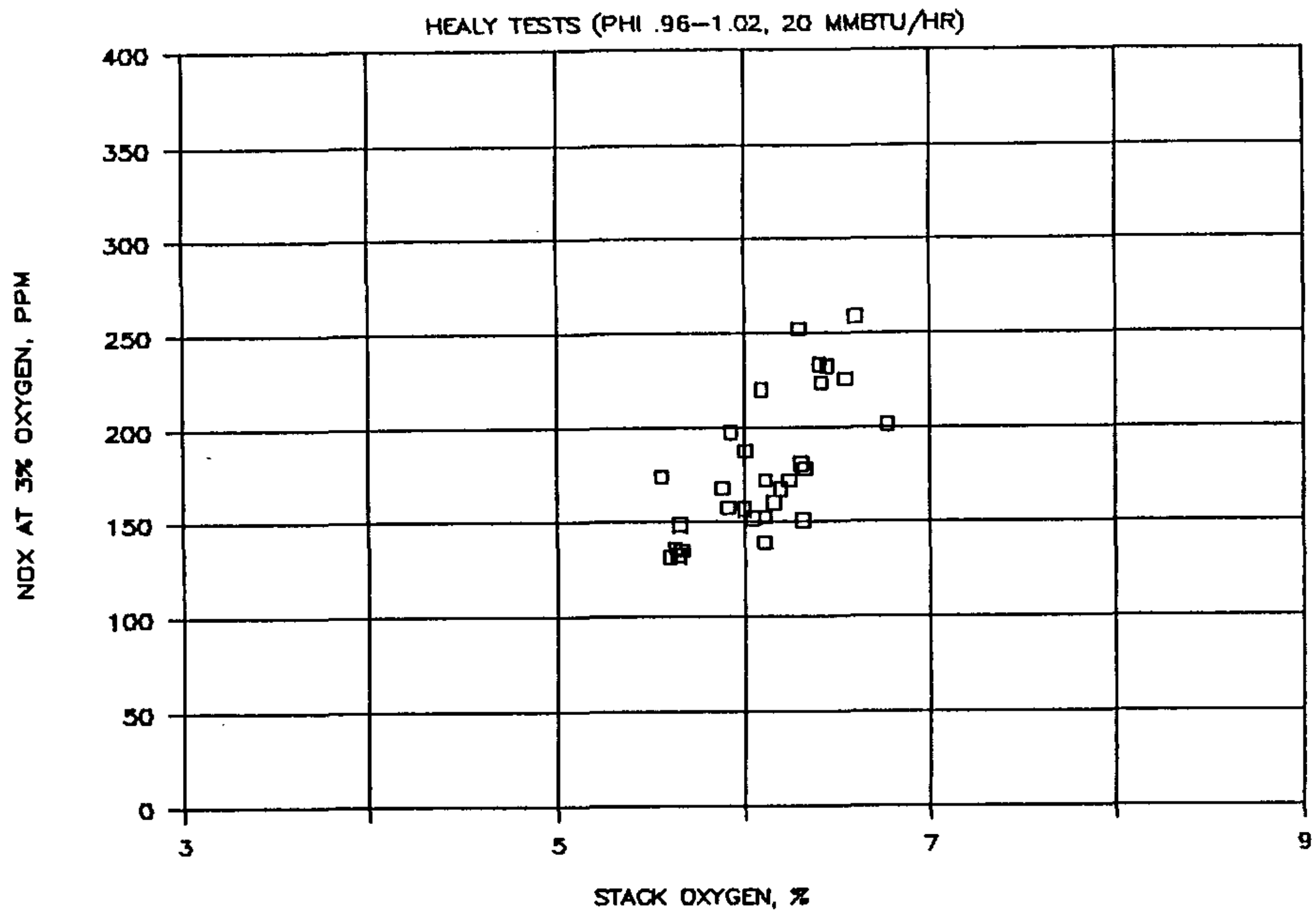

Figure 5-31. Effect of Stack Oxygen on NOx Formation

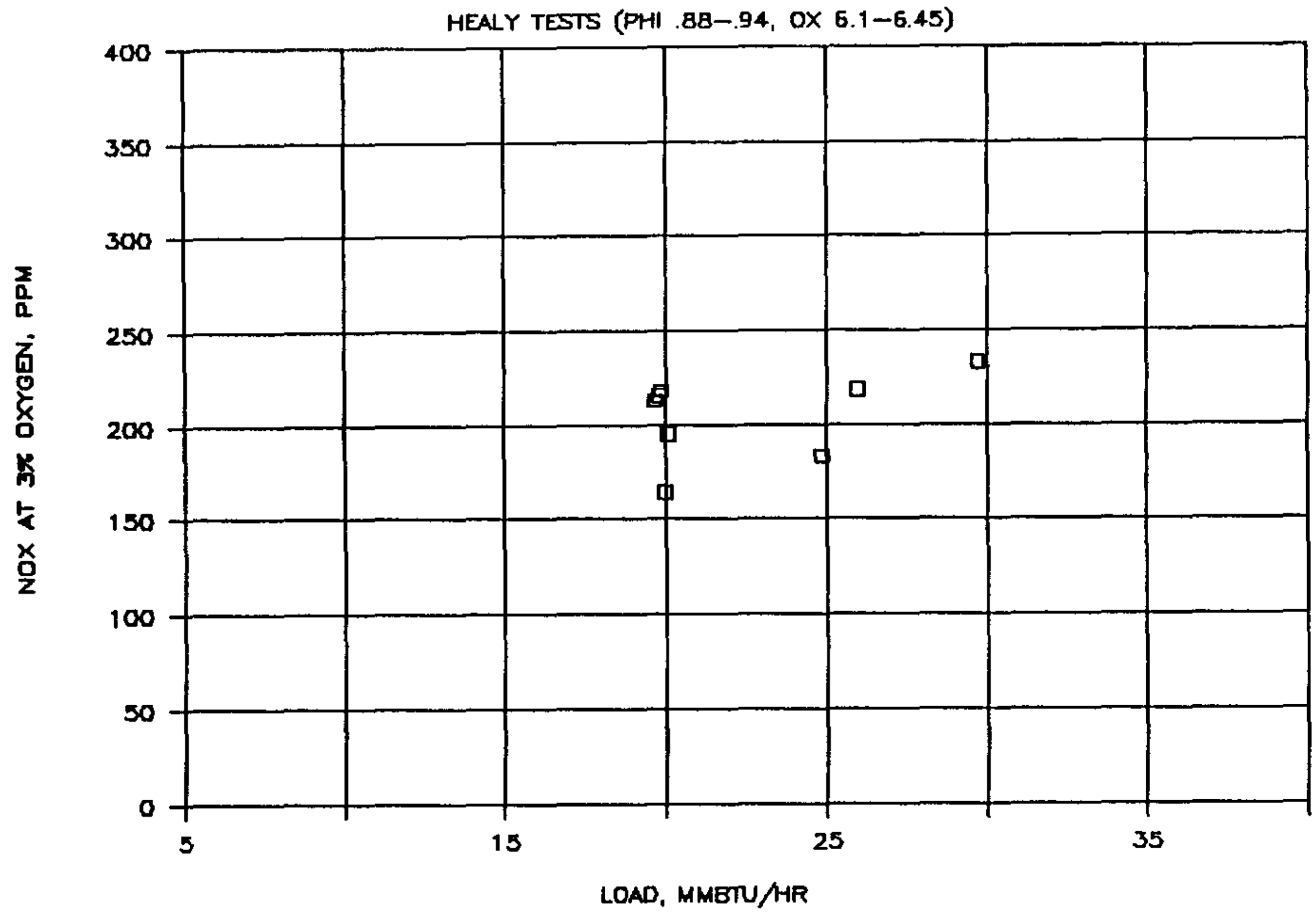

Figure 5-32. Effect of Load on NOx Formations

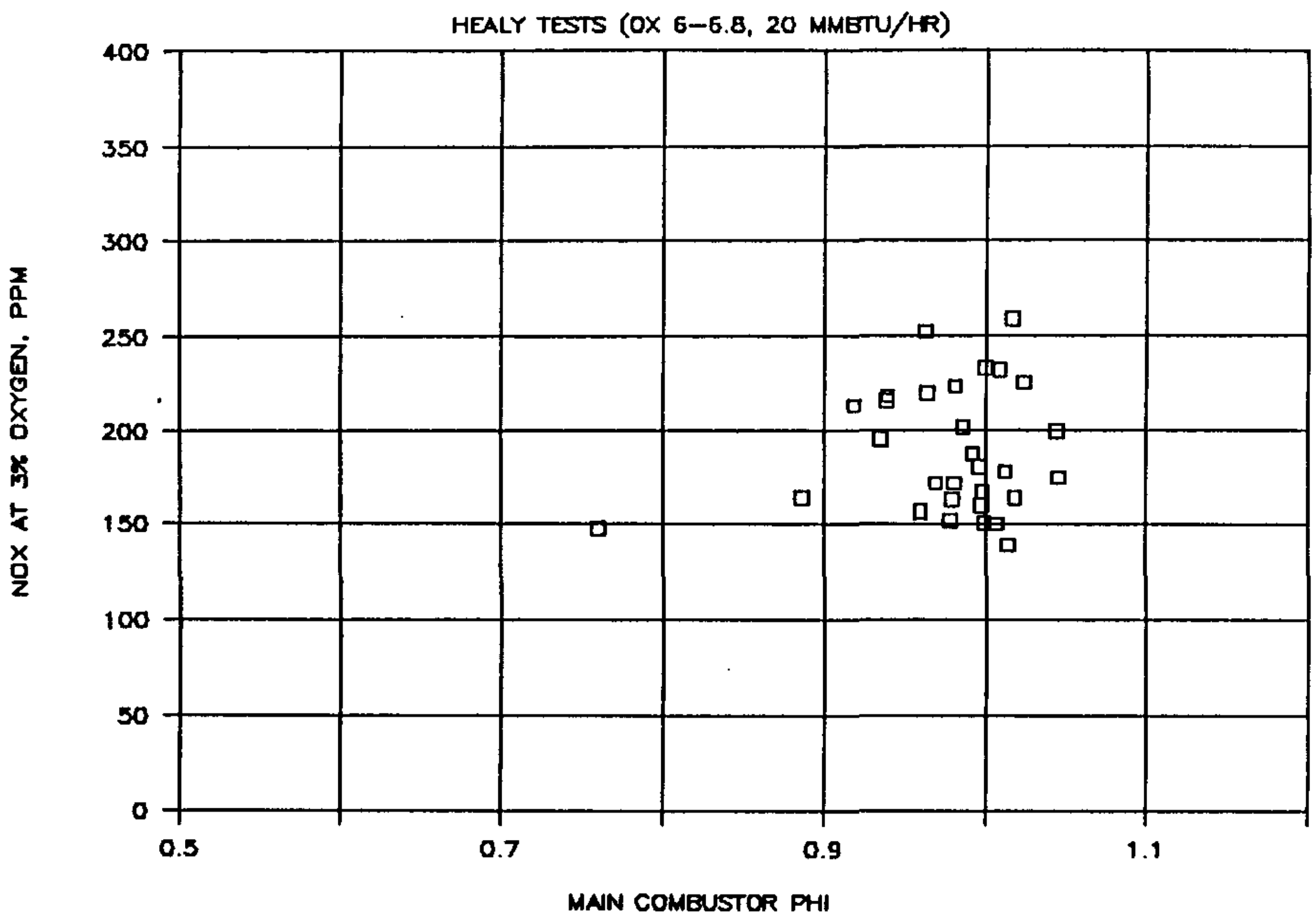

Figure 5-33. Effect of Main Combustor Equivalence Ratio on NOx Formation

Calcination

Limestone sorbent injection into the TRW coal combustion system captures sulfur dioxide from the gas and provides a flash-calcined material (FCM) for use in a back-end sulfur removal system. The level of calcination, or the percentage of calcium carbonate in the limestone which is calcined to CaO, is an important characteristic of the FCM.

The level of calcination was calculated using the following equation

$$\text{calcination} = \frac{[CaO]/56 + [CaSO4]/136}{[CaO]/56 + [CaSO4]/136 + [CaCO3]/100} * 100$$

where [CaO], [CaSO4], and [CaCO3] are the calcium oxide, calcium sulfate, and calcium carbonate weight percents, respectively, in the FCM after eliminating all contributions from the coal. Raw data from NIRO and their method of determination are presented in Appendix E.

The results are plotted in Figure 5-34 for available FCM tests with the performance coal. The level of calcination was observed to be moderate at 75% for test H22, but then decreased, reaching a plateau at a much lower value of 50% after test H25. For tests after H33, the level of calcination was observed to increase significantly to a level of 80 to 90%.

The variation in calcination trend appears to follow the limestone flowrate shown in Figure 5-35 fairly closely. The limestone flowrate was increased to counter the unexpectedly low levels of calcination previously achieved. As the limestone flow decreased as between tests H22 to H25, the calcination level also decreased. In addition, as the limestone flow increased as after test H33, the level of calcination also increased. The effect of limestone flowrate on calcination may be due to improved penetration and mixing of the limestone with the combustion gases.

Another factor which may have affected limestone mixing and calcination may be the slag buildup in the throat section of the secondary burner where the limestone is injected. Slag build up in the throat section is near the limestone stream and may influence contact and mixing with the combustion gases. This in turn lowers calcination, since calcination is dependent upon the temperatures in the combustion gases. Slag build up in the throat section is observed by an increase in the secondary burner throat pressures.

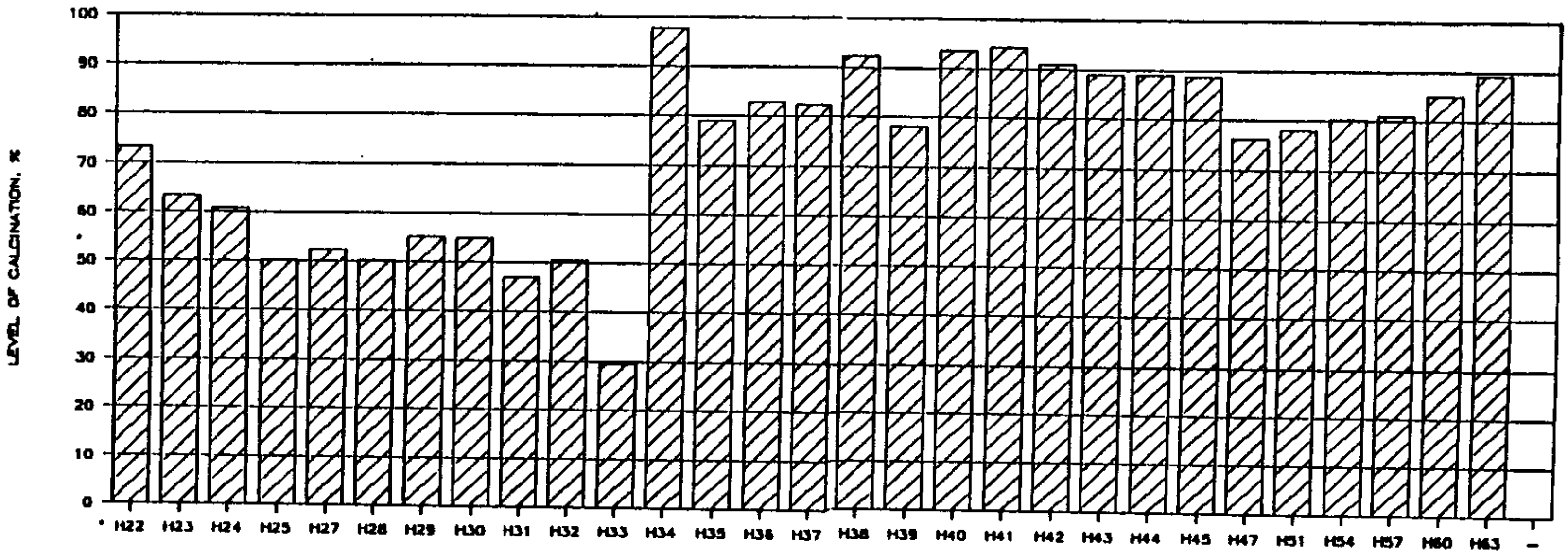

Figure 5-34. FCM Calcination Levels - Healy Performance Coal

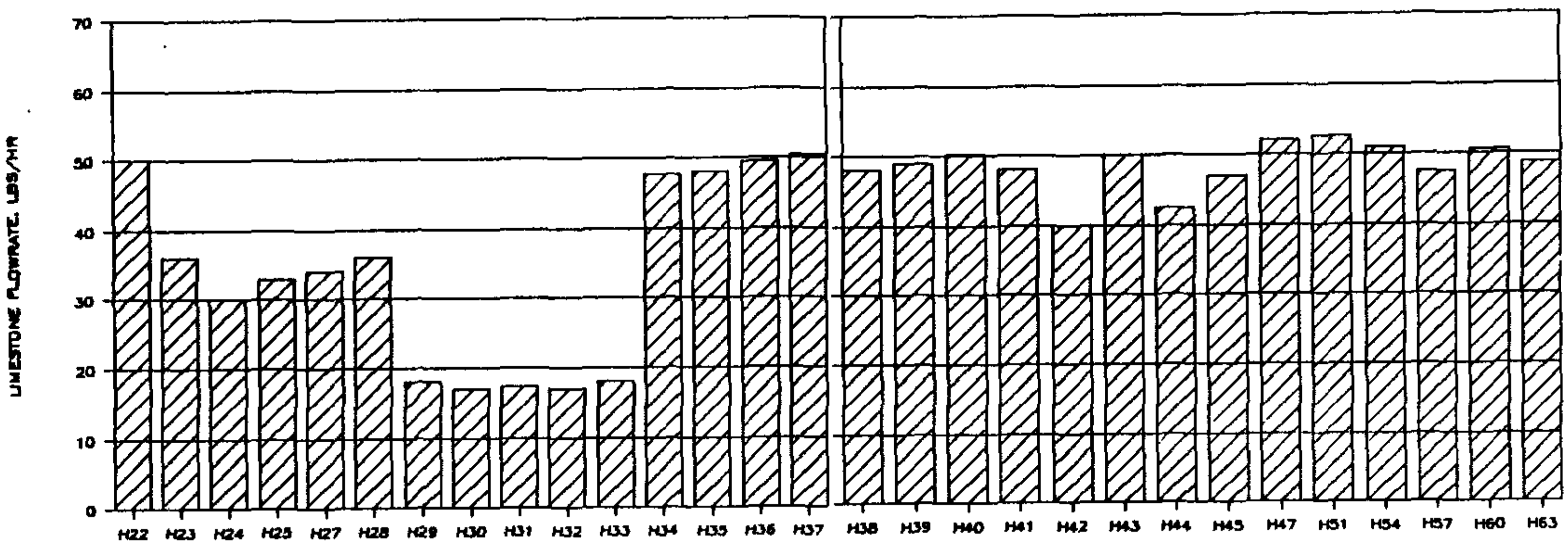

Figure 5-35. Variation in Limestone Flowrate During FCM Testing

The average secondary burner throat pressures for the FCM tests are shown in Figure 5-36. The secondary burner throat pressure for test H33 is observed to be the highest in Figure 5-36 which is consistent with the significant slag build up observed post test. Furthermore, calcination for this test was observed to be the lowest at 30%, consistent with poor contact and mixing of the limestone stream with the combustion gases.

Another possible reason for increased calcination could be due to a finer limestone size distribution. This may be true even though the limestone particle size distribution was not intentionally altered during the test series. This is because the Cantwell limestone was observed to agglomerate as seen by SEM photomicrographs shown in Figure 5-37. The Ohio (Bucyrus) limestone used in earlier Cleveland tests is our previous baseline and shows much less particle agglomeration. Thus, depending upon the level of agglomeration for the Cantwell limestone, the level of calcination may also vary.

In conclusion on calcination:

- The level of calcination was observed to be low during early Healy tests (50%), followed by much better calcination (80-90%) during later Healy tests.
- The level of calcination may be due to a combination of limestone flowrate and slag build up in the throat section of the secondary burner which in turn influences the mixing and contact of limestone with the combustion gases. Limestone agglomeration which affects the particle size distribution may also be a factor in the level of calcination obtained.

<u>SO2 Emissions and Sulfur Balance</u>

Sulfur dioxide emissions were monitored throughout each test and the measured values are given in the data tables. However, these values are suspect for the following reasons:

- Sulfur mass balances did not close (about <u>40%</u> of the input sulfur was accounted for in the output streams) while other mass balances closed reasonably well.
- SO_2 emissions measured in tests where no sorbent was injected were lower than the expected value (calculated from sulfur in the coal). Although the Healy coal ash contains calcium, because the slag recovery efficiency was high, very little calcium was available to capture sulfur in the furnace. Thus, low sulfur capture is expected without limestone addition.

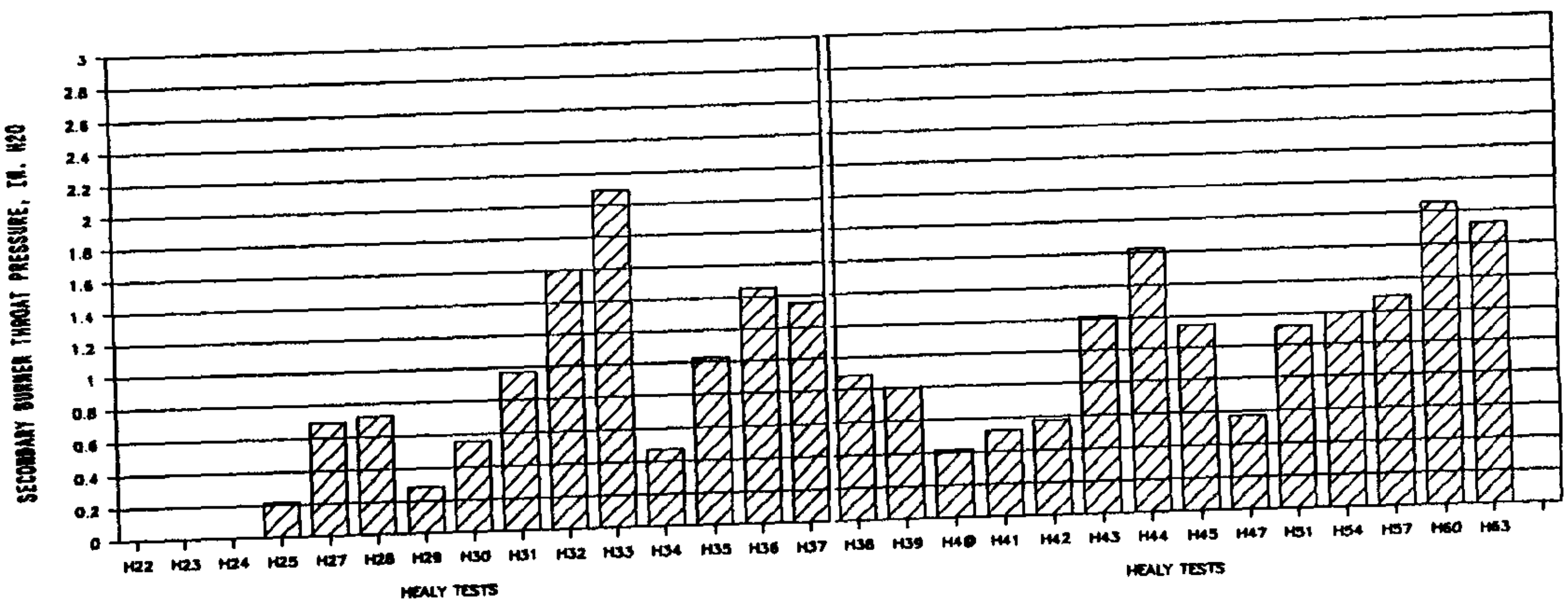

Figure 5-36. **Variation in Secondary Burner Throat Pressures During FCM Testing**

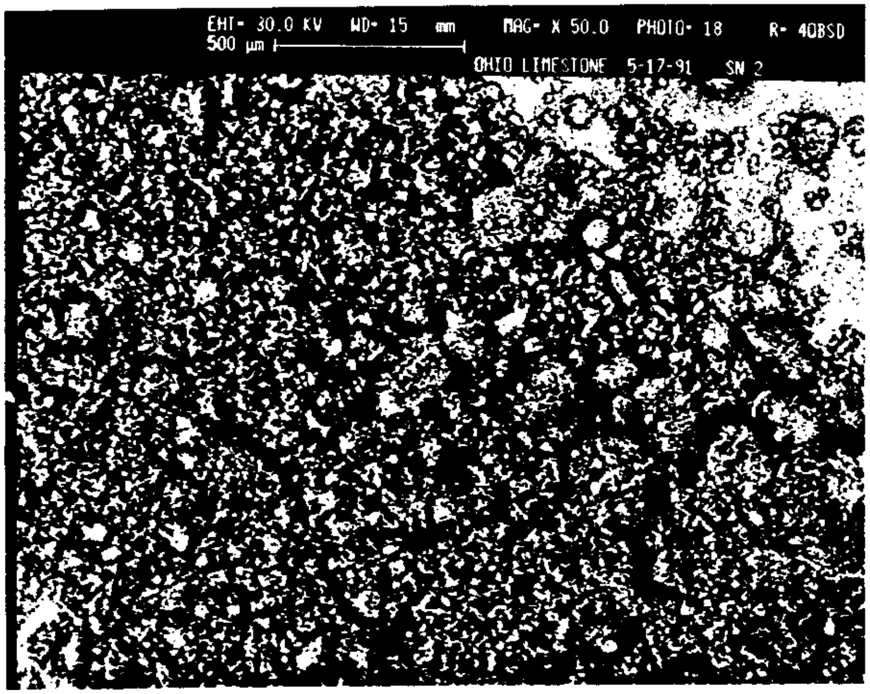

Figure 5-37. SEM Photomicrographs of Ohio Limestone and Cantwell Limestone (Mag. 50X)

- The flue gas contained more moisture than previous experience at Cleveland because the Healy coals contained 9 to 11% moisture as fed compared to 1 to 2% moisture for eastern bituminous coals. Moisture in the flue gas probably allowed a coating to build up on the in-situ probe, which scrubbed SO2 from the flue gas sample as it passed through the probe to the analyzer. NOx emissions, measured with the same analyzer, are not affected by moisture, thus the NOx readings can be expected to be accurate.

The sulfur found in solid streams in the FCM production tests account for about 15% of the input sulfur. Thus, for a Ca/S ratio of 1.6 with the Cantwell limestone, the sulfur capture was 15% using the performance coal.

Toxicity of Solid Material Leachates

For waste management purposes, coal, slag, and flyash samples from a test on the performance coal were collected for toxicity/leachability tests. The Toxicity Characteristics Leaching Procedure (TCLP) was utilized, and performed by the Commercial Testing and Engineering Company. The procedure was limited to the following metals: arsenic, barium, cadmium, chromium, lead, selenium, silver, mercury, copper, nickel, zinc, beryllium, iron, manganese, vanadium, rubidium, strontium, and zirconium. The procedure results are given in Table 5-14.

All results were found to be well below any given TCLP regulatory limit. At this time, there should be no problems with storing or disposing of the coal, slag, or flyash in a land fill.

Table 5-14. Analysis of Metals in the TCLP Leachate

	* Coal	** Slag	** Flyash	MDL	TCLP Regulatory Limit
Paste pH	6.11	9.15	N/A		
Units	MG/L	MG/L	MG/L	MG/L	MG/L
Arsenic	ND	ND	ND	0.5	5.0
Barium	ND	ND	ND	1.0	100.0
Cadmium	ND	ND	ND	0.2	1.0
Chromium	ND	ND	1.6	0.2	5.0
Lead	ND	ND	ND	2.0	5.0
Selenium	ND	ND	ND	0.5	1.0
Silver	ND	ND	ND	0.5	5.0
Mercury	ND	ND	ND	0.1	0.2
Copper	ND	ND	ND	0.5	N/A
Nickel	ND	ND	ND	0.5	N/A
Zinc	ND	ND	0.96	0.5	N/A
Beryllium	ND	ND	ND	0.2	N/A
Iron	ND	2.2	ND	0.5	N/A
Manganese	ND	ND	1.5	0.5	N/A
Vanadium	ND	ND	ND	2.0	N/A
Rubidium	ND	ND	ND	5.0	N/A
Strontium	ND	ND	ND	10.0	N/A
Zirconium	ND	ND	ND	5.0	N/A

MDL - Method Detection Limit
ND - Not Detected at a concentration greater than or equal to the MDL
N/A - Not Available
* - Coal sample taken post test H32.
** - Slag and fly ash samples taken post test H16.

6. SUMMARY OF CONCLUSIONS

- Both the performance coal and the Two Bull Ridge (TBR) coal were handled, pulverized, and fed safely and reliably in the Cleveland test facility coal preparation, feed, and transport systems.

- Light offs of the combustor (over 80 tests) were repeatable, without any indications of problems. Flame scanners were arranged so that no interferences causing a master fuel trip (MFT) occurred.

- Precombustor flame stability was marginal near full load. The precombustor was designed for a maximum coal split of 35%, not the 47% split used for these tests. The Healy precombustor will be designed to accommodate a higher coal split thereby increasing the flame stability and eliminating any need to leave the ignitor on.

- No mechanical operation problems were induced by the use of the Healy coal except for excessive wear of the main combustor pintle tip. This problem can be eliminated by use of a multi-port pintle-less injector system.

- Combustion performance was good to excellent for both coals as measured by carbon losses in the slag and flyash. The performance coal and the TBR coal had 98.9% and 98.5% carbon conversion, respectively. Indicated CO levels at the stack were near 40 ppm for the performance coal and 140 ppm for the TBR coal. This also was indicative of good combustion with a slight preference for the performance coal.

- Slag recovery for the performance coal was excellent at 85%. The slag recovery for the TBR coal was lower at 45%. Slag recovery for the performance coal was better because the slag T_{250} value (2750 F), for the performance coal was within the combustor's operating window. Slag recovery for the TBR coal was lower because the slag T_{250} was higher at 2900 F, which was outside the combustor's operating window. Higher air preheat temperatures and larger combustor size at Healy should accomodate the TBR coal.

- Low NOx emissions were demonstrated for both performance coal and TBR coal. The performance coal tests and the TBR coal tests averaged 188 ppm, and 231 ppm of NOx, respectively. The level of NOx was found to decrease with amounts of excess oxygen in the stack. Operation at excess oxygen levels below 5% was precluded by the high amounts of intrusion air present at the furnace in Cleveland.

- Cooling loads for the performance coal and the TBR coal tests averaged 10% and 7%, respectively. The slightly lower cooling loads for the TBR coal tests is primarily due to its higher T_{250} value. These loads are much lower than in previous Cleveland tests with Ohio coal, which averaged of 20-25%. Cooling loads for the Healy tests were lower than those for the Ohio tests due primarily to higher T_{250} values for the Healy coals.

- Ash accumulations were observed in the head end region of the combustor for the Healy tests. Ash accumulations in the combustor at Healy are not anticipated because of higher air preheat temperatures and larger size. It must also be recognized that operating loads at Cleveland were only 50% of full load. Higher loads will also alleviate the ash accumulation problem.

- The slag tap remained open for all tests except during the transition from performance coal to TBR coal.

- There were also some slag accumulations in the secondary burner throat probably related to the need to continuously operate at reduced load. This is consistent with TRW's prediction for the window of operability for the Cleveland test set up.

- Furnace ash accumulation did not appear significant throughout the performance coal test phase. They increased significantly during the TBR test phase. This is believed to be due to the inability to trap the larger ash particles as slag because of the higher T_{250} of the TBR coal.

- Furnace temperatures were found to vary as expected, depending upon load and location in the furnace. For the exit of the furnace, gas temperatures ranged from 1900 F to 2180 F at loads from 24.9 MMBtu/hr to 30.6 MMBtu/hr.

- Calcination levels in the baghouse catch were found to be low for early Healy tests (50-60%) followed by much better calcination (80-90%) during later Healy performance coal tests. The increase in calcination level was found to correspond to an increase in limestone flowrate. To a lesser degree, slag buildup in the secondary burner throat may also have been a factor. Limestone agglomeration may also be another factor in determining the level of calcination.

- Useage of high moisture content Healy coals, dried to 10-11% moisture, presented little operational problems during the test series. Further testing would be required, however, to determine whether the Healy combustor could utilize even higher moisture content Healy coals.

Appendices

APPENDIX A. SOLID SAMPLE ANALYSES PER TEST

Table A1. HEALY PERFORMANCE COAL ANALYSES

	HEALY PERFORMANCE COAL TESTS: COAL ANALYSES (AS FIRED)									
Test No.	309-H13-1	400-H13-2	401-H14	402-H14-1	406-H16	407-H17	408-H18	503-H23	510-H30	523-H34
Sample No.	1212-16B	1116-16B	1217-16B	1234-16B	1238-16B	1244-16B	1243-16B	1253-16B	1280-16B	1272-16B
PROXIMATE										
% Moisture	9.07	11.11	10.39	12.42	9.97	11.84	12.34	9.57	11.18	11.85
% Ash	22.22	22.22	20.14	17.22	18.14	21.45	21.16	26.30	19.32	22.37
% Volatile	39.02	38.20	39.61	40.18	40.28	38.72	38.29	37.18	39.59	38.89
% Fixed Carbon	29.69	28.47	29.86	30.18	31.61	27.99	28.21	26.95	29.91	26.89
Btu/lb	7950	7780	8157	8300	8337	7885	7782	7557	8183	7757
ULTIMATE										
% Moisture	9.07	11.11	10.39	12.42	9.97	11.84	12.34	9.57	11.18	11.85
% Carbon	48.23	46.71	48.37	48.86	49.39	46.61	46.21	44.64	48.36	46.04
% Hydrogen	3.62	3.53	3.72	3.73	3.86	3.51	3.56	3.40	3.69	3.41
% Nitrogen	0.73	0.75	0.76	0.74	0.76	0.75	0.73	0.68	0.76	0.77
% Sulfur	0.32	0.34	0.28	0.46	0.31	0.26	0.32	0.24	0.39	0.33
% Ash	22.22	22.22	20.14	17.22	18.14	21.45	21.16	26.30	19.32	22.37
% Oxygen	15.81	15.34	16.34	16.57	17.57	15.58	15.68	15.17	16.30	15.23
ASH ANALYSIS										
% SiO2	65.17	61.41	61.22	55.92	62.18	60.93	62.41	69.39	59.84	61.12
% Al2O3	12.74	14.92	14.62	16.31	14.02	15.39	15.26	11.49	14.93	15.11
% TiO2	0.55	0.63	0.67	0.76	0.68	0.71	0.69	0.55	0.80	0.66
% Fe2O3	4.92	4.38	4.56	5.09	4.52	4.50	4.42	3.93	4.52	4.46
% CaO	8.85	8.73	9.78	11.41	10.27	9.04	9.18	7.16	10.36	9.13
% MgO	1.60	1.69	1.74	1.99	1.76	1.80	1.74	1.39	1.78	1.77
% K2O	1.67	1.82	1.74	1.70	1.77	1.91	1.86	1.73	1.71	1.81
% Na2O	0.77	0.77	0.75	0.69	0.71	0.77	0.81	0.83	0.75	0.69
% SO3	2.57	3.19	3.17	3.27	2.81	2.74	2.67	1.86	2.74	3.53
% P4O5	0.16	0.17	0.16	0.17	0.16	0.16	0.16	0.14	0.16	0.17
% SrO	0.10	0.09	0.10	0.12	0.11	0.10	0.10	0.08	0.12	0.09
% BaO	0.32	0.30	0.19	0.18	0.06	0.19	0.17	0.11	0.00	0.30
% MnO	0.16	0.15	0.16	0.17	0.16	0.16	0.16	0.16	0.16	0.17
Undetermined	0.42	1.75	1.14	2.22	0.79	1.60	0.37	1.18	2.13	0.99
T 250	2744	2749	2683	2581	2667	2714	2732	2900	2652	2722

Table A1. **HEALY PERFORMANCE COAL ANALYSES**

		HEALY PERFORMANCE COAL TESTS: COAL ANALYSES (MOISTURE FREE BASIS)								
Test No.	309-H13-1	400-H13-2	401-H14	402-H14-1	406-H16	407-H17	408-H18	503-H23	510-H30	523-H34
Sample No.	1212-16B	1116-16B	1217-16B	1234-16B	1238-16B	1244-16B	1243-16B	1253-16B	1280-16B	1272-16B
Wt. %										
PROXIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Ash	24.44	25.00	22.48	19.66	20.15	24.33	24.14	29.08	21.75	25.38
% Volatile	42.91	42.97	44.20	47.02	44.74	43.92	43.68	41.11	44.57	44.12
% Fixed Carbon	32.65	32.03	33.32	34.46	35.11	31.75	32.18	29.80	33.67	30.50
Btu/lb	8743	8752	9103	9477	9260	8944	8877	8357	9213	8800
ULTIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Carbon	53.04	52.55	53.98	55.79	54.86	52.87	52.72	49.36	54.45	52.23
% Hydrogen	3.98	3.97	4.15	4.26	4.29	3.98	4.06	3.76	4.15	3.87
% Nitrogen	0.80	0.84	0.85	0.84	0.84	0.85	0.83	0.75	0.86	0.87
% Sulfur	0.35	0.38	0.31	0.53	0.34	0.29	0.37	0.27	0.44	0.37
% Ash	24.44	25.00	22.48	19.66	20.15	24.33	24.14	29.08	21.75	25.38
% Oxygen	17.39	17.26	18.23	18.92	19.52	17.67	17.89	16.78	18.35	17.28

Table A1. HEALY PERFORMANCE COAL ANALYSES

	HEALY PERFORMANCE COAL TESTS: COAL ANALYSES (AS FIRED)									FCM Tests	All Healy
Test No.	525-H36	529-H40	530-H41	534-H45	537-H48	541-H52	545-H56	548-H59	552-H63	H20-H63	Perf.
Sample No.	1296-16B	1306-16B	1309-16B	1321-16B	1337-16B	1358-16B	1365-16B	1370-16B	1383-16B	Average	Average
PROXIMATE											
% Moisture	11.62	11.24	10.58	11.33	11.54	10.85	11.84	12.19	7.99	10.98	11.00
% Ash	20.60	18.23	21.76	20.39	21.19	21.65	16.38	21.33	19.83	20.78	20.63
% Volatile	39.59	40.03	37.31	39.76	38.61	39.03	40.53	39.36	41.47	39.28	39.24
% Fixed Carbon	28.19	30.50	30.35	28.52	28.66	28.47	31.25	27.12	30.71	28.96	29.13
Btu/lb	8004	8258	8109	8148	7903	8022	8503	7738	8576	8063	8047
ULTIMATE											
% Moisture	11.62	11.24	10.58	11.33	11.54	10.85	11.84	12.19	7.99	10.98	11.00
% Carbon	47.60	49.93	48.10	48.16	46.86	47.01	50.38	46.66	50.30	47.84	47.81
% Hydrogen	3.57	3.69	3.51	3.61	3.58	3.57	3.85	3.56	3.89	3.61	3.62
% Nitrogen	0.84	0.83	0.82	0.77	0.75	0.88	0.79	0.76	0.78	0.79	0.77
% Sulfur	0.34	0.36	0.38	0.34	0.33	0.31	0.30	0.32	0.29	0.33	0.33
% Ash	20.60	18.23	21.76	20.39	21.19	21.65	16.38	21.33	19.83	20.78	20.61
% Oxygen	15.43	15.72	14.85	15.40	15.75	15.73	16.46	15.18	16.92	15.68	15.86
ASH ANALYSIS											
% SiO2	60.93	58.81	62.14	60.91	63.09	62.97	58.80	61.49	66.48	62.16	61.62
% Al2O3	14.64	15.17	14.89	14.25	14.56	14.98	14.55	15.35	10.98	14.24	14.46
% TiO2	0.62	0.63	0.63	0.62	0.60	0.61	0.62	0.63	0.46	0.62	0.64
% Fe2O3	4.54	4.76	4.37	4.46	4.22	4.31	5.14	4.46	4.23	4.45	4.53
% CaO	10.09	11.06	8.63	11.44	9.23	9.27	12.01	10.05	10.22	9.89	9.92
% MgO	1.82	1.90	1.63	1.72	1.67	1.68	2.01	1.85	1.53	1.73	1.78
% K2O	1.73	1.68	1.82	1.70	1.79	1.78	1.52	1.82	1.48	1.71	1.74
% Na2O	0.68	0.64	0.70	0.67	0.73	0.69	0.57	0.69	0.56	0.68	0.70
% SO3	4.21	4.58	4.41	3.56	3.36	2.89	3.96	2.84	3.40	3.45	3.31
% P4O5	0.17	0.18	0.17	0.16	0.18	0.21	0.19	0.18	0.15	0.17	0.17
% SrO	0.10	0.11	0.10	0.11	0.10	0.10	0.12	0.10	0.01	0.10	0.10
% BaO	0.31	0.31	0.35	0.23	0.31	0.35	0.34	0.37	0.23	0.27	0.23
% MnO	0.16	0.17	0.16	0.17	0.16	0.16	0.17	0.17	0.17	0.17	0.16
Undetermined	0.00	0.00	0	0.00	0.00	0.00	0.00	0.00	0.10	0.37	0.64
T 250	2668	2614	2773	2624	2751	2750	2582	2679	2725	2703	2692

Table A1. HEALY PERFORMANCE COAL ANALYSES

	HEALY PERFORMANCE COAL TESTS: COAL ANALYSES (MOISTURE FREE BASIS)									FCM Tests	All Healy
Test No.	525-H36	529-H40	530-H41	534-H45	537-H48	541-H52	545-H56	548-H59	552-H63	H20-H63	Perf.
Sample No.	1296-16B	1306-16B	1309-16B	1321-16B	1337-16B	1358-16B	1365-16B	1370-16B	1383-16B	Average	Average
Wt. %											
PROXIMATE											
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Ash	23.31	20.54	24.33	23.00	23.95	24.28	18.58	24.29	21.55	23.34	23.15
% Volatile	44.80	45.10	41.72	44.84	43.65	43.78	45.97	44.82	45.07	44.13	44.43
% Fixed Carbon	31.90	34.36	33.94	32.16	32.40	31.93	35.45	30.88	33.38	32.53	32.48
Btu/lb	9056	9304	9068	9189	8934	8998	9645	8812	9321	9058	9042
ULTIMATE											
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Carbon	53.86	56.25	53.79	54.31	52.97	52.73	57.15	53.14	54.67	53.74	53.73
% Hydrogen	4.04	4.16	3.93	4.07	4.05	4.00	4.37	4.05	4.23	4.06	4.07
% Nitrogen	0.95	0.94	0.92	0.87	0.85	0.99	0.90	0.87	0.85	0.88	0.87
% Sulfur	0.38	0.41	0.42	0.38	0.37	0.35	0.34	0.36	0.32	0.37	0.37
% Ash	23.31	20.54	24.33	23.00	23.95	24.28	18.58	24.29	21.55	23.34	23.15
% Oxygen	17.46	17.71	16.61	17.37	17.80	17.64	18.67	17.29	18.39	17.61	17.82

Table A2. **HEALY TWO BULL RIDGE COAL TESTS: Coal Analyses**

		HEALY TWO BULL RIDGE COAL TESTS: COAL ANALYSES (AS FIRED)								All Healy
Test No.	555-TBR3	556-TBR4	557-TBR5	559-TBR7	560-TBR8	562-TBR10	563-TBR11	564-TBR12	TBR Coal	Perf.
Sample No.	1391-16B	1396-16B	1399-16B	1405-16B	1408-16B	1414-16B	1417-16B	1419-16B	AVERAGE	Average
PROXIMATE										
% Moisture	10.68	9.39	9.06	9.39	10.39	10.14	9.94	9.53	9.82	11.00
% Ash	29.03	28.35	26.83	27.14	26.82	27.55	26.66	26.15	27.32	20.61
% Volatile	37.17	38.05	38.82	38.21	37.86	37.47	38.94	39.05	38.20	39.53
% Fixed Carbon	23.12	24.21	25.29	25.26	24.93	24.84	24.46	25.27	24.67	28.91
Btu/lb	7059	7204	7498	7416	7381	7293	7447	7566	7358	8047
ULTIMATE										
% Moisture	10.68	9.39	9.06	9.39	10.39	10.14	9.94	9.53	9.82	11.00
% Carbon	41.62	43.01	44.26	43.96	43.83	42.89	43.99	44.47	43.50	47.81
% Hydrogen	3.23	3.40	3.51	3.43	3.42	3.35	3.48	3.48	3.41	3.62
% Nitrogen	0.74	0.76	0.76	0.78	0.79	0.79	0.75	0.74	0.76	0.77
% Sulfur	0.35	0.36	0.36	0.37	0.36	0.36	0.36	0.37	0.36	0.33
% Ash	29.03	28.35	26.83	27.14	26.82	27.55	26.66	26.15	27.32	20.61
% Oxygen	14.35	14.73	15.22	14.93	14.39	14.92	14.82	15.26	14.83	15.86
ASH ANALYSIS										
% SiO2	58.41	58.05	57.93	58.45	58.23	58.49	57.33	57.54	58.05	61.62
% Al2O3	22.19	20.94	21.89	21.72	21.89	21.66	21.98	21.37	21.71	14.46
% TiO2	0.99	0.96	0.92	0.92	0.96	0.95	0.99	0.94	0.95	0.64
% Fe2O3	3.59	3.63	3.83	3.81	3.62	4.03	3.75	3.97	3.78	4.53
% CaO	5.77	5.89	6.40	6.32	6.40	6.44	6.39	6.62	6.28	9.92
% MgO	1.53	1.48	1.59	1.55	1.62	1.98	1.58	1.61	1.62	1.78
% K2O	2.02	1.96	1.93	1.93	2.01	1.90	1.95	1.94	1.96	1.74
% Na2O	0.08	0.12	0.13	0.15	0.15	0.27	0.08	0.13	0.14	0.70
% SO3	2.25	3.46	4.04	2.99	3.30	2.83	2.80	3.60	3.16	3.31
% P4O5	0.14	0.14	0.18	0.21	0.15	0.16	0.02	0.14	0.14	0.17
% SrO	0.06	0.07	0.07	0.08	0.06	0.06	0.07	0.07	0.07	0.10
% BaO	0.26	0.19	0.33	0.32	0.27	0.30	0.24	0.26	0.27	0.23
% MnO	0.15	0.15	0.15	0.14	0.15	0.15	0.15	0.15	0.15	0.16
Undetermined	2.56	2.96	0.61	1.41	1.19	0.78	2.67	1.66	1.73	0.64
T 250	2900	2900	2873	2888	2882	2842	2871	2848	2876	2692

Table A2. HEALY TWO BULL RIDGE COAL TESTS: Coal Analyses

		HEALY TWO BULL RIDGE COAL TESTS: (MOISTURE FREE BASIS)								All Healy
Test No.	555-TBR3	556-TBR4	557-TBR5	559-TBR7	560-TBR8	562-TBR10	563-TBR11	564-TBR12	TBR Coal	Perf.
Sample No.	1391-16B	1396-16B	1399-16B	1405-16B	1408-16B	1414-16B	1417-16B	1419-16B	AVERAGE	Average
Wt. %										
PROXIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Ash	32.50	31.29	29.50	29.95	29.93	30.66	29.60	28.90	30.29	23.15
% Volatile	41.61	41.99	42.69	42.17	42.25	41.70	43.24	43.16	42.35	44.43
% Fixed Carbon	25.88	26.72	27.81	27.88	27.82	27.64	27.16	27.93	27.36	32.48
Btu/lb	7903	7951	8245	8185	8237	8116	8269	8363	8158	9042
ULTIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Carbon	46.60	47.47	48.67	48.52	48.91	47.73	48.85	49.15	48.24	53.73
% Hydrogen	3.62	3.75	3.86	3.79	3.82	3.73	3.86	3.85	3.78	4.07
% Nitrogen	0.83	0.84	0.84	3.79	0.88	0.88	0.83	0.82	1.21	0.87
% Sulfur	0.39	0.40	0.40	0.86	0.40	0.40	0.40	0.41	0.46	0.37
% Ash	32.50	31.29	29.50	0.41	29.93	30.66	29.60	28.90	26.60	23.15
% Oxygen	16.07	16.26	16.74	29.95	16.06	16.60	16.46	16.87	18.12	17.82

Table A3. HEALY PERFORMANCE COAL: SLAG ANALYSES

		HEALY PERFORMANCE COAL TESTS: SLAG ANALYSES (AS FIRED)								
Test No.	309-H13-1	400-H13-2	401-H14	402-H14-1	406-H16	407-H17	408-H18	503-H23	510-H30	523-H34
Sample No.	1211-16B	1232-16B	1230-16B	1235-16B	1240-16B	1241-16B	1246-16B	1251-16B	1281-16B	1273-16B
Wt. %										
PROXIMATE										
% Moisture	15.53	13.78	13.53	15.70	15.35	17.20	12.34	17.31	12.14	19.96
% Ash	84.01	84.59	85.28	82.61	83.74	81.94	86.81	81.47	87.20	78.17
% Volatile	0.37	0.51	0.42	0.61	0.39	0.55	0.35	0.49	0.36	0.69
% Fixed Carbon	0.09	1.12	0.77	1.08	0.52	0.31	0.50	0.73	0.30	1.18
Btu/lb	0	99	99	99	99	99	99	99	99	233
ULTIMATE										
% Moisture	15.53	13.78	13.53	15.70	15.35	17.20	12.34	17.31	12.14	19.96
% Carbon	0.69	1.22	0.84	1.23	0.62	0.68	0.64	1.00	0.50	1.65
% Hydrogen	0.02	0.07	0.03	0.03	0.01	0.01	0.02	0.00	0.01	0.04
% Nitrogen	0.13	0.22	0.23	0.32	0.19	0.12	0.11	0.12	0.10	0.08
% Sulfur	0.13	0.11	0.09	0.10	0.08	0.04	0.07	0.09	0.04	0.10
% Ash	84.01	84.59	85.28	82.61	83.74	81.94	86.81	81.47	87.20	78.17
% Oxygen	-0.51	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00
ASH ANALYSIS										
% SiO2	67.65	66.58	67.61	65.95	69.22	68.65	65.09	67.19	64.47	68.17
% Al2O3	13.53	14.27	13.77	12.61	13.56	13.84	14.50	12.96	14.28	14.18
% TiO2	0.57	0.63	0.59	1.55	0.59	0.60	0.64	0.56	0.68	0.61
% Fe2O3	4.94	5.10	4.71	5.30	4.51	4.19	4.98	4.40	4.77	3.99
% CaO	8.33	8.25	7.87	7.27	7.20	7.36	7.90	8.00	8.92	8.07
% MgO	1.59	1.60	1.53	1.43	1.43	1.53	1.55	1.50	1.67	1.71
% K2O	1.77	1.80	1.82	1.59	1.82	1.84	0.79	1.73	1.72	1.75
% Na2O	0.93	0.85	0.88	0.90	0.89	0.95	0.77	0.85	0.74	0.79
% SO3	0.03	0.09	0.04	1.15	0.12	0.12	0.09	0.03	0.03	0.15
% P4O5	0.16	0.16	0.15	0.14	0.14	0.17	0.15	0.15	0.14	0.19
% SrO	0.09	0.09	0.09	0.12	0.09	0.09	0.09	0.09	0.10	0.09
% BaO	0.25	0.26	0.30	0.27	0.28	0.27	0.28	0.27	0.11	0.14
% MnO	0.16	0.15	0.16	0.15	0.15	0.15	0.16	0.16	0.16	0.16
Undetermined	0.00	0.17	0.48	1.57	0.00	0.24	2.01	2.11	2.21	0.00
T 250	2805	2789	2860	2855	2900	2900	2821	2865	2756	2900

Table A3. **HEALY PERFORMANCE COAL: SLAG ANALYSES**

		HEALY PERFORMANCE COAL TESTS: SLAG ANALYSES (MOISTURE FREE BASIS)								
Test No.	309-H13-1	400-H13-2	401-H14	402-H14-1	406-H16	407-H17	408-H18	503-H23	510-H30	523-H34
Sample No.	1211-16B	1232-16B	1230-16B	1235-16B	1240-16B	1241-16B	1246-16B	1251-16B	1281-16B	1273-16B
Wt. %										
PROXIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Ash	99.46	98.11	98.62	98.00	98.92	98.96	99.03	98.52	99.25	97.66
% Volatile	0.44	0.59	0.49	0.72	0.46	0.66	0.40	0.59	0.41	0.86
% Fixed Carbon	0.11	1.30	0.89	1.28	0.61	0.37	0.57	0.88	0.34	1.47
Btu/lb	0	115	114	117	117	120	113	120	113	291
ULTIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Carbon	0.82	1.41	0.97	1.46	0.73	0.82	0.73	1.21	0.57	2.06
% Hydrogen	0.02	0.08	0.03	0.04	0.01	0.01	0.02	0.00	0.01	0.05
% Nitrogen	0.15	0.26	0.27	0.38	0.22	0.14	0.13	0.15	0.11	0.10
% Sulfur	0.15	0.13	0.10	0.12	0.09	0.05	0.08	0.11	0.05	0.12
% Ash	99.46	98.11	98.62	98.00	98.92	98.96	99.03	98.52	99.25	97.66
% Oxygen	-0.60	0.01	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01

Table A3. HEALY PERFORMANCE COAL: SLAG ANALYSES

	HEALY PERFORMANCE COAL TESTS: SLAG ANALYSES (AS FIRED)									FCM Tests	All Healy
Test No.	525-H36	529-H40	530-H41	534-H45	537-H48	541-H52	545-H56	548-H59	552-H63	H20-H63	Perf.
Sample No.	1297-16B	1308-16B	1310-16B	1332-16B	1338-16B	1350-16B	1360-16B	1371-16B	1384-16B	Average	Average
Wt. %											
PROXIMATE											
% Moisture	19.54	13.07	21.95	11.71	13.72	13.35	8.08	14.49	17.71	15.25	14.81
% Ash	76.77	84.85	71.77	85.97	85.02	84.71	90.78	82.61	76.78	82.18	83.29
% Volatile	1.97	1.36	1.69	1.05	0.67	0.66	0.45	1.23	2.06	1.06	0.77
% Fixed Carbon	1.72	0.72	4.59	1.27	0.59	1.28	0.69	1.67	3.45	1.52	1.13
Btu/lb	305	269	756	270	209	212	133	340	715	303	200
ULTIMATE											
% Moisture	19.54	13.07	21.95	11.71	13.72	13.35	8.08	14.49	17.71	15.25	14.81
% Carbon	3.23	1.84	5.92	1.76	1.04	1.73	0.83	2.55	5.25	2.28	1.54
% Hydrogen	0.06	0.03	0.05	0.03	0.03	0.03	0.03	0.00	0.07	0.03	0.03
% Nitrogen	0.10	0.12	0.20	0.12	0.12	0.11	0.14	0.15	0.14	0.13	0.14
% Sulfur	0.10	0.08	0.11	0.41	0.06	0.06	0.06	0.10	0.05	0.11	0.18
% Ash	76.77	84.85	71.77	85.97	85.02	84.71	90.78	82.61	76.78	82.18	83.29
% Oxygen	0.20	0.01	0.00	0.00	0.01	0.01	0.08	0.10	0.00	0.04	0.00
ASH ANALYSIS											
% SiO2	68.59	66.77	67.56	66.67	66.59	67.29	63.95	64.76	63.93	66.33	66.70
% Al2O3	13.66	14.35	13.82	13.84	14.24	14.15	14.35	14.56	14.64	14.09	13.92
% TiO2	0.62	0.73	0.57	0.60	0.61	0.61	0.62	0.62	0.62	0.62	0.65
% Fe2O3	4.34	4.14	4.46	4.22	4.21	4.04	4.74	4.37	4.59	4.36	4.49
% CaO	7.92	9.39	8.59	9.65	9.37	9.03	11.13	10.23	11.11	9.28	8.85
% MgO	1.58	1.68	1.64	1.73	1.66	1.63	1.90	1.83	1.87	1.70	1.66
% K2O	1.80	1.72	1.69	1.70	1.76	1.75	1.59	1.63	1.61	1.70	1.68
% Na2O	0.83	0.77	0.77	0.75	0.78	0.79	0.73	0.82	0.66	0.77	0.80
% SO3	0.14	0.03	0.17	0.07	0.03	0.03	0.20	0.42	0.22	0.13	0.14
% P4O5	0.15	0.15	0.18	0.20	0.17	0.16	0.19	0.17	0.17	0.17	0.16
% SrO	0.08	0.10	0.09	0.10	0.10	0.10	0.11	0.11	0.11	0.10	0.10
% BaO	0.13	0.00	0.29	0.30	0.32	0.27	0.32	0.31	0.30	0.23	0.24
% MnO	0.16	0.17	0.17	0.17	0.16	0.15	0.17	0.17	0.17	0.16	0.16
Undetermined	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.36	0.39
T 250	2900	2798	2835	2766	2785	2830	2648	2706	2659	2787	2802

Table A3. **HEALY PERFORMANCE COAL: SLAG ANALYSES**

	HEALY PERFORMANCE COAL TESTS: SLAG ANALYSES (MOISTURE FREE BASIS)									FCM Tests	All Healy
Test No.	525-H36	529-H40	530-H41	534-H45	537-H48	541-H52	545-H56	548-H59	552-H63	H20-H63	Perf.
Sample No.	1297-16B	1308-16B	1310-16B	1332-16B	1338-16B	1350-16B	1360-16B	1371-16B	1384-16B	Average	Average
Wt. %											
PROXIMATE											
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Ash	95.41	97.61	91.95	97.37	98.54	97.76	98.76	96.61	93.30	96.90	97.73
% Volatile	2.45	1.56	2.17	1.19	0.78	0.76	0.49	1.44	2.50	1.27	0.92
% Fixed Carbon	2.14	0.83	5.88	1.44	0.68	1.48	0.75	1.95	4.19	1.84	1.35
Btu/lb	379	309	969	306	242	245	145	398	869	365	240
ULTIMATE											
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Carbon	4.01	2.12	7.58	1.99	1.21	2.00	0.90	2.98	6.38	2.75	1.85
% Hydrogen	0.07	0.03	0.06	0.03	0.03	0.03	0.03	0.00	0.09	0.04	0.03
% Nitrogen	0.12	0.14	0.26	0.14	0.14	0.13	0.15	0.18	0.17	0.15	0.16
% Sulfur	0.12	0.09	0.14	0.46	0.07	0.07	0.07	0.12	0.06	0.12	0.21
% Ash	95.41	97.61	91.95	97.37	98.54	97.76	98.76	96.61	93.30	96.90	97.73
% Oxygen	0.25	0.01	0.00	0.00	0.01	0.01	0.09	0.12	0.00	0.04	0.00

Table A4. **HEALY TWO BULL RIDGE COAL TESTS: Slag Analyses**

	HEALY TWO BULL RIDGE COAL TESTS: SLAG ANALYSES (AS FIRED)									All Healy
Test No.	555-TBR3	556-TBR4	557-TBR5	559-TBR7	560-TBR8	562-TBR10	563-TBR11	564-TBR12	TBR Coal	Perf.
Sample No.	1393-16B	1397-16B	1400-16B	1406-16B	1409-16B	1415-16B	1411-16B	1420-16B	AVERAGE	Average
Wt. %										
PROXIMATE										
% Moisture	15.85	46.61	23.68	38.31	31.00	56.34	50.75	30.99	36.69	14.81
% Ash	83.27	51.13	71.58	59.71	63.96	38.57	45.75	68.10	60.26	83.29
% Volatile	0.63	0.88	1.44	0.73	0.68	1.00	0.98	0.20	0.82	0.77
% Fixed Carbon	0.25	1.38	3.30	1.25	4.36	4.09	2.52	0.71	2.23	1.13
Btu/lb	92	282	582	225	455	680	457	150	365.38	200
ULTIMATE										
% Moisture	15.85	46.61	23.68	38.31	31.00	56.34	50.75	30.99	36.69	14.81
% Carbon	0.61	2.06	3.85	1.82	4.71	4.89	3.29	0.81	2.76	1.54
% Hydrogen	0.00	0.04	0.17	0.02	0.02	0.03	0.02	0.01	0.04	0.03
% Nitrogen	0.14	0.10	0.13	0.09	0.13	0.09	0.11	0.06	0.11	0.14
% Sulfur	0.13	0.06	0.08	0.04	0.10	0.07	0.07	0.03	0.07	0.18
% Ash	83.27	51.13	71.58	59.71	63.96	38.57	45.75	68.10	60.26	83.29
% Oxygen	0.00	0.00	0.51	0.01	0.08	0.01	0.01	0.00	0.08	0.00
ASH ANALYSIS										
% SiO2	63.63	62.52	62.74	62.93	62.95	61.35	58.23	59.29	61.71	66.70
% Al2O3	21.62	18.00	21.41	21.59	22.03	21.18	20.65	20.77	20.93	13.92
% TiO2	0.91	0.75	0.94	1.04	0.91	0.90	0.88	0.90	0.90	0.65
% Fe2O3	3.60	4.50	3.92	3.68	3.54	3.73	5.61	4.17	4.09	4.49
% CaO	5.81	9.31	6.49	6.55	6.02	8.10	10.02	10.33	7.83	8.85
% MgO	1.49	1.77	1.62	1.63	1.60	1.56	1.75	1.81	1.65	1.66
% K2O	2.03	1.79	1.97	1.99	2.03	1.97	1.79	1.86	1.93	1.68
% Na2O	0.16	0.47	0.19	0.21	0.18	0.21	0.23	0.18	0.23	0.80
% SO3	0.10	0.10	0.12	0.03	0.08	0.34	0.21	0.06	0.13	0.14
% P4O5	0.14	0.21	0.14	0.12	0.14	0.16	0.17	0.16	0.16	0.16
% SrO	0.06	0.09	0.07	0.08	0.06	0.07	0.07	0.08	0.07	0.10
% BaO	0.30	0.32	0.24	0.00	0.31	0.28	0.23	0.24	0.24	0.24
% MnO	0.15	0.17	0.15	0.15	0.15	0.15	0.16	0.15	0.15	0.16
Undetermined	0.00	0.00	0.00	0.00	0.00	0.00	0	0	0.00	0.39
T 250	2900	2747	2900	2900	2900	2831	2653	2693	2816	2802

Table A4. **HEALY TWO BULL RIDGE COAL TESTS: Slag Analyses**

		HEALY TWO BULL RIDGE COAL TESTS: SLAG ANALYSES (MOISTURE FREE BASIS)								All Healy
Test No.	555-TBR3	556-TBR4	557-TBR5	559-TBR7	560-TBR8	562-TBR10	563-TBR11	564-TBR12	TBR Coal	Perf.
Sample No.	1393-16B	1397-16B	1400-16B	1406-16B	1409-16B	1415-16B	1411-16B	1420-16B	AVERAGE	Average
Wt. %										
PROXIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Ash	98.95	95.77	93.79	96.79	92.70	88.34	92.89	98.68	94.74	97.73
% Volatile	0.75	1.65	1.89	1.18	0.99	2.29	1.99	0.29	1.38	0.92
% Fixed Carbon	0.30	2.58	4.32	2.03	6.32	9.37	5.12	1.03	3.88	1.35
Btu/lb	109	528	763	365	659	1557	928	217	641	240
ULTIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Carbon	0.72	3.86	5.04	2.95	6.83	11.20	6.68	1.17	4.81	1.85
% Hydrogen	0.00	0.07	0.22	0.03	0.03	0.07	0.04	0.01	0.06	0.03
% Nitrogen	0.17	0.19	0.17	0.15	0.19	0.21	0.22	0.09	0.17	0.16
% Sulfur	0.15	0.11	0.10	0.06	0.14	0.16	0.14	0.04	0.12	0.21
% Ash	98.95	95.77	93.79	96.79	92.70	88.34	92.89	98.68	94.74	97.73
% Oxygen	0.00	0.00	0.67	0.02	0.12	0.02	0.02	0.00	0.11	0.00

Table A5. **HEALY PERFORMANCE COAL: FLYASH ANALYSES**

	HEALY PERFORMANCE COAL TESTS: FLYASH ANALYSES (AS FIRED)									
Test No.	309-H13-1	400-H13-2	401-H14	402-H14-1	406-H16	407-H17	408-H18	503-H23	510-H30	523-H34
Sample No.	1215-16B	1233-16B	1231-16B	1236-16B	1239-16B	1242-16B	1245-16B	1252-16B	1282-16B	1292-16B
PROXIMATE										
% Moisture	0.09	0.08	0.04	0.07	0.16	0.02	0.02	0.01	0.42	0.02
% Ash	98.64	98.69	98.39	98.17	98.61	98.99	99.46	98.28	96.79	98.85
% Volatile	0.56	0.29	0.44	0.70	0.48	0.30	0.19	1.69	2.41	1.12
% Fixed Carbon	0.71	0.94	1.13	1.06	0.75	0.69	0.33	0.02	0.38	0.01
Btu/lb	99	99	99	99	99	99	0	0	65	99
ULTIMATE										
% Moisture	0.09	0.08	0.04	0.07	0.16	0.02	0.02	0.01	0.42	0.02
% Carbon	0.45	0.23	0.55	0.67	0.54	0.40	0.31	0.52	1.27	0.31
% Hydrogen	0.06	0.06	0.08	0.05	0.04	0.04	0.04	0.02	0.03	0.09
% Nitrogen	0.39	0.57	0.63	0.53	0.28	0.19	0.26	0.22	0.30	0.18
% Sulfur	0.36	0.36	0.30	0.50	0.36	0.35	0.37	0.59	0.15	0.55
% Ash	98.64	98.69	98.39	98.17	98.61	98.99	99.46	98.29	96.79	98.85
% Oxygen	0.01	0.01	0.01	0.01	0.01	0.01	-0.46	0.36	1.04	0.00
ASH ANALYSIS										
% SiO2	52.52	53.40	53.65	48.23	51.92	52.07	52.22	49.39	49.24	51.04
% Al2O3	18.90	18.99	18.71	17.97	18.23	18.40	18.42	16.36	15.04	18.42
% TiO2	0.76	0.78	0.94	0.68	0.70	0.78	0.72	0.72	0.70	0.68
% Fe2O3	6.66	6.65	6.57	6.87	6.72	6.60	6.75	6.29	5.89	6.03
% CaO	11.80	11.12	12.14	15.60	12.80	12.47	12.42	17.08	18.20	13.98
% MgO	2.54	2.40	2.60	3.20	2.60	2.40	2.44	2.48	3.20	2.40
% K2O	2.20	2.30	2.30	2.10	2.30	2.28	2.35	2.17	2.07	2.60
% Na2O	0.65	0.72	0.72	0.66	0.70	0.70	0.69	0.66	0.60	0.70
% SO3	0.90	0.53	0.61	1.21	0.77	0.78	0.84	1.01	1.85	1.29
% P4O5	0.10	0.08	0.08	0.13	0.08	0.11	0.10	0.08	0.13	0.10
LOI	1.50	1.30	1.42	2.07	1.68	1.60	1.6	2.88	2.7	1.42
Undetermined	1.47	1.73	0.26	1.28	1.50	1.81	1.45	0.88	0.38	1.34
% Ca	8.43	7.94	8.67	11.14	9.14	8.91	8.87	N/A	N/A	9.99
%CO2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.38
% CaCO3	3.22	2.91	3.18	4.41	3.64	3.54	3.54	N/A	N/A	3.14
% CaSO4	1.19	0.75	1.16	2.17	1.43	1.13	1.22	N/A	N/A	2.12

Table A5. HEALY PERFORMANCE COAL: FLYASH ANALYSES

	HEALY PERFORMANCE COAL TESTS: FLYASH ANALYSES (MOISTURE FREE BASIS)									
Test No.	309-H13-1	400-H13-2	401-H14	402-H14-1	406-H16	407-H17	408-H18	503-H23	510-H30	523-H34
Sample No.	1215-16B	1233-16B	1231-16B	1236-16B	1239-16B	1242-16B	1245-16B	1252-16B	1282-16B	1292-16B
Wt. %										
PROXIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Ash	98.73	98.77	98.43	98.24	98.77	99.01	99.48	98.29	97.20	98.87
% Volatile	0.56	0.29	0.44	0.70	0.48	0.30	0.19	1.69	2.42	1.12
% Fixed Carbon	0.71	0.94	1.13	1.06	0.75	0.69	0.33	0.02	0.38	0.01
Btu/lb										
ULTIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Carbon	0.45	0.23	0.55	0.67	0.54	0.40	0.31	0.52	1.28	0.31
% Hydrogen	0.06	0.06	0.08	0.05	0.04	0.04	0.04	0.02	0.03	0.09
% Nitrogen	0.39	0.57	0.63	0.53	0.28	0.19	0.26	0.22	0.30	0.18
% Sulfur	0.36	0.36	0.30	0.50	0.36	0.35	0.37	0.59	0.15	0.55
% Ash	98.73	98.77	98.43	98.24	98.77	99.01	99.48	98.30	97.20	98.87
% Oxygen	0.01	0.01	0.01	0.01	0.01	0.01	-0.46	0.36	1.04	0.00

Table A5. **HEALY PERFORMANCE COAL: FLYASH ANALYSES**

	HEALY PERFORMANCE COAL TESTS: FLYASH ANALYSES (AS FIRED)									FCM Tests	All Healy
Test No.	525-H36	529-H40	530-H41	534-H45	537-H48	541-H52	545-H56	548-H59	552-H63	H20-H63	Perf.
Sample No.	1298-16B	1315-16B	1311-16B	1312-16B	1340-16B	1351-16B	1361-16B	1372-16B	1385-16B	Average	Average
PROXIMATE											
% Moisture	0.04	0.04	0.19	0.09	0.14	0.11	0.06	0.06	0.06	0.10	0.36
% Ash	98.70	98.50	97.27	97.92	98.17	97.87	97.77	98.19	97.64	98.00	98.01
% Volatile	1.19	1.40	2.46	1.98	1.16	2.00	1.86	1.51	2.25	1.75	1.29
% Fixed Carbon	0.07	0.06	0.08	0.01	0.53	0.02	0.31	0.24	0.05	0.15	0.34
Btu/lb	0	99	99	0	99	99	99	99	99	71	67
ULTIMATE											
% Moisture	0.04	0.04	0.19	0.09	0.14	0.11	0.06	0.06	0.06	0.10	0.36
% Carbon	0.37	0.52	0.97	0.94	0.71	0.82	0.74	0.75	0.96	0.74	0.64
% Hydrogen	0.06	0.04	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.04	0.05
% Nitrogen	0.16	0.19	0.23	0.18	0.15	0.06	0.19	0.15	0.26	0.19	0.26
% Sulfur	0.67	0.71	0.83	0.84	0.80	0.95	1.20	0.82	0.98	0.76	0.57
% Ash	98.70	98.50	97.27	97.92	98.17	97.87	97.77	98.19	97.64	98.00	98.01
% Oxygen	0.00	0.00	0.49	0.00	0.00	0.17	0.01	0.00	0.07	0.18	0.12
ASH ANALYSIS											
% SiO2	48.23	47.77	47.93	46.61	48.51	44.10	44.83	46.31	45.57	47.46	50.03
% Al2O3	17.30	17.87	17.48	16.92	17.18	17.07	16.35	16.36	16.00	16.86	17.87
% TiO2	0.74	0.74	0.72	0.72	0.68	0.64	0.76	0.80	0.66	0.71	0.73
% Fe2O3	6.01	6.17	6.03	6.03	6.29	6.10	6.46	6.06	5.87	6.10	6.28
% CaO	16.80	18.00	17.60	17.72	16.80	21.08	20.32	18.40	20.80	18.07	15.37
% MgO	2.56	2.56	2.44	2.34	2.60	2.72	2.68	2.56	2.68	2.60	2.56
% K2O	2.40	2.41	2.32	2.24	2.30	2.12	2.16	2.14	2.02	2.25	2.26
% Na2O	0.65	0.65	0.64	0.62	0.70	0.64	0.64	0.63	0.60	0.64	0.66
% SO3	1.67	1.70	1.76	1.94	2.06	1.87	1.94	2.22	2.22	1.79	1.29
% P4O5	0.12	0.07	0.10	0.07	0.10	0.11	0.12	0.09	0.16	0.10	0.13
LOI	2.50	1.80	2.85	3.28	2.27	3.11	3.00	3.62	3.37	2.73	2.31
Undetermined	1.02	0.26	0.13	1.47	0.51	0.44	0.74	0.81	0.05	0.67	0.76
% Ca	12.00	12.86	12.58	12.69	12.00	15.06	14.52	13.15	14.86	12.97	9.20
%CO2	2.00	1.50	2.50	3.02	1.57	1.64	1.62	1.54	1.62	1.84	1.47
% CaCO3	4.54	3.40	5.68	6.86	5.00	6.86	6.77	8.18	4.98	5.54	3.84
% CaSO4	2.64	2.80	3.14	3.26	3.40	3.09	3.23	3.74	3.74	3.12	483.30

Table A5. **HEALY PERFORMANCE COAL: FLYASH ANALYSES**

	HEALY PERFORMANCE COAL TESTS: FLYASH ANALYSES				(MOISTURE FREE BASIS)					FCM Tests	All Healy
Test No.	525-H36	529-H40	530-H41	534-H45	537-H48	541-H52	545-H56	548-H59	552-H63	H20-H63	Perf.
Sample No.	1298-16B	1315-16B	1311-16B	1312-16B	1340-16B	1351-16B	1361-16B	1372-16B	1385-16B	Average	Average
Wt. %											
PROXIMATE											
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Ash	98.74	98.54	97.46	98.01	98.31	97.98	97.83	98.25	97.70	98.10	98.37
% Volatile	1.19	1.40	2.46	1.98	1.16	2.00	1.86	1.51	2.25	1.75	1.30
% Fixed Carbon	0.07	0.06	0.08	0.01	0.53	0.02	0.31	0.24	0.05	0.15	0.34
Btu/lb	0	99	99	0	99	99	99	99	99	77	60
ULTIMATE											
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Carbon	0.37	0.52	0.97	0.94	0.71	0.82	0.74	0.75	0.96	0.74	0.64
% Hydrogen	0.06	0.04	0.02	0.03	0.03	0.02	0.03	0.03	0.03	0.04	0.05
% Nitrogen	0.16	0.19	0.23	0.18	0.15	0.06	0.19	0.15	0.26	0.19	0.26
% Sulfur	0.67	0.71	0.83	0.84	0.80	0.95	1.20	0.82	0.98	0.76	0.57
% Ash	98.74	98.54	97.46	98.01	98.31	97.98	97.83	98.25	97.70	98.10	98.37
% Oxygen	0.00	0.00	0.49	0.00	0.00	0.17	0.01	0.00	0.07	0.18	0.12

Table A6. **HEALY TWO BULL RIDGE COAL TESTS: Flyash Analyses**

		HEALY TWO BULL RIDGE COAL TESTS: FLYASH ANALYSES (AS FIRED)								All Healy
Test No.	555-TBR3	556-TBR4	557-TBR5	559-TBR7	560-TBR8	562-TBR10	563-TBR11	564-TBR12	TBR Coal	Perf.
Sample No.	1392-16B	1398-16B	1401-16B	1407-16B	1410-16B	1416-16B	1418-16B	1421-16B	AVERAGE	Average
PROXIMATE										
% Moisture	0.08	0.13	0.22	0.04	0.08	0.24	0.14	0.23	0.15	0.36
% Ash	98.04	97.99	96.02	98.34	97.93	98.18	97.99	97.74	97.78	98.01
% Volatile	1.80	1.81	3.64	1.62	1.90	1.50	1.84	1.99	2.01	1.29
% Fixed Carbon	0.08	0.07	0.33	0.00	0.09	0.08	0.03	0.04	0.09	0.34
Btu/lb	106	100	100	18	100	156	106	161	106	67
ULTIMATE										
% Moisture	0.08	0.13	0.22	0.04	0.08	0.24	0.14	0.23	0.15	0.36
% Carbon	0.52	0.76	0.92	0.20	0.40	1.04	1.28	1.18	0.79	0.64
% Hydrogen	0.03	0.02	0.04	0.02	0.01	0.01	0.01	0.01	0.02	0.05
% Nitrogen	0.18	0.14	0.26	0.15	0.18	0.19	0.11	0.13	0.17	0.26
% Sulfur	0.58	0.33	0.34	0.28	0.27	0.34	0.33	0.47	0.37	0.57
% Ash	98.04	97.99	96.02	98.34	97.93	98.18	97.99	97.74	97.78	98.01
% Oxygen	0.57	0.63	2.42	0.97	1.13	0.00	0.14	0.24	0.76	0.12
ASH ANALYSIS										
% SiO2	51.17	53.83	54.40	57.19	57.55	58.88	57.21	57.11	55.92	50.03
% Al2O3	19.78	18.04	21.32	22.73	22.50	23.25	22.63	23.05	21.66	17.87
% TiO2	0.76	0.76	0.82	1.20	0.89	0.90	0.89	0.93	0.89	0.73
% Fe2O3	3.69	3.67	3.95	3.51	3.76	3.65	3.88	3.78	3.74	6.28
% CaO	17.81	14.16	13.08	8.42	9.60	7.77	9.61	9.25	11.21	15.37
% MgO	2.41	2.08	2.15	1.67	1.82	1.72	1.83	1.83	1.94	2.56
% K2O	1.98	2.02	2.15	2.09	2.23	2.25	2.21	2.27	2.15	2.26
% Na2O	0.28	0.24	0.24	0.14	0.16	0.17	0.17	0.15	0.19	0.66
% SO3	1.35	0.96	1.00	0.24	0.66	0.64	0.79	0.96	0.83	1.29
% P4O5	0.22	0.10	0.21	0.15	0.20	0.20	0.20	0.18	0.18	0.13
%SrO	0.09	N/A	0.08	0.09	0.07	0.07	0.07	0.08	0.08	2.31
%BaO	0.32	N/A	0.38	0.00	0.37	0.36	0.36	0.26	0.29	0.76
%MnO	0.14	N/A	0.15	0.14	0.14	0.14	0.15	0.15	0.14	9.20
Undetermined	0.00	1.34	0.07	2.43	0.05	0.00	0.00	0.00	0.49	1.47
T 250	2456		2581	2771	2708	2799	2701	2716	2676	3.84
LOI		2.80								483.30

Table A6. **HEALY TWO BULL RIDGE COAL TESTS: Flyash Analyses**

		HEALY TWO BULL RIDGE COAL TESTS: FLYASH ANALYSES (MOISTURE FREE BASIS)								All Healy
Test No.	555-TBR3	556-TBR4	557-TBR5	559-TBR7	560-TBR8	562-TBR10	563-TBR11	564-TBR12	TBR Coal	Perf.
Sample No.	1392-16B	1398-16B	1401-16B	1407-16B	1410-16B	1416-16B	1418-16B	1421-16B	AVERAGE	Average
Wt. %										
PROXIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Ash	98.12	98.12	96.23	98.38	98.01	98.42	98.13	97.97	97.92	98.37
% Volatile	1.80	1.81	3.65	1.62	1.90	1.50	1.84	1.99	2.02	1.30
% Fixed Carbon	0.08	0.07	0.33	0.00	0.09	0.08	0.03	0.04	0.09	0.34
Btu/lb	106	100	100	18	100	156	106	161	106	60
ULTIMATE										
% Moisture	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
% Carbon	0.52	0.76	0.92	0.20	0.40	1.04	1.28	1.18	0.79	0.64
% Hydrogen	0.03	0.02	0.04	0.02	0.01	0.01	0.01	0.01	0.02	0.05
% Nitrogen	0.18	0.14	0.26	0.15	0.18	0.19	0.11	0.13	0.17	0.26
% Sulfur	0.58	0.33	0.34	0.28	0.27	0.34	0.33	0.47	0.37	0.57
% Ash	98.12	98.12	96.23	98.38	98.01	98.42	98.13	97.97	97.92	98.37
% Oxygen	0.57	0.63	2.43	0.97	1.13	0.00	0.14	0.24	0.76	0.12

APPENDIX B. TEST DATA SUMMARIES

Table B1. Data Table Nomeclature

Nomeclature	
TESTS	First three digits indicate consecutive test number, second number indicates test condition.
SLAG RECVRY	Slag recovery numbers determined from coal ash and slag ash weights, corrected for sulfur. Equation is given in Appendix C.
COAL GRIND	Weight percent passing the 200 mesh screen (74 micron particle diameter)
DAMPER POS.	Damper postion at the precombustor exit. Damper A is the downstream damper from the main combustor's headend. The values are given in terms of percent of available movement (stroke). Damper configurations are shown in Appendix D.
PC EXIT	Precombustor exit velocity in FT/S. DCS values corrected in Appendix C for coal type and PC devolatilization.
COAL INJ. DEPTH	Main combustor coal injection depth.
PCC PHI	Precombustor can equivalence ratio.
PC PHI	Equivalence ratio at exit of precombustor
MC PHI	Equivalence ratio in main combustor.
SB PHI	Equivalence ratio at secondary burner.
LOAD	Total coal flow in MMBTU/HR.
COAL PC	Precombustor coal flow in LBS/HR.
COAL MC	Main combustor coal flow in LBS/HR.
COAL SPLIT	Percent of coal going to the precombustor.
PCCA	Precombustor can air in thousands of LBS/HR.
PCMB	Precombustor mix bustle air in thousands of LBS/HR.
SBCA	Secondary burner air in thousands of LBS/HR.
INTR. AIR	Intrusion air, determined by calculating the difference in air flows attributed to measured stack oxygen and secondary burner oxygen.
O2 SB	Percent oxygen in the gas at the secondary burner.
O2 STACK	Percent oxygen in the gas measured at the stack.

Table B1. (continued)

CO @3%	Carbon monoxide emissions in stack in ppm, corrected to 3% oxygen.
NOX @3%	Nitrogen oxides emissions in stack in ppm, corrected to 3% oxygen.
SO2 @3%	Sulfur dioxide emissions in stack in ppm, corrected to 3% oxygen.
SO2 W/O LS	Calculated sulfur dioxide emissions in ppm, without limestone, corrected to 3% oxygen.
LS	Limestone flowrate in LBS/HR.
CA/S	Molar ratio of calcium in limestone to sulfur in the coal.
S	Percent sulfur in the coal.
SO2 REDUC	Sulfur dioxide reduction due to limestone addition.
PC EXIT	Precombustor exit temperature calculated assuming that only coal devolatilization occurs.
TOT STM	Total steam produced in thousands of LBS/HR - Sum of flash tank steam (combustor) plus boiler steam.
COOL LOAD	Combustor heat transfer to the cooling system relative to the thermal input, in percent.
BLR EFF	Boiler efficiency.
FUEL/STM CORR	Fuel to steam flow correlation (value of 1 indicates a match between BTU's released in the system and available BTU's in the coal fired.
HEAT LOSS	Total combustor heat loss (precombustor, main combustor, secondary burner).
HEAT FLUX	1 - Headend + Air inlet 2 - Spool + Air inlet 3 - Baffle 4 - Slag recovery section front 5 - Slag recovery section right + half of back side 6 - Slag recovery section left + half of back side 7 - Precombustor + secondary burner 9 - Slag tap

HEALY TESTS	SLAG RECYRY %	COAL GRIND %*	DAMPER POS. A/B,%	PC EXIT FT/S	COAL INJ. DEPTH IN.	PCC PHI	PC PHI	HC PHI	SB PHI	LOAD MMBTU /HR	COAL PC #/HR	COAL HC #/HR	COAL SPLIT %	PCCA KPPH	PCHB KPPH	SBCA KPPH	INTR. AIR #/HR	O2 SB %	O2 STACK %	CO 03% PPM	NOX 03% PPM	NOX #/MMBTU
398-H13		76	25/25	327	2	0.93	1.70	0.76	1.15	20.1	959	1558	38.1	4.38	4.45	5.87	4401	2.55	6.13	126	148	0.233
399-H13-1	70	83	50/50	253	2	1.02	2.11	0.92	1.22	19.7	938	1522	38.1	4.88	6.11	4.43	3481	3.55	6.27	0	213	0.321
400-H13-2	94	83	65/65	253	2	1.03	2.21	1.00	1.20	20.2	1013	1513	40.1	5.28	7.17	3.14	3866	3.34	6.31	0	180	0.272
401-H14	87	77	90/90	255	2	1.01	2.37	1.00	1.29	24.9	1200	1913	38.5	6.30	9.75	5.39	1502	4.47	5.40	109	180	0.270
402-H14-1	62	81	85/85	257	2	1.01	2.29	0.98	1.42	24.7	1200	1880	38.9	6.28	9.21	8.05	-118	5.86	5.00	65	215	0.321
404-H14-2			65/65	262	2	1.04	2.23	0.91	1.35	25.9	1200	2048	36.9	6.54	8.53	8.65	1630	5.21	6.10	0	219	0.320
405-H15			60/60	302	2	1.09	2.07	0.88	1.21	24.9	1192	1920	38.3	6.00	7.01	6.16	4491	3.45	6.25	4	183	0.276
406-H16	97		90/90	306	2	0.87	2.07	0.91	1.22	29.7	1492	2228	40.1	6.29	11.25	6.94	5364	3.51	6.30	15	233	0.351
407-H17	63	79	80/80	303	2	0.89	2.01	0.88	1.21	30.1	1368	2399	36.3	6.37	9.16	9.06	4795	3.37	5.90	105	239	0.360
408-H18	85	78	80/80	308	2	0.95	2.45	0.89	1.20	30.6	1272	2561	33.2	6.28	11.43	7.15	7455	3.25	6.90	2	211	0.400
AVG	80	80		283		0.98	2.15	0.90	1.25	25.1	1183	1955	37.9	5.93	8.41	6.48	3698	3.85	6.14	52	208	0.314

Table B2. Healy Performance Coal Parametric Test Summary

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 1
Date: 5/16/91

TEST: 308-H13 Date 04/12/91
PURPOSE: DEMONSTRATE SYSTEM OPERABILITY

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: % CaCO3: N/A NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 95 Section: 1 OF 1 Time of Test: 11:30

FLOW RATES:

Coal PC (#/hr)	959.000	LS (#/hr)	______	Total Air (#/hr)	17316.644
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	______	Stoi Air (#/hr)	15065.656
Combustion Air PC (kpph)	4.380	# Nozzles	______	Xcss Air SB (#/hr)	2250.928
Mix Bustle Air PC (kpph)	4.450	Carr'r A/LS (scfn)	0.000	Total Coal (#/hr)	2517.300
Coal MC (#/hr)	1558.300	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	19303.80[illegible]
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	2.547
Cmbn Air Sec Brnr (kpph)	5.873	Injector (tube):	______	Coal Split PC (%)	38.096
		Ca/S Ratio	N/A	Ca Utilization, %	______

STOICHIOMETRIC AIR: (for Coal) 5.985 SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.985
PHI's: PCC phi 0.930 Clng Calc (Btu/sec) 361.090 Clng Meas (Btu/sec) 583.555 Flow #/sec 28.800
PC phi 1.705 Total flow assumed equal over all 8 circuits:
MC phi 0.760 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.149

#1 AI	1.365	#2 AI	1.766	#3 BAF	2.030	#4 SRS	2.190
#5 SRS	4.076	#6 SRS	2.696	#7 PC ET	1.003	#9 TAP	0.772

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.130			
CO (ppm)	104.000	125.891	129.058	
NOx (ppm)	122.000	147.680	151.395	0.223
SO2 w/LS (ppm)	287.700	348.258	357.019	0.732
SO2 w/o LS (ppm), calc	337.811	405.101	414.834	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 112.700 Preheat Outlet 362.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 579.700 FG Preheat Outlet 393.700 N. Gas MMBtu/hr______ % of Total Load: N/A

STEAMS (KPPH): Boiler 15.670 Flash Tank 2.080 Total Steam 17.750
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler 338.000 Flash Tank 338.000 Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.108 Cooling (Coal + N Gas) - % 10.447 Cooling H2O Inlet (deg F) 342.300
Coal + N. Gas - MMBtu/hr 20.108

RESULTS: Steam Gen Eff'cy (%) 82.986 Fuel to Steam Flow Corr. 0.929

Boiler Efficiency (%) 81.932 % SO2 Reduction 13.937 Intrusion Air (#/hr) 4401.39

REMARKS: TEST CONDITIONS: MEDIUM LOAD AT PHI=.8

HEALY TESTS   TEST SUMMARY   # Pgs: 2   Revision: 1
Date: 5/16/91

TEST: 309-H13-1   Date 04/12/91
PURPOSE: DEMONSTRATE SYSTEM OPERABILITY

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: % CaCO3: N/A   NATURAL GAS: Btu/lb ______   Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 59   Section: 1 OF 1   Time of Test: 16:30

FLOW RATES:

Coal PC (#/hr)	938.300	LS (#/hr)	______	Total Air (#/hr)	17953.644
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	______	Stoi Air (#/hr)	14724.520
Combustion Air PC (kpph)	4.800	# Nozzles	______	Xcss Air SB (#/hr)	3229.124
Mix Bustle Air PC (kpph)	6.110	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	2460.300
Coal MC (#/hr)	1522.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	19895.805
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	3.545
Cmbn Air Sec Brnr (kpph)	4.430	Injector (tube):	______	Coal Split PC (%)	38.138
		Ca/S Ratio	N/A	Ca Utilization, %	______

STOICHIOMETRIC AIR: (for Coal) 5.985   SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.985
PHI's: PCC phi 1.025   Clng Calc (Btu/sec) 241.920 Clng Meas (Btu/sec) 510.611 Flow #/sec 28.800
PC phi 2.113   Total flow assumed equal over all 8 circuits:
MC phi 0.918   FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.219

#1 AI	0.871	#2 AI	1.330	#3 BAF	1.633	#4 SRS	2.010
#5 SRS	1.633	#6 SRS	1.269	#7 PC ET	0.960	#9 TAP	1.498

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.270			
CO (ppm)	6.210	7.589	7.359	
NOx (ppm)	174.300	212.994	206.542	0.321
SO2 w/LS (ppm)	274.700	335.682	325.513	0.704
SO2 w/o LS (ppm), calc	334.802	405.101	393.377	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 114.700   Preheat Outlet 373.000   Ambient 77.000

FLUE GAS TEMPERATURES (deg F):   NATURAL GAS INPUTS:
FG Air Preheat Inlet 593.300   FG Preheat Outlet 398.300   N. Gas MMBtu/hr______   % of Total Load: N/A

STEAMS (KPPH): Boiler 15.670   Flash Tank 1.820   Total Steam 17.490
Press. (psig): Boiler 103.000   Flash Tank 103.000
Temps. (dg F): Boiler 339.000   Flash Tank 339.000   Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.653   Cooling (Coal + N Gas) - % 9.353   Cooling H2O Inlet (deg F) 344.000
Coal + N. Gas - MMBtu/hr 19.653

RESULTS: Steam Gen Eff'cy (%) 82.760   Fuel to Steam Flow Corr. 0.919

Boiler Efficiency (%) 81.801   % SO2 Reduction 17.252   Intrusion Air (#/hr) 3486.89

REMARKS: TEST CONDITIONS: MEDIUM LOAD AT PHI=.9
SWIRL DAMPER SET AT VEL. OF 250 FT/S

HEALY TESTS   TEST SUMMARY   # Pgs: 2   Revision: 1
Date: 5/16/91

TEST: 400-H13-2   Date 04/12/91
PURPOSE: DEMONSTRATE SYSTEM OPERABILITY

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: % CaCO3: N/A   NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 92   Section: 1 OF 1   Time of Test: 21:15

FLOW RATES:

Coal PC (#/hr)	1013.300	LS (#/hr)	______	Total Air (#/hr)	18203.644
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	______	Stoi Air (#/hr)	15119.520
Combustion Air PC (kpph)	5.260	# Nozzles	______	Xcss Air SB (#/hr)	3084.124
Mix Bustle Air PC (kpph)	7.170	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	2526.300
Coal MC (#/hr)	1513.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	20197.905
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbr	3.335
Cmbn Air Sec Brnr (kpph)	3.140	Injector (tube):	______	Coal Split PC (%)	40.110
		Ca/S Ratio	N/A	Ca Utilization, %	______
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 1.028   Clng Calc (Btu/sec) 353.880 Clng Meas (Btu/sec) 617.222 Flow #/sec 28.800
PC phi 2.210   Total flow assumed equal over all 8 circuits:
MC phi 0.996   FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.204

#1 AI	0.827	#2 AI	1.260	#3 BAF	2.636	#4 SRS	3.317
#5 SRS	3.124	#6 SRS	2.268	#7 PC ET	1.419	#9 TAP	1.362

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.310			
CO (ppm)	0.000	0.000	0.000	
NOx (ppm)	147.300	180.490	177.127	0.272
SO2 w/LS (ppm)	291.300	356.937	350.285	0.749
SO2 w/o LS (ppm), calc	333.942	405.101	397.888	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 109.000   Preheat Outlet 375.000   Ambient 77.000

FLUE GAS TEMPERATURES (deg F):   NATURAL GAS INPUTS:
FG Air Preheat Inlet 609.300   FG Preheat Outlet 400.000   N. Gas MMBtu/hr______   % of Total Load: N/A

STEAMS (KPPH): Boiler 16.050   Flash Tank 2.200   Total Steam 18.250
Press. (psig): Boiler 103.000   Flash Tank 103.000
Temps. (dg F): Boiler 338.700   Flash Tank 338.700   Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.180   Cooling (Coal + N Gas) - % 11.011   Cooling H2O Inlet (deg F) 343.000
Coal + N. Gas - MMBtu/hr 20.180

RESULTS: Steam Gen Eff'cy (%) 82.682   Fuel to Steam Flow Corr. 0.903

Boiler Efficiency (%) 81.470   % SO2 Reduction 11.964   Intrusion Air (#/hr) 3867.70

REMARKS: TEST CONDITIONS: MEDIUM LOAD AT PHI=1.
SWIRL DAMPER SET AT VEL. OF 250 FT/S

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 1
Date: 5/16/91

TEST: 401-H14 Date 04/13/91
PURPOSE: DEMONSTRATE SYSTEM OPERABILITY

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: % CaCO3: N/A NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 77 Section: 1 OF 1 Time of Test: 12:00

FLOW RATES:

Coal PC (#/hr)	1200.000	LS (#/hr)	________	Total Air (#/hr)	24053.644
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	________	Stoi Air (#/hr)	18630.830
Combustion Air PC (kpph)	6.300	# Nozzles	________	Xcss Air SB (#/hr)	5422.814
Mix Bustle Air PC (kpph)	9.750	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3113.000
Coal MC (#/hr)	1913.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	26511.046
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	4.468
Cmbn Air Sec Brnr (kpph)	5.390	Injector (tube):	________	Coal Split PC (%)	38.548
		Ca/S Ratio	N/A	Ca Utilization, %	________
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:
PCC phi 1.010
PC phi 2.368
MC phi 1.002
Overall phi at Sec. Brnr 1.291

Clng Calc (Btu/sec) 324.000 Clng Meas (Btu/sec) 583.556 Flow #/sec 28.800
Total flow assumed equal over all 8 circuits:
FLUX (Btu/ft2-sec):

#1 AI	0.581	#2 AI	0.942	#3 BAF	3.033	#4 SRS	3.268
#5 SRS	2.696	#6 SRS	2.220	#7 PC ET	1.387	#9 TAP	0.454

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.400			
CO (ppm)	163.500	188.654	173.267	
NOx (ppm)	156.000	180.000	165.319	0.270
SO2 w/LS (ppm)	315.700	364.269	334.559	0.762
SO2 w/o LS (ppm), calc	353.505	405.101	373.538	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 97.300 Preheat Outlet 417.700 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 699.700 FG Preheat Outlet 448.700 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler 20.320 Flash Tank 2.080 Total Steam 22.400
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler 338.000 Flash Tank 338.000 Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 24.867 Cooling (Coal + N Gas) - % 8.448 Cooling H2O Inlet (deg F) 342.000
Coal + N. Gas - MMBtu/hr 24.867

RESULTS: Steam Gen Eff'cy (%) 81.710 Fuel to Steam Flow Corr. 0.896

Boiler Efficiency (%) 80.926 % SO2 Reduction 10.435 Intrusion Air (#/hr) 1502.40

REMARKS: TEST CONDITION: MAXIMUM LOAD (30 MMBTU/HR) AT PHI=.9
COAL FEED VALVE SPEED 24.5%, SWIRL DAMPER AT V=250 FT/S

HEALY TESTS   TEST SUMMARY   # Pgs: 2   Revision: 1
Date: 5/16/91

TEST: 402-H14-1   Date 04/15/91
PURPOSE: DEMONSTRATE SYSTEM OPERABILITY

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: % CaCO3: N/A   NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 55   Section: 1 OF 1   Time of Test: 15:00

FLOW RATES:

Coal PC (#/hr)	1200.000	LS (#/hr)	______	Total Air (#/hr)	26153.644
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	______	Stoi Air (#/hr)	18481.209
Combustion Air PC (kpph)	6.280	# Nozzles	______	Xcss Air SB (#/hr)	7672.435
Mix Bustle Air PC (kpph)	9.210	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3088.000
Coal MC (#/hr)	1888.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	28591.311
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	5.852
Cmbn Air Sec Brnr (kpph)	8.050	Injector (tube):	______	Coal Split PC (%)	38.860
		Ca/S Ratio	N/A	Ca Utilization, %	______

STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076
STOICH. AIR: (# air/# tot fuel)	5.985		

PHI's:

PCC phi	1.007	Clng Calc (Btu/sec) 378.000 Clng Meas (Btu/sec) 660.708 Flow #/sec 28.800
PC phi	2.293	Total flow assumed equal over all 8 circuits:
MC phi	0.980	FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr	1.415	#1 AI 0.435 #2 AI 0.942 #3 BAF 3.266 #4 SRS 4.304
		#5 SRS 4.203 #6 SRS 2.062 #7 PC ET 1.387 #9 TAP 1.362

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.800			
CO (ppm)	54.650	64.717	54.428	
NOx (ppm)	181.500	214.934	180.763	0.321
SO2 w/LS (ppm)	271.500	321.513	270.397	0.669
SO2 w/o LS (ppm), calc	344.905	405.101	343.578	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 106.000   Preheat Outlet 363.000   Ambient 77.000

FLUE GAS TEMPERATURES (deg F):   NATURAL GAS INPUTS:
FG Air Preheat Inlet 630.000   FG Preheat Outlet 390.000   N. Gas MMBtu/hr ______ % of Total Load: N/A

STEAMS (KPPH): Boiler	20.845	Flash Tank	2.355	Total Steam	23.200
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 24.667   Cooling (Coal + N Gas) - % 9.643   Cooling H2O Inlet (deg F) 344.000
Coal + N. Gas - MMBtu/hr 24.667

RESULTS: Steam Gen Eff'cy (%) 83.282   Fuel to Steam Flow Corr. 0.874

Boiler Efficiency (%) 82.428   % SO2 Reduction 21.300   Intrusion Air (#/hr) -110.02

REMARKS: TEST CONDITION: REPEAT OF TEST 401-H14

TEST: 404-H14-2 Date 04/16/91
PURPOSE: DEMONSTRATE SYSTEM OPERABILITY

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: % CaCO3: N/A NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 11 Section: 1 OF 1 Time of Test: 12:20

FLOW RATES:

Coal PC (#/hr)	1200.000	LS (#/hr)	________	Total Air (#/hr)	26333.644
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	________	Stoi Air (#/hr)	19438.784
Combustion Air PC (kpph)	6.540	# Nozzles	________	Xcss Air SB (#/hr)	6894.850
Mix Bustle Air PC (kpph)	8.530	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3248.000
Coal MC (#/hr)	2048.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	28897.615
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	5.212
Cmbr Air Sec Brnr (kpph)	8.650	Injector (tube):	________	Coal Split PC (%)	36.946
		Ca/S Ratio	N/A	Ca Utilization, %	________
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 1.044
PC phi 2.231
MC phi 0.910
Overall phi at Sec. Brnr 1.355

Clng Calc (Btu/sec) 306.000 Clng Meas (Btu/sec) 566.722 Flow #/sec 28.800
Total flow assumed equal over all 8 circuits:
FLUX (Btu/ft2-sec):

#1 AI	0.581	#2 AI	1.177	#3 BAF	2.800	#4 SRS	3.432
#5 SRS	2.379	#6 SRS	1.744	#7 PC ET	1.280	#9 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.100			
CO (ppm)	7.000	8.456	7.417	
NOx (ppm)	181.000	218.658	191.789	0.328
SO2 w/LS (ppm)	274.000	331.007	290.333	0.691
SO2 w/o LS (ppm), calc	338.456	405.101	357.550	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 109.000 Preheat Outlet 361.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F):
FG Air Preheat Inlet 642.000 FG Preheat Outlet 382.000

NATURAL GAS INPUTS:
N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler	21.430	Flash Tank	2.020	Total Steam	23.450
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	339.000	Flash Tank	339.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 25.945 Cooling (Coal + N Gas) - % 7.864 Cooling H20 Inlet (deg F) 343.000
Coal + N. Gas - MMBtu/hr 25.945

RESULTS: Steam Gen Eff'cy (%) 83.371 Fuel to Steam Flow Corr. 0.912

Boiler Efficiency (%) 82.869 % SO2 Reduction 18.799 Intrusion Air (#/hr) 1630.23

REMARKS: TEST CONDITION: MAXIMUM LOAD (30 MMBTU/HR) AT PHI=.8, REPEAT OF TEST 401-H14 WITH HIGHER MEYERS VALVE SPEED, COAL FEED VALVE SPEED=24.5%, SWIRL DAMPER AT V=300 FT/S

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 1
Date: 5/16/91

TEST: 405-H15 Date 04/16/91
PURPOSE: DEMONSTRATE SYSTEM OPERABILITY

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: % CaCO3: N/A NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 1 Section: 1 OF 1 Time of Test: 16:00

FLOW RATES:

Coal PC (#/hr)	1192.000	LS (#/hr)	________	Total Air (#/hr)	22583.644
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	________	Stoi Air (#/hr)	18624.845
Combustion Air PC (kpph)	6.800	# Nozzles	________	Xcss Air SB (#/hr)	3958.799
Mix Bustle Air PC (kpph)	7.010	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3112.000
Coal MC (#/hr)	1920.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	25040.257
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	3.453
Cmbn Air Sec Brnr (kpph)	6.160	Injector (tube):	________	Coal Split PC (%)	38.303
		Ca/S Ratio	N/A	Ca Utilization, %	________

STOICHIOMETRIC AIR: (for Coal) 5.985 SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.985

PHI's: PCC phi 1.087 Clng Calc (Btu/sec) 0.000 Clng Meas (Btu/sec) 0.000 Flow #/sec 28.800
PC phi 2.070 Total flow assumed equal over all 8 circuits:
MC phi 0.882 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.213

#1 AI	0.000	#2 AI	0.000	#3 BAF	0.000	#4 SRS	0.000
#5 SRS	0.000	#6 SRS	0.000	#7 PC ET	0.000	#9 TAP	0.030

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.250			
CO (ppm)	3.300	4.027	3.926	
NOx (ppm)	150.000	183.051	178.440	0.276
SO2 w/LS (ppm)	261.000	318.508	310.485	0.668
SO2 w/o LS (ppm), calc	335.231	405.101	395.351	

AIR TEMPERATURES (deg F):
Air Preheat Inlet________ Preheat Outlet________ Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet________ FG Preheat Outlet________ N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler 20.690 Flash Tank________ Total Steam 20.690
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler________ Flash Tank________ Feed H20 (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 24.859 Cooling (Coal + N Gas) - % 0.000 Cooling H20 Inlet (deg F)________
Coal + N. Gas - MMBtu/hr 24.859

RESULTS: Steam Gen Eff'cy (%) 95.425 Fuel to Steam Flow Corr. 1.135

Boiler Efficiency (%) 96.408 % SO2 Reduction 21.466 Intrusion Air (#/hr) 4490.68

REMARKS: TEST CONDITION: MAXIMUM LOAD (30 MMBTU/HR) AT PHI=.9
COAL FEED VALVE SPEED = 24.5%, SWIRL DAMPER AT 300 FT/S

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 1
Date: 5/16/91

TEST: 406-H16 Date 04/17/91
PURPOSE: DEMONSTRATE SYSTEM OPERABILITY

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: % CaCO3: N/A NATURAL GAS: Btu/lb _______ Stoich air (# air/# NG): _______
Hydrogen (# H2/# NG): _______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 31 Section: 1 OF 1 Time of Test: 10:00

FLOW RATES:

Coal PC (#/hr)	1491.500	LS (#/hr)	_______	Total Air (#/hr)	27088.644
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	_______	Stoi Air (#/hr)	22260.640
Combustion Air PC (kpph)	6.290	# Nozzles	_______	Xcss Air SB (#/hr)	4828.004
Mix Bustle Air PC (kpph)	11.250	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3719.500
Coal MC (#/hr)	2228.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	30024.817
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	_______	% O2 post SB Cmbn	3.512
Cmbn Air Sec Brnr (kpph)	6.935	Injector (tube):	_______	Coal Split PC (%)	40.099
		Ca/S Ratio	N/A	Ca Utilization, %	_______

STOICHIOMETRIC AIR: (for Coal) 5.985 SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.985

PHI's: PCC phi 0.812 Clng Calc (Btu/sec) 401.400 Clng Meas (Btu/sec) 580.750 Flow #/sec 28.800
PC phi 2.072 Total flow assumed equal over all 8 circuits:
MC phi 0.905 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.217

#1 AI	0.218	#2 AI	0.765	#3 BAF	4.200	#4 SRS	5.719
#5 SRS	3.885	#6 SRS	1.824	#7 PC ET	1.494	#9 TAP	0.227

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.300			
CO (ppm)	12.000	14.694	14.276	
NOx (ppm)	190.500	233.265	226.624	0.351
SO2 w/LS (ppm)	274.500	336.122	326.553	0.705
SO2 w/o LS (ppm), calc	334.157	405.101	394.082	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 100.500 Preheat Outlet 368.500 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 653.500 FG Preheat Outlet 394.000 N. Gas MMBtu/hr_______ % of Total Load: N/A

STEAMS (KPPH): Boiler	21.165	Flash Tank	2.070	Total Steam	23.235
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	336.500	Flash Tank	336.500	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 29.711 Cooling (Coal + N Gas) - % 7.037 Cooling H2O Inlet (deg F) 341.500
Coal + N. Gas - MMBtu/hr 29.711

RESULTS: Steam Gen Eff'cy (%) 82.879 Fuel to Steam Flow Corr. 1.050

Boiler Efficiency (%) 82.488 % SO2 Reduction 17.136 Intrusion Air (#/hr) 5384.46

REMARKS: TEST CONDITION: MAXIMUM LOAD (30 MMBTU/HR) AT PHI=.9
COAL VALVE SPEED = 24.5%

HEALY TESTS | TEST SUMMARY | # Pgs: 2 | Revision: 1
Date: 5/16/91

TEST: 407-H17 Date 04/17/91
PURPOSE: DEMONSTRATE SYSTEM OPERABILITY

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: % CaCO3: N/A NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 36 Section: 1 OF 1 Time of Test: 13:00

FLOW RATES:

Coal PC (#/hr)	1367.500	LS (#/hr)	______	Total Air (#/hr)	27188.644
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	______	Stoi Air (#/hr)	22541.927
Combustion Air PC (kpph)	6.365	# Nozzles	______	Xcss Air SB (#/hr)	4646.717
Mix Bustle Air PC (kpph)	9.155	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3766.500
Coal MC (#/hr)	2399.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	30161.919
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	3.365
Cmbn Air Sec Brnr (kpph)	9.055	Injector (tube):	______	Coal Split PC (%)	36.307
		Ca/S Ratio	N/A	Ca Utilization, %	______
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	0.894	Clng Calc (Btu/sec) 273.600	Clng Meas (Btu/sec) 547.083 Flow #/sec 28.800
PC phi	2.013	Total flow assumed equal over all 8 circuits:	
MC phi	0.804	FLUX (Btu/ft2-sec):	
Overall phi at Sec. Brnr	1.206	#1 AI 0.363 #2 AI 0.706	#3 BAF 2.916 #4 SRS 3.187
		#5 SRS 2.537 #6 SRS 1.348	#7 PC ET 1.067 #9 TAP 0.454

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.900			
CO (ppm)	88.000	104.901	102.772	
NOx (ppm)	200.500	239.007	234.157	0.360
SO2 w/LS (ppm)	282.000	336.159	329.338	0.705
SO2 w/o LS (ppm), calc	342.756	405.101	397.248	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 102.500 Preheat Outlet 377.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 662.500 FG Preheat Outlet 397.500 N. Gas MMBtu/hr______ % of Total Load: N/A

STEAMS (KPPH): Boiler	21.685	Flash Tank	1.950	Total Steam	23.635
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	340.000	Flash Tank	340.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 30.087 Cooling (Coal + N Gas) - % 6.546 Cooling H2O Inlet (deg F) 344.500
Coal + N. Gas - MMBtu/hr 30.087

RESULTS: Steam Gen Eff'cy (%) 82.995 Fuel to Steam Flow Corr. 1.046

Boiler Efficiency (%) 82.708 % SO2 Reduction 17.095 Intrusion Air (#/hr) 4795.21

REMARKS: TEST CONDITION: MAXIMUM LOAD (30 MMBTU/HR) AT PHI=.8
COAL VALVE SPEED = 24.5%

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 1
Date: 5/16/91

TEST: 402-H18 Date 04/17/91
PURPOSE: DEMONSTRATE SYSTEM OPERABILITY

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 *Hydrogen:* 3.620 *Oxygen:* 15.980 *Nitrogen:* 0.730 *Sulfur:* 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: % CaCO3: N/A NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 14 Section: 1 OF 1 Time of Test: 17:00

FLOW RATES:

Coal PC (#/hr)	1272.000	LS (#/hr)	________	Total Air (#/hr)	27473.644
Carrier Air PC (scfh)	12500.000	LS Split (I/W)	________	Stoi Air (#/hr)	22939.920
Combustion Air PC (kpph)	6.280	# Nozzles	________	Xcss Air SB (#/hr)	4533.724
Mix Bustle Air PC (kpph)	11.430	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3833.000
Coal MC (#/hr)	2561.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	30499.414
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	3.247
Cmbn Air Sec Brnr (kpph)	7.150	Injector (tube):	________	Coal Split PC (%)	33.185
		Ca/S Ratio	N/A	Ca Utilization, %	________

STOICHIOMETRIC AIR: (for Coal) 5.985 SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.985

PHI's: PCC phi 0.950 Clng Calc (Btu/sec) 0.000 Clng Meas (Btu/sec) 0.000 Flow #/sec 28.800
PC phi 2.452 Total flow assumed equal over all 8 circuits:
MC phi 0.886 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.198

#1 AI	0.000	#2 AI	0.000	#3 BAF	0.000	#4 SRS	0.000
#5 SRS	0.000	#6 SRS	0.000	#7 PC ET	0.000	#9 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.900			
CO (ppm)	1.300	1.660	1.637	
NOx (ppm)	212.000	270.638	266.924	0.408
SO2 w/LS (ppm)	267.000	340.851	336.173	0.715
SO2 w/o LS (ppm), calc	321.258	405.101	399.788	

AIR TEMPERATURES (deg F):
Air Preheat Inlet________ Preheat Outlet________ Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet________ FG Preheat Outlet________ N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler 22.210 Flash Tank________ Total Steam 22.210
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler________ Flash Tank________ Feed H20 (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 30.618 Cooling (Coal + N Gas) - % 0.000 Cooling H20 Inlet (deg F)________
Coal + N. Gas - MMBtu/hr 30.618

RESULTS: Steam Gen Eff'cy (%) 95.520 Fuel to Steam Flow Corr. 1.303

Boiler Efficiency (%) 96.504 % SO2 Reduction 15.912 Intrusion Air (#/hr) 7455.45

REMARKS: TEST CONDITION: MAXIMUM LOAD (35 MMBTU/HR) AT PHI=.9
COAL VALVE SPEED = 24.5%

HEALY TESTS	SLAG RECVRY %	COAL GRIND %*	DAMPER POS. A/B,%	PC EXIT FT/S	COAL INJ. DEPTH IN.	PCC PHI	PC PHI	NC PHI	SB PHI	LOAD MMBTU /HR	COAL PC #/HR	COAL NC #/HR	COAL SPLIT %	PCCA KPPH	PCNB KPPH	SBCA KPPH	INTN. AIR #/HR	O2 SB %	O2 STACK %	CO 03% PPM	NOX 03% PPM	NOX #/MMBTU
500-H20			60/60	184	2	1.00	1.94	0.89	1.17	19.9	1000	1496	40.1	5.04	5.59	4.10	3882	3.40	6.45	24	164	0.247
501-H21		77	75/75	181	2	0.95	2.05	0.92	1.11	22.1	1105	1667	39.9	5.34	7.26	3.19	5581	2.60	6.59	4	154	0.232
502-H22		78	65/65	183	2	0.99	2.24	1.01	1.10	19.5	971	1465	39.9	4.79	7.25	1.37	5017	2.55	6.63	14		0.000
503-H23	63	51	65/65	184	2	1.06	2.34	1.04	1.11	19.6	977	1472	39.9	5.25	7.45	1.00	4300	2.74	6.27	0	199	0.301
504-H24	65	62	35/35	244	2	1.06	2.35	1.01	1.08	20.0	954	1547	38.1	5.10	7.38	1.02	5226	2.18	6.45	7	232	0.351
505-H25	82	77	25/25	246	2	1.27	2.84	1.02	1.10	19.8	799	1604	32.2	5.13	7.48	1.19	4928	2.61	6.55	4	225	0.340
507-H27	77	78	0/50	296	2	1.05	1.83	0.96	1.02	19.9	1160	1331	46.6	6.30	5.45	0.85	5510	1.26	6.10	78	220	0.333
508-H28	86	77	0/50	309	2	1.02	1.84	0.97	1.06	19.9	1162	1332	46.6	6.12	5.72	1.31	4742	1.85	5.93	14	197	0.290
509-H29	81	78	0/50	310	2	1.06	1.91	1.00	1.07	20.0	1168	1330	46.6	6.45	5.93	1.82	5313	2.03	6.41	1	233	0.353
510-H30		77	0/50	310	2	1.06	1.94	1.02	1.00	19.9	1162	1332	46.6	6.40	6.16	0.94	5405	2.22	6.60	3	259	0.391
511-H31	76	75	0/50	304	2	1.00	1.83	0.96	1.14	20.0	1167	1342	46.5	6.06	5.70	2.63	4104	3.98	6.30	29	252	0.300
512-H32	90	78	0/50	302	2	0.97	1.78	0.94	1.00	19.0	1152	1325	46.5	5.74	5.56	0.92	5814	0.92	6.13	20	215	0.327
513-H33	82	77	0/50	305	2	0.97	1.78	0.94	1.04	19.9	1155	1330	46.5	5.74	5.61	1.56	5449	1.65	6.30	17	218	0.330
523-H34		80	0/50	301	2	0.99	1.77	0.93	1.09	20.1	1167	1344	46.5	5.94	5.49	2.27	4919	2.31	6.32	19	195	0.295
524-H35		75	0/50	307	2	1.05	1.89	0.99	1.02	20.2	1177	1356	46.5	6.45	5.90	0.52	4817	1.26	5.56	21	174	0.264
525-H36	91	78	0/50	309	2	1.01	1.85	0.97	0.97	19.9	1160	1337	46.5	6.05	5.82	0.00	6324	0.34	6.12	8	172	0.261
526-H37			0/50	302	2	1.05	1.88	0.99	0.99	20.1	1168	1344	46.5	6.37	5.84	0.00	7134	0.65	6.77	7	201	0.305
527-H38	83		0/50	311	2	1.06	1.94	1.01	1.01	19.8	1156	1331	46.5	6.30	6.10	0.00	5290	1.15	5.89	9	168	0.255
528-H39	72		0/50	307	2	1.02	1.88	0.98	1.07	20.2	1173	1352	46.5	6.19	6.02	1.29	4259	2.08	5.66	15	148	0.225
529-H40	81	76	40/70	239	2	1.01	1.86	0.98	1.05	20.0	1165	1342	46.5	6.10	5.93	1.09	4501	1.72	5.67	89	135	0.204
530-H41	79	80	0/50	310	6	1.02	1.87	0.98	1.03	20.3	1170	1357	46.5	6.23	6.00	0.00	4775	1.42	5.63	24	138	0.210
531-H42	101		0/50	310	6	1.03	1.87	0.98	1.00	20.1	1160	1345	46.5	6.22	5.80	0.34	5704	0.91	6.05	41	152	0.230
532-H43	90		0/50	304	6	1.06	1.94	1.01	1.02	19.8	1154	1328	46.5	6.36	6.07	0.18	5776	1.33	6.33	21	178	0.270
533-H44	90		0/55	304	6	1.02	1.87	0.96	1.00	19.8	1154	1330	46.5	6.00	5.80	0.35	5966	0.97	6.25	27	172	0.261
534-H45	91	77	10/70	274	6	0.99	1.83	0.96	0.97	20.1	1171	1340	46.5	6.00	5.85	0.22	6137	0.43	6.01	37	157	0.230
535-H46			60/100	176	6	0.96	1.74	0.92	0.96	20.0	1165	1342	46.5	5.75	5.44	0.61	6104	0.18	5.92	34	141	0.214
536-H47			0/80	259	6	1.04	1.91	1.00	1.00	19.8	1150	1323	46.5	6.17	6.01	0.00	6100	0.90	6.32	16	151	0.229
537-H48		78	0/90	250	6	1.06	1.95	1.02	1.02	19.7	1147	1322	46.5	6.34	6.10	0.00	5662	1.24	6.22	27	164	0.249
539-H50			20/100	213	6	1.04	1.86	0.98	1.03	19.9	1159	1334	46.5	6.26	5.72	0.05	5334	1.50	6.12	20	152	0.231
540-H51	83		100/100	153	6	1.01	1.87	0.98	0.98	20.1	1169	1346	46.5	6.11	6.05	0.00	6656	0.56	6.42	8	223	0.339
541-H52	88	78	100/100	152	6	1.01	1.87	0.98	0.98	20.1	1171	1350	46.4	6.11	6.02	0.00	5553	0.48	5.63	71	136	0.206
542-H53	74		60/60	215	6	1.06	1.94	1.01	1.10	19.9	1160	1337	46.5	6.30	6.17	1.20	4436	2.46	6.12	17	138	0.210
543-H54	89		50/50	217	6	1.04	1.86	0.98	0.98	19.6	1143	1317	46.5	6.15	5.65	0.00	7023	0.64	6.79	14	163	0.240
544-H55	73		70/70	192	6	1.05	1.93	1.01	1.06	19.7	1147	1320	46.5	6.20	5.98	1.06	4850	2.21	6.27	67	151	0.228
545-H56	92	73	0/75	250	6	1.04	1.90	0.99	1.04	20.1	1167	1345	46.5	6.20	6.06	0.75	4542	1.66	5.65	30	133	0.201
546-H57	90		0/50	309	8	0.99	1.82	0.96	0.96	20.2	1173	1352	46.5	5.90	5.85	0.00	5843	0.06	5.60	56	131	0.199
547-H58			0/50	300	8	1.04	1.91	1.00	1.00	19.9	1156	1333	46.5	6.23	6.02	0.00	5991	0.07	6.20	19	167	0.253
548-H59		76	0/50	304	8	1.04	1.89	0.99	0.99	19.8	1154	1329	46.5	6.20	5.93	0.00	5701	0.77	6.01	11	107	0.204
549-H60			0/55	294	8	1.01	1.86	0.98	0.98	19.6	1140	1314	46.5	5.96	5.80	0.00	5510	0.54	5.74	32	153	0.233
550-H61	103		0/50	323	8	1.04	1.93	1.01	1.01	20.1	1168	1344	46.5	6.20	6.28	0.00	5466	1.06	5.92	49	158	0.239
551-H62	94		0/50	305	8	1.03	1.90	1.00	1.11	19.8	1153	1327	46.5	6.14	6.05	1.69	4238	2.71	6.17	30	160	0.242
552-H63	106	78	10/50	289	8	1.09	2.01	1.05	1.17	19.5	1134	1306	46.5	6.44	6.23	1.78	3599	3.52	6.35	102	175	0.264
AVG	84			266		1.03	1.94	0.98	1.04	20.0	1133	1367	45.3	6.02	6.07	0.86	5327	1.55	6.15	28	177	0.261

* - PERCENT THRU 200 MESH

Table B3. Healy Performance Coal FCM Collection Test Data

HEALY TESTS	SO2 @3% PPM	SO2 W/O LS	LS #/HR	CA/S RATIO	S %	SO2 REDUC %	PC EXIT DEG F	TOT STM KPPH	COOL LOAD %	BLR EFF %	FUEL /STM CORR	HEAT LOSS Bt/s	FLX 1 Btu/ f2-s	FLX 2 Btu/ f2-s	FLX 3 Btu/ f2-s	FLX 4 Btu/ f2-s	FLX 5 Btu/ f2-s	FLX 6 Btu/ f2-s	FLX 7 Btu/ f2-s	FLX 9 Btu/ f2-s	COMMENTS:
500-N20	259	404	60.0	2.05	0.34	36.2	2120	18.0	19.0	82.7	0.93	1052	3.19	4.94	6.07	4.74	4.76	6.82	3.31	1.36	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 250 FT/S, NIRO COLLECT'N
501-N21	280	405	55.5	1.71	0.34	38.8	2050	18.3	9.3	82.8	1.00	572	1.02	2.12	2.57	3.27	2.54	2.22	2.56	1.36	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 250 FT/S, NIRO COLLECT'N
502-N22		405	50.0	1.75	0.34		1920	16.0													MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 250 FT/S, NIRO COLLECT'N
503-N23	330	405	36.0	1.25	0.34	10.4	1850	18.1													MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 250 FT/S, NIRO COLLECT'N
504-N24	369	405	30.0	1.02	0.34	0.7	1850	17.6	11.4	82.6	0.94	631	1.38	1.77	2.80	2.86	2.30	1.98	1.17	1.13	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 330 FT/S, NIRO COLLECT'N
505-N25	325	405	33.0	1.13	0.34	19.6	1820	17.7	11.0	81.6	0.92	606	0.87	1.65	3.27	3.27	2.54	3.01	1.71	0.91	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 330 FT/S, NIRO COLLECT'N
507-N27	352	405	34.0	1.16	0.34	12.0	2200	16.7													MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 375 FT/S, NIRO COLLECT'N
508-N28	321	405	36.0	1.23	0.34	20.6	2200	18.2													MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 380 FT/S, NIRO COLLECT'N
509-N29	365	405	38.0	1.22	0.34	9.6	2150	17.0	10.2	81.7	0.96	570	0.50	1.08	3.27	3.76	3.17	2.38	1.71	0.91	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 380 FT/S, NIRO COLLECT'N
510-N30	336	405	37.0	1.16	0.34	16.8	2150	17.8	12.7	79.9	0.90	704	0.73	1.29	3.97	4.09	4.12	2.54	2.03	1.36	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 440 FT/S, NIRO COLLECT'N
511-N31	320	405	33.3	1.17	0.34	18.9	2200	18.4	10.1	80.2	0.87	561	0.51	1.47	3.27	3.84	3.81	2.22	1.81	0.23	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 440 FT/S, NIRO COLLECT'N
512-N32	326	405	37.0	1.17	0.34	19.2	2250	17.8													MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 440 FT/S, NIRO COLLECT'N
513-N33	355	405	38.0	1.24	0.34	12.0	2250	18.0	10.3	80.3	0.89	570	0.44	1.10	2.33	3.10	2.38	2.06	1.71	0.91	MEDIUM LOAD AT PHI=1., SWIRL VELOCITY AT 440 FT/S, NIRO COLLECT'N
523-N34	252	405	47.7	1.62	0.34	37.6	2250	17.5	9.8	81.9	0.94	547	1.28	0.92	2.29	3.24	2.03	2.19	2.54	0.82	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
524-N35	249	405	48.0	1.62	0.34	38.3	2150	18.1	10.2	81.3	0.91	575	0.87	1.06	2.22	3.27	2.22	2.22	2.24	1.27	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
525-N36	169	405	49.6	1.69	0.34	50.0	2200	17.0	8.0	81.4	0.95	489	0.65	1.08	2.15	2.81	2.38	2.03	2.22	0.54	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
526-N37	182	405	50.4	1.71	0.34	54.7	2150	15.6	10.2	81.3	1.05	518	0.50	1.29	2.80	3.76	3.33	2.06	2.56	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
527-N38	193	405	48.0	1.65	0.34	52.1	2150	16.9	10.0	81.0	0.95	550	0.32	1.00	2.92	3.60	2.05	2.06	2.51	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
528-N39	201	405	49.6	1.65	0.34	50.3	2200	17.5	9.3	81.2	0.93	521	0.22	0.82	2.33	3.19	2.38	2.14	1.24	0.06	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
529-N40	221	405	50.3	1.71	0.34	45.3	2200	18.0	10.4	81.4	0.90	570	0.32	0.74	2.68	4.09	2.82	2.65	2.40	-0.77	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
530-N41	228	405	48.0	1.61	0.34	45.4	2200	17.5	10.0	82.2	0.95	609	0.44	1.18	3.03	3.92	3.01	2.06	2.24	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
531-N42	213	405	40.0	1.36	0.34	47.1	2200	17.7	11.2	80.7	0.92	626	0.44	1.41	3.27	4.09	2.85	2.22	2.35	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
532-N43	177	405	50.0	1.72	0.34	56.2	2150	17.2	11.1	80.6	0.93	609	0.29	1.29	2.00	4.09	2.70	2.54	2.24	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
533-N44	195	405	42.5	1.46	0.34	51.5	2200	16.9	9.6	80.7	0.95	527	0.51	1.12	2.33	3.43	2.06	2.54	2.24	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
534-N45	189	405	47.0	1.59	0.34	52.9	2200	17.0	9.4	80.5	0.91	525	0.44	1.06	2.57	3.27	2.22	2.38	2.24	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
535-N46	197	405	51.0	1.73	0.34	51.0	2250	17.6	9.1	81.6	0.92	506	0.29	1.24	2.80	3.19	2.14	1.90	2.00	0.23	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
536-N47	186	405	52.0	1.79	0.34	53.7	2150	16.7	9.6	81.4	0.96	527	0.91	0.98	2.52	3.32	3.22	1.95	2.30	0.14	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
537-N48	196	405	51.0	1.76	0.34	51.4	2150	17.1	11.5	80.9	0.94	631	0.58	1.18	3.27	3.92	3.33	3.01	2.67	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
539-N50	172	405	50.0	1.71	0.34	57.4	2200	17.3	9.8	81.3	0.93	542	0.57	1.17	2.78	3.91	3.47	2.60	2.61	0.41	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
540-N51	175	405	52.5	1.78	0.34	56.4	2200	16.5	8.0	83.3	1.01	491	0.44	1.29	3.27	4.09	2.85	2.30	2.24	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
541-N52	210	405	47.0	1.59	0.34	47.9	2200	17.5	11.6	80.6	0.93	640	0.44	1.18	3.27	4.58	3.17	2.70	3.31	-0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
542-N53	190	405	51.6	1.76	0.34	52.9	2150	18.4	12.0	80.6	0.88	665	1.02	1.29	3.50	4.90	3.01	3.01	2.99	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
543-N54	197	405	51.0	1.77	0.34	51.1	2200	15.9	10.4	80.5	1.00	566	0.50	1.06	2.80	4.25	3.65	2.54	2.67	0.90	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
544-N55	194	405	40.9	1.69	0.34	51.9	2150	17.9	10.5	80.9	0.89	575	0.55	1.04	3.45	4.30	3.77	2.82	2.75	-0.54	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
545-N56	181	405	48.0	1.63	0.34	55.2	2150	19.4	11.0	81.3	0.84	614	0.73	1.41	4.43	4.09	3.96	2.54	2.45	0.00	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
546-N57	200	405	47.6	1.61	0.34	48.4	2200	17.6	9.9	81.4	0.94	553	1.10	1.06	3.73	3.86	2.85	2.35	2.19	0.23	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
547-N58	181	405	48.5	1.66	0.34	55.1	2150	16.5	9.5	80.9	0.98	523	0.76	1.50	2.74	3.72	2.50	2.50	2.21	1.25	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
548-N59	186	405	50.0	1.72	0.34	53.0	2150	16.9	9.6	82.9	0.97	527	0.87	1.41	2.57	3.43	2.38	2.54	2.13	0.91	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
549-N60	199	405	50.5	1.75	0.34	50.5	2200	16.9	9.0	81.0	0.95	490	0.80	1.24	2.45	3.35	2.62	2.46	2.19	0.68	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
550-N61	223	405	50.0	1.70	0.34	44.7	2150	16.5	9.6	81.9	0.99	534	0.40	1.33	2.61	3.40	2.65	2.65	2.19	0.54	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
551-N62	266	405	49.5	1.70	0.34	34.1	2150	16.0	8.0	81.9	0.96	483	0.29	1.41	2.33	2.94	2.70	2.70	2.13	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
552-N63	183	405	48.0	1.71	0.34	54.0	2100	18.5	8.0	81.1	0.85	476	0.44	1.29	2.57	3.43	2.70	2.38	2.24	0.45	CONTINUE NIRO COLLECTION AT MEDIUM LOAD
AVG	238	405	47.0	1.60	0.34	41.1	2143	17.4	10.4	81.4	0.94	577	0.70	1.34	2.97	3.69	2.92	2.53	2.31	0.44	

TEST: 500-H2C Date 04/22/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 111 Section: 1 OF 1 Time of Test: 15:00

FLOW RATES:

Coal PC (#/hr)	1000.000	LS (#/hr)	60.000	Total Air (#/hr)	18152.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14938.179
Combustion Air PC (kpph)	5.040	# Nozzles	________	Xcss Air SB (#/hr)	3214.342
Mix Bustle Air PC (kpph)	5.590	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2496.000
Coal MC (#/hr)	1496.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	20149.724
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	3.485
Cmbn Air Sec Brnr (kpph)	4.180	Injector (tube):	50.000	Coal Split PC (%)	40.064
		Ca/S Ratio	2.049	Ca Utilization, %	17.641
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.002	
PC phi	1.936	
MC phi	0.887	
Overall phi at Sec. Brnr	1.166	

Clng Calc (Btu/sec) 813.600 Clng Meas (Btu/sec) 1052.083 Flow #/sec 28.800
Total flow assumed equal over all 8 circuits:
FLUX (Btu/ft2-sec):

#1 AI	3.194	#2 AI	4.944	#3 BAF	6.066	#4 SRS	4.739
#5 SRS	4.758	#6 SRS	6.819	#7 PC ET	3.308	#9 TAP	1.362

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.450			
CO (ppm)	19.450	24.062	23.414	
NOx (ppm)	132.540	163.967	159.553	0.247
SO2 w/LS (ppm)	209.000	258.557	251.596	0.543
SOx w/o LS (ppm), calc	330.407	404.458	394.056	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 114.000 Preheat Outlet 299.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 491.000 FG Preheat Outlet 318.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH):	Boiler	14.240	Flash Tank	3.750	Total Steam	17.990
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	336.000	Flash Tank	336.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.938 Cooling (Coal + N Gas) - % 18.996 Cooling H2O Inlet (deg F) 340.000
Coal + N. Gas - MMBtu/hr 19.938

RESULTS: Steam Gen Eff'cy (%) 84.985 Fuel to Steam Flow Corr. 0.930

Boiler Efficiency (%) 82.732 % SO2 Reduction 36.152 Intrusion Air (#/hr) 3881.60

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 250 FT/S

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 1

Date: 5/16/91

TEST: 50'-H21 Date 04/22/91

PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND

Ultimate Analysis Applied

Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340

Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CARTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________

Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:

Duration (mins): 141 Section: 1 OF 1 Time of Test: 19:00

FLOW RATES:

Coal PC (#/hr)	1105.000	LS (#/hr)	55.500	Total Air (#/hr)	19132.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	16589.997
Combustion Air PC (kpph)	5.340	# Nozzles	________	Xcss Air SB (#/hr)	2542.524
Mix Bustle Air PC (kpph)	7.260	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2772.000
Coal MC (#/hr)	1667.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	21345.584
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbr	2.602
Crbn Air Sec Brnr (kpph)	3.190	Injector (tube):	50.000	Coal Split PC (%)	39.863
		Ca/S Ratio	1.707	Ca Utilization, %	18.027
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOIC. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 0.952 Clng Calc (Btu/sec) 406.800 Clng Meas (Btu/sec) 572.333 Flow #/sec 28.803

PC phi 2.050 Total flow assumed equal over all 8 circuits:

MC phi 0.917 FLUX (Btu/ft2-sec):

Overall phi at Sec. Brnr 1.109

#1 AI	1.016	#2 AI	2.119	#3 BAF	2.566	#4 SRS	3.268
#5 SRS	2.537	#6 SRS	2.220	#7 PC ET	2.561	#9 TAP	1.363

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.590			
CO (ppm)	2.820	3.523	3.600	
NOx (ppm)	123.000	153.643	157.042	0.232
SO2 w/LS (ppm)	224.000	279.806	285.995	0.589
SOx w/o LS (ppm), calc	327.489	404.565	413.112	

AIR TEMPERATURES (deg F):

Air Preheat Inlet 111.000 Preheat Outlet 349.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:

FG Air Preheat Inlet 533.000 FG Preheat Outlet 365.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH):	Boiler	16.290	Flash Tank	2.040	Total Steam	18.330
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	336.000	Flash Tank	336.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 22.143 Cooling (Coal + N Gas) - % 9.305 Cooling H2O Inlet (deg F) 340.000

Coal + N. Gas - MMBtu/hr 22.143

RESULTS: Steam Gen Eff'cy (%) 83.438 Fuel to Steam Flow Corr. 0.998

Boiler Efficiency (%) 82.845 % SO2 Reduction 30.771 Intrusion Air (#/hr) 5580.87

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 250 FT/S

TEST: 502-H22 Date 04/23/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 169 Section: 1 OF 1 Time of Test: 11:00

FLOW RATES:

Coal PC (#/hr)	970.700	LS (#/hr)	50.000	Total Air (#/hr)	16762.121
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	14575.497
Combustion Air PC (kpph)	4.793	# Nozzles	________	Xcss Air SB (#/hr)	2186.623
Mix Bustle Air PC (kpph)	7.253	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2435.400
Coal MC (#/hr)	1464.700	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	18707.009
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	2.553
Cmbn Air Sec Brnr (kpph)	1.373	Injector (tube):	50.000	Coal Split PC (%)	39.858
		Ca/S Ratio	1.750	Ca Utilization, %	57.134
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 0.989 Clng Calc (Btu/sec) 0.000 Clng Meas (Btu/sec) 0.000 Flow #/sec 28.800
PC phi 2.235 Total flow assumed equal over all 8 circuits:
MC phi 1.006 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.100

#1 AI	0.000	#2 AI	0.000	#3 BAF	0.000	#4 SRS	0.000
#5 SRS	0.000	#6 SRS	0.000	#7 PC ET	0.000	#9 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.633			
CO (ppm)	11.110	13.919	14.265	
NOx (ppm)	________	0.000	0.000	0.000
SO2 w/LS (ppm)	________	0.000	0.000	0.000
SOx w/o LS (ppm), calc	326.555	404.552	414.141	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 124.000 Preheat Outlet 326.330 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 505.330 FG Preheat Outlet 341.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler 16.840 Flash Tank________ Total Steam 16.840
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler________ Flash Tank________ Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.454 Cooling (Coal + N Gas) - % 0.000 Cooling H2O Inlet (deg F)________
Coal + N. Gas - MMBtu/hr 19.454

RESULTS: Steam Gen Eff'cy (%) 84.190 Fuel to Steam Flow Corr. 0.963

Boiler Efficiency (%) 85.232 % SO2 Reduction 100.000 Intrusion Air (#/hr) 5017.47

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 250 FT/S

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 1
Date: 5/16/91

TEST: 503-H23 Date 04/23/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): _______
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 178 Section: ________ Time of Test: 16:30

FLOW RATES:

Coal PC (#/hr)	976.700	LS (#/hr)	36.000	Total Air (#/hr)	17042.521
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	14656.891
Combustion Air PC (kpph)	5.250	# Nozzles	________	Xcss Air SB (#/hr)	2385.630
Mix Bustle Air PC (kpph)	7.450	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2449.000
Coal MC (#/hr)	1472.300	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	18991.878
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 pcst SB Cmbn	2.744
Cmbn Air Sec Brnr (kpph)	1.000	Injector (tube):	50.000	Coal Split PC (%)	39.882
		Ca/S Ratio	1.253	Ca Utilization, %	14.701
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.062	Clng Calc (Btu/sec)	0.000	Clng Meas (Btu/sec)	0.000	Flow #/sec	28.800			
PC phi	2.336	Total flow assumed equal over all 8 circuits:								
MC phi	1.045	FLUX (Btu/ft2-sec):								
Overall phi at Sec. Brnr	1.113	#1 AI	0.000	#2 AI	0.000	#3 BAF	0.000	#4 SRS	0.000	
		#5 SRS	0.000	#6 SRS	0.000	#7 PC ET	0.000	#9 TAP	0.000	

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.270			
CO (ppm)	6.700	8.187	8.304	
NOx (ppm)	163.000	199.185	202.020	0.301
SO2 w/LS (ppm)	270.000	329.939	334.634	0.694
SOx w/o LS (ppm), calc	334.477	404.708	410.207	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 124.700 Preheat Outlet 353.700 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 544.300 FG Preheat Outlet 367.000 N. Gas MMBtu/hr_______ % of Total Load: N/A

STEAMS (KPPH): Boiler 18.140 Flash Tank________ Total Steam 18.140
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler________ Flash Tank________ Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.563 Cooling (Coal + N Gas) - % 0.000 Cooling H2O Inlet (deg F)________
Coal + N. Gas - MMBtu/hr 19.563

RESULTS: Steam Gen Eff'cy (%) 83.601 Fuel to Steam Flow Corr. 0.892

Boiler Efficiency (%) 84.588 % SO2 Reduction 18.423 Intrusion Air (#/hr) 4300.05

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 250 FT/S

TEST: 504-H24 Date 04/24/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 117 Section: ________ Time of Test: 21:15

FLOW RATES:

Coal PC (#/hr)	953.500	LS (#/hr)	30.000	Total Air (#/hr)	16837.521
Carrier Air PC (scfh)	12500.000	LS Split (I/W)	100/0	Stoi Air (#/hr)	14962.118
Combustion Air PC (kpph)	5.100	# Nozzles	________	Xcss Air SB (#/hr)	1875.402
Mix Bustle Air PC (kpph)	7.380	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2500.000
Coal MC (#/hr)	1546.500	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	18824.451
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	2.176
Cmbn Air Sec Brnr (kpph)	1.015	Injector (tube):	50.000	Coal Split PC (%)	38.140
		Ca/S Ratio	1.023	Ca Utilization, %	8.547
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 1.061 Clng Calc (Btu/sec) 340.200 Clng Meas (Btu/sec) 631.250 Flow #/sec 28.800
PC phi 2.354 Total flow assumed equal over all 8 circuits:
MC phi 1.009 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.077

#1 AI	1.379	#2 AI	1.766	#3 BAF	2.800	#4 SRS	2.860
#5 SRS	2.300	#6 SRS	1.982	#7 PC ET	1.174	#9 TAP	1.135

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.450			
CO (ppm)	5.700	7.052	7.374	
NOx (ppm)	187.500	231.959	242.575	0.351
SO2 w/LS (ppm)	298.000	368.660	385.532	0.776
SOx w/o LS (ppm), calc	330.670	404.780	422.474	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 114.000 Preheat Outlet 334.500 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 549.000 FG Preheat Outlet 364.500 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler 15.305 Flash Tank 2.250 Total Steam 17.555
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler 339.000 Flash Tank 339.000 Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.970 Cooling (Coal + N Gas) - % 11.380 Cooling H2O Inlet (deg F) 343.500
Coal + N. Gas - MMBtu/hr 19.970

RESULTS: Steam Gen Eff'cy (%) 83.614 Fuel to Steam Flow Corr. 0.940

Boiler Efficiency (%) 82.564 % SO2 Reduction 8.744 Intrusion Air (#/hr) 5226.37

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 330 FT/S

HEALY TESTS　　TEST SUMMARY　　# Pgs: 2　　Revision: 1
Date: 5/16/91

TEST: 505-H25　　Date 04/25/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL　　% CaCO3: 90.400　　NATURAL GAS: Btu/lb ________　　Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 149　　Section: ________　　Time of Test: 1:45

FLOW RATES:

Coal PC (#/hr)	799.000	LS (#/hr)	33.000	Total Air (#/hr)	17142.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14860.376
Combustion Air PC (kpph)	5.130	# Nozzles	________	Xcss Air SB (#/hr)	2282.145
Mix Bustle Air PC (kpph)	7.480	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2483.000
Coal MC (#/hr)	1684.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	19117.374
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	2.608
Cmbn Air Sec Brnr (kpph)	1.190	Injector (tube):	50.000	Coal Split PC (%)	32.179
		Ca/S Ratio	1.133	Ca Utilization, %	17.295
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOIC. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.273	Clng Calc (Btu/sec)	385.200	Clng Meas (Btu/sec)	606.000	Flow #/sec	2?.800
PC phi	2.837	Total flow assumed equal over all 8 circuits:					
MC phi	1.024	FLUX (Btu/ft2-sec):					
Overall phi at Sec. Brnr	1.105	#1 AI 0.871	#2 AI 1.648	#3 BAF 3.265	#4 SRS 3.268		
		#5 SRS 2.537	#6 SRS 3.013	#7 PC ET 1.707	#9 TAP 0.908		

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.550			
CO (ppm)	3.180	3.961	4.048	
NOx (ppm)	181.000	225.467	230.382	0.340
SO2 w/LS (ppm)	261.000	325.121	332.209	0.684
SOx w/o LS (ppm), calc	328.494	404.745	413.172	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 115.000　　Preheat Outlet 372.000　　Ambient 77.000

FLUE GAS TEMPERATURES (deg F):　　NATURAL GAS INPUTS:
FG Air Preheat Inlet 569.000　　FG Preheat Outlet 392.000　　N. Gas MMBtu/hr ________　　% of Total Load: N/A

STEAMS (KPPH):	Boiler 15.490	Flash Tank	2.160	Total Steam	17.650
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.834　　Cooling (Coal + N Gas) - % 10.999　　Cooling H2O Inlet (deg F) 342.000
Coal + N. Gas - MMBtu/hr 19.834

RESULTS: Steam Gen Eff'cy (%) 82.656　　Fuel to Steam Flow Corr. 0.918

Boiler Efficiency (%) 81.562　　% SO2 Reduction 19.596　　Intrusion Air (#/hr) 4928.04

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 330 FT/S

HEALY TESTS   TEST SUMMARY   # Pgs: 2   Revision: 1
Date: 5/16/91

TEST: 507-H27   Date 04/25/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL   % CaCO3: 90.400   NATURAL GAS: Btu/lb ______   Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 117   Section: ______   Time of Test: 10:20

FLOW RATES:

Coal PC (#/hr)	1160.000	LS (#/hr)	34.000	Total Air (#/hr)	15942.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14908.255
Combustion Air PC (kpph)	6.300	# Nozzles	______	Xcss Air SB (#/hr)	1034.266
Mix Bustle Air PC (kpph)	5.450	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2491.000
Coal MC (#/hr)	1331.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17924.137
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	1.260
Cmbn Air Sec Brnr (kpph)	0.850	Injector (tube):	50.000	Coal Split PC (%)	46.568
		Ca/S Ratio	1.164	Ca Utilization, %	10.998
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.045	Clng Calc (Btu/sec)	0.000	Clng Meas (Btu/sec)	0.000	Flow #/sec	28.800		
PC phi	1.630	Total flow assumed equal over all 8 circuits:							
MC phi	0.963	FLUX (Btu/ft2-sec):							
Overall phi at Sec. Brnr	1.020	#1 AI	0.000	#2 AI	0.000	#3 BAF	0.000	#4 SRS	0.000
		#5 SRS	0.000	#6 SRS	0.000	#7 PC ET	0.000	#9 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.100			
CO (ppm)	64.600	78.040	85.582	
NOx (ppm)	182.000	219.866	241.114	0.333
SO2 w/LS (ppm)	291.000	351.544	385.518	0.742
SOx w/o LS (ppm), calc	338.151	404.736	442.097	

AIR TEMPERATURES (deg F):
Air Preheat Inlet______   Preheat Outlet______   Ambient 77.000

FLUE GAS TEMPERATURES (deg F):   NATURAL GAS INPUTS:
FG Air Preheat Inlet______   FG Preheat Outlet______   N. Gas MMBtu/hr______   % of Total Load: N/A

STEAMS (KPPH): Boiler 16.700   Flash Tank______   Total Steam 16.700
Press. (psig): Boiler 103.000   Flash Tank 103.000
Temps. (dg F): Boiler______   Flash Tank______   Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.898   Cooling (Coal + N Gas) - % 0.000   Cooling H2O Inlet (deg F)______
Coal + N. Gas - MMBtu/hr 19.898

RESULTS: Steam Gen Eff'cy (%) 95.275   Fuel to Steam Flow Corr. 1.124

Boiler Efficiency (%) 96.385   % SO2 Reduction 12.798   Intrusion Air (#/hr) 5509.80

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 375 FT/S

HEALY TESTS | TEST SUMMARY | # Pgs: 2 | Revision: 1
Date: 5/16/91

TEST: SCB-H28 | Date 04/25/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL | % CaCO3: 90.400 | NATURAL GAS: Btu/lb ________ | Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 146 | Section: ________ | Time of Test: 14:30

FLOW RATES:

Coal PC (#/hr)	1162.000	LS (#/hr)	36.000	Total Air (#/hr)	16492.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14928.005
Combustion Air PC (kpph)	6.120	# Nozzles	________	Xcss Air SB (#/hr)	1564.516
Mix Bustle Air PC (kpph)	5.720	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2494.300
Coal MC (#/hr)	1332.300	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	13477.638
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	1.850
Cmbn Air Sec Brnr (kpph)	1.310	Injector (tube):	50.000	Coal Split PC (%)	46.586
		Ca/S Ratio	1.230	Ca Utilization, %	16.732

STOICHIOMETRIC AIR: (for Coal) 5.985 | SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.985
PHI's: PCC phi 1.017 | Clng Calc (Btu/sec) 0.000 Clng Meas (Btu/sec) 0.000 Flow #/sec 28.800
PC phi 1.840 | Total flow assumed equal over all 8 circuits:
MC phi 0.968 | FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.056

#1 AI	0.000	#2 AI	0.000	#3 BAF	0.003	#4 SRS	0.000
#5 SRS	0.000	#6 SRS	0.003	#7 PC ET	0.000	#9 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.933			
CO (ppm)	11.433	13.659	14.532	
NOx (ppm)	165.000	197.120	209.718	0.298
SO2 w/LS (ppm)	268.300	320.528	341.015	0.675
SOx w/o LS (ppm), calc	341.720	404.715	429.422	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 128.000 | Preheat Outlet 382.330 | Ambient 77.000

FLUE GAS TEMPERATURES (deg F): | NATURAL GAS INPUTS:
FG Air Preheat Inlet 397.700 | FG Preheat Outlet ________ | N. Gas MMBtu/hr ________ | % of Total Load: N/A

STEAMS (KPPH): Boiler 18.210 | Flash Tank ________ | Total Steam 18.210
Press. (psig): Boiler 103.000 | Flash Tank 103.000
Temps. (dg F): Boiler ________ | Flash Tank ________ | Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.924 | Cooling (Coal + N Gas) - % 0.000 | Cooling H2O Inlet (deg F) ________
Coal + N. Gas - MMBtu/hr 19.924

RESULTS: Steam Gen Eff'cy (%) 95.245 | Fuel to Steam Flow Corr. 1.032
Boiler Efficiency (%) 96.362 | % SO2 Reduction 20.588 | Intrusion Air (#/hr) 4742.26

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 388 FT/S

HEALY TESTS   TEST SUMMARY   # Pgs: 2   Revision: 1
Date: 5/16/91

TEST: 509-H29   Date 04/25/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL   % CaCO3: 90.400   NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 124   Section: ________   Time of Test: 21:20

FLOW RATES:

Coal PC (#/hr)	1168.000	LS (#/hr)	18	Total Air (#/hr)	16742.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/C	Stoi Air (#/hr)	14998.027
Combustion Air PC (kpph)	6.450	# Nozzles	________	Xcss Air SB (#/hr)	1744.493
Mix Bustle Air PC (kpph)	5.930	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2506.000
Coal MC (#/hr)	1338.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	18736.874
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	2.034
Cmbn Air Sec Brnr (kpph)	1.020	Injector (tube):	50.000	Coal Split PC (%)	46.608
		Ca/S Ratio	0.012	Ca Utilization, %	
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 1.059; PC phi 1.308; MC phi 1.000; Overall phi at Sec. Brnr 1.068

Clng Calc (Btu/sec) 370.800 Clng Meas (Btu/sec) 569.528 Flow #/sec 28.800
Total flow assumed equal over all 8 circuits:
FLUX (Btu/ft2-sec):

#1 AI	0.581	#2 AI	1.060	#3 BAF	3.266	#4 SRS	3.759
#5 SRS	3.172	#6 SRS	2.379	#7 PC ET	1.707	#9 TAF	0.908

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.410			
CO (ppm)	1.000	1.234	1.300	
NOx (ppm)	189.000	233.173	245.690	0.353
SO2 w/LS (ppm)	296.000	365.182	384.785	0.769
SOx w/o LS (ppm), calc	331.477	404.717	425.468	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 122.000   Preheat Outlet 368.000   Ambient 77.000

FLUE GAS TEMPERATURES (deg F):
FG Air Preheat Inlet 594.000   FG Preheat Outlet 395.000

NATURAL GAS INPUTS:
N. Gas MMBtu/hr________   % of Total Load: N/A

STEAMS (KPPH):	Boiler	14.980	Flash Tank	2.030	Total Steam	17.010
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.018   Cooling (Coal + N Gas) - % 10.242   Cooling H2O Inlet (deg F) 342.000
Coal + N. Gas - MMBtu/hr 20.018

RESULTS: Steam Gen Eff'cy (%) 82.631   Fuel to Steam Flow Corr. 0.962

Boiler Efficiency (%) 81.701   % SO2 Reduction 9.562   Intrusion Air (#/hr) 5312.84

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 440 FT/S

TEST: 510-H30 Date 04/25/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 161 Section: ________ Time of Test: 1:45

FLOW RATES:

Coal PC (#/hr)	1162.000	LS (#/hr)	17	Total Air (#/hr)	16842.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14926.209
Combustion Air PC (kpph)	6.400	# Nozzles	________	Xcss Air SB (#/hr)	1916.311
Mix Bustle Air PC (kpph)	6.160	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2494.000
Coal MC (#/hr)	1332.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	18826.505
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	2.223
Cmbn Air Sec Brnr (kpph)	0.940	Injector (tube):	50.000	Coal Split PC (%)	46.592
		Ca/S Ratio	0.581	Ca Utilization, %	

STOICHIOMETRIC AIR: (for Coal) 5.985 SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.985

PHI's: PCC phi 1.058 Clng Calc (Btu/sec) 439.200 Clng Meas (Btu/sec) 704.194 Flow #/sec 28.800
PC phi 1.943 Total flow assumed equal over all 8 circuits:
MC phi 1.017 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.080

#1 AI	0.726	#2 AI	1.295	#3 BAF	3.966	#4 SRS	4.085
#5 SRS	4.123	#6 SRS	2.537	#7 PC ET	2.027	#9 TAP	1.362

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.600			
CO (ppm)	2.600	3.250	3.390	
NOx (ppm)	207.000	258.750	269.913	0.391
SO2 w/LS (ppm)	269.000	336.250	350.757	0.708
SOx w/o LS (ppm), calc	327.412	404.736	421.414	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 125.000 Preheat Outlet 406.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 616.000 FG Preheat Outlet 426.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH):	Boiler	15.320	Flash Tank	2.510	Total Steam	17.830
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.922 Cooling (Coal + N Gas) - % 12.725 Cooling H2O Inlet (deg F) 343.000
Coal + N. Gas - MMBtu/hr 19.922

RESULTS: Steam Gen Eff'cy (%) 81.519 Fuel to Steam Flow Corr. 0.899

Boiler Efficiency (%) 79.873 % SO2 Reduction 16.767 Intrusion Air (#/hr) 5405.20

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 440 FT/S

TEST: 511-H31 Date 04/26/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 141 Section: ________ Time of Test: 9:00

FLOW RATES:

Coal PC (#/hr)	1166.500	LS (#/hr)	17.25	Total Air (#/hr)	17802.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	15012.990
Combustion Air PC (kpph)	6.060	# Nozzles	________	Xcss Air SB (#/hr)	2789.531
Mix Bustle Air PC (kpph)	5.775	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2508.500
Coal MC (#/hr)	1342.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	19798.175
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbr	3.078
Cmbn Air Sec Brnr (kpph)	2.625	Injector (tube):	50.000	Coal Split PC (%)	46.502
		Ca/S Ratio	0.55	Ca Utilization, %	

STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076
STOICH. AIR: (# air/# tot fuel)	5.985		

PHI's:

PCC phi	1.005	Clng Calc (Btu/sec) 392.400 Clng Meas (Btu/sec) 561.111 Flow #/sec 28.800
PC phi	1.832	Total flow assumed equal over all 8 circuits:
MC phi	0.962	FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr	1.137	

#1 AI	0.508	#2 AI	1.472	#3 BAF	3.266	#4 SRS	3.840
#5 SRS	3.806	#6 SRS	2.220	#7 PC ET	1.814	#9 TAP	0.227

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.300			
CO (ppm)	23.340	28.580	28.456	
NOx (ppm)	206.000	252.245	251.155	0.380
SO2 w/LS (ppm)	268.000	328.163	326.746	0.689
SOx w/o LS (ppm), calc	333.853	404.733	403.062	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 126.500 Preheat Outlet 417.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 639.000 FG Preheat Outlet 440.500 N. Gas MMBtu/hr ________ % of Total Load: N/A

STEAMS (KPPH): Boiler	16.400	Flash Tank	2.000	Total Steam 18.400
Press. (psig): Boiler	103.000	Flash Tank	103.000	
Temps. (dg F): Boiler	336.500	Flash Tank	336.500	Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.038 Cooling (Coal + N Gas) - % 10.081 Cooling H2O Inlet (deg F) 340.500
Coal + N. Gas - MMBtu/hr 20.038

RESULTS: Steam Gen Eff'cy (%) 81.250 Fuel to Steam Flow Corr. 0.873

Boiler Efficiency (%) 80.174 % SO2 Reduction 18.934 Intrusion Air (#/hr) 4104.20

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 440 FT/S

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 1
Date: 5/16/91

TEST: 512-H32 Date 04/26/91

PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 151 Section: ______ Time of Test: 11:16

FLOW RATES:

Coal PC (#/hr)	1152.000	LS (#/hr)	17	Total Air (#/hr)	15562.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14824.467
Combustion Air PC (kpph)	5.740	# Nozzles	______	Xcss Air SB (#/hr)	738.054
Mix Bustle Air PC (kpph)	5.560	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2477.000
Coal MC (#/hr)	1325.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	17533.086
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	0.920
Cmbn Air Sec Brnr (kpph)	0.920	Injector (tube):	50.000	Coal Split PC (%)	46.508
		Ca/S Ratio	0.555	Ca Utilization, %	
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	0.971	Clng Calc (Btu/sec) 0.000	Clng Meas (Btu/sec) 0.000 Flow #/sec 28.800
PC phi	1.777	Total flow assumed equal over all 8 circuits:	
MC phi	0.939	FLUX (Btu/ft2-sec):	
Overall phi at Sec. Brnr	1.001		

#1 AI	0.000	#2 AI	0.000	#3 BAF	0.000	#4 SRS	0.000
#5 SRS	0.000	#6 SRS	0.000	#7 PC ET	0.000	#8 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.130			
CO (ppm)	16.440	19.900	22.201	
NOx (ppm)	178.000	215.467	240.372	0.327
SO2 w/LS (ppm)	269.000	325.622	363.258	0.687
SOx w/o LS (ppm), calc	337.505	404.734	449.418	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 133.000 Preheat Outlet 417.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 616.000 FG Preheat Outlet 441.000 N. Gas MMBtu/hr ______ % of Total Load: N/A

STEAMS (KPPH): Boiler 17.760 Flash Tank ______ Total Steam 17.760
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler ______ Flash Tank ______ Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.786 Cooling (Coal + N Gas) - % 0.000 Cooling H2O Inlet (deg F) ______
Coal + N. Gas - MMBtu/hr 19.786

RESULTS: Steam Gen Eff'cy (%) 81.346 Fuel to Steam Flow Corr. 0.897

Boiler Efficiency (%) 82.301 % SO2 Reduction 19.171 Intrusion Air (#/hr) 5813.76

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 440 FT/S

TEST: 513-H33 Date 04/26/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied

Composition (%) - Carbon:	47.450	Hydrogen:	3.620	Oxygen:	15.980	Nitrogen:	0.730	Sulfur:	0.340
Moisture:	10.830	Ash:	21.060	T250 (calc. deg F):	2715			HHV (Btu/lb):	7988

LIMESTONE: CANTWELL % $CaCO_3$: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 146 Section: ________ Time of Test: 16:00

FLOW RATES:

Coal PC (#/hr)	1155.000	LS (#/hr)	18	Total Air (#/hr)	16252.521
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	14872.346
Combustion Air PC (kpph)	5.740	# Nozzles	________	Xcss Air SB (#/hr)	1380.175
Mix Bustle Air PC (kpph)	5.610	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2485.000
Coal MC (#/hr)	1330.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	18230.296
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	1.654
Cmbn Air Sec Brnr (kpph)	1.560	Injector (tube):	50.000	Coal Split PC (%)	46.479
		Ca/S Ratio	0.49	Ca Utilization, %	
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	0.969	Clng Calc (Btu/sec) 316.800	Clng Meas (Btu/sec) 569.528 Flow #/sec 28.800
PC phi	1.780	Total flow assumed equal over all 8 circuits:	
MC phi	0.939	FLUX (Btu/ft2-sec):	
Overall phi at Sec. Brnr	1.044		

#1 AI	0.435	#2 AI	1.177	#3 BAF	2.333	#4 SRS	3.105
#5 SRS	2.379	#6 SRS	2.062	#7 PC ET	1.707	#9 TAP	0.908

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.300			
CO (ppm)	14.000	17.143	18.425	
NOx (ppm)	178.000	217.959	234.261	0.330
SO2 w/LS (ppm)	290.000	355.102	381.661	0.749
SOx w/o LS (ppm), calc	333.837	404.713	433.626	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 136.000 Preheat Outlet 414.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F):
FG Air Preheat Inlet 618.000 FG Preheat Outlet 436.000

NATURAL GAS INPUTS:
N. Gas MMBtu/hr ________ % of Total Load: N/A

STEAMS (KPPH):	Boiler 15.970	Flash Tank 2.030	Total Steam 18.000
Press. (psig):	Boiler 103.000	Flash Tank 103.000	
Temps. (dg F):	Boiler 338.000	Flash Tank 338.000	Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.850 Cooling (Coal + N Gas) - % 10.329 Cooling H2O Inlet (deg F) 343.000
Coal + N. Gas - MMBtu/hr 19.850

RESULTS: Steam Gen Eff'cy (%) 81.386 Fuel to Steam Flow Corr. 0.886

Boiler Efficiency (%) 80.278 % SO2 Reduction 11.984 Intrusion Air (#/hr) 5449.31

REMARKS: TEST CONDITION: 20 MMBTU/HR, PHI=1, MAXIMUM DURATION, SWIRL DAMPER AT 440 FT/S

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision:
Date: 5/20/91

TEST: 523-H34 Date 05/14/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 154 Section: ________ Time of Test: 12:24

FLOW RATES:

Coal PC (#/hr)	1167.000	LS (#/hr)	95.400	Total Air (#/hr)	17042.521
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	15027.952
Combustion Air PC (kpph)	5.940	# Nozzles	________	Xcss Air SB (#/hr)	2014.569
Mix Bustle Air PC (kpph)	5.490	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2511.000
Coal MC (#/hr)	1344.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	19067.413
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	2.308
Cmbn Air Sec Brnr (kpph)	2.270	Injector (tube):	50.000	Coal Split PC (%)	46.476
		Ca/S Ratio	3.239	Ca Utilization, %	11.571
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	0.987	Clng Calc (Btu/sec) 354.240 Clng Meas (Btu/sec) 547.093 Flow #/sec	28.800
PC phi	1.773	Total flow assumed equal over all 8 circuits:	
MC phi	0.935	FLUX (Btu/ft2-sec):	
Overall phi at Sec. Brnr	1.086		

#1 AI	1.277	#2 AI	0.918	#3 BAF	2.286	#4 SRS	3.236
#5 SRS	2.030	#6 SRS	2.189	#7 PC ET	2.539	#8 TAP	0.817

EMISSIONS.

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.320			
CO (ppm)	15.530	19.042	19.774	
NOx (ppm)	159.100	195.082	202.583	0.295
SO2 w/LS (ppm)	205.700	252.221	261.919	0.532
SOx w/o LS (ppm), calc	332.891	404.086	418.926	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 136.000 Preheat Outlet 368.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 568.600 FG Preheat Outlet 392.000 N. Gas MMBtu/hr______ % of Total Load: N/A

STEAMS (KPPH):	Boiler	15.520	Flash Tank	1.950	Total Steam	17.470
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	338.400	Flash Tank	338.400	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.058 Cooling (Coal + N Gas) - % 9.819 Cooling H2O Inlet (deg F) 342.200
Coal + N. Gas - MMBtu/hr 20.058

RESULTS: Steam Gen Eff'cy (%) 82.529 Fuel to Steam Flow Corr. 0.937

Boiler Efficiency (%) 81.885 % SO2 Reduction 37.479 Intrusion Air (#/hr) 4927.95

REMARKS: TEST CONDITION: 20 MMBTU/HR, DAMPER SETTINGS 0%,50%

TEST: 524-H35 Date 05/14/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb _______ Stoich air (# air/# NG): _______
Hydrogen (# H2/# NG): _______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 146 Section: _______ Time of Test: 16:50

FLOW RATES:

Coal PC (#/hr)	1177.000	LS (#/hr)	48.000	Total Air (#/hr)	16208.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	15159.618
Combustion Air PC (kpph)	6.450	# Nozzles	_______	Xcss Air SB (#/hr)	1048.902
Mix Bustle Air PC (kpph)	5.896	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2533.000
Coal MC (#/hr)	1356.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	18229.559
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	_______	% O2 post SB Cmbn	1.257
Cmbn Air Sec Brnr (kpph)	0.520	Injector (tube):	50.000	Coal Split PC (%)	46.467
		Ca/S Ratio	1.616	Ca Utilization, %	23.728
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.051	Clng Calc (Btu/sec) 346.680 Clng Meas (Btu/sec) 575.139 Flow #/sec 28.800
PC phi	1.888	Total flow assumed equal over all 8 circuits:
MC phi	0.987	FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr	1.021	#1 AI 0.871 #2 AI 1.060 #3 BAF 2.216 #4 SRS 3.268
		#5 SRS 2.220 #6 SRS 2.220 #7 PC ET 2.241 #9 TAP 1.271

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.560			
CO (ppm)	18.420	21.474	23.554	
NOx (ppm)	149.200	173.938	190.782	0.264
SO2 w/LS (ppm)	213.170	248.514	272.581	0.524
SOx w/o LS (ppm), calc	349.627	404.594	442.020	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 139.500 Preheat Outlet 403.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 603.500 FG Preheat Outlet 421.800 N. Gas MMBtu/hr_______ % of Total Load: N/A

STEAMS (KPPH): Boiler	16.080	Flash Tank	2.050	Total Steam	18.130
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.234 Cooling (Coal + N Gas) - % 10.233 Cooling H2O Inlet (deg F) 343.000
Coal + N. Gas - MMBtu/hr 20.234

RESULTS: Steam Gen Eff'cy (%) 82.233 Fuel to Steam Flow Corr. 0.906

Boiler Efficiency (%) 81.298 % SO2 Reduction 38.333 Intrusion Air (#/hr) 4817.34

REMARKS: TEST CONDITION: 20 MMBTU/HR, DAMPER SETTINGS 0%,50%

TEST: 525-H36 Date 05/15/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.080 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 180 Section: ________ Time of Test: 14:25

FLOW RATES:

Coal PC (#/hr)	1160.000	LS (#/hr)	49.600	Total Air (#/hr)	15212.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14944.164
Combustion Air PC (kpph)	6.050	# Nozzles	________	Xcss Air SB (#/hr)	268.357
Mix Bustle Air PC (kpph)	5.820	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2497.000
Coal MC (#/hr)	1337.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17205.257
Carrier Air MC (scfh)	21713.000	Nozzles (throat):	________	% O2 post SB Cmbn	0.341
Cmbn Air Sec Brnr (kpph)	0.000	Injector (tube):	50.000	Coal Split PC (%)	46.456
		Ca/S Ratio	1.693	Ca Utilization, %	34.224
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 1.009 Clng Calc (Btu/sec) 321.840 Clng Meas (Btu/sec) 489.289 Flow #/sec 28.830
PC phi 1.847 Total flow assumed equal over all 8 circuits:
MC phi 0.959 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 0.969

#1 AI	0.653	#2 AI	1.083	#3 BAF	2.146	#4 SRS	2.811
#5 SRS	2.300	#6 SRS	2.030	#7 PC ET	2.219	#9 TAP	0.545

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.120			
CO (ppm)	5.860	8.298	9.524	
NOx (ppm)	142.300	172.137	197.569	0.261
SO2 w/LS (ppm)	139.800	169.113	194.098	0.358
SOx w/o LS (ppm), calc	337.583	404.570	461.663	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 151.600 Preheat Outlet 396.300 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 596.600 FG Preheat Outlet 417.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler	15.256	Flash Tank	1.744	Total Steam	17.000
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	338.200	Flash Tank	338.200	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.946 Cooling (Coal + N Gas) - % 8.831 Cooling H2O Inlet (deg F) 341.000
Coal + N. Gas - MMBtu/hr 19.946

RESULTS: Steam Gen Eff'cy (%) 82.045 Fuel to Steam Flow Corr. 0.952

Boiler Efficiency (%) 81.387 % SO2 Reduction 57.957 Intrusion Air (#/hr) 8324.06

REMARKS: TEST CONDITION: 20 MMBTU/HR, DAMPER SETTINGS 0%,50%

TEST: 526-H37 Date 05/16/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 149 Section: ________ Time of Test: 20:30

FLOW RATES:

Coal PC (#/hr)	1168.000	LS (#/hr)	50.400	Total Air (#/hr)	15552.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	15033.936
Combustion Air PC (kpph)	6.370	# Nozzles	________	Xcss Air SB (#/hr)	518.584
Mix Bustle Air PC (kpph)	5.840	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2512.000
Coal MC (#/hr)	1344.000	C.A. Press (psig) Edc Nz Dia 0.375		Total Gas (#/hr)	17558.057
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	0.645
Cmbn Air Sec Brnr (kpph)	0.000	Injector (tube):	50.000	Coal Split PC (%)	46.497
		Ca/S Ratio	1.710	Ca Utilization, %	32.004
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi	1.048	Clng Calc (Btu/sec)	392.400	Clng Meas (Btu/sec)	569.528	Flow #/sec	28.800
PC phi	1.883	Total flow assumed equal over all 8 circuits:					
MC phi	0.926	FLUX (Btu/ft2-sec):					
Overall phi at Sec. Brnr	0.986	#1 AI 0.581	#2 AI 1.295	#3 BAF 2.800	#4 SRS 3.759		
		#5 SRS 3.330	#6 SRS 2.062	#7 PC ET 2.561	#9 TAP 0.454		

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.770			
CO (ppm)	5.800	7.337	8.296	
NOx (ppm)	159.000	201.124	227.436	0.305
SO2 w/LS (ppm)	144.000	182.150	205.980	0.385
SO2 w/o LS (ppm), calc	323.624	404.564	455.120	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 143.000 Preheat Outlet 382.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F):
FG Air Preheat Inlet 599.000 FG Preheat Outlet 399.000

NATURAL GAS INPUTS:
N. Gas MMBtu/hr ________ % of Total Load: N/A

STEAMS (KPPH): Boiler	13.570	Flash Tank	2.030	Total Steam	15.600
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.066 Cooling (Coal + N Gas) - % 10.218 Cooling H2O Inlet (deg F) 341.000
Coal + N. Gas - MMBtu/hr 20.066

RESULTS: Steam Gen Eff'cy (%) 82.223 Fuel to Steam Flow Corr. 1.048
Boiler Efficiency (%) 81.295 % SO2 Reduction 54.742 Intrusion Air (#/hr) 7134.27

REMARKS: TEST CONDITION: 20 MMBTU/HR, DAMPER SETTINGS 0%,50%

HEALY TESTS   TEST SUMMARY   # Pgs: 2   Revision: 0
Date: 5/31/91

TEST: 527-H38   Date 05/17/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL   % CaCO3: 90.400   NATURAL GAS: Btu/lb ________   Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 164   Section: ________   Time of Test: 1:35

FLOW RATES:

Coal PC (#/hr)	1156.000	LS (#/hr)	48.000	Total Air (#/hr)	15822.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14884.315
Combustion Air PC (kpph)	6.350	# Nozzles	________	Xcss Air SB (#/hr)	938.205
Mix Bustle Air PC (kpph)	6.100	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2487.000
Coal MC (#/hr)	1331.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17807.247
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	1.151
Cmbn Air Sec Brnr (kpph)	0.000	Injector (tube):	50.000	Coal Split PC (%)	46.482
		Ca/S Ratio	1.645	Ca Utilization, %	31.664
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 1.060   Clng Calc (Btu/sec) 358.920 Clng Meas (Btu/sec) 549.889 Flow #/sec 28.800
PC phi 1.942   Total flow assumed equal over all 8 circuits:
MC phi 1.014   FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.014

#1 AI	0.319	#2 AI	1.001	#3 BAF	2.916	#4 SRS	3.595
#5 SRS	2.855	#6 SRS	2.062	#7 PC ET	2.507	#9 TAP	0.003

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.890			
CO (ppm)	7.830	9.328	10.286	
NOx (ppm)	141.000	167.968	185.223	0.255
SO2 w/LS (ppm)	162.000	192.985	212.810	0.407
SOx w/o LS (ppm), calc	342.534	404.585	444.285	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 142.000   Preheat Outlet 401.000   Ambient 77.000

FLUE GAS TEMPERATURES (deg F):   NATURAL GAS INPUTS:
FG Air Preheat Inlet 627.000   FG Preheat Outlet 424.500   N. Gas MMBtu/hr________   % of Total Load: N/A

STEAMS (KPPH): Boiler 14.900   Flash Tank 1.960   Total Steam 16.860
Press. (psig): Boiler 103.000   Flash Tank 103.000
Temps. (dg F): Boiler 338.000   Flash Tank 338.000   Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.866   Cooling (Coal + N Gas) - % 9.965   Cooling H2O Inlet (deg F) 342.000
Coal + N. Gas - MMBtu/hr 19.866

RESULTS: Steam Gen Eff'cy (%) 81.954   Fuel to Steam Flow Corr. 0.955

Boiler Efficiency (%) 81.042   % SO2 Reduction 52.101   Intrusion Air (#/hr) 5289.71

REMARKS: TEST CONDITION: 20 MMBTU/HR, DAMPER SETTINGS 0%,50%

TEST: 528-H39 Date 05/17/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 130 Section: ________ Time of Test: 6:46

FLOW RATES:

Coal PC (#/hr)	1173.000	LS (#/hr)	49.000	Total Air (#/hr)	16842.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	15111.740
Combustion Air PC (kpph)	6.190	# Nozzles	________	Xcss Air SB (#/hr)	1730.781
Mix Bustle Air PC (kpph)	6.020	Carr'r A/LS (scfn)	9540.270	Total Coal (#/hr)	2525.000
Coal MC (#/hr)	1352.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	18857.692
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	2.005
Cmbr Air Sec Brnr (kpph)	1.290	Injector (tube):	50.000	Coal Split PC (%)	45.455
		Ca/S Ratio	1.654	Ca Utilization, %	30.397
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.018	Clng Calc (Btu/sec)	315.000	Clng Meas (Btu/sec)	521.833	Flow #/sec	28.800
PC phi	1.875	Total flow assumed equal over all 8 circuits:					
MC phi	0.981	FLUX (Btu/ft2-sec):					
Overall phi at Sec. Brnr	1.066	#1 AI 0.218	#2 AI 0.824	#3 BAF 2.333	#4 SRS 3.187		
		#5 SRS 2.379	#6 SRS 2.141	#7 PC ET 2.241	#9 TAP 0.000		

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.660			
CO (ppm)	12.800	15.020	15.850	
NOx (ppm)	127.000	149.022	157.261	0.225
SO2 w/LS (ppm)	171.000	200.652	211.745	0.423
SOx w/o LS (ppm), calc	347.470	404.582	425.947	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 140.800 Preheat Outlet 409.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 650.600 FG Preheat Outlet 429.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH):	Boiler	15.740	Flash Tank	1.860	Total Steam	17.600
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	337.000	Flash Tank	337.000	Feed H20 (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.170 Cooling (Coal + N Gas) - % 9.314 Cooling H20 Inlet (deg F) 342.000
Coal + N. Gas - MMBtu/hr 20.170

RESULTS: Steam Gen Eff'cy (%) 81.950 Fuel to Steam Flow Corr. 0.928

Boiler Efficiency (%) 81.177 % SO2 Reduction 50.288 Intrusion Air (#/hr) 4259.07

REMARKS: TEST CONDITION: 20 MMBTU/HR, DAMPER SETTINGS 0%,50%

TEST: 529-H40 Date 05/17/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.080 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG):______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 144 Section: ______ Time of Test: 10:42

FLOW RATES:
Coal PC (#/hr) 1164.500 LS (#/hr) 50.300 Total Air (#/hr) 16457.521
Carrier Air PC (scfh) 12500.000 LS Split (I/M) 100/0 Stoi Air (#/hr) 15001.020
Combustion Air PC (kpph) 6.096 # Nozzles ______ Xcss Air SB (#/hr) 1456.501
Mix Bustle Air PC (kpph) 5.934 Carr'r A/LS (scfh) 9540.270 Total Coal (#/hr) 2506.500
Coal MC (#/hr) 1342.000 C.A. Press (psig) Edc Nzl Dia 0.375 Total Gas (#/hr) 18458.670
Carrier Air MC (scfh) 21710.000 Nozzles (throat): ______ % O2 post SB Cmbn 1.724
Cmbn Air Sec Brnr (kpph) 1.085 Injector (tube): 50.000 Coal Split PC (%) 46.459
Ca/S Ratio 1.711 Ca Utilization, % 26.467

STOICHIOMETRIC AIR: (for Coal) 5.985 SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.985
PHI's: PCC phi 1.012 Clng Calc (Btu/sec) 361.080 Clng Meas (Btu/sec) 577.944 Flow #/sec 28.300
PC phi 1.863 Total flow assumed equal over all 8 circuits:
MC phi 0.976 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.049

#1 AI	0.319	#2 AI	0.742	#3 BAF	2.583	#4 SRS	4.085
#5 SRS	2.823	#6 SRS	2.648	#7 PC ET	2.401	#9 TAP	-0.772

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.668			
CO (ppm)	84.300	98.969	105.987	
NOx (ppm)	115.000	135.012	144.586	0.204
SO2 w/LS (ppm)	188.000	220.715	236.366	0.465
SOx w/o LS (ppm), calc	347.283	404.564	431.966	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 139.500 Preheat Outlet 427.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 612.000 FG Preheat Outlet 416.000 N. Gas MMBtu/hr______ % of Total Load: N/A

STEAMS (KPPH): Boiler 15.950 Flash Tank 2.060 Total Steam 18.010
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler 338.000 Flash Tank 338.000 Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.022 Cooling (Coal + N Gas) - % 10.392 Cooling H2O Inlet (deg F) 343.000
Coal + N. Gas - MMBtu/hr 20.022

RESULTS: Steam Gen Eff'cy (%) 82.338 Fuel to Steam Flow Corr. 0.904

Boiler Efficiency (%) 81.392 % SO2 Reduction 45.281 Intrusion Air (#/hr) 4501.08

REMARKS: TEST CONDITION: 20 MMBTU/HR, DAMPER SETTINGS 0%,50%

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 0
Date: 5/31/91

TEST: 530-H41 Date 05/20/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG):______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 202 Section: ______ Time of Test: 12:50

FLOW RATES:

Coal PC (#/hr)	1179.000	LS (#/hr)	48.000	Total Air (#/hr)	16375.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	15177.573
Combustion Air PC (kpph)	6.230	# Nozzles	______	Xcss Air SB (#/hr)	1197.948
Mix Bustle Air PC (kpph)	6.000	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2536.000
Coal MC (#/hr)	1357.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	18398.928
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	1.422
Cmbn Air Sec Brnr (kpph)	0.803	Injector (tube):	50.000	Coal Split PC (%)	46.491
		Ca/S Ratio	1.614	Ca Utilization, %	28.127
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PC2 phi	1.018	Clng Calc (Btu/sec)	374.400	Clng Meas (Btu/sec)	608.805	Flow #/sec	28.800
PC phi	1.869	Total flow assumed equal over all 8 circuits:					
MC phi	0.978	FLUX (Btu/ft2-sec):					
Overall phi at Sec. Brnr	1.031	#1 AI 0.435	#2 AI 1.177	#3 BAF 3.033	#4 SRS 3.922		
		#5 SRS 3.013	#6 SRS 2.062	#7 PC ET 2.241	#9 TAP 0.454		

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.630			
CO (ppm)	20.420	23.914	26.010	
NOx (ppm)	118.170	138.390	150.521	0.210
SO2 w/LS (ppm)	188.000	220.169	239.468	0.464
SOx w/o LS (ppm), calc	348.125	404.595	438.469	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 133.000 Preheat Outlet 366.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 580.000 FG Preheat Outlet 392.000 N. Gas MMBtu/hr______ % of Total Load: N/A

STEAMS (KPPH): Boiler	15.280	Flash Tank	2.170	Total Steam	17.450
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.258 Cooling (Coal + N Gas) - % 10.819 Cooling H2O Inlet (deg F) 343.000
Coal + N. Gas - MMBtu/hr 20.258

RESULTS: Steam Gen Eff'cy (%) 83.110 Fuel to Steam Flow Corr. 0.954

Boiler Efficiency (%) 82.168 % SO2 Reduction 45.386 Intrusion Air (#/hr) 4774.85

REMARKS: COAL INJECTOR PUSHED IN 4". (6" total - previously 2" total) Combustor cleared prior to test.

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 0
Date: 6/10/91

TEST: 531-H42 Date 05/20/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 148 Section: ________ Time of Test: 18:15

FLOW RATES:

Coal PC (#/hr)	1168.000	LS (#/hr)	40.000	Total Air (#/hr)	15783.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	15039.921
Combustion Air PC (kpph)	6.220	# Nozzles	________	Xcss Air SB (#/hr)	743.599
Mix Bustle Air PC (kpph)	5.880	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2513.000
Coal MC (#/hr)	1345.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17785.190
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	0.913
Cmbn Air Sec Brnr (kpph)	0.341	Injector (tube):	50.000	Coal Split PC (%)	46.478
		Ca/S Ratio	1.357	Ca Utilization, %	34.703
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 1.026 Clng Calc (Btu/sec) 392.400 Clng Meas (Btu/sec) 625.639 Flow #/sec 28.800
PC phi 1.868 Total flow assumed equal over all 8 circuits:
MC phi 0.978 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.001

#1 AI	0.435	#2 AI	1.413	#3 BAF	3.266	#4 SRS	4.085
#5 SRS	2.855	#6 SRS	2.220	#7 PC ET	2.347	#9 TAP	0.454

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.050			
CO (ppm)	34.300	41.298	46.085	
NOx (ppm)	126.000	151.706	169.293	0.230
SO2 w/LS (ppm)	177.000	213.110	237.816	0.450
SO2 w/o LS (ppm), calc	339.174	404.675	449.486	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 138.000 Preheat Outlet 405.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 625.000 FG Preheat Outlet 423.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler 15.450 Flash Tank 2.230 Total Steam 17.680
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler 338.000 Flash Tank 338.000 Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.074 Cooling (Coal + N Gas) - % 11.220 Cooling H2O Inlet (deg F) 342.000
Coal + N. Gas - MMBtu/hr 20.074

RESULTS: Steam Gen Eff'cy (%) 81.940 Fuel to Steam Flow Corr. 0.919

Boiler Efficiency (%) 80.723 % SO2 Reduction 47.092 Intrusion Air (#/hr) 5784.40

REMARKS: USING 8.5" LIME INJECTOR. (Nozzle ring assembly)

HEALY TESTS — TEST SUMMARY — # Pgs: 2 — Revision: 0 — Date: 6/10/91

TEST: 532-H43 Date 05/20/91

PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied

Composition (%) - Carbon:	47.450	Hydrogen:	3.620	Oxygen:	15.980	Nitrogen:	0.730	Sulfur:	0.340
Moisture:	10.830	Ash:	21.060	T250 (calc. deg F):	2718	HHV (Btu/lb):	7988		

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:

Duration (mins): 185 Section: ________ Time of Test: 22:48

FLOW RATES:

Coal PC (#/hr)	1154.000	LS (#/hr)	50.000	Total Air (#/hr)	15947.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14854.391
Combustion Air PC (kpph)	6.360	# Nozzles	________	Xcss Air SB (#/hr)	1093.130
Mix Bustle Air PC (kpph)	6.070	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2482.000
Coal MC (#/hr)	1328.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17929.195
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	1.332
Cmbn Air Sec Brnr (kpph)	0.175	Injector (tube):	50.000	Coal Split PC (%)	46.495
		Ca/S Ratio	1.717	Ca Utilization, %	32.700
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:	PCC phi	1.059
	PC phi	1.938
	MC phi	1.013
	Overall phi at Sec. Brnr	1.025

Clng Calc (Btu/sec) 374.400 Clng Meas (Btu/sec) 608.806 Flow #/sec 28.830
Total flow assumed equal over all 8 circuits:
FLUX (Btu/ft2-sec):

#1 AI	0.290	#2 AI	1.295	#3 BAF	2.800	#4 SRS	4.085
#5 SRS	2.696	#6 SRS	2.537	#7 PC ET	2.241	#9 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.330			
CO (ppm)	17.400	21.350	23.328	
NOx (ppm)	145.000	177.914	194.403	0.270
SO2 w/LS (ppm)	144.000	176.687	193.062	0.373
SOx w/o LS (ppm), calc	333.068	404.562	440.376	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 137.600 Preheat Outlet 406.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 624.000 FG Preheat Outlet 422.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH):	Boiler 15.020	Flash Tank	2.170	Total Steam	17.190
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.826 Cooling (Coal + N Gas) - % 11.055 Cooling H2O Inlet (deg F) 343.000
Coal + N. Gas - MMBtu/hr 19.826

RESULTS: Steam Gen Eff'cy (%) 81.753 Fuel to Steam Flow Corr. 0.932

Boiler Efficiency (%) 80.583 % SO2 Reduction 56.160 Intrusion Air (#/hr) 5776.41

REMARKS: ____________________

HEALY TESTS　　TEST SUMMARY　　# Pgs: 2　　Revision: 0
Date: 6/10/91

TEST: 533-h44　　Date 05/21/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL　　% CaCO3: 90.400　　NATURAL GAS: Btu/lb ________　　Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 147　　Section: ________　　Time of Test: 3:46

FLOW RATES:

Coal PC (#/hr)	1154.000	LS (#/hr)	42.500	Total Air (#/hr)	15652.521
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	14866.361
Combustion Air PC (kpph)	6.080	# Nozzles	________	Xcss Air SB (#/hr)	786.160
Mix Bustle Air PC (kpph)	5.880	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2484.000
Coal MC (#/hr)	1330.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17632.417
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	0.974
Cmbn Air Sec Brnr (kpph)	0.350	Injector (tube):	50.000	Coal Split PC (%)	46.457
		Ca/S Ratio	1.459	Ca Utilization, %	35.326
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.019	Clng Calc (Btu/sec)	338.400	Clng Meas (Btu/sec)	527.444	Flow #/sec	28.800
PC phi	1.810	Total flow assumed equal over all 8 circuits:					
MC phi	0.980	FLUX (Btu/ft2-sec):					
Overall phi at Sec. Brnr	1.004	#1 AI 0.508	#2 AI 1.118	#3 BAF 2.333	#4 SRS 3.432		
		#5 SRS 2.062	#6 SRS 2.537	#7 PC ET 2.241	#8 TAP 0.000		

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.250			
CO (ppm)	22.500	27.458	30.548	
NOx (ppm)	141.000	172.068	191.436	0.261
SO2 w/LS (ppm)	160.000	195.254	217.232	0.412
SOx w/o LS (ppm), calc	334.853	404.643	448.149	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 134.000　　Preheat Outlet 413.000　　Ambient 77.000

FLUE GAS TEMPERATURES (deg F):　　NATURAL GAS INPUTS:
FG Air Preheat Inlet 640.000　　FG Preheat Outlet 429.000　　N. Gas MMBtu/hr ________　　% of Total Load: N/A

STEAMS (KPPH): Boiler	15.010	Flash Tank	1.880	Total Steam	16.890
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.842　　Cooling (Coal + N Gas) - % 9.570　　Cooling H2O Inlet (deg F) 341.000
Coal + N. Gas - MMBtu/hr 19.842

RESULTS: Steam Gen Eff'cy (%) 81.613　　Fuel to Steam Flow Corr. 0.948

Boiler Efficiency (%) 80.724　　% SO2 Reduction 51.527　　Intrusion Air (#/hr) 5965.85

REMARKS: ____

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 0
Date: 6/10/91

TEST: 534-H45 Date 05/21/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 172 Section: ______ Time of Test: 8:29

FLOW RATES:

Coal PC (#/hr)	1171.000	LS (#/hr)	47.000	Total Air (#/hr)	15416.521
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stci Air (#/hr)	15075.830
Combustion Air PC (kpph)	6.000	# Nozzles	______	Xcss Air SB (#/hr)	340.630
Mix Bustle Air PC (kpph)	5.850	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2519.000
Coal MC (#/hr)	1348.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17426.060
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Crbn	0.427
Cmbr Air Sec Brnr (kpph)	0.224	Injector (tube):	50.000	Coal Split PC (%)	46.487
		Ca/S Ratio	1.591	Ca Utilization, %	33.269
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:
PCC phi 0.992 Clng Calc (Btu/sec) 339.400 Clng Meas (Btu/sec) 524.639 Flow #/sec 28.800
PC phi 1.827 Total flow assumed equal over all 8 circuits:
MC phi 0.959 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 0.974

#1 AI	0.435	#2 AI	1.060	#3 BAF	2.566	#4 SRS	3.268
#5 SRS	2.220	#6 SRS	2.379	#7 PC ET	2.241	#8 TAP	0.454

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.005			
CO (ppm)	30.620	36.756	42.010	
NOx (ppm)	130.860	157.084	179.538	0.238
SO2 w/LS (ppm)	157.800	189.423	216.500	0.400
SOx w/o LS (ppm), calc	340.079	404.602	459.845	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 138.700 Preheat Outlet 423.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 647.000 FG Preheat Outlet 441.000 N. Gas MMBtu/hr ______ % of Total Load: N/A

STEAMS (KPPH):	Boiler	15.940	Flash Tank	1.870	Total Steam	17.810
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	336.000	Flash Tank	336.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.122 Cooling (Coal + N Gas) - % 9.386 Cooling H2O Inlet (deg F) 341.000
Coal + N. Gas - MMBtu/hr 20.122

RESULTS: Steam Gen Eff'cy (%) 81.373 Fuel to Steam Flow Corr. 0.908

Boiler Efficiency (%) 80.510 % SO2 Reduction 52.919 Intrusion Air (#/hr) 6136.95

REMARKS: ______

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 0

Date: 6/10/91

TEST: 535-H46 Date 05/21/91

PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND

Ultimate Analysis Applied

Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340

Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________

Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:

Duration (mins): 149 Section: ________ Time of Test: 13:22

FLOW RATES:

Coal PC (#/hr)	1165.000	LS (#/hr)	51.000	Total Air (#/hr)	15142.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	15004.012
Combustion Air PC (kpph)	5.750	# Nozzles	________	Xcss Air SB (#/hr)	138.508
Mix Bustle Air PC (kpph)	5.440	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2507.000
Coal MC (#/hr)	1342.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17144.378
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	0.176
Cmbn Air Sec Brnr (kpph)	0.610	Injector (tube):	50.000	Coal Split PC (%)	46.470
		Ca/S Ratio	1.734	Ca Utilization, %	29.418
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 0.962 — Clng Calc (Btu/sec) 324.000 Clng Meas (Btu/sec) 505.842 Flow #/sec 28.800

PC phi 1.742 — Total flow assumed equal over all 8 circuits:

MC phi 0.920 — FLUX (Btu/ft2-sec):

Overall phi at Sec. Brnr 0.961

#1 AI	0.290	#2 AI	1.236	#3 BAF	2.800	#4 SRS	3.187
#5 SRS	2.141	#6 SRS	1.982	#7 PC ET	2.081	#9 TAP	0.227

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.920			
CO (ppm)	28.300	33.780	39.079	
NOx (ppm)	118.000	140.849	162.943	0.214
SO2 w/LS (ppm)	165.000	196.950	227.844	0.417
SO2 w/o LS (ppm), calc	341.866	404.557	465.174	

AIR TEMPERATURES (deg F):

Air Preheat Inlet 135.000 Preheat Outlet 395.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F):

FG Air Preheat Inlet 626.000 FG Preheat Outlet 414.500

NATURAL GAS INPUTS:

N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH):	Boiler	15.837	Flash Tank	1.803	Total Steam	17.640
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	337.500	Flash Tank	337.500	Feed H20 (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.026 Cooling (Coal + N Gas) - % 9.093 Cooling H20 Inlet (deg F) 342.500

Coal + N. Gas - MMBtu/hr 20.026

RESULTS: Steam Gen Eff'cy (%) 82.237 Fuel to Steam Flow Corr. 0.923

Boiler Efficiency (%) 81.552 % SO2 Reduction 51.020 Intrusion Air (#/hr) 6183.79

REMARKS: ____________________

TEST: 536-H47 Date 05/22/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 133 Section: ________ Time of Test: 1:30

FLOW RATES:

Coal PC (#/hr)	1150.000	LS (#/hr)	52.000	Total Air (#/hr)	15522.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14800.527
Combustion Air PC (kpph)	5.170	# Nozzles	________	Xcss Air SB (#/hr)	721.993
Mix Bustle Air PC (kpph)	6.010	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2473.000
Coal MC (#/hr)	1323.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17497.986
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	0.901
Cmbn Air Sec Brnr (kpph)	0.000	Injector (tube):	50.000	Coal Split PC (%)	46.502
		Ca/S Ratio	1.793	Ca Utilization, %	29.963
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 1.035 Clng Calc (Btu/sec) 363.240 Clng Meas (Btu/sec) 527.444 Flow #/sec 28.830
PC phi 1.908 Total flow assumed equal over all 8 circuits:
MC phi 1.000 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.000

#1 AI	0.915	#2 AI	0.977	#3 BAF	2.520	#4 SRS	3.317
#5 SRS	3.219	#6 SRS	1.951	#7 PC ET	2.379	#9 TAP	0.136

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.320			
CO (ppm)	13.000	15.940	17.799	
NOx (ppm)	123.000	150.817	168.402	0.229
SO2 w/LS (ppm)	152.000	186.376	208.106	0.394
SOx w/o LS (ppm), calc	333.264	404.539	449.592	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 131.000 Preheat Outlet 378.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 624.500 FG Preheat Outlet 407.500 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler 14.840 Flash Tank 1.880 Total Steam 16.720
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler 338.000 Flash Tank 338.000 Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.754 Cooling (Coal + N Gas) - % 9.613 Cooling H20 Inlet (deg F) 341.700
Coal + N. Gas - MMBtu/hr 19.754

RESULTS: Steam Gen Eff'cy (%) 82.214 Fuel to Steam Flow Corr. 0.961

Boiler Efficiency (%) 81.422 % SO2 Reduction 53.712 Intrusion Air (#/hr) 6107.82

REMARKS: ____

TEST: 537-H48 Date 05/22/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 169 Section: ________ Time of Test: 5:53

FLOW RATES:

Coal PC (#/hr)	1147.000	LS (#/hr)	51.000	Total Air (#/hr)	15782.521
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	14776.588
Combustion Air PC (kpph)	6.340	# Nozzles	________	Xcss Air SB (#/hr)	1005.933
Mix Bustle Air PC (kpph)	6.100	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2469.000
Coal MC (#/hr)	1322.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17754.381
Carrier Air MC (scfh)	21710.030	Nozzles (throat):	________	% O2 post SB Cmbn	1.238
Crbn Air Sec Brnr (kpph)	0.000	Injector (tube):	50.000	Coal Split PC (%)	46.456
		Ca/S Ratio	1.761	Ca Utilization, %	29.204
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.063	Clng Calc (Btu/sec) 421.200 Clng Meas (Btu/sec) 631.250 Flow #/sec 28.800
PC phi	1.951	Total flow assumed equal over all 8 circuits:
MC phi	1.019	FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr	1.019	

#1 AI	0.581	#2 AI	1.177	#3 BAF	3.266	#4 SRS	3.922
#5 SRS	3.330	#6 SRS	3.013	#7 PC ET	2.667	#8 TAP	3.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.220			
CO (ppm)	22.400	27.280	29.951	
NOx (ppm)	134.800	164.168	180.241	0.249
SO2 w/LS (ppm)	160.700	195.710	214.872	0.413
SO2 w/o LS (ppm), calc	335.419	404.549	442.383	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 138.200 Preheat Outlet 398.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 618.000 FG Preheat Outlet 413.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH):	Boiler	14.840	Flash Tank	2.250	Total Steam	17.090
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	337.000	Flash Tank	337.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.722 Cooling (Coal + N Gas) - % 11.522 Cooling H2O Inlet (deg F) 342.000
Coal + N. Gas - MMBtu/hr 19.722

RESULTS: Steam Gen Eff'cy (%) 82.103 Fuel to Steam Flow Corr. 0.936

Boiler Efficiency (%) 80.884 % SO2 Reduction 51.428 Intrusion Air (#/hr) 5661.82

REMARKS: ____

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 0
Date: 6/10/91

TEST: 539-H50 Date 05/22/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 196 Section: ________ Time of Test: 16:45

FLOW RATES:

Coal PC (#/hr)	1159.000	LS (#/hr)	50.000	Total Air (#/hr)	16168.521
Carrier Air PC (scfm)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14920.224
Combustion Air PC (kpph)	6.260	# Nozzles	________	Xcss Air SB (#/hr)	1248.296
Mix Bustle Air PC (kpph)	5.720	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2493.000
Coal MC (#/hr)	1334.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	18158.879
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	1.502
Cmbr Air Sec Brnr (kpph)	0.846	Injector (tube):	50.000	Coal Split PC (%)	46.490
		Ca/S Ratio	1.710	Ca Utilization, %	33.567
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:
PCC phi 1.040 Clng Calc (Btu/sec) 409.680 Clng Meas (Btu/sec) 541.753 Flow #/sec 28.800
PC phi 1.865 Total flow assumed equal over all 8 circuits:
MC phi 0.978 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.035

#1 AI	0.566	#2 AI	1.165	#3 BAF	2.776	#4 SRS	3.906
#5 SRS	3.473	#6 SRS	2.680	#7 PC ET	2.614	#9 TAP	0.409

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.120			
CO (ppm)	16.150	19.536	21.163	
NOx (ppm)	126.000	152.419	165.107	0.231
SO2 w/LS (ppm)	142.000	171.774	186.073	0.362
SOx w/o LS (ppm), calc	337.579	404.565	436.733	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 139.000 Preheat Outlet 395.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F):
FG Air Preheat Inlet 636.000 FG Preheat Outlet 415.000

NATURAL GAS INPUTS:
N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler	15.399	Flash Tank	1.931	Total Steam	17.330
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	336.000	Flash Tank	336.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.914 Cooling (Coal + N Gas) - % 9.794 Cooling H2O Inlet (deg F) 340.100
Coal + N. Gas - MMBtu/hr 19.914

RESULTS: Steam Gen Eff'cy (%) 82.106 Fuel to Steam Flow Corr. 0.933

Boiler Efficiency (%) 81.255 % SO2 Reduction 57.394 Intrusion Air (#/hr) 5333.64

REMARKS: ____

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 0
Date: 6/10/91

TEST: 540-H51 Date 05/23/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 44 Section: ________ Time of Test: 1:04

FLOW RATES:

Coal PC (#/hr)	1169.000	LS (#/hr)	52.500	Total Air (#/hr)	15497.521
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	15051.891
Combustion Air PC (kpph)	6.105	# Nozzles	________	Xcss Air SB (#/hr)	445.630
Mix Bustle Air PC (kpph)	6.050	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2515.000
Coal MC (#/hr)	1346.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	17505.365
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	0.556
Cmbn Air Sec Brnr (kpph)	0.000	Injector (tube):	50.000	Coal Split PC (%)	46.481
		Ca/S Ratio	1.780	Ca Utilization, %	31.710
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOIC. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.009	Clng Calc (Btu/sec) 385.200 Clng Meas (Btu/sec) 490.972 Flow #/sec 29.800
PC phi	1.874	Total flow assumed equal over all 8 circuits:
MC phi	0.991	FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr	0.981	#1 AI 0.435 #2 AI 1.295 #3 BAF 3.266 #4 SRS 4.085
		#5 SRS 2.855 #6 SRS 2.379 #7 PC ET 2.241 #9 TAP 0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.420			
CO (ppm)	6.170	7.617	8.652	
NOx (ppm)	181.000	223.457	253.797	0.339
SO2 w/LS (ppm)	142.000	175.309	199.111	0.371
SOx w/o LS (ppm), calc	331.120	404.543	457.009	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 139.000 Preheat Outlet 348.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 582.000 FG Preheat Outlet 357.000 N. Gas MMBtu/hr______ % of Total Load: N/A

STEAMS (KPPH):	Boiler 14.780	Flash Tank	1.750	Total Steam	16.530
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 335.000	Flash Tank	335.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.090 Cooling (Coal + N Gas) - % 8.798 Cooling H2O Inlet (deg F) 339.000
Coal + N. Gas - MMBtu/hr 20.090

RESULTS: Steam Gen Eff'cy (%) 83.777 Fuel to Steam Flow Corr. 1.008

Boiler Efficiency (%) 83.328 % SO2 Reduction 56.432 Intrusion Air (#/hr) 6655.75

REMARKS: ____

TEST: 541-H52 Date 05/23/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 184 Section: ______ Time of Test: 10:02

FLOW RATES:

Coal PC (#/hr)	1171.000	LS (#/hr)	47.000	Total Air (#/hr)	15472.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	15087.800
Combustion Air PC (kpph)	6.110	# Nozzles	______	Xcss Air SB (#/hr)	384.721
Mix Bustle Air PC (kpph)	6.020	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2521.000
Coal MC (#/hr)	1350.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17483.639
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	0.481
Cmbn Air Sec Brnr (kpph)	0.000	Injector (tube):	50.000	Coal Split PC (%)	46.450
		Ca/S Ratio	1.589	Ca Utilization, %	30.139

STOICHIOMETRIC AIR: (for Coal) 5.985 SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.985

PHI's: PCC phi 1.003
PC phi 1.867
MC phi 0.977
Overall phi at Sec. Brnr 0.977

Clng Calc (Btu/sec) 439.200 Clng Meas (Btu/sec) 639.667 Flow #/sec 28.800
Total flow assumed equal over all 8 circuits:
FLUX (Btu/ft2-sec):

#1 AI	0.435	#2 AI	1.177	#3 BAF	3.266	#4 SRS	4.576
#5 SRS	3.172	#6 SRS	2.896	#7 PC ET	3.308	#8 TAP	-0.454

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.630			
CO (ppm)	61.000	71.438	81.437	
NOx (ppm)	116.000	135.849	154.863	0.206
SO2 w/LS (ppm)	179.000	209.629	238.970	0.443
SOx w/o LS (ppm), calc	348.131	404.602	458.654	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 148.000 Preheat Outlet 410.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F):
FG Air Preheat Inlet 636.600 FG Preheat Outlet 433.000

NATURAL GAS INPUTS:
N. Gas MMBtu/hr ______ % of Total Load: N/A

STEAMS (KPPH):	Boiler 15.178	Flash Tank	2.280	Total Steam	17.450
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 337.000	Flash Tank	337.000	Feed H20 (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.138 Cooling (Coal + N Gas) - % 11.435 Cooling H20 Inlet (deg F) 342.000
Coal + N. Gas - MMBtu/hr 20.138

RESULTS: Steam Gen Eff'cy (%) 81.852 Fuel to Steam Flow Corr. 0.933

Boiler Efficiency (%) 80.600 % SO2 Reduction 47.902 Intrusion Air (#/hr) 5552.64

REMARKS: ______

TEST: 542-H53 Date 05/23/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG):______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 138 Section: ______ Time of Test: 19:18

FLOW RATES:

Coal PC (#/hr)	1160.000	LS (#/hr)	51.600	Total Air (#/hr)	17089.521
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	14941.171
Combustion Air PC (kpph)	6.380	# Nozzles	______	Xcss Air SB (#/hr)	2148.349
Mix Bustle Air PC (kpph)	6.165	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2496.500
Coal MC (#/hr)	1336.500	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	19083.358
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	2.459
Cmbn Air Sec Brnr (kpph)	1.202	Injector (tube):	50.000	Coal Split PC (%)	46.465
		Ca/S Ratio	1.762	Ca Utilization, %	30.015
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: POC phi 1.057 Clng Calc (Btu/sec) 482.400 Clng Meas (Btu/sec) 664.917 Flow #/sec 28.800
PC phi 1.945 Total flow assumed equal over all 8 circuits:
MC phi 1.015 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.095

#1 AI	1.016	#2 AI	1.295	#3 BAF	3.500	#4 SRS	4.902
#5 SRS	3.806	#6 SRS	3.013	#7 PC ET	2.988	#9 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.115			
CO (ppm)	13.692	16.557	17.055	
NOx (ppm)	115.000	139.066	143.245	0.210
SO2 w/LS (ppm)	157.400	190.339	196.059	0.401
SOx w/o LS (ppm), calc	337.672	404.548	416.159	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 140.200 Preheat Outlet 393.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 639.400 FG Preheat Outlet 418.800 N. Gas MMBtu/hr______ % of Total Load: N/A

STEAMS (KPPH): Boiler	16.000	Flash Tank	2.370	Total Steam	18.370
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	336.000	Flash Tank	336.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.942 Cooling (Coal + N Gas) - % 12.003 Cooling H2O Inlet (deg F) 340.000
Coal + N. Gas - MMBtu/hr 19.942

RESULTS: Steam Gen Eff'cy (%) 81.982 Fuel to Steam Flow Corr. 0.878

Boiler Efficiency (%) 80.639 % SO2 Reduction 52.888 Intrusion Air (#/hr) 4435.62

REMARKS: COMBUSTOR CLEANED PRIOR TO THIS TEST.

HEALY TESTS | TEST SUMMARY | # Pgs: 2 | Revision: 0
Date: 6/10/91

TEST: 543-H54 Date 05/24/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 129 Section: ________ Time of Test: 0:17

FLOW RATES:

Coal PC (#/hr)	1143.000	LS (#/hr)	51.000	Total Air (#/hr)	15222.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14719.732
Combustion Air PC (kpph)	6.150	# Nozzles	________	Xcss Air SB (#/hr)	502.789
Mix Bustle Air PC (kpph)	5.650	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2459.500
Coal MC (#/hr)	1316.500	C.A. Press (psig) Edc Nzl D'a	0.375	Total Gas (#/hr)	17186.882
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	0.639
Cmbn Air Sec Brnr (kpph)	0.080	Injector (tube):	50.000	Coal Split PC (%)	46.473
		Ca/S Ratio	1.768	Ca Utilization, %	28.899

STOICHIOMETRIC AIR: (for Coal) 5.985 SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.985

PHI's: PCC phi 1.039 Clng Calc (Btu/sec) 414.000 Clng Meas (Btu/sec) 565.600 Flow #/sec 28.800
PC phi 1.865 Total flow assumed equal over all 8 circuits:
MC phi 0.979 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 0.985

#1 AI	0.581	#2 AI	1.000	#3 BAF	2.803	#4 SRS	4.249
#5 SRS	3.648	#6 SRS	2.537	#7 PC ET	2.667	#9 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.790			
CO (ppm)	10.867	13.765	15.571	
NOx (ppm)	129.000	163.406	184.839	0.248
SO2 w/LS (ppm)	155.400	196.847	222.667	0.416
SO2 w/o LS (ppm), calc	323.180	404.546	455.231	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 135.800 Preheat Outlet 397.600 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 636.000 FG Preheat Outlet 418.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH):	Boiler	13.904	Flash Tank	2.016	Total Steam	15.920
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	337.000	Flash Tank	337.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.645 Cooling (Coal + N Gas) - % 10.364 Cooling H2O Inlet (deg F) 341.000
Coal + N. Gas - MMBtu/hr 19.646

RESULTS: Steam Gen Eff'cy (%) 81.579 Fuel to Steam Flow Corr. 0.996

Boiler Efficiency (%) 80.542 % SO2 Reduction 51.087 Intrusion Air (#/hr) 7022.58

REMARKS: ____

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 0
Date: 6/10/91

TEST: 544-H55 Date 05/23/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 160 Section: ________ Time of Test: 4:36

FLOW RATES:

Coal PC (#/hr)	1147.000	LS (#/hr)	48.900	Total Air (#/hr)	16651.521
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	14764.618
Combustion Air PC (kpph)	6.283	# Nozzles	________	Xcss Air SB (#/hr)	1886.902
Mix Bustle Air PC (kpph)	5.978	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2467.000
Coal MC (#/hr)	1320.000	C.A. Press (psig) Ecc Nzl Dia	0.375	Total Gas (#/hr)	18620.862
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	2.213
Crbn Air Sec Brnr (kpph)	1.048	Injector (tube):	50.000	Coal Split PC (%)	46.494
		Ca/S Ratio	1.690	Ca Utilization, %	30.739
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.054	Clng Calc (Btu/sec) 433.440 Clng Meas (Btu/sec) 575.139 Flow #/sec 28.900
PC phi	1.925	Total flow assumed equal over all 8 circuits:
MC phi	1.007	FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr	1.078	#1 AI 0.552 #2 AI 1.036 #3 BAF 3.453 #4 SRS 4.379
		#5 SRS 3.774 #6 SRS 2.823 #7 PC ET 2.753 #9 TAP -0.545

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.270			
CO (ppm)	54.800	66.965	69.891	
NOx (ppm)	123.300	150.672	157.256	0.228
SO2 w/LS (ppm)	158.800	194.053	202.532	0.409
SOx w/o LS (ppm), calc	334.364	404.571	421.456	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 138.800 Preheat Outlet 401.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 642.000 FG Preheat Outlet 417.000 N. Gas MMBtu/hr_______ % of Total Load: N/A

STEAMS (KPPH):	Boiler	15.800	Flash Tank	2.050	Total Steam	17.850
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	337.000	Flash Tank	337.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.706 Cooling (Coal + N Gas) - % 10.507 Cooling H2O Inlet (deg F) 340.203
Coal + N. Gas - MMBtu/hr 19.706

RESULTS: Steam Gen Eff'cy (%) 81.954 Fuel to Steam Flow Corr. 0.893

Boiler Efficiency (%) 80.928 % SO2 Reduction 51.945 Intrusion Air (#/hr) 4850.20

REMARKS: ____

TEST: 545-H56 Date 05/24/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied

Composition (%) - Carbon:	47.450	Hydrogen:	3.620	Oxygen:	15.980	Nitrogen:	0.730	Sulfur:	0.340
Moisture:	10.830	Ash:	21.063	T250 (calc. deg F):	2715	HHV (Btu/lb):	7988		

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 141 Section: ________ Time of Test: 9:28

FLOW RATES:

Coal PC (#/hr)	1167.000	LS (#/hr)	48.000	Total Air (#/hr)	16432.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	15030.944
Combustion Air PC (kpph)	6.280	# Nozzles	________	Xcss Air SB (#/hr)	1401.577
Mix Bustle Air PC (kpph)	6.050	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2511.500
Coal MC (#/hr)	1344.500	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	18436.587
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	1.661
Cmbn Air Sec Brnr (kpph)	0.750	Injector (tube):	50.000	Coal Split PC (%)	46.466
		Ca/S Ratio	1.629	Ca Utilization, %	33.895
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 1.036 Clng Calc (Btu/sec) 450.000 Clng Meas (Btu/sec) 614.417 Flow #/sec 28.830
PC phi 1.904 Total flow assumed equal over all 8 circuits:
MC phi 0.995 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.045

#1 AI	0.726	#2 AI	1.413	#3 BAF	4.433	#4 SRS	4.085
#5 SRS	3.965	#6 SRS	2.537	#7 PC ET	2.454	#9 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.650			
CO (ppm)	25.700	30.137	32.379	
NOx (ppm)	113.000	132.508	142.368	0.201
SO2 w/LS (ppm)	154.000	180.586	194.024	0.381
SOx w/o LS (ppm), calc	347.691	404.590	433.346	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 133.000 Preheat Outlet 397.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F):
FG Air Preheat Inlet 638.000 FG Preheat Outlet 415.000

NATURAL GAS INPUTS:
N. Gas MMBtu/hr ________ % of Total Load: N/A

STEAMS (KPPH): Boiler	17.250	Flash Tank	2.190	Total Steam	19.440
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	334.800	Flash Tank	334.800	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.062 Cooling (Coal + N Gas) - % 11.025 Cooling H2O Inlet (deg F) 339.000
Coal + N. Gas - MMBtu/hr 20.062

RESULTS: Steam Gen Eff'cy (%) 82.390 Fuel to Steam Flow Corr. 0.838

Boiler Efficiency (%) 81.307 % SO2 Reduction 55.227 Intrusion Air (#/hr) 4541.94

REMARKS: ________________________________

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 0
Date: 6/10/91

TEST: 548-H59 Date 05/29/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 108 Section: ________ Time of Test: 00:18

FLOW RATES:

Coal PC (#/hr)	1154.000	LS (#/hr)	50.000	Total Air (#/hr)	15472.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14860.376
Combustion Air PC (kpph)	6.200	# Nozzles	________	Xcss Air SB (#/hr)	612.145
Mix Bustle Air PC (kpph)	5.930	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2483.000
Coal MC (#/hr)	1329.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17454.985
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	0.766
Cmbr Air Sec Brnr (kpph)	0.000	Injector (tube):	50.000	Coal Split PC (%)	46.476
		Ca/S Ratio	1.717	Ca Utilization, %	31.318
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 1.036 Clng Calc (Btu/sec) 370.800 Clng Meas (Btu/sec) 527.444 Flow #/sec 28.800
PC phi 1.895 Total flow assumed equal over all 8 circuits:
MC phi 0.992 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 0.992

#1 AI	0.871	#2 AI	1.413	#3 BAF	2.566	#4 SRS	3.432
#5 SRS	2.379	#6 SRS	2.537	#7 PC ET	2.134	#9 TAP	0.908

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.010			
CO (ppm)	9.380	11.264	12.661	
NOx (ppm)	156.000	187.325	210.573	0.284
SO2 w/LS (ppm)	155.000	186.124	209.224	0.393
SOx w/o LS (ppm), calc	339.939	404.582	452.522	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 141.000 Preheat Outlet 358.500 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 548.500 FG Preheat Outlet 371.000 N. Gas MMBtu/hr_______ % of Total Load: N/A

STEAMS (KPPH): Boiler 15.040 Flash Tank 1.880 Total Steam 16.920
Press. (psig): Boiler 103.000 Flash Tank 103.000
Temps. (dg F): Boiler 336.000 Flash Tank 336.000 Feed H20 (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.834 Cooling (Coal + N Gas) - % 9.573 Cooling H2O Inlet (deg F) 341.000
Coal + N. Gas - MMBtu/hr 19.834

RESULTS: Steam Gen Eff'cy (%) 83.552 Fuel to Steam Flow Corr. 0.969

Boiler Efficiency (%) 82.924 % SO2 Reduction 53.765 Intrusion Air (#/hr) 5780.87

REMARKS: ____

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 0
Date: 6/10/91

TEST: 549-H60 Date 05/29/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 157 Section: ________ Time of Test: 6:07

FLOW RATES:

Coal PC (#/hr)	1140.000	LS (#/hr)	50.500	Total Air (#/hr)	15108.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14686.815
Combustion Air PC (kpph)	5.964	# Nozzles	________	Xcss Air SB (#/hr)	421.705
Mix Bust'e Air PC (kpph)	5.802	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2454.000
Coal MC (#/hr)	1314.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17068.316
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	0.540
Crbn Air Sec Brnr (kpph)	0.000	Injector (tube):	50.000	Coal Split PC (%)	46.455
		Ca/S Ratio	1.754	Ca Utilization, %	28.763
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.014	Clng Calc (Btu/sec) 363.600 Clng Meas (Btu/sec) 490.411 Flow #/sec	28.800
PC phi	1.865	Total flow assumed equal over all 8 circuits:	
MC phi	0.979	FLUX (Btu/ft2-sec):	
Overall phi at Sec. Brnr	0.979	#1 AI 0.798 #2 AI 1.236 #3 BAF 2.450 #4 SRS	3.350
		#5 SRS 2.617 #6 SRS 2.458 #7 PC ET 2.187 #8 TAP	0.691

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.739			
CO (ppm)	27.000	31.846	36.199	
NOx (ppm)	130.000	153.332	174.290	0.233
SO2 w/LS (ppm)	169.000	199.332	226.577	0.421
SOx w/o LS (ppm), calc	345.747	404.551	457.369	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 142.500 Preheat Outlet 390.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 602.000 FG Preheat Outlet 410.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH):	Boiler	15.132	Flash Tank	1.748	Total Steam	16.880
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	336.500	Flash Tank	336.500	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.603 Cooling (Coal + N Gas) - % 9.006 Cooling H2O Inlet (deg F) 340.500
Coal + N. Gas - MMBtu/hr 19.603

RESULTS: Steam Gen Eff'cy (%) 82.478 Fuel to Steam Flow Corr. 0.947

Boiler Efficiency (%) 81.841 % SO2 Reduction 50.461 Intrusion Air (#/hr) 5510.39

REMARKS: ____

HEALY TESTS | TEST SUMMARY | # Pgs: 2 | Revision: 0
Date: 6/10/91

TEST: 553-H61 Date 05/29/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 196 Section: ________ Time of Test: 11:12

FLOW RATES:

Coal PC (#/hr)	1168.000	LS (#/hr)	50.000	Total Air (#/hr)	15902.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	15033.936
Combustion Air PC (kpph)	6.280	# Nozzles	________	Xcss Air SB (#/hr)	868.584
Mix Bustle Air PC (kpph)	6.280	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2512.000
Coal MC (#/hr)	1344.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	17907.877
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbr	1.059
Crbn Air Sec Brnr (kpph)	0.000	Injector (tube):	50.000	Coal Split PC (%)	46.497
		Ca/S Ratio	1.697	Ca Utilization, %	26.327
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's:

PCC phi	1.035	Clng Calc (Btu/sec)	367.920	Clng Meas (Btu/sec)	533.617	Flow #/sec	28.800		
PC phi	1.933	Total flow assumed equal over all 8 circuits:							
MC phi	1.009	FLUX (Btu/ft2-sec):							
Overall phi at Sec. Brnr	1.009	#1 AI	0.479	#2 AI	1.330	#3 BAF	2.613	#4 SRS	3.481
		#5 SRS	2.648	#6 SRS	2.648	#7 PC ET	2.187	#9 TAP	0.545

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.920			
CO (ppm)	41.100	49.058	54.347	
NOx (ppm)	132.000	157.563	174.546	0.239
SO2 w/LS (ppm)	186.700	222.851	246.876	0.470
SOx w/o LS (ppm), calc	341.876	404.569	446.229	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 140.300 Preheat Outlet 384.500 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 596.300 FG Preheat Outlet 401.300 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH):	Boiler	14.598	Flash Tank	1.902	Total Steam	16.500
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	337.000	Flash Tank	337.000	Feed H20 (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 20.066 Cooling (Coal + N Gas) - % 9.574 Cooling H20 Inlet (deg F) 342.000
Coal + N. Gas - MMBtu/hr 20.066

RESULTS: Steam Gen Eff'cy (%) 82.654 Fuel to Steam Flow Corr. 0.995

Boiler Efficiency (%) 81.915 % SO2 Reduction 44.675 . Intrusion Air (#/hr) 5466.14

REMARKS: ______________________________

HEALY TESTS　　TEST SUMMARY　　# Pgs: 2　　Revision: 0
Date: 6/10/9'

TEST: 551-H62　　Date 05/29/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied
Composition (%) - Carbon: 47.450 Hydrogen: 3.620 Oxygen: 15.980 Nitrogen: 0.730 Sulfur: 0.340
Moisture: 10.830 Ash: 21.060 T250 (calc. deg F): 2715 HHV (Btu/lb): 7988

LIMESTONE:CANTWELL　　% CaCO3: 90.400　　NATURAL GAS: Btu/lb ______　　Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG):______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 93　　Section: ______　　Time of Test: 18:17

FLOW RATES:

Coal PC (#/hr)	1153.000	LS (#/hr)	49.500	Total Air (#/hr)	17222.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14842.421
Combustion Air PC (kpph)	6.140	# Nozzles	______	Xcss Air SB (#/hr)	2380.099
Mix Bustle Air PC (kpph)	6.050	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2480.000
Coal MC (#/hr)	1327.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	19202.393
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbr	2.707
Cmbn Air Sec Brnr (kpph)	1.690	Injector (tube):	50.000	Coal Split PC (%)	46.492
		Ca/S Ratio	1.702	Ca Utilization, %	20.030
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi 1.028　　Clng Calc (Btu/sec) 349.200 Clng Meas (Btu/sec) 482.556 Flow #/sec 28.800
PC phi 1.905　　Total flow assumed equal over all 8 circuits:
MC phi 0.997　　FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.111

#1 AI	0.290	#2 AI	1.413	#3 BAF	2.333	#4 SRS	2.941
#5 SRS	2.696	#6 SRS	2.696	#7 PC ET	2.134	#9 TAP	0.454

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.167			
CO (ppm)	25.000	30.338	30.831	
NOx (ppm)	132.000	160.183	162.786	0.242
SO2 w/LS (ppm)	219.600	266.487	270.817	0.561
SOx w/o LS (ppm), calc	336.572	404.567	410.846	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 138.000　　Preheat Outlet 381.000　　Ambient 77.000

FLUE GAS TEMPERATURES (deg F):　　NATURAL GAS INPUTS:
FG Air Preheat Inlet 620.500　　FG Preheat Outlet 401.800　　N. Gas MMBtu/hr______　　% of Total Load: N/A

STEAMS (KPPH):	Boiler 15.060	Flash Tank	1.720	Total Steam	16.780
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.810　　Cooling (Coal + N Gas) - % 8.769　　Cooling H2O Inlet (deg F) 341.000
Coal + N. Gas - MMBtu/hr 19.810

RESULTS: Steam Gen Eff'cy (%) 82.497　　Fuel to Steam Flow Corr. 0.963

Boiler Efficiency (%) 81.903　　% SO2 Reduction 34.083　　Intrusion Air (#/hr) 4237.54

REMARKS: ______________________________

HEALY TESTS　　TEST SUMMARY　　# Pgs: 2　　Revision: 0
Date: 6/10/91

TEST: 552-H63　　Date 05/29/91
PURPOSE: GENERATE 5 TONS OF BAGHOUSE CATCH FOR NIRO

COAL: Source: HEALY PERF BLEND
Ultimate Analysis Applied

Composition (%) - Carbon:	47.450	Hydrogen:	3.620	Oxygen:	15.980	Nitrogen:	0.730	Sulfur:	0.340
Moisture:	10.830	Ash:	21.060	T250 (calc. deg F):	2715			HHV (Btu/lb):	7986

LIMESTONE: CANTWELL　　% CaCO3: 90.400　　NATURAL GAS: Btu/lb ________　　Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 111　　Section: ________　　Time of Test: 22:04

FLOW RATES:

Coal PC (#/hr)	1134.000	LS (#/hr)	48.600	Total Air (#/hr)	17787.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14603.027
Combustion Air PC (kpph)	6.435	# Nozzles	________	Xcss Air SB (#/hr)	3184.493
Mix Bustle Air PC (kpph)	6.230	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2440.000
Coal MC (#/hr)	1306.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	19735.503
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	3.525
Cmbn Air Sec Brnr (kpph)	1.780	Injector (tube):	50.000	Coal Split PC (%)	46.475
		Ca/S Ratio	1.705	Ca Utilization, %	32.145
STOICHIOMETRIC AIR: (for Coal)	5.985	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.985				

PHI's: PCC phi	1.089	Clng Calc (Btu/sec)	360.000	Clng Meas (Btu/sec)	475.542	Flow #/sec	28.803
PC phi	2.007	Total flow assumed equal over all 8 circuits:					
MC phi	1.046	FLUX (Btu/ft2-sec):					
Overall phi at Sec. Brnr	1.168	#1 AI 0.435	#2 AI 1.295	#3 BAF 2.566	#4 SRS 3.432		
		#5 SRS 2.696	#6 SRS 2.379	#7 PC ET 2.241	#9 TAP 0.454		

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.350			
CO (ppm)	83.000	101.980	99.007	
NOx (ppm)	142.500	175.085	169.982	0.264
SO2 w/LS (ppm)	149.000	183.072	177.735	0.384
SOx w/o LS (ppm), calc	332.642	404.566	393.300	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 133.800　　Preheat Outlet 403.000　　Ambient 77.000

FLUE GAS TEMPERATURES (deg F):　　NATURAL GAS INPUTS:
FG Air Preheat Inlet 620.500　　FG Preheat Outlet 422.000　　N. Gas MMBtu/hr______　　% of Total Load: N/A

STEAMS (KPPH):	Boiler 16.775	Flash Tank	1.695	Total Steam	18.470
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 335.000	Flash Tank	335.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.491　　Cooling (Coal + N Gas) - % 8.783　　Cooling H2O Inlet (deg F) 339.000
Coal + N. Gas - MMBtu/hr 19.491

RESULTS: Steam Gen Eff'cy (%) 81.742　　Fuel to Steam Flow Corr. 0.851

Boiler Efficiency (%) 81.061　　% SO2 Reduction 54.809　　Intrusion Air (#/hr) 3598.82

REMARKS: ______________________________________

HEALY TESTS	SLAG RECVRY %	COAL GRIND	DAMPER POS. A/B%	PC EXIT FT/S	COAL INJ. DEPTH IN.	PCC PHI	PC PHI	HC PHI	SB PHI	LOAD MMBTU /HR	COAL PC #/HR	COAL HC #/HR	COAL SPLIT %	PCCA KPPH	PCHD KPPH	SBCA KPPH	INTR. AIR #/HR	O2 SB %	O2 STACK %	CO @3% PPM	NOX @3% PPM	NOX #/MMBTU
553-TBR1			0/50	154	6	1.33	1.96	0.94	1.05	12.0	679	1060	39.0	4.02	2.37	1.02	6167	2.12	8.80	19	193	0.292
554-TBR2			0/50	254	6	0.98	2.05	0.91	1.05	20.0	1060	1650	39.0	4.79	6.23	2.03	6549	0.84	6.53	111	174	0.264
555-TBR3			0/50	343	6	0.79	1.42	0.74	0.91	25.4	1600	1855	46.3	6.00	5.55	3.15	9032	-1.05	5.80	31	207	0.318
556-TBR4		95	0/50	347	6	0.90	2.06	1.06	1.31	23.2	1480	1674	46.9	6.39	9.47	4.33	1048	4.71	5.89	82	241	0.361
557-TBR5	54	97	0/75	313	6	0.88	2.06	1.06	1.43	23.1	1474	1666	46.9	6.16	9.60	6.45	-140	6.06	5.97	156	242	0.361
558-TBR6	40		0/75	321	6	0.85	2.03	1.04	1.32	23.9	1523	1720	47.0	6.21	9.84	4.93	1096	4.81	5.50	130	343	0.514
559-TBR7	43	96	100/100	180	6	0.87	2.00	1.07	1.40	23.3	1489	1683	46.9	6.22	9.91	5.70	455	5.73	6.00	126	224	0.336
560-TBR8		82	100/100	180	6	0.91	2.09	1.08	1.42	23.2	1482	1675	46.9	6.49	9.66	6.03	-280	5.96	5.79	234	211	0.315
561-TBR9	49		100/100	182	6	0.90	2.07	1.07	1.27	23.6	1504	1700	46.9	6.52	9.71	3.53	2350	4.16	5.70	344	253	0.380
562-TBR10	30		0/50	279	6	1.04	1.94	1.03	1.23	18.7	1192	1347	46.9	5.07	5.91	2.79	2755	3.66	5.96	207	236	0.355
563-TBR11		92	0/50	278	6	1.13	2.09	1.10	1.43	17.0	1135	1282	47.0	6.12	5.98	4.34	-590	6.54	6.11	186	231	0.345
564-TBR12	73	88	0/50	274	6	1.10	2.07	1.09	1.35	17.0	1134	1281	47.0	5.95	6.01	3.47	1103	5.70	6.60	30	226	0.340
AVG	48			259		0.97	1.99	1.02	1.26	21.1	1313	1550	45.6	5.09	7.52	3.99	2527	4.11	6.23	138	232	0.348

Table B4. Two Bull Ridge Parametric Test Data

REALT TESTS	SO2 @3% PPM	SO2 U/O LS	LS t/HR	CA/S RATIO	S %	SO2 REDUC %	PC EXIT DEG F	TOT STM KPPH	COOL LOAD %	BLR EFF %	FUEL /STM CORR	HEAT LOSS Bt/s	FLX 1 Btu/ f2-s	FLX 2 Btu/ f2-s	FLX 3 Btu/ f2-s	FLX 4 Btu/ f2-s	FLX 5 Btu/ f2-s	FLX 6 Btu/ f2-s	FLX 7 Btu/ f2-s	FLX 9 Btu/ f2-s	COMMENTS:
553-TBR1	240	465	40.0	2.22	0.36	48.2	2000	0.0	14.9	82.7	1.21	529	0.87	1.29	2.57	3.60	2.06	1.74	2.56	0.00	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
554-TBR2	289	464			0.36	37.7	1950	15.9	7.1	83.0	1.05	394	0.58	1.86	1.63	2.61	1.59	1.27	2.24	0.00	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
555-TBR3	371	461	553.0	12.89	0.36	18.7	2450	16.9	6.2	82.2	1.21	435	1.02	0.82	1.17	1.80	1.74	1.59	3.20	1.36	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
556-TBR4	331	464			0.36	29.2	1950	19.1	7.2	83.2	1.00	463	1.02	1.06	0.93	1.63	2.38	2.06	2.13	0.91	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
557-TBR5	346	464			0.36	26.4	1950	21.1	6.0	82.7	0.89	385	0.87	0.71	1.17	2.29	1.27	1.27	2.13	0.91	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
558-TBR6	242	464			0.36	48.4	1950	18.5	4.8	84.1	1.07	317	0.73	1.06	0.93	1.63	1.11	1.27	1.71	0.91	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
559-TBR7	302	464			0.36	18.7	1950	19.6	5.7	82.3	0.97	370	0.44	1.06	1.17	2.61	1.43	0.95	1.92	0.00	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
560-TBR8	348	464			0.36	25.9	1950	19.6	5.3	82.3	0.96	339	0.58	1.06	1.63	2.61	1.59	1.11	2.03	-0.45	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
561-TBR9	313	464			0.36	33.0	1950	16.0	6.9	86.0	1.21	452	0.44	0.82	1.17	2.29	2.54	1.90	1.17	0.91	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
562-TBR10	365	464			0.36	21.0	2000	15.3	6.6	83.9	1.02	342	0.58	0.82	0.70	1.63	1.59	1.59	1.17	1.36	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
563-TBR11	310	465	82.0	2.73	0.36	32.3	1950	16.1	6.2	83.9	0.91	309	0.58	0.82	0.70	1.31	0.95	1.11	1.07	1.36	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
564-TBR12	324	464	166.0	5.53	0.36	30.7	1950	14.5	4.7	83.1	0.99	230	0.29	0.82	0.93	1.31	0.79	0.63	1.07	0.45	TESTS TO IDENTIFY OPERATING CONDITIONS FOR TBR COAL
AVG	322	465	212.3	5.04	0.36	30.9	2000	16.8	6.8	83.3	1.04	380	0.67	0.95	1.22	2.11	1.59	1.37	1.07	0.64	

Table B4. (Continued)

TEST: 553-TBR1 Date 05/30/90
PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE
Ultimate Analysis Applied
Composition (%) - Carbon: 43.500 Hydrogen: 3.410 Oxygen: 14.830 Nitrogen: 0.760 Sulfur: 0.360
Moisture: 9.820 Ash: 27.320 T250 (calc. deg F): 2876 HHV (Btu/lb): 7358

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 31 Section: 1 OF 1 Time of Test: 19:57

FLOW RATES:

Coal PC (#/hr)	679.000	LS (#/hr)	40.000	Total Air (#/hr)	10752.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	9585.494
Combustion Air PC (kpph)	4.020	# Nozzles	________	Xcss Air SB (#/hr)	1167.027
Mix Bustle Air PC (kpph)	2.370	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	1739.000
Coal MC (#/hr)	1060.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	12037.914
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	2.118
Cmbn Air Sec Brnr (kpph)	1.020	Injector (tube):	50.000	Coal Split PC (%)	39.045
		Ca/S Ratio	2.222	Ca Utilization, %	21.667

STOICHIOMETRIC AIR: (for Coal) 5.512 SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.512

PHI's:
PCC phi 1.329
PC phi 1.962
MC phi 0.939
Overall phi at Sec. Brnr 1.046

Clng Calc (Btu/sec) 352.800 Clng Meas (Btu/sec) 528.847 Flow #/sec 28.000
Total flow assumed equal over all 8 circuits:
FLUX (Btu/ft2-sec):

#1 AI	0.871	#2 AI	1.295	#3 BAF	2.666	#4 SRS	3.595
#5 SRS	2.962	#6 SRS	1.744	#7 PC ET	2.561	#8 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	9.800			
CO (ppm)	13.000	19.180	20.121	
NOx (ppm)	131.000	193.276	202.753	0.282
SO2 w/LS (ppm)	163.000	240.492	252.280	0.507
SOx w/o LS (ppm), calc	321.817	464.918	486.580	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 146.000 Preheat Outlet 284.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 426.000 FG Preheat Outlet 299.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler	6.935	Flash Tank	1.885	Total Steam	8.820
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	336.000	Flash Tank	336.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 12.796 Cooling (Coal + N Gas) - % 14.879 Cooling H2O Inlet (deg F) 340.000
Coal + N. Gas - MMBtu/hr 12.796

RESULTS: Steam Gen Eff'cy (%) 83.767 Fuel to Steam Flow Corr. 1.210

Boiler Efficiency (%) 82.669 % SO2 Reduction 48.152 Intrusion Air (#/hr) 6167.86

REMARKS:

HEALY TESTS   TEST SUMMARY   # Pgs: 2   Revision: 0
Date: 6/19/91

TEST: 554-TBR2   Date 05/31/91
PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE
Ultimate Analysis Applied
Composition (%) - Carbon: 43.500 Hydrogen: 3.410 Oxygen: 14.830 Nitrogen: 0.760 Sulfur: 0.360
Moisture: 9.820 Ash: 27.320 T250 (calc. deg F): 2876 HHV (Btu/lb): 7358

LIMESTONE:CANTWELL   % CaCO3: 90.400   NATURAL GAS: Btu/lb ________   Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 97   Section: 1 OF 1   Time of Test: 9:54

FLOW RATES:

Coal PC (#/hr)	1060.000	LS (#/hr)	________	Total Air (#/hr)	15663.644
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	14981.813
Combustion Air PC (kpph)	4.790	# Nozzles	________	Xcss Air SB (#/hr)	681.831
Mix Bustle Air PC (kpph)	6.230	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	2718.000
Coal MC (#/hr)	1658.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	17639.086
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	0.844
Cmbn Air Sec Brnr (kpph)	2.030	Injector (tube):	50.000	Coal Split PC (%)	38.999
		Ca/S Ratio	N/A	Ca Utilization, %	________

STOICHIOMETRIC AIR: (for Coal) 5.512   SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.512

PHI's:
PCC phi 0.983   Clng Calc (Btu/sec) 270.000 Clng Meas (Btu/sec) 394.181 Flow #/sec 28.000
PC phi 2.050   Total flow assumed equal over all 8 circuits:
MC phi 0.910   FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.046

#1 AI	0.581	#2 AI	1.060	#3 BAF	1.633	#4 SRS	2.615
#5 SRS	1.586	#6 SRS	1.269	#7 PC ET	2.241	#8 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.530			
CO (ppm)	89.000	110.712	123.970	
NOx (ppm)	140.000	174.153	195.010	0.264
SO2 w/LS (ppm)	232.000	288.597	323.159	0.609
SOx w/o LS (ppm), calc	370.489	465.737	519.014	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 137.000   Preheat Outlet 351.000   Ambient 77.000

FLUE GAS TEMPERATURES (deg F):   NATURAL GAS INPUTS:
FG Air Preheat Inlet 670.000   FG Preheat Outlet 370.000   N. Gas MMBtu/hr________   % of Total Load: N/A

STEAMS (KPPH):	Boiler 14.485	Flash Tank	1.405	Total Steam	15.890
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 337.000	Flash Tank	337.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 19.999   Cooling (Coal + N Gas) - % 7.096   Cooling H2O Inlet (deg F) 340.000
Coal + N. Gas - MMBtu/hr 19.999

RESULTS: Steam Gen Eff'cy (%) 82.901   Fuel to Steam Flow Corr. 1.033

Boiler Efficiency (%) 82.950   % SO2 Reduction 37.736   Intrusion Air (#/hr) 6548.98

REMARKS: ____

HEALY TESTS — TEST SUMMARY — # Pgs: 2 — Revision: 0 — Date: 6/19/91

TEST: 555-TBR3 — Date 06/03/91

PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE
Ultimate Analysis Applied

Composition (%) - Carbon:	43.500	Hydrogen:	3.410	Oxygen:	14.830	Nitrogen:	0.760	Sulfur:	0.360
Moisture:	9.820	Ash:	27.320	T250 (calc. deg F):	2876			HHV (Btu/lb):	7358

LIMESTONE: CANTWELL — % CaCO3: 90.400 — NATURAL GAS: Btu/lb ________ — Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 70 — Section: 1 OF 1 — Time of Test: 18:22

FLOW RATES:

Coal PC (#/hr)	1600.000	LS (#/hr)	553.000	Total Air (#/hr)	18042.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	19044.210
Combustion Air PC (kpph)	6.000	# Nozzles	________	Xcss Air SB (#/hr)	-1001.690
Mix Bustle Air PC (kpph)	5.550	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	3455.000
Coal MC (#/hr)	1855.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	20801.182
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	-1.052
Cmbn Air Sec Brnr (kpph)	3.150	Injector (tube):	50.000	Coal Split PC (%)	46.310
		Ca/S Ratio	12.887	Ca Utilization, %	1.448
STOICHIOMETRIC AIR: (for Coal)	5.512	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.512				

PHI's:

PCC phi	0.789	Clng Calc (Btu/sec)	302.400	Clng Meas (Btu/sec)	434.861	Flow #/sec	28.000
PC phi	1.418	Total flow assumed equal over all 8 circuits:					
MC phi	0.744	FLUX (Btu/ft2-sec):					
Overall phi at Sec. Brnr	0.909						

#1 AI	1.016	#2 AI	0.824	#3 BAF	1.167	#4 SRS	1.798
#5 SRS	1.744	#6 SRS	1.586	#7 PC ET	3.201	#8 TAP	1.362

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.880			
CO (ppm)	26.000	30.952	37.920	
NOx (ppm)	174.000	207.143	253.772	0.318
SO2 w/LS (ppm)	312.000	371.429	455.039	0.795
SOx w/o LS (ppm), calc	390.569	461.032	569.456	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 136.000 — Preheat Outlet 356.000 — Ambient 77.000

FLUE GAS TEMPERATURES (deg F):
FG Air Preheat Inlet 640.000 — FG Preheat Outlet 303.000

NATURAL GAS INPUTS:
N. Gas MMBtu/hr ________ — % of Total Load: N/A

STEAMS (KPPH):	Boiler 15.320	Flash Tank	1.550	Total Steam	16.870
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 25.422 — Cooling (Coal + N Gas) - % 6.158 — Cooling H2O Inlet (deg F) 341.000
Coal + N. Gas - MMBtu/hr 25.422

RESULTS: Steam Gen Eff'cy (%) 80.686 — Fuel to Steam Flow Corr. 1.207

Boiler Efficiency (%) 82.227 — % SO2 Reduction 18.664 — Intrusion Air (#/hr) 9832.44

REMARKS: ________________________________

HEALY TESTS — TEST SUMMARY — # Pgs: 2 — Revision: 0 — Date: 6/19/91

TEST: 556-TBR4 — Date 06/04/91

PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE

Ultimate Analysis Applied

Composition (%) - Carbon: 43.500 Hydrogen: 3.410 Oxygen: 14.830 Nitrogen: 0.760 Sulfur: 0.360

Moisture: 9.820 Ash: 27.320 T250 (calc. deg F): 2876 HHV (Btu/lb): 7358

LIMESTONE:CANTWELL — % CaCO3: 90.400 — NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________

Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:

Duration (mins): 60 — Section: 1 OF 1 — Time of Test: 17:51

FLOW RATES:

Coal PC (#/hr)	1480.000	LS (#/hr)	________	Total Air (#/hr)	22798.644
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	17385.077
Combustion Air PC (kpph)	6.385	# Nozzles	________	Xcss Air SB (#/hr)	5413.567
Mix Bustle Air PC (kpph)	9.470	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3154.000
Coal NC (#/hr)	1674.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	25890.971
Carrier Air NC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	4.713
Cmbn Air Sec Brnr (kpph)	4.330	Injector (tube):	50.000	Coal Split PC (%)	46.925
		Ca/S Ratio	N/A	Ca Utilization, %	________
STOICHIOMETRIC AIR: (for Coal)	5.512	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.512				

PHI's:

PCC phi	0.900
PC phi	2.061
NC phi	1.062
Overall phi at Sec. Brnr	1.311

Clng Calc (Btu/sec) 288.000 Clng Meas (Btu/sec) 462.917 Flow #/sec 20.800

Total flow assumed equal over all 8 circuits:

FLUX (Btu/ft2-sec):

#1 AI	1.016	#2 AI	1.060	#3 BAF	0.933	#4 SRS	1.634
#5 SRS	2.379	#6 SRS	2.062	#7 PC ET	2.134	#8 TAP	0.908

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.088			
CO (ppm)	68.500	81.591	73.826	
NOx (ppm)	202.000	240.603	217.707	0.361
SO2 w/LS (ppm)	278.000	331.128	299.616	0.692
SOx w/o LS (ppm), calc	394.356	465.737	423.399	

AIR TEMPERATURES (deg F):

Air Preheat Inlet 124.000 — Preheat Outlet 342.000 — Ambient 77.000

FLUE GAS TEMPERATURES (deg F):

FG Air Preheat Inlet 662.000 — FG Preheat Outlet 374.000

NATURAL GAS INPUTS: N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH):	Boiler 17.450	Flash Tank	1.650	Total Steam	19.100
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 23.207 — Cooling (Coal + N Gas) - % 7.181 — Cooling H2O Inlet (deg F) 342.000

Coal + N. Gas - MMBtu/hr 23.207

RESULTS: Steam Gen Eff'cy (%) 83.115 — Fuel to Steam Flow Corr. 0.999

Boiler Efficiency (%) 83.170 — % SO2 Reduction 29.236 — Intrusion Air (#/hr) 1047.80

REMARKS: ____

HEALY TESTS	TEST SUMMARY	# Pgs: 2	Revision: 0
			Date: 6/19/91

TEST: 557-TBR5 Date 06/04/91
PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE
Ultimate Analysis Applied

Composition (%) - Carbon:	43.500	Hydrogen:	3.410	Oxygen:	14.830	Nitrogen:	0.760	Sulfur:	0.360
Moisture:	9.820	Ash:	27.320	T250 (calc. deg F):	2076			HHV (Btu/lb):	7358

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 31 Section: 1 OF 1 Time of Test: 21:18

FLOW RATES:

Coal PC (#/hr)	1474.000	LS (#/hr)	______	Total Air (#/hr)	24823.644
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	17307.908
Combustion Air PC (kpph)	6.160	# Nozzles	______	Xcss Air SB (#/hr)	7515.736
Mix Bustle Air PC (kpph)	9.600	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3140.000
Coal MC (#/hr)	1666.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	27105.796
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	6.057
Cmbn Air Sec Brnr (kpph)	6.450	Injector (tube):	50.000	Coal Split PC (%)	46.943
		Ca/S Ratio	N/A	Ca Utilization, %	______
STOICHIOMETRIC AIR: (for Coal)	5.512	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.512				

PHI's: PCC phi	0.876	Clng Calc (Btu/sec) 240.400 Clng Meas (Btu/sec) 302.950 Flow #/sec 28.800
PC phi	2.057	Total flow assumed equal over all 8 circuits:
MC phi	1.062	FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr	1.434	#1 AI 0.871 #2 AI 0.706 #3 BAF 1.167 #4 SRS 2.288
		#5 SRS 1.269 #6 SRS 1.269 #7 PC ET 2.134 #8 TAP 0.908

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.970			
CO (ppm)	130.000	155.689	120.250	
NOx (ppm)	202.000	241.916	200.835	0.361
SO2 w/LS (ppm)	289.000	346.108	287.333	0.720
SOx w/o LS (ppm), calc	392.330	465.737	390.188	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 109.500 Preheat Outlet 375.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 718.000 FG Preheat Outlet 394.000 N. Gas MMBtu/hr ______ % of Total Load: N/A

STEAMS (KPPH):	Boiler 19.725	Flash Tank	1.365	Total Steam	21.090
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 336.000	Flash Tank	336.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 23.104 Cooling (Coal + N Gas) - % 5.967 Cooling H2O Inlet (deg F) 340.000
Coal + N. Gas - MMBtu/hr 23.104

RESULTS: Steam Gen Eff'cy (%) 82.446 Fuel to Steam Flow Corr. 0.893

Boiler Efficiency (%) 82.669 % SO2 Reduction 26.360 Intrusion Air (#/hr) -140.86

REMARKS: ______

HEALY TESTS | TEST SUMMARY | # Pgs: 2 | Revision: 0
Date: 6/19/91

TEST: 558-TBR6 Date 06/05/91
PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE
Ultimate Analysis Applied
Composition (%) - Carbon: 43.500 Hydrogen: 3.410 Oxygen: 14.830 Nitrogen: 0.760 Sulfur: 0.360
Moisture: 9.820 Ash: 27.320 T250 (calc. deg F): 2076 HHV (Btu/lb): 7358

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ______ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 15 Section: 1 OF 1 Time of Test: 11:20

FLOW RATES:

Coal PC (#/hr)	1523.000	LS (#/hr)	______	Total Air (#/hr)	23588.644
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	17875.651
Combustion Air PC (kpph)	6.205	# Nozzles	______	Xcss Air SB (#/hr)	5712.993
Mix Bustle Air PC (kpph)	9.840	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3243.000
Coal MC (#/hr)	1720.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	25945.656
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	4.010
Cmbn Air Sec Brnr (kpph)	4.930	Injector (tube):	50.000	Coal Split PC (%)	46.963
		Ca/S Ratio	N/A	Ca Utilization, %	______

STOICHIOMETRIC AIR: (for Coal) 5.512 SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.512

PHI's: PCC phi 0.853 | Clng Calc (Btu/sec) 219.600 Clng Meas (Btu/sec) 317.028 Flow #/sec 28.800
PC phi 2.025 | Total flow assumed equal over all 8 circuits:
MC phi 1.044 | FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.320

#1 AI	0.726	#2 AI	1.068	#3 BAF	0.933	#4 SRS	1.634
#5 SRS	1.110	#6 SRS	1.269	#7 PC ET	1.707	#8 TAP	0.988

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.500			
CO (ppm)	119.000	138.194	124.290	
NOx (ppm)	295.000	342.581	308.136	0.514
SO2 w/LS (ppm)	208.000	241.548	217.262	0.504
SOx w/o LS (ppm), calc	403.946	465.737	421.006	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 114.000 Preheat Outlet 340.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 719.000 FG Preheat Outlet 364.000 N. Gas MMBtu/hr______ % of Total Load: N/A

STEAMS (KPPH):	Boiler	17.400	Flash Tank	1.130	Total Steam	18.530
Press. (psig):	Boiler	103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler	339.000	Flash Tank	339.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 23.862 Cooling (Coal + N Gas) - % 4.703 Cooling H2O Inlet (deg F) 340.000
Coal + N. Gas - MMBtu/hr 23.862

RESULTS: Steam Gen Eff'cy (%) 83.614 Fuel to Steam Flow Corr. 1.066

Boiler Efficiency (%) 84.138 % SO2 Reduction 48.395 Intrusion Air (#/hr) 1095.70

REMARKS: ______________________________

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 0
Date: 6/19/91

TEST: 559-TBR7 Date 06/05/91
PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE
Ultimate Analysis Applied
Composition (%) - Carbon: 43.500 Hydrogen: 3.410 Oxygen: 14.830 Nitrogen: 0.760 Sulfur: 0.380
Moisture: 9.820 Ash: 27.320 T250 (calc. deg F): 2876 HHV (Btu/lb): 7358

LIMESTONE:CANTWELL % $CaCO_3$: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 55 Section: 1 OF 1 Time of Test: 14:45

FLOW RATES:

Coal PC (#/hr)	1489.000	LS (#/hr)	________	Total Air (#/hr)	24523.644
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	17484.294
Combustion Air PC (kpph)	6.220	# Nozzles	________	Xcss Air SB (#/hr)	7039.350
Mix Bustle Air PC (kpph)	9.910	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3172.000
Coal NC (#/hr)	1683.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	26829.854
Carrier Air NC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	5.731
Cmbn Air Sec Brnr (kpph)	5.780	Injector (tube):	50.000	Coal Split PC (%)	46.942
		Ca/S Ratio	N/A	Ca Utilization, %	________

STOICHIOMETRIC AIR: (for Coal) 5.512 SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.512
PHI's: PCC phi 0.874 Clng Calc (Btu/sec) 237.600 Clng Meas (Btu/sec) 370.333 Flow #/sec 20.800
PC phi 2.082 Total flow assumed equal over all 8 circuits:
NC phi 1.072 FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.403

#1 AI	0.435	#2 AI	1.060	#3 BAF	1.167	#4 SRS	2.615
#5 SRS	1.427	#6 SRS	0.952	#7 PC ET	1.021	#8 TAP	0.000

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.000			
CO (ppm)	105.000	126.000	106.881	
NOx (ppm)	187.000	224.400	190.350	0.336
SO2 w/LS (ppm)	318.000	381.600	323.696	0.795
SOx w/o LS (ppm), calc	391.580	465.737	398.230	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 120.000 Preheat Outlet 382.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 735.000 FG Preheat Outlet 407.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler 18.300 Flash Tank 1.320 Total Steam 19.620
Press. (psig): Boiler 183.000 Flash Tank 183.000
Temps. (dg F): Boiler 338.000 Flash Tank 338.000 Feed H2O (deg F) 212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 23.340 Cooling (Coal + N Gas) - % 5.712 Cooling H2O Inlet (deg F) 341.000
Coal + N. Gas - MMBtu/hr 23.340

RESULTS: Steam Gen Eff'cy (%) 82.021 Fuel to Steam Flow Corr. 0.965

Boiler Efficiency (%) 82.259 % SO2 Reduction 18.716 Intrusion Air (#/hr) 454.98

REMARKS: ____

HEALY TESTS   TEST SUMMARY   # Pgs: 2   Revision: 0
Date: 6/19/91

TEST: 560-TBR8   Date 06/05/91
PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE
Ultimate Analysis Applied
Composition (%) - Carbon: 43.500 Hydrogen: 3.410 Oxygen: 14.830 Nitrogen: 0.760 Sulfur: 0.360
Moisture: 9.820 Ash: 27.320 T250 (calc. deg F): 2076 HHV (Btu/lb): 7358

LIMESTONE: CANTWELL   % CaCO3: 90.400   NATURAL GAS: Btu/lb ______   Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 66   Section: 1 OF 1   Time of Test: 10:15

FLOW RATES:

Coal PC (#/hr)	1482.000	LS (#/hr)	______	Total Air (#/hr)	24793.644
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	17401.613
Combustion Air PC (kpph)	6.490	# Nozzles	______	Xcss Air SB (#/hr)	7392.031
Mix Bustle Air PC (kpph)	9.660	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3157.000
Coal MC (#/hr)	1675.000	C.A. Press (psig)	Edc Nzl Dia 0.375	Total Gas (#/hr)	27088.152
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	5.961
Cmbn Air Sec Brnr (kpph)	6.030	Injector (tube):	50.000	Coal Split PC (%)	46.943
		Ca/S Ratio	N/A	Ca Utilization, %	______

STOICHIOMETRIC AIR: (for Coal) 5.512   SCFH to #/hr 0.076
STOICH. AIR: (# air/# tot fuel) 5.512

PHI's:
PCC phi 0.911
PC phi 2.094
MC phi 1.076
Overall phi at Sec. Brnr 1.425

Clng Calc (Btu/sec) 255.600 Clng Meas (Btu/sec) 330.472 Flow #/sec 20.800
Total flow assumed equal over all 8 circuits:
FLUX (Btu/ft2-sec):

#1 AI	0.501	#2 AI	1.060	#3 BAF	1.633	#4 SRS	2.615
#5 SRS	1.586	#6 SRS	1.110	#7 PC ET	2.027	#9 TAP	-0.454

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.790			
CO (ppm)	198.000	234.320	195.775	
NOx (ppm)	178.000	210.651	176.000	0.315
SO2 w/LS (ppm)	294.000	347.929	290.697	0.724
SOx w/o LS (ppm), calc	396.779	465.737	392.556	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 110.000   Preheat Outlet 393.000   Ambient 77.000

FLUE GAS TEMPERATURES (deg F):   NATURAL GAS INPUTS:
FG Air Preheat Inlet 696.000   FG Preheat Outlet 412.000   N. Gas MMBtu/hr ______   % of Total Load: N/A

STEAMS (KPPH):	Boiler 10.350	Flash Tank	1.210	Total Steam	10.560
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 337.000	Flash Tank	337.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 23.229   Cooling (Coal + N Gas) - % 5.261   Cooling H2O Inlet (deg F) 330.000
Coal + N. Gas - MMBtu/hr 23.229

RESULTS: Steam Gen Eff'cy (%) 81.005   Fuel to Steam Flow Corr. 0.963

Boiler Efficiency (%) 82.307   % SO2 Reduction 25.948   Intrusion Air (#/hr) -208.36

REMARKS: ______________________________

TEST: 561-TBR9 Date 06/06/91
PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE
Ultimate Analysis Applied

Composition (%) - Carbon:	43.500	Hydrogen:	3.410	Oxygen:	14.830	Nitrogen:	0.760	Sulfur:	0.360
Moisture:	9.820	Ash:	27.320	T250 (calc. deg F):			2076	HHV (Btu/lb):	7350

LIMESTONE:CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG):________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 32 Section: 1 OF 1 Time of Test: 14:15

FLOW RATES:

Coal PC (#/hr)	1504.000	LS (#/hr)	________	Total Air (#/hr)	22368.644
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	17660.680
Combustion Air PC (kpph)	6.520	# Nozzles	________	Xcss Air SB (#/hr)	4707.964
Mix Bustle Air PC (kpph)	9.705	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	3204.000
Coal MC (#/hr)	1700.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	24697.311
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	4.164
Cmbn Air Sec Brnr (kpph)	3.530	Injector (tube):	50.000	Coal Split PC (%)	46.941
		Ca/S Ratio	N/A	Ca Utilization, %	____________
STOICHIOMETRIC AIR: (for Coal)	5.512	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.512				

PHI's:

PCC phi	0.902
PC phi	2.072
MC phi	1.067
Overall phi at Sec. Brnr	1.267

Clng Calc (Btu/sec) 252.000 Clng Meas (Btu/sec) 451.694 Flow #/sec 28.000
Total flow assumed equal over all 8 circuits:
FLUX (Btu/ft2-sec):

#1 AI	0.435	#2 AI	0.824	#3 DAF	1.107	#4 SRS	2.288
#5 SRS	2.537	#6 SRS	1.903	#7 PC ET	1.174	#8 TAP	0.908

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.700			
CO (ppm)	292.000	343.529	321.315	
NOx (ppm)	215.000	252.941	236.584	0.380
SO2 w/LS (ppm)	266.000	312.941	292.704	0.655
SOx w/o LS (ppm), calc	399.003	465.737	436.067	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 130.000 Preheat Outlet 240.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 499.000 FG Preheat Outlet 270.000 N. Gas MMBtu/hr______ % of Total Load: N/A

STEAMS (KPPH): Boiler	15.150	Flash Tank	1.610	Total Steam	16.760
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	337.000	Flash Tank	337.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 23.575 Cooling (Coal + N Gas) - % 6.898 Cooling H2O Inlet (deg F) 343.000
Coal + N. Gas - MMBtu/hr 23.575

RESULTS: Steam Gen Eff'cy (%) 80.423 Fuel to Steam Flow Corr. 1.206

Boiler Efficiency (%) 80.836 % SO2 Reduction 33.015 Intrusion Air (#/hr) 2340.83

REMARKS: ____
____

HEALY TESTS	TEST SUMMARY	# Pgs: 2		Revision: 0
				Date: 6/19/91

TEST: 562-TBR10 Date 06/06/91
PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE
Ultimate Analysis Applied

Composition (%) - Carbon:	43.500	Hydrogen:	3.410	Oxygen:	14.830	Nitrogen:	0.760	Sulfur:	0.360
Moisture:	9.820	Ash:	27.320	T250 (calc. deg F):		2876		HHV (Btu/lb):	7358

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________
Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 59 Section: 1 OF 1 Time of Test: 16:47

FLOW RATES:

Coal PC (#/hr)	1192.000	LS (#/hr)	________	Total Air (#/hr)	17183.644
Carrier Air PC (scfh)	12500.000	LS Split (I/M)	100/0	Stoi Air (#/hr)	13995.152
Combustion Air PC (kpph)	5.070	# Nozzles	________	Xcss Air SB (#/hr)	3188.492
Mix Bustle Air PC (kpph)	5.910	Carr'r A/LS (scfh)	0.000	Total Coal (#/hr)	2539.000
Coal MC (#/hr)	1347.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	19028.989
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	3.660
Cmbn Air Sec Brnr (kpph)	2.790	Injector (tube):	50.000	Coal Split PC (%)	46.948
		Ca/S Ratio	N/A	Ca Utilization, %	________
STOICHIOMETRIC AIR: (for Coal)	5.512	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.512				

PHI's: PCC phi	1.039	Clng Calc (Btu/sec)	288.000	Clng Meas (Btu/sec)	342.270	Flow #/sec	28.800		
PC phi	1.938	Total flow assumed equal over all 8 circuits:							
MC phi	1.028	FLUX (Btu/ft2-sec):							
Overall phi at Sec. Brnr	1.228	#1 AI	0.581	#2 AI	0.824	#3 BAF	0.780	#4 SRS	1.634
		#5 SRS	1.586	#6 SRS	1.586	#7 PC ET	1.174	#8 TAP	1.362

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	5.960			
CO (ppm)	169.000	202.261	194.843	
NOx (ppm)	197.000	235.771	227.125	0.355
SO2 w/LS (ppm)	305.000	365.027	351.640	0.765
SOx w/o LS (ppm), calc	392.577	465.736	440.421	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 132.000 Preheat Outlet 339.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:
FG Air Preheat Inlet 572.000 FG Preheat Outlet 356.000 N. Gas MMBtu/hr ________ % of Total Load: N/A

STEAMS (KPPH): Boiler	13.910	Flash Tank	1.220	Total Steam	15.130
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	338.000	Flash Tank	338.000	Feed H20 (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 18.682 Cooling (Coal + N Gas) - % 6.596 Cooling H20 Inlet (deg F) 341.000
Coal + N. Gas - MMBtu/hr 18.682

RESULTS: Steam Gen Eff'cy (%) 83.642 Fuel to Steam Flow Corr. 1.022

Boiler Efficiency (%) 83.052 % SO2 Reduction 21.757 Intrusion Air (#/hr) 2756.28

REMARKS: ______________________________

HEALY TESTS   TEST SUMMARY   # Pgs: 2   Revision: 0
Date: 6/19/91

TEST: 563-TBR11   Date 06/07/91
PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE
Ultimate Analysis Applied
Composition (%) - Carbon: 43.500 Hydrogen: 3.410 Oxygen: 14.030 Nitrogen: 0.780 Sulfur: 0.360
Moisture: 9.820 Ash: 27.320 T250 (calc. deg F): 2876 HHV (Btu/lb): 7358

LIMESTONE:CANTWELL   % CaCO3: 90.400   NATURAL GAS: Btu/lb ______   Stoich air (# air/# NG): ______
Hydrogen (# H2/# NG): ______

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:
Duration (mins): 94   Section: 1 OF 1   Time of Test: 9:22

FLOW RATES:

Coal PC (#/hr)	1135.000	LS (#/hr)	82.000	Total Air (#/hr)	19782.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	13322.679
Combustion Air PC (kpph)	6.120	# Nozzles	______	Xcss Air SB (#/hr)	6459.841
Mix Bustle Air PC (kpph)	5.980	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2417.000
Coal MC (#/hr)	1282.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	21575.906
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	______	% O2 post SB Cmbn	6.540
Cmbn Air Sec Brnr (kpph)	4.340	Injector (tube):	50.000	Coal Split PC (%)	46.959
		Ca/S Ratio	2.732	Ca Utilization, %	11.829
STOICHIOMETRIC AIR: (for Coal)	5.512	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.512				

PHI's: PCC phi 1.131   Clng Calc (Btu/sec) 172.800 Clng Meas (Btu/sec) 308.611 Flow #/sec 28.800
PC phi 2.087   Total flow assumed equal over all 8 circuits:
MC phi 1.104   FLUX (Btu/ft2-sec):
Overall phi at Sec. Brnr 1.430

#1 AI	0.581	#2 AI	0.824	#3 BAF	0.780	#4 SRS	1.307
#5 SRS	0.952	#6 SRS	1.110	#7 PC ET	1.067	#8 TAP	1.362

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.110			
CO (ppm)	154.000	186.165	149.552	
NOx (ppm)	191.000	230.893	185.484	0.345
SO2 w/LS (ppm)	263.000	317.931	255.404	0.662
SOx w/o LS (ppm), calc	388.030	464.731	377.323	

AIR TEMPERATURES (deg F):
Air Preheat Inlet 126.000   Preheat Outlet 337.000   Ambient 77.000

FLUE GAS TEMPERATURES (deg F):   NATURAL GAS INPUTS:
FG Air Preheat Inlet 589.000   FG Preheat Outlet 350.000   N. Gas MMBtu/hr ______   % of Total Load: N/A

STEAMS (KPPH):	Boiler 15.030	Flash Tank	1.100	Total Steam	16.130
Press. (psig):	Boiler 103.000	Flash Tank	103.000		
Temps. (dg F):	Boiler 338.000	Flash Tank	338.000	Feed H2O (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 17.784   Cooling (Coal + N Gas) - % 6.247   Cooling H2O Inlet (deg F) 342.000
Coal + N. Gas - MMBtu/hr 17.784

RESULTS: Steam Gen Eff'cy (%) 83.372   Fuel to Steam Flow Corr. 0.909

Boiler Efficiency (%) 83.946   % SO2 Reduction 32.312   Intrusion Air (#/hr) -589.71

REMARKS: Limestone added with coal as fluxing agent

HEALY TESTS TEST SUMMARY # Pgs: 2 Revision: 0

Date: 6/19/91

TEST: 564-TBR12 Date 06/07/91

PURPOSE: IDENTIFY SUCCESSFUL OPERATING CONDITIONS FOR TBR COAL.

COAL: Source: TWO BULL RIDGE

Ultimate Analysis Applied

Composition (%) - Carbon:	43.500	Hydrogen:	3.410	Oxygen:	14.830	Nitrogen:	0.760	Sulfur:	0.360
Moisture:	9.820	Ash:	27.320	T250 (calc. deg F):	2076	HHV (Btu/lb):	7350		

LIMESTONE: CANTWELL % CaCO3: 90.400 NATURAL GAS: Btu/lb ________ Stoich air (# air/# NG): ________

Hydrogen (# H2/# NG): ________

TEST PARAMETERS - COMBUSTOR FIRING CONFIGURATION:

Duration (mins): 61 Section: 1 OF 1 Time of Test: 13:28

FLOW RATES:

Coal PC (#/hr)	1134.000	LS (#/hr)	166.000	Total Air (#/hr)	18764.521
Carrier Air PC (scfh)	12500.000	LS Split (I/N)	100/0	Stoi Air (#/hr)	13311.655
Combustion Air PC (kpph)	5.945	# Nozzles	________	Xcss Air SB (#/hr)	5452.866
Mix Bustle Air PC (kpph)	6.012	Carr'r A/LS (scfh)	9540.270	Total Coal (#/hr)	2415.000
Coal MC (#/hr)	1281.000	C.A. Press (psig) Edc Nzl Dia	0.375	Total Gas (#/hr)	20594.058
Carrier Air MC (scfh)	21710.000	Nozzles (throat):	________	% O2 post SB Cmbn	5.784
Cmbn Air Sec Brnr (kpph)	3.465	Injector (tube):	50.000	Coal Split PC (%)	46.957
		Ca/S Ratio	5.534	Ca Utilization, %	5.549
STOICHIOMETRIC AIR: (for Coal)	5.512	SCFH to #/hr	0.076		
STOICH. AIR: (# air/# tot fuel)	5.512				

PHI's:

PCC phi	1.104	Clng Calc (Btu/sec)	147.000	Clng Meas (Btu/sec)	230.056	Flow #/sec	28.800				
PC phi	2.066	Total flow assumed equal over all 8 circuits:									
MC phi	1.095	FLUX (Btu/ft2-sec):									
Overall phi at Sec. Brnr	1.365	#1 AI	0.290	#2 AI	0.824	#3 UAF	0.933	#4 SRS	1.307		
		#5 SRS	0.793	#6 SRS	0.634	#7 PC ET	1.067	#8 TAP	0.454		

EMISSIONS:

At stack	As meas.	At 3% O2	At Calc SB O2	#/MMBtu
O2 (%)	6.600			
CO (ppm)	24.000	30.000	25.360	
NOx (ppm)	181.000	226.250	191.260	0.340
SO2 w/LS (ppm)	259.000	323.750	273.681	0.677
SOx w/o LS (ppm), calc	375.115	463.704	394.986	

AIR TEMPERATURES (deg F):

Air Preheat Inlet 124.000 Preheat Outlet 357.000 Ambient 77.000

FLUE GAS TEMPERATURES (deg F): NATURAL GAS INPUTS:

FG Air Preheat Inlet 593.000 FG Preheat Outlet 372.000 N. Gas MMBtu/hr________ % of Total Load: N/A

STEAMS (KPPH): Boiler	13.680	Flash Tank	0.820	Total Steam	14.500
Press. (psig): Boiler	103.000	Flash Tank	103.000		
Temps. (dg F): Boiler	336.000	Flash Tank	336.000	Feed H20 (deg F)	212.000

COMBUSTOR LOADS: Coal - MMBtu/hr 17.770 Cooling (Coal + N Gas) - % 4.061 Cooling H20 Inlet (deg F) 340.000

Coal + N. Gas - MMBtu/hr 17.770

RESULTS: Steam Gen Eff'cy (%) 82.012 Fuel to Steam Flow Corr. 0.995

Boiler Efficiency (%) 83.088 % SO2 Reduction 30.711 Intrusion Air (#/hr) 1102.73

REMARKS: Limestone added with coal as fluxing agent

APPENDIX C. LIST OF EQUATIONS

List of Equations:

1. Coal Weight = (coal flowrate)(.75*20+(duration-20))/60
(assumes 75% load for first 20 minutes)

2. Solids Balance

= Output/Input * 100

Output = (slag wt)*(slag ash/100)*(1-slag ash SO3/100) +
(flyash wt)*(flyash ash/100)*(1-flyash ash SO3/100)

Input = (coal wt)*(coal ash/100)*(1-coal ash SO3/100) +
(limestone flow)*duration/60*((CaCO3/100)*MW(CaO)/
MW(CaCO3)+(1-CaCO3/100)*MW(MgO)/MW(MgCO3))

3. Slag Recovery

= (slag wt)*(slag ash/100)*(1-slag ash SO3/100)/
(coal wt)*(coal ash/100)*(1-coal ash SO3/100) *100

4. Carbon Conversion

= (1 - losses/input) * 100

Losses = (slag wt)*(slag carbon/100) + (flyash wt)*(flyash
carbon/100)

Input = (coal wt)*(coal carbon/100)

5. Calcium Balance

= Output/Input * 100

Output = (slag wt)*(slag CaO/100)*MW(Ca)/MW(CaO)+
(flyash wt)*(flyash Ca/100)

Input = (coal wt)*(coal CaO/100)*MW(Ca)/MW(CaO) +
(limestone flowrate)*duration/60*(CaCO3/100)*MW(Ca)/
MW(CaCO3)

6. PCC Phi = (PC coal carrier air + PCCA)/(PC coal * (A/F)o)
where (A/F)o is the stoichiometric air to fuel ratio

7. PC Phi = (PC coal carrier air + PCCA + PCMB)/(PC coal *
(A/F)o)

8. MC Phi = (coal carrier airs + PCCA + PCMB)/(PC & MC coals *
(A/F)o)

9. SB Phi = (coal carrier airs + PCCA + PCMB + SBCA)/
(PC & MC coals * (A/F)o)

10. Ca/S = (limestone flow)*(CaCO3/100)/MW(CaCO3)/
((PC & MC coals)*(S/100)/MW(S))

11. Total Air = PC & MC coal carrier air + PCCA + PCMB + SBCA +
Limestone carrier air

12. Stoichiometric air = (PC & MC coal)*(A/F)o

13. Total gas flow = Total air + total ash free coal +
(ls flow)*(CaCO3/100)*.44
+ (ls flow)*(1-CaCO3/100)*.52
(out secondary burner)

Total gas out stack = (stoic. air + total ash free coal +
(ls flow)*(CaCO3/100)*.44 +
(ls flow)*(1-CaCO3/100)*.52)
*(.233/(.233-stack O2/100*MW(O2)/MW(gas)))
(out stack)

14. Excess air = Total air - stoichiometric air
(out secondary burner)

Excess air out stack = (stoic. air + total ash free coal +
(ls flow)*(CaCO3/100)*.44 +
(ls flow)*(1-CaCO3/100)*.52)
*(stack O2/100)*MW(O2)/MW(gas)/
(.233-stack O2/100*MW(O2)/MW(gas))
(out stack)

15. Intrusion air = Excess air out stack - Excess air (out
secondary burner)

16. %SB O2 = (excess air)*.233/MW(O2)/((total gas)/MW(gas))*100

17. SO2 @ 3% O2 = SO2(meas.)*(21-3)/(21-stack O2(meas.))

18. SO2 @ SB O2 = SO2(meas.)*(21-SB O2)/(21-stack O2(meas.))

```
19. SO2 (#/MMbtu) = (SO2 @ SB O2)/1e6*MW(SO2)/MW(gas)*
                    (total gas)/load

20. NOx (#/MMbtu) = (NOx @ SB O2)/1e6*MW(NO2)/MW(gas)*
                    (total gas)/load

21. SO2 w/o LS = (total coal)*(%S/100)/MW(S)*1e6/
                 ((total out stack)/MW(gas))

22. SO2 capture = (SO2 @ SB(w/o ls)-SO2 @ SB(w/ls))/
                  (SO2 @ SB(w/o ls))*100

23. Ca utilization = SO2 capture/(Ca/S)

24. Cooling load = flash tank steam/load/1e6*1010*100

                               A - B - D - E - F - G
25. Boiler Efficiency =     ---------------------------- * 100
                                     A - B - C

 where    A - hhv*(1-cooling load/100)      thermal load minus
                                           heat to cooling water

          B - ash/100*.75*.2*(T250-77)         slag heating

          C - limestone/coal*.56*1385     limestone calcination

          D - (9H+H2O)/100*(1100+0.46*       sensible heat of
              (flue gas preheat - 77))           moisture

          E - .25*(flue gas preheat - 77)*    sensible heat of
              ((21*(A/F)o/(21-stack O2/100))     flue gas
              + 1 + .44*(limestone/coal) -
              ash/100)

          F - ash/100*(1-.75)*.2*             sensible heat of
              (flue gas preheat - 77)     in flight ash particles

          G - limestone/coal*.56*            sensible heat of ls
              (1385 + .2*                     plus calcination
              (flue gas preheat - 77))

26. Fuel to Steam Corr. =

  total coal*(hhv-%ash/100*.75*.2*(T250-77)-LS/total coal*775.6)
  ---------------------------------------------------------------
  (boiler steam/boiler efficiency + flash tank steam)*(1190-180)
```

27. Calcination level = $$\frac{CaO + CaSO4*56/136}{CaO + CaSO4*56/136 + CaCO3*56/100} * 100$$

APPENDIX D. DAMPER CONFIGURATIONS PER TEST

Explanation of Figure D1 and Table D1.

Figure D1 shows the damper configuration at the exit of the precombustor. Damper A is the damper downstream of the main combustor's head end. Dampers A and B can be adjusted independently, in terms of length or stroke. The 30 degree angle is a fixed angle in which the dampers are positioned. The fully closed position shown in Figure D1 is when the dampers are both pushed in as far as they are designed to go. The width of the flow path in this damper configuration is 5 inches (0% position). The fully open position shown in Figure D1 is when the dampers are both pulled out as far as they are designed to go. The width of the flow path in this damper configuration is 25 inches (100% position).

Table D1 shows the damper configurations used in each test with the performance coal and the Two Bull Ridge coal. The corresponding flow areas have been calculated and are also given in Table D1. Furthermore, DCS precombustor exit temperatures and velocities are also given in Table D1. These values, however, are incorrect mainly because the DCS temperatures were determined utilizing Ohio coal properties. Also, the DCS temperatures assumed 100% carbon utilization in the precombustor, which is thought to be incorrect. Oxidation of the char remaining in the precombustor after devolatilization is assumed to be delayed until reaching the main combustor. Corrections have thus been made for this as well as the utilization of Healy coal properties in the calculations. The last two columns in Table D1 gives the corrected precombustor exit velocities and temperatures for the Healy tests.

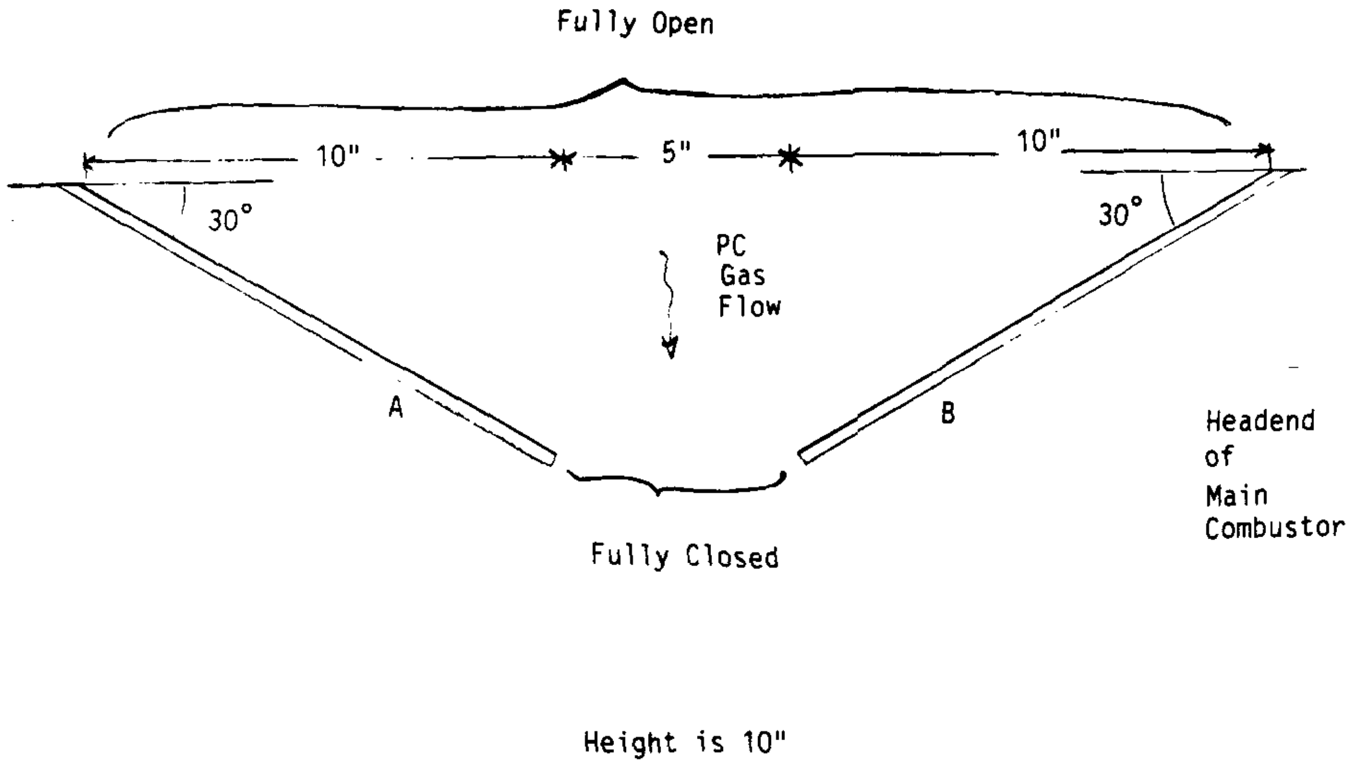

Figure D1. Damper Configurations

Table D1. Damper Configurations Per Test

HEALY TESTS	DAMPER POS. A/B,%	AREA FT2	COAL PC #/HR	COAL MC #/HR	LOAD MMBTU /HR	COAL SPLIT %	PCCA KPPH	PCMB KPPH	PC CARR #/HR	A/F PC	DCS VEL FT/S	DCS EXIT DEG F	CALC TEMP DEG F	CALC VEL FT/S
308-H13	25/25	0.70	959	1558	20.1	38.1	4.38	4.45	950	10.2	327	3000	2300	251
309-H13-1	50/50	1.05	938	1522	19.7	38.1	4.80	6.11	950	12.6	253	2820	2000	179
400-H13-2	65/65	1.26	1013	1513	20.2	40.1	5.28	7.17	950	13.2	253	2696	1950	183
401-H14	90/90	1.60	1200	1913	24.9	38.5	6.30	9.75	950	14.2	265	2545	1820	182
402-H14-1	85/85	1.55	1200	1888	24.7	38.9	6.28	9.21	950	13.7	257	2597	1870	185
404-H14-2	65/65	1.26	1200	2048	25.9	36.9	6.54	8.53	950	13.4	262	2631	1920	191
405-H15	60/60	1.20	1192	1920	24.9	38.3	6.80	7.01	950	12.4	302	2784	2050	222
406-H16	90/90	1.60	1492	2228	29.7	40.1	6.29	11.25	950	12.4	306	2796	2050	224
407-H17	80/80	1.50	1368	2399	30.1	36.3	6.37	9.16	950	12.0	303	2870	2090	220
408-H18	80/80	1.50	1272	2561	30.6	33.2	6.28	11.43	950	14.7	308	2412	1750	223
500-H20	60/60	1.20	1000	1496	19.9	40.1	5.04	5.59	950	11.6	257	2962	2120	184
501-H21	75/75	1.40	1105	1667	22.1	39.9	5.34	7.26	950	12.3	252	2848	2050	181
502-H22	65/65	1.26	971	1465	19.5	39.9	4.79	7.25	950	13.4	251	2629	1920	183
503-H23	65/65	1.26	977	1472	19.6	39.9	5.25	7.45	950	14.0	255	2565	1850	184
504-H24	35/35	0.82	954	1547	20.0	38.1	5.10	7.38	950	14.1	332	2510	1850	244
505-H25	25/25	0.70	799	1684	19.8	32.2	5.13	7.48	950	17.0	331	2184	1620	246
507-H27	0/50	0.73	1160	1331	19.9	46.6	6.30	5.45	950	10.9	401	2980	2200	296
508-H28	0/50	0.73	1162	1332	19.9	46.6	6.12	5.72	950	11.0	421	3000	2200	309
509-H29	0/50	0.73	1168	1338	20.0	46.6	6.45	5.93	950	11.4	444	3000	2150	318
510-H30	0/50	0.73	1162	1332	19.9	46.6	6.40	6.16	950	11.6	443	2996	2150	318
511-H31	0/50	0.73	1167	1342	20.0	46.5	6.06	5.78	950	11.0	420	3000	2200	308
512-H32	0/50	0.73	1152	1325	19.8	46.5	5.74	5.56	950	10.6	403	3000	2250	302
513-H33	0/50	0.73	1155	1330	19.9	46.5	5.74	5.61	950	10.6	406	3000	2250	305
523-H34	0/50	0.73	1167	1344	20.1	46.5	5.94	5.49	950	10.6	401	3000	2250	301
524-H35	0/50	0.73	1177	1356	20.2	46.5	6.45	5.90	950	11.3	428	3000	2150	307
525-H36	0/50	0.73	1160	1337	19.9	46.5	6.05	5.82	950	11.1	422	3000	2200	309
526-H37	0/50	0.73	1168	1344	20.1	46.5	6.37	5.84	950	11.3	422	3000	2150	302
527-H38	0/50	0.73	1156	1331	19.9	46.5	6.38	6.10	950	11.6	434	2996	2150	311
528-H39	0/50	0.73	1173	1352	20.2	46.5	6.19	6.02	950	11.2	419	3000	2200	307
529-H40	40/70	1.12	1165	1342	20.0	46.5	6.10	5.93	950	11.1	328	3000	2200	239
530-H41	0/50	0.73	1179	1357	20.3	46.5	6.23	6.00	950	11.2	423	3000	2200	310
531-H42	0/50	0.73	1168	1345	20.1	46.5	6.22	5.88	950	11.2	423	3000	2200	310
532-H43	0/50	0.73	1154	1328	19.8	46.5	6.36	6.07	950	11.6	421	2976	2150	304
533-H44	0/55	0.76	1154	1330	19.8	46.5	6.08	5.88	950	11.2	415	2996	2200	304
534-H45	10/70	0.94	1171	1348	20.1	46.5	6.00	5.85	950	10.9	374	3000	2200	274
535-H46	60/100	1.47	1165	1342	20.0	46.5	5.75	5.44	950	10.4	235	3000	2250	176
536-H47	0/80	0.96	1150	1323	19.8	46.5	6.17	6.01	950	11.4	361	3000	2150	259
537-H48	0/90	1.04	1147	1322	19.7	46.5	6.34	6.10	950	11.7	346	2974	2150	250
539-H50	20/100	1.23	1159	1334	19.9	46.5	6.26	5.72	950	11.2	289	2982	2200	213
540-H51	100/100	1.74	1169	1346	20.1	46.5	6.11	6.05	950	11.2	208	3000	2200	153
541-H52	100/100	1.74	1171	1350	20.1	46.4	6.11	6.02	950	11.2	207	3000	2200	152
542-H53	60/60	1.20	1160	1337	19.9	46.5	6.38	6.17	950	11.6	298	2974	2150	215
543-H54	50/50	1.05	1143	1317	19.6	46.5	6.15	5.65	950	11.2	296	3000	2200	217
544-H55	70/70	1.34	1147	1320	19.7	46.5	6.28	5.88	950	11.5	268	3000	2150	192
545-H56	0/75	0.84	1167	1345	20.1	46.5	6.28	6.06	950	11.4	348	3000	2150	250
546-H57	0/50	0.73	1173	1352	20.2	46.5	5.98	5.85	950	10.9	422	3000	2200	309
547-H58	0/50	0.73	1156	1333	19.9	46.5	6.23	6.02	950	11.4	430	2991	2150	309
548-H59	0/50	0.73	1154	1329	19.8	46.5	6.20	5.83	950	11.3	424	3000	2150	304
549-H60	0/55	0.76	1140	1314	19.6	46.5	5.96	5.80	950	11.2	401	3000	2200	294
550-H61	0/50	0.73	1168	1344	20.1	46.5	6.28	6.28	950	11.6	447	2977	2150	323
551-H62	0/50	0.73	1153	1327	19.8	46.5	6.14	6.05	950	11.4	425	3000	2150	305
552-H63	10/50	0.78	1134	1306	19.5	46.5	6.44	6.23	950	12.0	396	2959	2160	289

HEALY TESTS	DAMPER POS. A/B,%	AREA FT2	COAL PC #/HR	COAL MC #/HR	LOAD MMBTU /HR	COAL SPLIT %	PCCA KPPH	PCMB KPPH	PC CARR #/HR	A/F PC	DCS VEL FT/S	DCS EXIT DEG F	CALC TEMP DEG F	CALC VEL FT/S
553-TBR1	0/50	0.73	679	1060	12.8	39.0	4.02	2.37	950	10.8	230	2992	2000	154
554-TBR2	0/50	0.73	1060	1658	20.0	39.0	4.79	6.23	950	11.3	373	2858	1950	254
555-TBR3	0/50	0.73	1600	1855	25.4	46.3	6.00	5.55	950	7.8	420	3000	2450	343
556-TBR4	0/50	0.73	1480	1674	23.2	46.9	6.39	9.47	950	11.4	498	2801	1950	347
557-TBR5	0/75	0.84	1474	1666	23.1	46.9	6.16	9.60	950	11.3	454	2824	1950	313
558-TBR6	0/75	0.84	1523	1720	23.9	47.0	6.21	9.84	950	11.2	465	2824	1950	321
559-TBR7	100/100	1.74	1489	1683	23.3	46.9	6.22	9.91	950	11.5	259	2800	1950	180
560-TBR8	100/100	1.74	1482	1675	23.2	46.9	6.49	9.66	950	11.5	259	2802	1950	180
561-TBR9	100/100	1.74	1504	1700	23.6	46.9	6.52	9.71	950	11.4	270	2900	1950	182
562-TBR10	0/50	0.73	1192	1347	18.7	46.9	5.87	5.91	950	10.7	417	2994	2000	279
563-TBR11	0/50	0.73	1135	1282	17.8	47.0	6.12	5.98	950	11.5	423	2963	1950	278
564-TBR12	0/50	0.73	1134	1281	17.8	47.0	5.95	6.01	950	11.4	419	2979	1950	274

APPENDIX E. CALCINATION DATA

Explanation of Tables E1 to E3.

The following Tables were constructed by NIRO. Their variables were defined as follows.

Ca (wt%) - is the weight percent of calcium in the FCM sample. This was determined by treatment in HCL followed by atomic absorption.

CO2 (wt%) - is the carbon dioxide released due to decomposition of carbonate in excess HCL. The CO2 is measured by absorption on Ascarite (weight difference in absorbent determines content).

SO4 (wt%) - is determined by treatment with HCL followed by ion chromotograph. The SO4 content is utilized to determine the amount of CaSO4 in the FCM.

CaO (wt%) - is the calcium oxide in the FCM. This was determined by titration with an HCL standard.

Ca-diff - tells something about how much Ca is bound as non-reactive CaO.

$$= Ca - (CO2*40/44 + SO4*40/96 + CaO*40/56)$$

HCL Insol. (wt%) - is the weight percent of insolubles in the HCL solution.

Flyash (wt%) - amount of flyash in the FCM.

$$= \frac{\text{(wt\% HCL Insol. in FCM)}}{\text{(wt\% HCL Insol. in avg. Flyash)}} * 100$$

CaO (wt%) without flyash - amount of CaO in FCM contributed by limestone.

= CaO in FCM - CaO in avg. Flyash * (flyash%/100)

CaCO3 (wt%) without flyash - amount of CaCO3 in FCM contributed by limestone.

= CaCO3 in FCM - CaCO3 in avg. Flyash * (flyash%/100)

CaSO4 (wt%) without flyash - amount of CaSO4 in FCM contributed by limestone.

= CaSO4 in FCM - CaSO4 in avg. Flyash * (flyash%/100)

Table E-1. NIRO Data on Calcination

Sample	Ca	CO2	SO4	CaSO4	CaCO3	CaO	Ca diff.	HCl insol.	Fly ash	CaO (without fly ash)	CaCO3 (without fly ash)	CaSO4 (without fly ash)	sum
	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	
H-13-2, fly ash	4.60	0.52	1.58	2.24	1.18	0.55	3.08	74.56	100.0	0.0	0.0	0.0	100.0
H-13-1, fly ash	5.78	0.18	2.01	2.85	0.41	0.96	4.09	71.54	100.0	0.0	0.0	0.0	100.0
H-14, fly ash	6.58	0.20	2.59	3.67	0.45	1.09	4.54	67.46	100.0	0.0	0.0	0.0	100.0
H-22, FCM	9.06	1.94	2.45	3.47	4.41	6.20	1.85	64.65	90.8	5.4	3.8	0.8	100.8
H-23, FCM	8.97	2.37	2.73	3.87	5.39	4.86	2.21	62.47	87.8	4.1	4.8	1.3	98.1
H-24, FCM	10.66	3.60	3.80	5.38	8.18	6.20	1.38	67.00	94.1	5.4	7.5	2.6	109.6
H-25, FCM	8.95	3.80	3.50	4.96	8.64	4.90	0.54	65.70	92.3	4.1	8.0	1.0	105.4
H-27, FCM	9.55	3.50	3.20	4.53	7.95	4.50	1.82	63.90	89.8	3.7	7.3	1.9	102.7
H-28, FCM	9.95	4.00	3.30	4.68	9.09	4.60	1.65	60.00	84.3	3.9	8.5	2.2	98.9
H-29, FCM	9.51	3.15	3.84	5.44	7.16	4.04	2.16	59.58	83.7	3.3	6.6	3.0	96.6
H-30, FCM	9.68	2.95	3.96	5.61	6.70	3.82	2.62	67.85	95.3	3.0	6.1	2.8	107.2
H-31, FCM	8.29	2.93	3.09	4.38	6.66	3.10	2.12	67.44	94.7	2.3	6.0	1.6	104.6
H-32, FCM	8.14	2.58	3.03	4.29	5.86	3.09	2.32	65.18	91.6	2.3	5.2	1.6	100.7
H-33, FCM	12.34	7.62	5.96	8.44	17.32	2.14	1.40	57.94	81.4	1.4	16.8	6.1	105.7
H-33A, FCM	8.56	2.57	3.87	5.48	5.84	2.53	2.80	58.38	82.0	1.8	5.3	3.1	92.2
Average									89.7	3.7	6.3	2.0	101.7

Table E-2. NIRO Data on Calcination (Cont.)

Sample	Ca	CO2	SO4	CaSO4	CaCO3	CaO	Ca diff.	HCl insol.	Fly ash	CaO	CaCO3 (without fly ash)	CaSO4	sum
	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	
H-44, limestone	37.78	42.25											
H-41, limestone	37.69	42.27											
H-34, FCM	7.25	0.32	3.00	4.25	0.73	2.5	3.92	64.94	91.2	1.7	0.1	1.6	94.6
H-35, FCM	9.44	1.00	3.08	4.36	2.27	3.56	4.70	59.95	84.2	2.8	1.7	1.9	90.6
H-36, FCM	9.50	1.04	3.08	4.36	2.36	4.79	3.85	59.76	83.9	4.1	1.8	1.9	91.7
H-37, FCM	9.44	1.04	3.16	4.48	2.36	4.61	3.89	62.05	87.2	3.9	1.8	1.9	94.8
H-38, FCM	9.25	0.58	3.16	4.48	1.32	4.72	4.03	63.11	88.7	4.0	0.7	1.9	95.3
H-39, FCM	9.58	1.27	2.82	3.99	2.89	4.60	3.96	59.85	84.1	3.9	2.3	1.5	91.8
H-40, FCM	10.05	0.55	3.10	4.39	1.25	5.52	4.32	54.21	76.2	4.9	0.7	2.2	83.9
H-41, FCM	9.85	0.52	3.57	5.06	1.18	5.32	4.09	59.75	83.9	4.6	0.6	2.6	91.7
H-42, FCM	9.00	0.64	3.56	5.04	1.45	4.73	3.56	57.79	81.2	4.0	0.9	2.7	88.8
H-43, FCM	8.89	0.74	3.59	5.09	1.68	4.78	3.31	64.79	91.0	4.0	1.1	2.4	98.5
H-44, FCM	9.04	0.70	3.38	4.79	1.59	4.59	3.72	56.43	79.3	3.9	1.1	2.5	86.8
H-45, FCM	10.04	0.77	3.44	4.87	1.75	5.05	4.30	58.63	82.4	4.3	1.2	2.5	90.4
Average									84.4	3.8	1.2	2.1	91.5

Table E-3. NIRO Data on Calcination (Cont.)

Sample	Ca wt%	CO2 wt%	SO4 wt%	CaSO4 wt%	CaCO3 wt%	CaO wt%	Ca diff. wt%	HCl insol. wt%	Fly ash wt%	CaO wt% (without fly ash)	CaCO3 wt% (without fly ash)	CaSO4 wt% (without fly ash)	sum
H-46, FCM						4.92							
H-47, FCM	7.15	1.22	2.44	3.46	2.77	4.55	1.77	75.42	105.9	3.6	2.1	0.4	112.0
H-48, FCM						4.65							
H-50, FCM						6.10							
H-51, FCM	8.90	1.37	2.60	3.68	3.11	5.40	2.71	68.06	95.6	4.6	2.5	0.9	103.6
H-52, FCM						5.02							
H-53, FCM						5.62							
H-54, FCM	7.82	1.13	2.52	3.57	2.57	4.87	2.26	70.67	99.3	4.0	1.9	0.7	105.9
H-55, FCM						5.45							
H-56, FCM						5.85							
H-57, FCM	9.50	1.25	2.90	4.11	2.84	5.53	3.21	65.92	92.6	4.7	2.2	1.4	100.9
H-58, FCM						6.00							
H-59, FCM						5.57							
H-60, FCM	8.75	1.00	3.01	4.26	2.27	5.27	2.82	67.23	94.4	4.5	1.6	1.5	102.0
H-61, FCM						5.41							
H-62, FCM						5.79							
H-63, FCM	9.91	0.90	3.05	4.32	2.05	6.58	3.12	62.35	87.6	5.8	1.4	1.8	96.6
Average									95.9	4.5	2.0	1.1	103.5