INTERMOUNTAIN GENERATING STATION
BURNER MODIFICATION REPORT
January, 1994

INTERMOUNTAIN POWER SERVICE CORPORATION
TECHNICAL REPORT- EXECUTIVE SUMMARY

TITLE:

Burner Modifications made at the Intermountain Generation Station, Units 1 and 2.

SUMMARY:

In November, 1991, flame stabilizers were added to the burners and the register lineup was changed on Unit 2. In April, 1992, new burners with stabilizers were installed on Unit 1. In addition to these modifications, extensive secondary air flow testing and balancing was done, primary air/coal flow was balanced and a new burner register setup philosophy was adopted. These modifications were required due to mechanical and structural thermal degradation observed on the burners, due primarily to overheating when the burners were out-of-service.

CONCLUSIONS:

Based on windbox and fireside inspections since the modifications, the burners are in excellent condition. The high rate of mechanical and structural degradation due to overheat conditions has been curtailed. This was accomplished without changes to the operating criteria of the burners or boiler, which would have had adverse impact on performance and emissions.

The new burner setup has functioned well, without overheating or plugging the flame stabilizers. LOIs, NO_x levels and flame stability have all proven satisfactory.

The new burners installed on Unit 1 should last for the remaining life of the plant. It is not known if we can expect full plant life out of Unit 2's burners since they were not replaced. Replacement may be inevitable due to pre-existing damage.

Coal nozzle flaring has been observed on some of the burners during outage inspections. This seems to occur randomly and affects 5 to 10 percent of the burners.

Early detection has reduced burner line fire damage. Coal transport line fires are an unrelated issue to the mechanical degradation observed on the burners.

RECOMMENDATIONS:

The existing burner register setup and flame stabilizer installation should be retained. Periodic inspections of the burners should also be continued during major outages.

The Unit 2 burners should be replaced when the outage inspections indicate irrepairable damage. This is not foreseen in the near future.

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Additional investigation and testing needs to be conducted to address nozzle tip overheating which causes some to droop or become out of round. The solution may be a materials change or possibly moving the flame front further out.

No more analysis into burner line fires should be done until economic conditions warrant.

PREPARED BY: _____ DATE: 1/26/94
Aaron Nissen

APPROVED BY: _____ DATE: 1-26-94
Superintendent

APPROVED BY: _____ DATE: 1-26-94
President and Chief Executive Officer

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Aaron Nissen

APPROVED BY: _____ DATE: _____
Superintendent

APPROVED BY: _____ DATE: _____
President and Chief Executive Officer

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SECTION 1 - INTRODUCTION AND HISTORY

1.1 Introduction

This report summarizes results of burner modifications made on Units 1 and 2 at the Intermountain Generating Station. These modifications were recommended based on serious concerns with the mechanical and structural integrity of the burners. The original equipment manufacturer, Babcock and Wilcox (B&W), did not adequately resolve structural and thermal degradation that had occurred, and was still occurring, to IPSC's satisfaction. No misoperation was documented that could have caused the degradation and the units were operated at the intended design conditions.

1.2 History

During the Unit 1 Boiler Performance Acceptance testing in 1986, it became apparent that the guarantees could not be met without making adjustments to some of the boiler parameters. The allowable temperature on out-of-service burners was changed to 1350^0 F. to lower the amount of cooling air required to protect the burner. The original setting was 1200^0 F. Soon after the change, problems were noticed with the burner structure and operation. B&W attempted to correct this problem through various design changes on Unit 1 that are summarized by year as follows:

Unit 1, November, 1986 - Repaired many failed welds, straightened warped register plates, replaced rope packing, installed reinforcing band in packing area, straightened door shafts and repaired register linkages.

Unit 1, April, 1987 - Inner air sleeves on many burners were barrel shaped and distorted. Carbon steel reinforcing bars were exfoliated, many welds broken, backplates were warped and many of

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the doors would not adjust. Backplate attachment was modified to try and stop warping. Three nozzle tips were replaced due to fire damage and several more showed signs of overheating.

IPSC installed 30 additional thermocouples so overheating damage could be documented and corrected (see Attachment #4, 1987 Spring Outage Inspection Report).

Unit 2, November, 1987 - B&W Construction installed new heavy duty (HD) registers on both the front and rear burners on Level Four on a trial basis to determine if the new design would allow outer register adjustment while on-line. The 22 inch alloy tips on all 48 coal nozzle assemblies were replaced with a new 33 inch alloy tip. Modifications were made to the throat and inner air sleeve attachment to the outer register frame front plates. A register retaining lug and clip system replaced the previous weld attachment. These modifications were made to eliminate recurring weld cracking and permit thermal expansion between sections of the burner register assembly (see Attachment #5, 1987 Fall Outage Inspection Report).

Unit 2, April, 1988 - Outer register vanes were trimmed in a trapezoidal shape to prevent vane binding and freezing that occurred because the backplates continued to deform (oil can). Lighter shrouds were replaced on two burners. Many welds were still found broken. Burner to waterwall seal was missing on almost all burners (see Attachment #6, 1988 Spring Outage Inspection Report).

Unit 1, April, 1989 - Even though burner backplate temperatures were maintained below the B&W recommended 1350^0 F., evidence of overheating damage was found. Permanent warping, rippling, barreling, discoloration, flaking and thermal expansion damage was observed on the heavy duty and standard outer register assemblies, register vanes, drive handles, throat sleeves, inner air sleeve casing rings and lighter shrouds.

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IPSC decided that an outside consultant was needed to do an independent evaluation of the burners and estimate remaining burner life (see Attachment #7, 1989 Spring Outage Inspection Report).

Unit 1, April, 1990 - Energy and Environmental Research (EER) Corporation was hired to do an evaluation of the burners. They inspected the burners and concluded that "excessive temperatures have severely warped the stainless steel components and exfoliation of the carbon steel exists on 20 separate burners. The burners were also improperly supported which, along with the high temperature conditions, results in permanent warpage of the burners. In an effort to correct these problems, the burners received field modifications that created additional stresses." It was EER's recommendation that the burners be redesigned and replaced (see Attachment #12, EER Report).

Unit 1, April, 1991 - The burners were in the worst shape to date. William Newkirk, an ex-employee of B&W and independent consultant, came on-site to inspect the burners. He found numerous evidences of overheating. In his report he indicated that the burners only had two to five years remaining life. He raised serious concerns about a possible furnace explosion caused by overheated burners. Some of the outer air register spin vanes had gotten so hot that the steel went molten (see Attachment #13, William Newkirk Report).

1.3 Unit Description

The two Babcock & Wilcox coal fired steam generators at the Intermountain Generating Station are subcritical, single drum, opposed fired, balanced draft, parallel backend, Carolina type radiant boilers. Furnace dimensions are 85 feet wide, 60 feet deep and 229.5 feet high from the lower wall header to the drum center lines (see Attachment #3, Page 3.1, Boiler Cross Sectional View and Page 3.2, Boiler Fact Sheet).

Each unit fires pulverized coal from 48 low NO_x dual register burners, arranged in four rows of six burners on both the front and rear furnace walls (see Attachment #3, Page 3.4, Burner Arrangement Drawing). Secondary air is provided to the compartmentalized windbox by a wrap-around windbox (plenum principle). No individual burner row air flow measurement is provided.

The Mark V B&W burner is a low NO_x design, two zone burner with a conical coal diffuser. The inner and outer registers rotate secondary air flow in the same direction, with the three right hand burners spinning counter clockwise and three left hand burners rotating air flow clockwise into the furnace (see Attachment #3, Page 3.3, Burner Cross-Sectional View).

Eight pulverizers supply primary air and coal to six burners at 150 F. Normal operation requires seven pulverizers to be in-service, with the eighth pulverizer out for routine maintenance and overhauls. The seventh pulverizer is redundant and can be taken out on an emergency basis for maintenance repairs. As many as twelve burners may be taken out of service and still provide full load availability to the unit.

Coal, supplied from Utah, is bituminous, underground mined coal. Typical fuel quality is as follows:

TYPICAL COAL QUALITY

Heating Value (Btu/lb)	11850	Carbon (%)	65.0
MAF Heat Value(Btu/lb)	14275	Hydrogen (%)	4.60
Total Moisture (%)	8.10	Nitrogen (%)	1.15
Air Dry Loss (%)	6.00	HGI Index	44.5
Ash (%)	8.90	Ash Softening Temp (F)	2285
Sulphur (%)	0.45	Ash Na_2O Content (%)	1.80

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The boiler maximum continuous rating of each unit is 6,600,000 lb/hr of main steam at 2640 psig at 1005 F at the superheater outlet, with a reheat steam flow of 5,285,000 lb/hr at 551 psig and 1005 F. Unit design was based on constant and variable turbine throttle pressure from 25% to 100% load. The units do not use gas recirculation for temperature or NO_x control.

Startup on Unit 1 was in February, 1986, and it went commercial on July 1, 1986. Unit 2 started up in February, 1987, and it went into commercial operation May 1, 1987.

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SECTION 2 - GOALS AND PURPOSE OF BURNER MODIFICATION PROJECT

Despite all of the mechanical reliability problems that were experienced with the initial burner design, the actual operational performance of the burners remained good. Boiler performance, NO_x levels, ash loss on ignition (LOI) and flame stability were all acceptable based on the original setups. The justification for redesigning and replacing the burners was based solely on physical damage due to overheating. Modifications were not expected to improve the combustion and performance of the burners. The dual register design, originally supplied by B&W, had excellent combustion characteristics and the intent was not to deviate from that basic burner design philosophy.

The established goals and design criteria for the project were as follows:

Goal 1:
Design and install a burner that can structurally handle the operating temperatures, both in and out of service, without deformation or exfoliation. Burner registers must be operable during both in and out of service conditions. This should be done at the lowest possible cost.

Goal 2:
The new burner design should be able to operate with only minor maintenance for 25-30 years.

Goal 3:
The combustion performance and operating parameters of the burners should remain about the same or better than when they were originally installed.

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SECTION 3 - PROJECT DEVELOPMENT

3.1 Discussion

With the end of the boiler warranty period, efforts began in earnest to identify alternative methods of quantifying and prioritizing the maintenance and operational impacts of the observed burner degradation. Several respected entities within the burner design/development industry were consulted.

Frequent discussions with B&W continued regarding appropriate tuning and/or modifications to correct burner degradation concerns. In one of the letters written during this period, B&W stated that without windbox flow measurement, it would be virtually impossible to achieve an air flow balance to meet both combustion and cooling requirements. Installation of B&W's proposed system for windbox airflow measurement was approximately $1,000,000 per unit.

Initially IPSC chose to involve Mr. Bill Newkirk, a retired B&W employee who, while with B&W, was responsible in large measure for the design and manufacturing quality assurance of IGS's burners. Mr. Newkirk provided meaningful information with regard to both design and manufacturing concerns. A copy of his report is attached (Attachment #13, William Newkirk Burner Report).

Based on the rate of observed burner degradation, a survey was conducted within the burner industry to select a capable firm to assess burner concerns and to provide economically based recommendations for their resolution. Energy and Environmental Research Corporation (EER) was selected to perform this evaluation. (See Attachment #12 EER Report).

EER recommended redesign and replacement of the entire register assembly, throat sleeves and casings. This report was reviewed

with the original equipment manufacturer (OEM), B&W, to obtain whatever guidance they would provide. B&W responded with a new burner assembly for IGS. The new design was essentially the same burner using thicker steel, a modified throat seal and a much more expensive alloy. B&W quoted $1,600,000 per unit for the new design.

IPSC was concerned that just thicker steel sections would not enable the burner to withstand the significant thermal stresses of operation and IPSC asked B&W to perform a finite element analysis to support their new design. Their response was that a finite element analysis would serve no meaningful purpose.

In an effort to fully assess B&W's proposal and investigate our stated concerns, we felt that further outside investigation and analysis was justified. Discussions began with other sources knowledgeable in burner design and performance.

Among those consulted was RJM Corporation (RJM), a company specializing in burner performance and combustion profiling. Following on-site discussions and presentations from RJM, it became apparent that the problem was as much a function of burner design philosophy, as it was of burner stress analysis.

3.2 Proposed Solutions

A program was proposed and completed by RJM which included several parts (see Attachment #14, RJM Report):

- Aerodynamic flow evaluation of the burner that used a two-dimensional flow modeling program of air flow through the burner. This analysis established proper register settings and criteria for flame stabilizer design (see Attachment #3, Page 3.7 and 3.8).

- Secondary air flow balancing program was implemented utilizing inner and outer air zone measuring equipment.

This provided the basis for diagnosing unbalanced air flow through each burner and identify vortex generation zones.

- Structural finite element analysis was performed on the burner assembly to identify specific areas of concern at various temperatures and at various temperature ramps. A temperature grid was also generated from which "hot spot" analysis was performed to allow proper dissipation of stresses in areas experiencing the highest temperatures.

  Among the more notable results of the finite element analysis was the design of a "petal" type backplate and verification that a much lower cost alloy would be satisfactory. Based on B&W quotes dated September 12, 1991, **RJM's verification of the suitability of the 304/309 stainless steel materials versus B&W's recommended Inconel 800H, produced a savings of approximately $620,000 and cut B&W's quoted material delivery time nearly in half.** The finite element analysis cost approximately $27,000.

- To address the combustion profile and air flow concerns associated with varying register settings for balance and cooling, RJM recommended installing fixed vane 'stabilizers' at the inner air throat. Tests, both foreign and domestic, had shown this type of assembly to provide stable ignition zones and minimize the harmful recirculation effects which were consistently observed on the IGS burners (see Attachment #3, Page 3.5 and 3.6).

- Burner line restrictors were modified to ensure proper fuel and primary air flow balancing. IPSC conducted the clean air and dirty air flow testing and made the required restrictor change outs.

A team approach was established to redesign the burners. B&W assisted as OEM, RJM as design consultant and DWP's Power Design and Construction Group, assisted by IPSC, as manufacturing and

installation quality control and assurance. With expedited support from DWP's Power Design and Construction Group, the modified burners were designed and manufactured in time to complete installation during the Unit 1, Spring, 1992, Outage.

3.3 SUMMARY OF BURNER DESIGN MODIFICATIONS

Modification (what)	Objective (why)	Detail (how)	Provided By (who)
Unit 2 Burner Modifications	Reduce thermal degradation	Repair existing damaged burners, add flame stabilizers, balance air flow & lineup registers	Joint: RJM/ B&W/ DWP/ IPSC
Unit 1 Burner Replacement	Reduce high rate of damage caused by thermal degradation	HD outer register assembly (hardware centered in air path), petaled backplate, material (309 SS) & thickness changes Improved throat seal	Joint: RJM/ B&W/ DWP/ IPSC
Design Review of New Burners	Cost evaluation material and thickness study	Design evaluation & finite element analysis	Joint: RJM/ B&W/ DWP/ IPSC
Flame Stabilizers	Improve flame position & stability by improving air flow dynamics	Stabilizers with fixed blade design were added to the inner air zone (between coal flow & outer air zone)	RJM
Secondary Air Flow Balancing	Balance sec air flow through the burners (inner and outer zones) [+ side-to-side, top-to-bottom & front-to-rear]	Sec air flow tested, shrouding installed on outer registers, backplates set for inner register	RJM/ IPSC

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Coal Flow Balancing	Balance primary air and coal flow across the burner row	Clean air flow testing conducted and coal line restrictors added	IPSC
Improved Register Lineup	Change from trying to balance air flow with registers to positioning registers for actual flame conditions	With air balancing conducted (with shrouding and fixing backplates), plus installation of the flame stabilizers, registers could be set for flame conditions	RJM/ IPSC

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SECTION 4 - RESULTS OF MODIFICATIONS

One of the primary concerns with making any burner modifications was adverse operational impact on the combustion characteristics. As stated previously, the intent of the burner modifications was to resolve the accelerated mechanical degradation, not to improve on combustion. The objective was not to allow any of the combustion parameters to get worse and to try, where possible, to improve conditions.

It should be noted that the same boiler operating parameters were utilized to operate the unit both before and after the burner modifications. These parameters include fuel-to-air ratio, excess air levels, cooling air flow requirements to out-of-service burners (i.e., same windbox damper positions) and burner front metal temperature alarms. The following sections provide performance information both before and after the modification.

4.1 Fly Ash LOI Levels

Carbon content in fly ash is generally determined by a loss on ignition (LOI) test. This test measures the percentage of weight loss that occurs by raising the ash to combustion temperatures (approx. 1500 degrees F). From a performance perspective, LOI values are not a problem until they get above 2.0 to 2.5%. Typical LOI values for IGS's units are below 1.0% which would be considered excellent throughout the industry.

When LOIs are greater than 1.0%, we feel confident we can identify and assign specific causes. For example, problems such as a nonfunctioning windbox damper, bad O_2 probe, a burner register problem, pulverizer problem (such as on a hydraulic loading skid), or a feeder calibration will cause enough of a change in LOIs to increase levels to greater than 1.0%. We

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consistently monitor daily and weekly LOI values and conduct regular boiler walkdowns to identify combustion problems.

Fluctuations of LOI values between 0.30 and 1.00% occur on a regular basis (reference Attachment #1, Page 1.4 for the daily Unit 1 and 2 average LOI values over the three summer months in 1993). Specific causes of these fluctuations are difficult to pinpoint. Most are caused by one or a combination of several of the following causes: coal quality fluctuations, fuel-to-air ratio fluctuations (including both coal feeder and oxygen probe calibrations), differences due to out-of-service pulverizer configurations, pulverizer performance condition (degree of wear, loading skid, or rotating throats problems), windbox damper position and other fuel and air discrepancies.

Fly ash LOI values have been extensively sampled by Pozzolanic since January, 1991. For the first two years, as many as 96 fly ash samples were collected and analyzed daily. These daily values were averaged to compute the monthly composite average (reference Attachment #1, Page 1.1 Fly Ash LOI Summary)and are summarized below:

Fly Ash Loss on Ignition Summary

	Unit 1	Unit 2	Station
LOI average over entire period (9/91-9/93)	0.72%	0.60%	0.66%
LOI average before modifications	0.65%	0.57%	0.61%
LOI average after modifications	0.75%	0.60%	0.68%
% Change	15.6%	5.8%	11.0%

This summary shows that there has been a slight increase in LOI levels since the modifications; however, this increase was within a reasonable range that still allows us to market our fly ash. The amount of ash sales has continued to increase and LOI levels are not a limiting factor. Pozzolanic sales of fly ash have steadily increased since July, 1991, and LOI's are not currently limiting ash sales. June, July, August and September, 1993, have been the highest tonnage collection months to date (Attachment #1, Page 1.5, Fly Ash Sales to Pozzolanic).

Attached are graphs of monthly LOI averages for the entire period (Attachment #1, Page 1.6). The individual monthly tally sheets for each day, unit and east and west sides, for the entire period are also included in the attachments (Attachment #1, Pages 1.7 through 1.39).

4.2 NO_x Emission Levels

NO_x emission levels were another area of major concern. Due to changes in the burner register setup and the addition of flame stabilizers, RJM was predicting an improvement in NO_x levels. Both NO_x daily emission averages and 30 day rolling averages increased slightly on both units. We believe these increases are within acceptable levels and well below State and Federal emission limits.

We did not attempt to correlate NO_x increases with other operating factors such as unit load, load variations (dispatch control), coal quality, or other parameters which impact NO_x production over the same period. Many factors determine NO_x levels such as burner register setup, fuel-to-air ratio, out-of-service cooling air flow, configuration of out-of-service pulverizers, pulverizer condition, boiler bias damper position, cleanliness of the boiler, etc. Since NO_x values are within acceptable values, major research was not conducted to determine and quantify all NO_x contributing factors and their impact.

A spread sheet was created showing the daily NO_x emission averages and 30-day rolling NO_x emission average values for the last 48 months (since 10/1/89). Daily Emission Averages (DEA) and 30-Day Rolling Averages (30-DRA) showed almost identical results, giving validity to the original data. The 30-DRA averages plus the CEM NO_x values for the 10/1/89 through 8/3/93 are included in the attachments (see Attachment #2, Pages 2.3 through 2.38).

Prior to any burner modifications, Unit 1's DEA was 0.377 lbs/mbtu (over a 31 month period) and Unit 2's DEA was 0.350 lbs/mbtu (over 25 months). After the modifications, Unit 1's DEA went to 0.385 lbs/mbtu (over 16 months) and Unit 2's went to 0.374 lbs/mbtu (over 21 months). This is a 2.1% increase in NO_x levels on Unit 1 and a 6.8% increase on Unit 2.

NO_x Daily Emissions Average (DEA) Summary

	Unit 1	Unit 2	Station
NO_x average (10/1/89-8/31/93)	0.380 lb/mbtu	0.361 lb/mbtu	0.370 lb/mbtu
NO_x average before modifications	0.377 lb/mbtu	0.350 lb/mbtu	0.364 lb/mbtu
NO_x average after modifications	0.385 lb/mbtu	0.374 lb/mbtu	0.379 lb/mbtu
% Change	2.1%	6.8%	4.4%

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4.3 LOI to NO_x Relationship

The relationship between LOI's in fly ash and NO_x emissions are inversely proportionate. A decrease in excess air levels will generally decrease NO_x emission levels, but will adversely increase LOI levels in fly ash. An optimum balance was sought to maintain the lowest LOI levels possible (to meet fly ash sales obligations) and the lowest NO_x levels to satisfy State and Federal emission requirements and IPSC environmental consciousness. The original excess air targets recommended by B&W of 3.20% O_2 at full load (one pulverizer out-of-service) have been determined as the optimum.

4.4 Eyebrow Formation

Eyebrow formations above and to the sides of the burners have been an on-going problem since start-up. Evaluating the severity of eyebrow formulations is highly subjective. We had hoped to reduce eyebrow severity with the air and fuel flow balancing, but eyebrows still keep recurring. However, even with the extended outage cycle of 12 months duration, eyebrows do not interfere with burner or scanner operation.

Eyebrow problems won't totally be eliminated until coal purchased excludes coal with ash fusion temperatures below 2350^0. Approximately half of our coal purchased has ash fusion temperatures below this level. We are not recommending changing coal purchase specifications at this time, the amount of eyebrow formation does not warrant this.

4.5 Burner Front Temperatures

It has been difficult to distinguish temperature reductions on individual burners. Only within recent outages have burner thermocouples on Unit 2 been brought to a reliable status. Unit

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1 thermocouples were not replaced with care when the new burners were installed, as a result, available data is not consistent. Based on the available temperature data, it is clear burner temperatures have not risen for the same windbox damper locations (i.e., same cooling air flow).

4.6 Burner Physical Inspections

Outage inspections on Unit 2 since the stabilizers were added and the air and fuel flow balanced, indicate that the rate of burner deterioration has significantly decreased. During the Unit 2 Fall, 1992, Outage Inspection (see Attachment #10) only minor problems were found with the burners. Some nozzle flaring and weld splitting was noticed at the tips, but none required change out. During the Unit 2 Fall, 1993, Outage Inspection, many nozzles were replaced due to erosion of the nozzle back at the diffuser and not to flaring or splitting. This is a new problem; previously nozzles would not last long enough to erode.

The Spring 1993 Outage Inspection on Unit 1 (see Attachment #11) showed that the new burners installed the year before were in good condition. Of particular interest was the condition of the "petaled" backplates which were found to have no signs of deformation or warpage. One of the coal nozzles was deformed and split and needed to be replaced. This burner was taken out-of-service prior to the outage because of combustion problems. Several other burners were deformed or split. In general, the amount of burner damage was minimal and many years of service should be expected from these new burners.

4.7 Burner Line Fires

Burner line fires have been noticed on both units since first operation. The fires are located in the coal transport lines in between the last elbow and diffusers. They generally occur within a few hours of initiating pulverizer operation, but sometimes they occur after days of operation. If undetected, the

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fires can destroy the diffuser which requires the burner be removed from service until the next outage.

All of the modifications made to the burners were in the secondary air system. Only burner line air flow balancing was done to the primary air system. Nothing was changed that would either reduce or increase the amount or severity of burner line fires.

Shortly after the modifications were made to the Unit 2 burners, it was decided to address the problem of burner line fires at the diffuser by installing temperature switches on the pipe exterior that would give an early warning to the Operators of a line fire. This would allow the Operators time to remove the burner row from service before damage was done to the diffusers. Since this warning system was installed, numerous burner line fires have occurred, but none have damaged the diffusers.

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SECTION 5 - CONCLUSIONS

Based on both performance testing and inspections since installation, the new burners and associated hardware are documented to be in excellent condition. All current information supports the following conclusions:

- The Unit 1 burners should operate reliably throughout the design life of the plant.

- Degradation on the Unit 2 burners has subsided sufficiently to indefinitely postpone burner replacement.

- The nozzle flaring phenomenon is still being observed at a small number of burner nozzle tips. This problem is being monitored carefully in an attempt to correlate suspected recirculation patterns and nozzle degradation on specific burners.

- An early warning detection system installed during the 92-93 Fiscal Year has been successful in eliminating major equipment damage which previously resulted from burner line fires.

- The inner air zone turning vanes or "stabilizers", located near the burner throat, have been successful in helping stabilize flame characteristics throughout the load range. Earlier concerns regarding the long-term survivability of the stabilizers (due to overheating and/or pluggage) have proven to be unfounded.

- Balancing combustion air, by installing shrouds and stabilizers at each burner, has proven valuable. Proper cooling and combustion requires both proper volume flow and swirl in each burner zone. By allowing proper register door

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settings for required "swirl" control, the shrouds and stabilizers have markedly improved the consistency of the flame shape, color and ignition zone location at all loads. Elimination of inner burner degradation on Unit 1 and the significantly reduced rate of degradation on Unit 2, substantiates the improvements in airflow distribution.

- Burner combustion performance tracking shows LOI and NO_x at slightly higher levels as were seen prior to the burner modifications. Eyebrow formation and burner front temperatures are at the same levels as before any modifications. Overall, there have not been any significant changes in the combustion parameters.

- The stress analysis performed by RJM saved $1,600,000 (the cost of another set of burners). Additional burners would have been necessary when the B&W redesigned burner ultimately failed again due to thermal stress. The RJM thermal analysis also saved $620,000 by recommending different material for the new burners instead of the B&W recommended Inconel 800H. The cost of all RJM services including the 96 stainless steel stabilizers and air flow balancing was approximately $350,000.

- The approach taken to resolve the burner overheating problem was to employ all the recommendations at hand. These included flame stabilizer installation on Unit 2, new burner design assemblies with flame stabilizers installed on Unit 1, new burner lineup on the inner and outer air registers and backplate settings, secondary air flow balancing of inner and outer zones, and also primary air and coal flow balancing.

  Which modification made the largest contribution to solving the overheating problem is indeterminate; all are believed to have significantly contributed to the overall success.

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To resolve the matter at hand and to avoid a lengthy testing phase, all recommendations were applied at the same time.

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SECTION 6 - RECOMMENDATIONS

Based on the results of the testing and inspections, IPSC recommends the following:

1. The flame stabilizers, installed on both units, should be left in place and fully maintained.

2. The Unit 2 burners should not be replaced until additional structural degradation is observed. This degradation is likely due to thermal stresses inherent in the original B&W design.

3. When the Unit 2 burners are replaced, the design should be the same as on Unit 1.

4. The burners should be carefully inspected at each opportunity. Of particular interest is the long-term condition of the registers, stabilizers and nozzles.

5. More investigative testing should be conducted on the burner flame front position to find the causes of coal nozzle flaring. By determining where the flame fronts are located, correlations can be applied and action taken to avoid nozzles from flaring due to flame overheat.

6. Additional testing should be planned on the coal burner transport lines. A nondirectional velocity probe should be used to test dirty air (primary air and coal flow) velocities. Several different techniques have been used in the past, including clean air flow, dirty air flow and roto-probe, with conflicting results.

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7. If the direct velocity measurement proves successful as hoped, an additional iteration of coal line restrictor change outs will be done if warranted.

8. No further analysis should be done on the causes of burner line fires. Since the installation of the temperature switches on the coal elbows, the damage caused by fires has greatly diminished due to early detection and intervention. If damage to the burners increases, further analysis should be done.

9. The addition of windbox air flow measuring devices is not recommended. This is no longer required due to the secondary air flow balancing that was done. Air flow balancing has resolved in-service to out-of-service (low flow to high flow) problems.

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Fly Ash Loss on Ignition Summary

	Unit 1	Unit 2	Station
LOI average over entire period (9/91-9/93)	0.72%	0.60%	0.66%
LOI average before modifications	0.65%	0.57%	0.61%
LOI average after modifications	0.75%	0.60%	0.68%
% Change	15.6%	5.8%	11.0%

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Fly Ash Loss On Ignition (LOI) Summary (based on Pozzolantic analysis)

For 1/91 thru 9/93 IGS Unit 1 and 2, east and west

	Ave for per months		Pre-outage	months	Post-Outage	months	% increase
	1/91-9/93	33	U1 4/10/92	16	U1 4/27/92	17	
			U2 10/25/91	10	U2 12/7/91	22	
U1	0.65		0.55		0.75		36.5
U2	0.56		0.45		0.61		34.9
IGS	0.60		0.50		0.68		35.8
New	9/91-9/93	24	U1 4/10/92	7	U1 4/27/92	17	
Baseline			U2 10/25/91	1	U2 12/7/91	22	
U1	0.72		0.65		0.75		14.9
U2	0.60		0.57		0.61		6.3
IGS	0.66		0.61		0.68		10.9

	1/91 - 9/91	last 9 months	7/93-9/93
U1	0.47	U1	0.70
U2	0.44	U2	0.54
IGS	0.45	IGS	0.62

	Unit 1			Unit 2		
	East	West	Total	East	West	Total
Jan-91	0.51	0.51	0.50	0.50	0.50	0.50
Feb-91	0.49	0.51	0.50	0.48	0.48	0.48
Mar-91	0.54	0.51	0.53	0.42	0.42	0.42
Apr-91	0.52	0.47	0.50	0.39	0.34	0.36
May-91	0.47	0.48	0.49	0.40	0.41	0.40
Jun-91	0.34	0.34	0.35	0.33	0.34	0.34
Jul-91	0.45	0.42	0.44	0.42	0.44	0.44
Aug-91	0.45	0.46	0.46	0.52	0.51	0.52
Sep-91	0.44	0.42	0.44	0.45	0.46	0.46
Oct-91	0.66	0.66	0.66	0.55	0.59	0.57
Nov-91	0.62	0.65	0.63			
Dec-91	0.72	0.84	0.78	0.81	0.71	0.76
Jan-92	0.57	0.65	0.61	0.56	0.72	0.64
Feb-92	0.56	0.53	0.55	0.63	0.71	0.67
Mar-92	0.74	0.59	0.67	0.65	0.74	0.70
Apr-92	0.63	0.68	0.66	0.55	0.72	0.64
May-92	1.13	0.84	0.98	0.56	0.92	0.73
Jun-92	0.83	0.72	0.77	0.38	0.54	0.46
Jul-92	0.72	0.67	0.70	0.54	0.69	0.62
Aug-92	0.84	0.75	0.80	0.62	0.80	0.71
Sep-92	0.93	0.70	0.82	0.55	0.75	0.65
Oct-92	0.91	0.91	0.91	0.52	0.65	0.59
Nov-92	0.79	0.64	0.71	0.71	0.74	0.73
Dec-92	0.63	0.62	0.62	0.62	0.59	0.60
Jan-93	0.63	0.62	0.63	0.54	0.50	0.52
Feb-93	0.70	0.64	0.67	0.46	0.50	0.48
Mar-93	0.85	0.66	0.76	0.44	0.43	0.44
Apr-93	0.73	0.88	0.81	0.57	0.51	0.54
May-93	0.57	0.58	0.58	0.48	0.41	0.45
Jun-93	0.78	0.76	0.77	0.53	0.63	0.58
Jul-93	0.72	0.74	0.73	0.53	0.65	0.59
Aug-93	0.74	0.83	0.79	0.50	0.61	0.56
Sep-93	0.65	0.68	0.67	0.68	0.65	0.67

SUM-LOI.XLS

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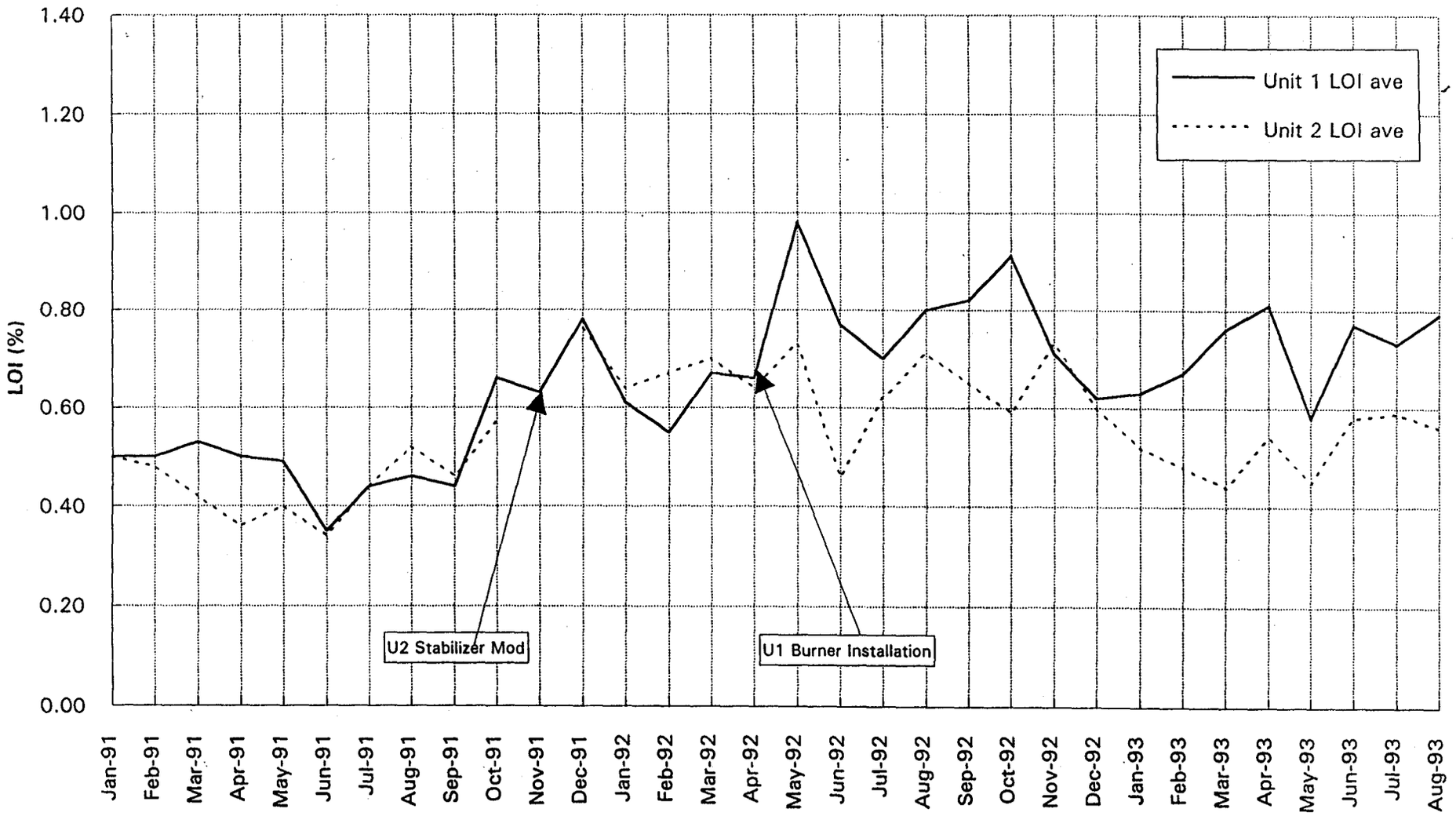
IGS Unit 1 and 2, Historical LOI Average Values



SUM-LOI.XLC

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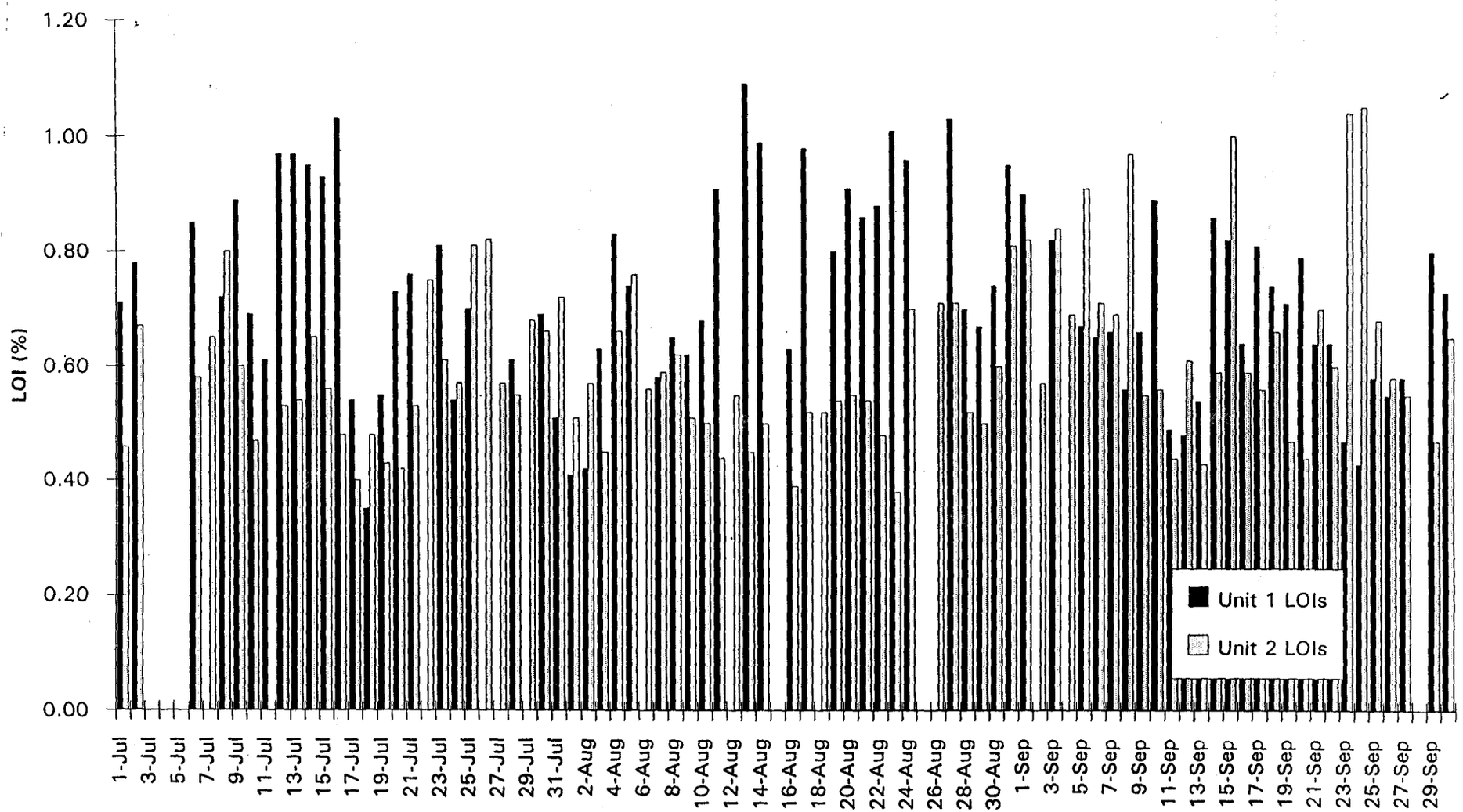
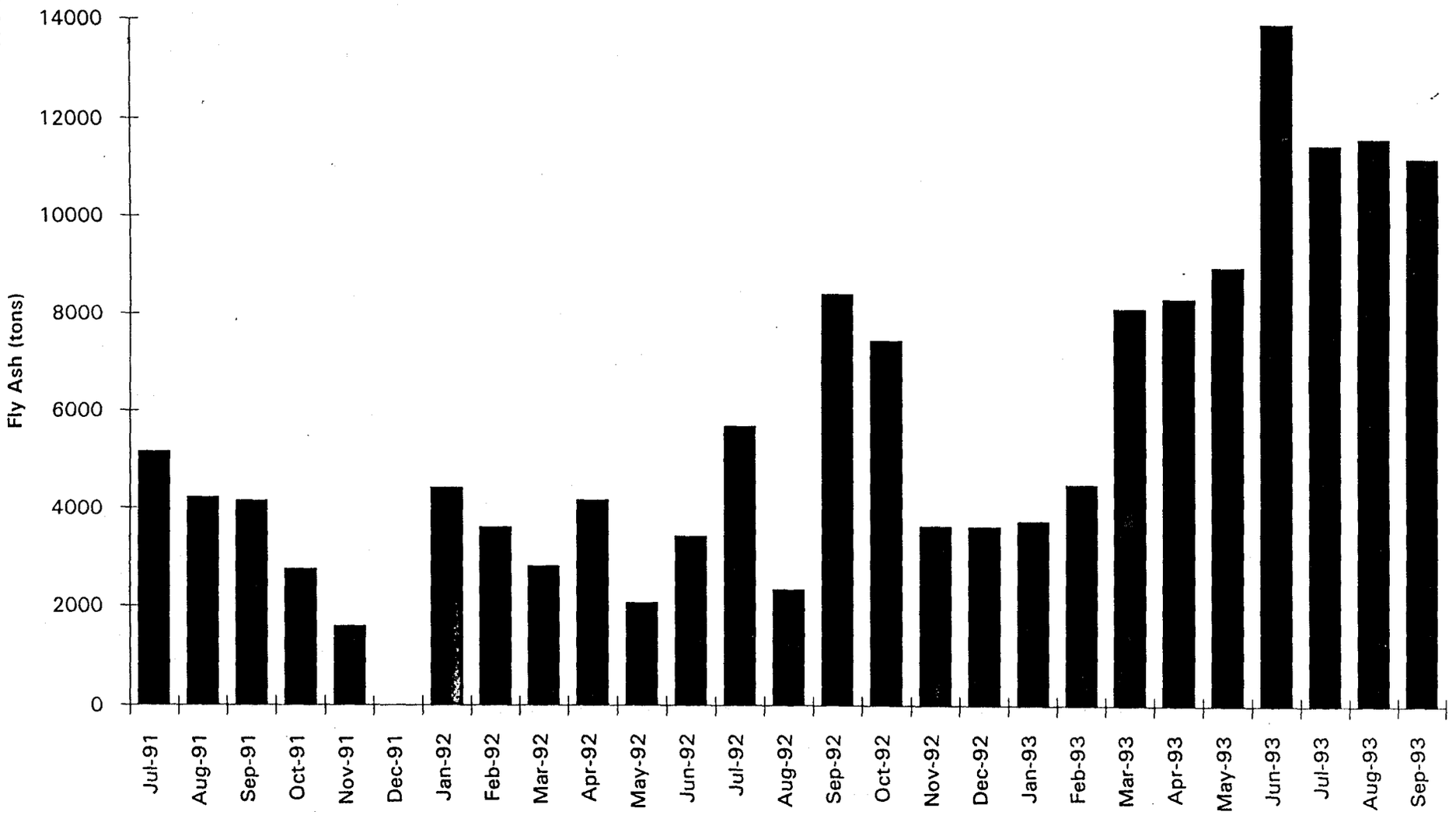
Daily Fly Ash LOI Values For July, August and September 1993



93VALUES.XLC

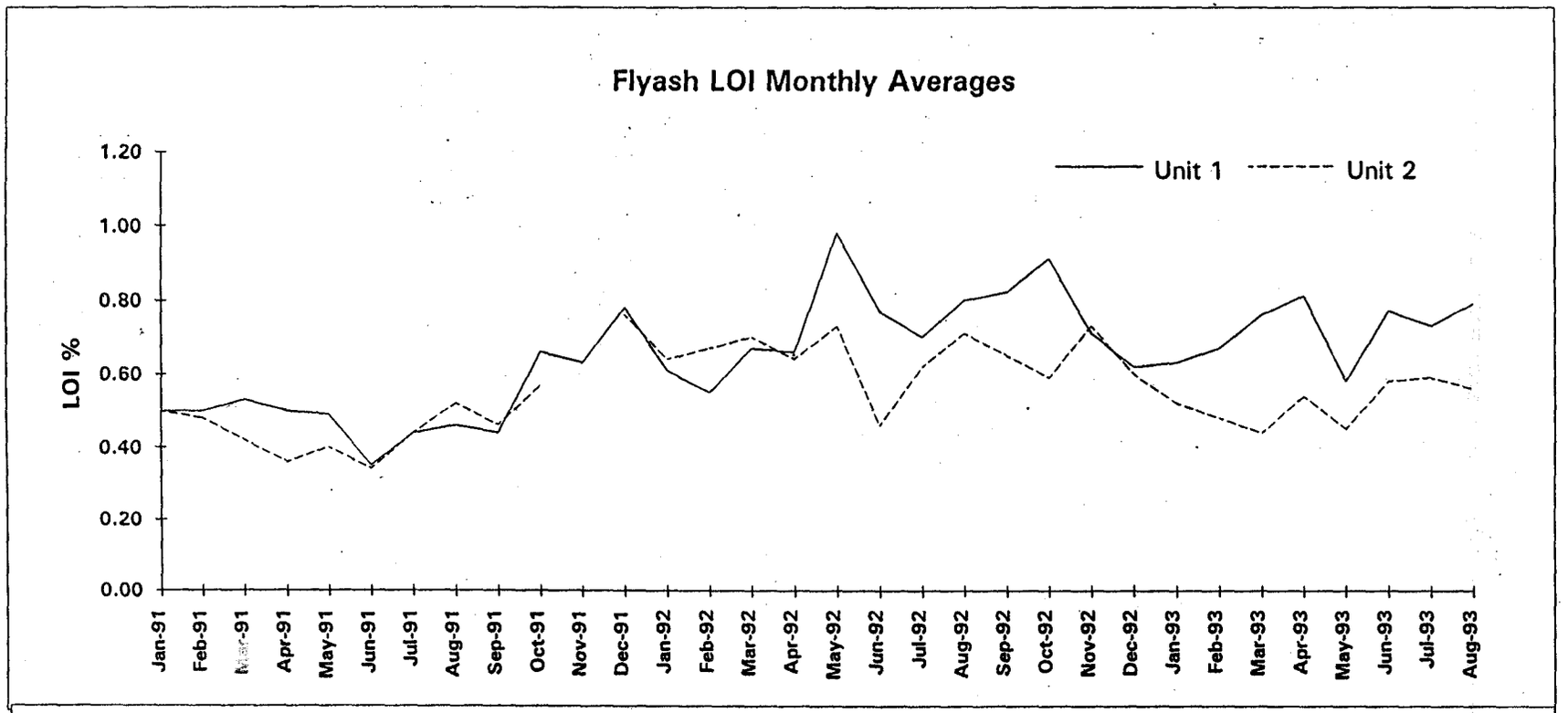
IP7_000269

FLY ASH SALES TO POZZOLANIC



FA-SALES.XLC

IP7_000270


Flyash LOI Monthly Averages
Unit 1
Unit 2
LOI %
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Jan-91
Feb-91
Mar-91
Apr-91
May-91
Jun-91
Jul-91
Aug-91
Sep-91
Oct-91
Nov-91
Dec-91
Jan-92
Feb-92
Mar-92
Apr-92
May-92
Jun-92
Jul-92
Aug-92
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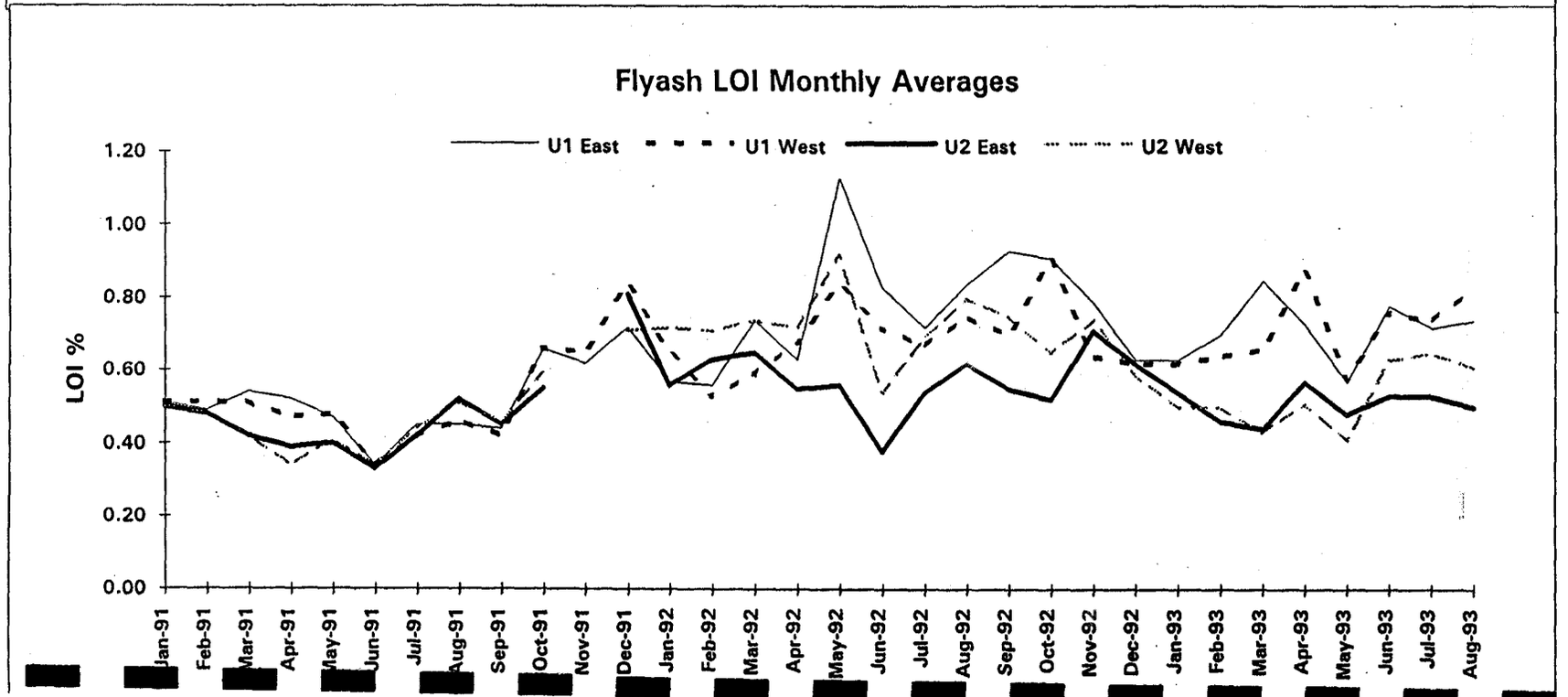
May-93
Jun-93
Jul-93
Aug-93


Flyash LOI Monthly Averages
U1 East
U1 West
U2 East
U2 West
LOI %
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Jan-91
Feb-91
Mar-91
Apr-91
May-91
Jun-91
Jul-91
Aug-91
Sep-91
Oct-91
Nov-91
Dec-91
Jan-92
Feb-92
Mar-92
Apr-92
May-92
Jun-92
Jul-92
Aug-92
Sep-92
Oct-92
Nov-92
Dec-92
Jan-93
Feb-93
Mar-93
Apr-93
May-93
Jun-93
Jul-93
Aug-93

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January 1991 Flyash LOI Monthly Summary

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Jan	AM															
	PM															
2-Jan	AM	0.54	0.41	0.49	0.49	0.38	0.46									
	PM	0.41	0.63	0.50	0.57	0.40	0.49									
3-Jan	AM	0.61	0.58	0.60												
	PM	0.47	0.61	0.54	0.60	0.57	0.58									
4-Jan	AM	0.40	0.37	0.38	0.56	0.39	0.48									
	PM				0.45	0.30	0.34									
5-Jan	AM		0.42	0.42	0.48	0.47	0.48									
	PM	0.32		0.32	0.42	0.39	0.38									
6-Jan	AM	0.35	0.36	0.36	0.41	0.42	0.42									
	PM															
7-Jan	AM															
	PM	0.27	0.38	0.33	0.33	0.30	0.32									
8-Jan	AM	0.35	0.30	0.32	0.36	0.28	0.32									
	PM	0.62	0.57	0.60	0.41	0.47	0.41									
9-Jan	AM	0.49	0.42	0.44	0.39	0.47	0.46									
	PM	0.23	0.44	0.37	0.30	0.33	0.32									
10-Jan	AM	0.34	0.40	0.38	0.35	0.40	0.37									
	PM	0.32	0.42	0.36	0.44	0.45	0.44									
11-Jan	AM	0.35	0.42	0.39	0.47	0.61	0.55									
	PM	0.47	0.46	0.47	0.45	0.54	0.43									
12-Jan	AM	0.54	0.44	0.49	0.64	0.52	0.53									
	PM	0.54	0.42	0.48	0.57	0.54	0.56									
13-Jan	AM	0.63	0.75	0.63	0.70	0.47	0.58									
	PM	0.67	0.79	0.67	0.48	0.47	0.60									
14-Jan	AM	0.98	0.67	0.77	0.46	0.53	0.49									
	PM	0.57	0.30	0.46	0.39	0.32	0.35									
15-Jan	AM	0.47	0.40	0.39	0.35	0.42	0.37									
	PM	0.60	0.42	0.52	0.39	0.34	0.36									
16-Jan	AM	0.53	0.43	0.48	0.25	0.39	0.32									
	PM	0.49	0.47	0.43	0.34	0.34	0.32									
17-Jan	AM				0.34	0.37	0.33									
	PM				0.32	0.36	0.37									
18-Jan	AM	0.39	0.47	0.43	0.39	0.38	0.39									
	PM	0.36	0.27	0.32	0.36	0.32	0.36									
19-Jan	AM	0.46	0.51	0.44	0.43	0.37	0.41									
	PM	0.31	0.40	0.35	0.38	0.33	0.35									
20-Jan	AM	0.32	0.31	0.31	0.37	0.42	0.38									
	PM															
21-Jan	AM	0.30	0.27	0.27	0.37	0.38	0.36									
	PM	0.32	0.35	0.32	0.36	0.35	0.36									
22-Jan	AM															
	PM	0.39	0.45	0.41	0.48	0.65	0.52									
23-Jan	AM	0.48	0.51	0.49	0.57	0.59	0.59									
	PM	0.69	0.71	0.69	0.90	0.94	0.92									
24-Jan	AM	0.68	0.75	0.71	0.73	0.96	0.85									
	PM	0.47	0.51	0.50	0.68	0.62	0.65									
25-Jan	AM	0.44	0.52	0.47	0.63	0.73	0.68									
	PM	0.64	0.64	0.64	0.48	0.70	0.58									
26-Jan	AM	0.61	0.62	0.60	0.50	0.70	0.58									
	PM	0.52	0.47	0.52	0.57	0.43	0.50									
27-Jan	AM	0.73	0.73	0.73	0.67	0.73	0.70									
	PM															
28-Jan	AM	0.71	0.70	0.71	0.80	0.73	0.81									
	PM	0.74	0.67	0.70	0.80	0.77	0.75									
29-Jan	AM	0.64	0.63	0.64	0.78	0.77	0.78									
	PM	0.65	0.73	0.69	0.67	0.58	0.62									
30-Jan	AM	0.79	0.71	0.75	0.80	0.72	0.76									
	PM	0.71	0.64	0.68	0.56	0.59	0.57									
31-Jan	AM	0.61	0.55	0.58	0.44	0.67	0.56									
	PM				0.51	0.53	0.52									
averages		0.51	0.51	0.50	0.50	0.50	0.50	0	Approx Total Tons Saved							

February 1991 Flyash LOI Monthly Summary

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Feb	AM	0.51	0.44	0.48	0.46	0.58	0.52									
	PM				0.41	0.41	0.41									
2-Feb	AM	0.58	0.52	0.55	0.34	0.40	0.38									
	PM	0.50	0.40	0.45	0.31	0.29	0.29									
3-Feb	AM	0.39	0.48	0.44	0.32	0.32	0.31									
	PM	0.32	0.25	0.29	0.31	0.34	0.33									
4-Feb	AM	0.30	0.39	0.35	0.24	0.35	0.25									
	PM	0.37	0.34	0.36	0.27	0.28	0.29									
5-Feb	AM	0.40	0.38	0.38	0.33	0.41	0.38									
	PM	0.61	0.48	0.54	0.45	0.46	0.45									
6-Feb	AM	0.54	0.53	0.53	0.50	0.44	0.47									
	PM	0.75	0.88	0.82	0.83	0.86	0.87									
7-Feb	AM															
	PM	0.60	0.57	0.57	0.69	0.58	0.64									
8-Feb	AM	0.61	0.57	0.58												
	PM	0.51	0.39	0.45	0.64	0.48	0.55									
9-Feb	AM	0.35	0.50	0.42												
	PM	0.37	0.36	0.37												
10-Feb	AM	0.36	0.46	0.40												
	PM	0.28	0.28	0.29												
11-Feb	AM	0.47	0.42	0.42												
	PM	0.46	0.43	0.45												
12-Feb	AM	0.56	0.58	0.57												
	PM	0.61	0.58	0.60												
13-Feb	AM	0.41	0.50	0.46												
	PM	0.46	0.40	0.43												
14-Feb	AM	0.59	0.59	0.59												
	PM	0.50	0.57	0.54												
15-Feb	AM	0.52	0.71	0.62												
	PM	0.59	0.66	0.63												
16-Feb	AM	0.49	0.71	0.60												
	PM	0.49	0.66	0.58												
17-Feb	AM	0.58	0.68	0.63	0.78	0.74	0.76									
	PM	0.73	0.69	0.71	0.48	0.50	0.49									
18-Feb	AM	0.55	0.63	0.59	0.55	0.51	0.53									
	PM	0.56	0.69	0.63	0.69	0.67	0.68									
19-Feb	AM															
	PM	0.61	0.51	0.56	0.52	0.55	0.54									
20-Feb	AM	0.40	0.46	0.43												
	PM	0.48	0.45	0.47	0.48	0.47	0.48									
21-Feb	AM	0.50	0.44	0.47												
	PM	0.45	0.51	0.48	0.58	0.53	0.56									
22-Feb	AM															
	PM	0.34	0.50	0.42	0.43	0.57	0.57									
23-Feb	AM	0.44	0.49	0.47	0.50	0.55	0.53									
	PM	0.39	0.36	0.38	0.50	0.46	0.48									
24-Feb	AM	0.54	0.42	0.48	0.52	0.47	0.50									
	PM				0.41	0.40	0.41									
25-Feb	AM	0.50	0.60	0.55												
	PM	0.53	0.53	0.53	0.42	0.44	0.43									
26-Feb	AM	0.44	0.52	0.48	0.45	0.38	0.42									
	PM															
27-Feb	AM	0.50	0.55	0.53	0.50	0.48	0.48									
	PM	0.55	0.50	0.53	0.50	0.34	0.42									
28-Feb	AM	0.47	0.37	0.42	0.49	0.50	0.50									
	PM															
29-Feb	AM															
	PM															
	AM															
	PM															
	AM															
	PM															
averages		0.49	0.51	0.50	0.48	0.48	0.48	0	Approx Total Tons Saved							

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March 1991Flyash LOI Monthly Summary

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Mar	AM	0.56	0.50	0.53	0.36	0.33	0.36									
	PM	0.86	0.54	0.70	0.40	0.37	0.39									
2-Mar	AM	No Test														
	PM	0.52	0.35	0.44	0.39	0.36	0.38									
3-Mar	AM	0.40	0.27	0.34	0.29	0.24	0.27									
	PM	0.35	0.17	0.26	0.34	0.36	0.35									
4-Mar	AM	0.37	0.35	0.36	0.37	0.42	0.40									
	PM				0.35	0.38	0.37									
5-Mar	AM	0.41	0.24	0.33	0.30	0.28	0.29									
	PM	0.58	0.38	0.48	0.33	0.37	0.35									
6-Mar	AM	0.54	0.36	0.45	0.34	0.45	0.40									
	PM	0.76	0.49	0.63	0.43	0.52	0.48									
7-Mar	AM	0.61	0.50	0.56	0.40	0.57	0.49									
	PM	0.68	0.56	0.62												
8-Mar	AM	0.46	0.50	0.48	0.39	0.43	0.41									
	PM	0.42	0.44	0.43												
9-Mar	AM	0.40	0.43	0.42	0.35	0.38	0.37									
	PM	0.35	0.37	0.36	0.36	0.35	0.36									
10-Mar	AM	0.40	0.47	0.44	0.52	0.55	0.54									
	PM	0.58	0.77	0.68	0.41	0.50	0.46									
11-Mar	AM	0.54	0.82	0.68	0.50	0.59	0.55									
	PM	0.54	0.61	0.58	0.49	0.52	0.51									
12-Mar	AM	0.28	0.29	0.29	0.33	0.38	0.36									
	PM	0.61	0.74	0.68	0.42	0.41	0.42									
13-Mar	AM	0.59	0.64	0.62	0.42	0.41	0.42									
	PM	0.59	0.54	0.57	0.55	0.59	0.57									
14-Mar	AM	0.57	0.64	0.61	0.48	0.57	0.53									
	PM	0.60	0.70	0.65	0.50	0.51	0.51									
15-Mar	AM	0.51	0.56	0.54	0.54	0.52	0.53									
	PM	0.52	0.44	0.48	0.56	0.51	0.54									
16-Mar	AM	0.61	0.78	0.70	0.62	0.57	0.60									
	PM															
17-Mar	AM															
	PM															
18-Mar	AM															
	PM	0.49	0.49	0.49	0.40	0.46	0.43									
19-Mar	AM	0.37	0.37	0.37	0.30	0.34	0.32									
	PM	0.80	0.75	0.78	0.47	0.51	0.49									
20-Mar	AM	0.75	0.63	0.69	0.52	0.53	0.53									
	PM				0.53	0.52	0.53									
21-Mar	AM	0.60	0.56	0.58												
	PM	0.67	0.57	0.62												
22-Mar	AM	0.53	0.49	0.50	0.41	0.39	0.40									
	PM	0.58	0.42	0.50	0.40	0.30	0.35									
23-Mar	AM				0.43	0.41	0.42									
	PM				0.52	0.51	0.52									
24-Mar	AM				0.51	0.55	0.53									
	PM				0.40	0.42	0.41									
25-Mar	AM				0.31	0.35	0.33									
	PM				0.33	0.31	0.32									
26-Mar	AM				0.62	0.51	0.57									
	PM				0.53	0.46	0.50									
27-Mar	AM				0.44	0.36	0.40									
	PM															
28-Mar	AM				0.33	0.23	0.28									
	PM				0.25	0.22	0.24									
29-Mar	AM				0.31	0.29	0.30									
	PM				0.37	0.34	0.36									
30-Mar	AM				0.40	0.37	0.39									
	PM				0.39	0.35	0.37									
31-Mar	AM															
	PM															
averages		0.54	0.51	0.53	0.42	0.42	0.42	0	Approx Total Tons Saved							

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April 1991Flyash LOI Monthly Summary

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Apr	AM				0.28	0.29	0.29									
	PM				0.38	0.34	0.36									
2-Apr	AM				0.29	0.25	0.27									
	PM				0.28	0.22	0.25									
3-Apr	AM				0.36	0.37	0.36									
	PM				0.40	0.38	0.38									
4-Apr	AM				0.42	0.42	0.42									
	PM				0.42	0.44	0.43									
5-Apr	AM				0.19	0.13	0.16									
	PM				0.45	0.33	0.39									
6-Apr	AM				0.38	0.19	0.25									
	PM				0.43	0.32	0.38									
7-Apr	AM				0.40	0.29	0.35									
	PM				0.47	0.28	0.38									
8-Apr	AM				0.34	0.30	0.32									
	PM				0.21	0.18	0.20									
9-Apr	AM				0.32	0.29	0.31									
	PM				0.27	0.22	0.25									
10-Apr	AM				0.20	0.16	0.18									
	PM															
11-Apr	AM				0.25	0.20	0.23									
	PM				0.34	0.28	0.31									
12-Apr	AM				0.25	0.17	0.21									
	PM				0.36	0.27	0.32									
13-Apr	AM				0.33	0.26	0.30									
	PM				0.37	0.34	0.36									
14-Apr	AM				0.20	0.18	0.19									
	PM				0.19	0.21	0.20									
15-Apr	AM				0.30	0.27	0.29									
	PM				0.54	0.41	0.48									
16-Apr	AM															
	PM				0.52	0.36	0.44									
17-Apr	AM				0.67	0.47	0.57									
	PM				0.66	0.49	0.58									
18-Apr	AM				0.56	0.50	0.53									
	PM				0.46	0.36	0.41									
19-Apr	AM				0.54	0.49	0.52									
	PM				0.51	0.42	0.47									
20-Apr	AM															
	PM															
21-Apr	AM															
	PM															
22-Apr	AM	0.40	0.52	0.46	0.44	0.43	0.44									
	PM	0.47	0.47	0.47	0.41	0.39	0.40									
23-Apr	AM															
	PM															
24-Apr	AM				0.34	0.37	0.36									
	PM	0.81	0.69	0.75	0.78	0.65	0.72									
25-Apr	AM	0.62	0.43	0.53	0.46	0.50	0.48									
	PM	0.61	0.47	0.54	0.55	0.65	0.60									
26-Apr	AM				0.40	0.49	0.45									
	PM	0.23	0.12	0.18	0.80	0.23	0.21									
27-Apr	AM															
	PM															
28-Apr	AM															
	PM															
29-Apr	AM				0.14	0.25	0.20									
	PM	0.53	0.61	0.57	0.35	0.38	0.37									
30-Apr	AM	0.48	0.43	0.46												
	PM				0.34	0.42	0.38									
4/31/91	AM															
	PM															
averages		0.52	0.47	0.50	0.39	0.34	0.36	0	Approx Total Tons Saved							

May 1991Flyash LOI Monthly Summary

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-May	AM				0.27	0.37	0.32									
	PM															
2-May	AM															
	PM															
3-May	AM				0.32	0.35	0.34									
	PM															
4-May	AM															
	PM															
5-May	AM															
	PM															
6-May	AM															
	PM				0.27	0.23	0.25									
7-May	AM				0.22	0.28	0.25									
	PM				0.18	0.32	0.25									
8-May	AM				0.24	0.33	0.29									
	PM				0.25	0.27	0.26									
9-May	AM	0.64	0.40	0.52	0.26	0.35	0.31									
	PM				0.26	0.35	0.31									
10-May	AM	0.49	0.44	0.47	0.31	0.36	0.34									
	PM				0.38	0.32	0.35									
11-May	AM															
	PM															
12-May	AM															
	PM															
13-May	AM	0.40	0.32	0.36	0.35	0.28	0.32									
	PM				0.34	0.31	0.33									
14-May	AM															
	PM				0.54	0.50	0.52									
15-May	AM				0.47	0.46	0.47									
	PM	0.35	0.27	0.31	0.36	0.31	0.34									
16-May	AM				0.34	0.27	0.31									
	PM	0.41	0.34	0.38	0.40	0.24	0.32									
17-May	AM	0.65	0.45	0.55	0.42	0.38	0.40									
	PM	0.57	0.40	0.49	0.45	0.40	0.43									
18-May	AM	0.47	0.49	0.48	0.54	0.59	0.57									
	PM															
19-May	AM	0.46	0.36	0.41	0.49	0.55	0.52									
	PM															
20-May	AM	0.37	0.38	0.38												
	PM	0.45	0.33	0.39	0.51	0.41	0.46									
21-May	AM															
	PM				0.40	0.32	0.36									
22-May	AM				0.43	0.44	0.44									
	PM				0.39	0.33	0.36									
23-May	AM				0.39	0.29	0.34									
	PM	0.34	0.40	0.36	0.26	0.22	0.24									
24-May	AM				0.37	0.34	0.35									
	PM	0.36	0.42	0.40												
25-May	AM															
	PM															
26-May	AM															
	PM															
27-May	AM															
	PM															
28-May	AM				0.20	0.16	0.19									
	PM	0.55	1.79	1.44	1.98	2.97	2.25									
29-May	AM				0.29	0.27	0.28									
	PM	0.47	0.38	0.44												
30-May	AM				0.31	0.35	0.33									
	PM															
31-May	AM	0.44	0.34	0.34	0.45	0.38	0.43									
	PM	0.60	0.57	0.58	0.23	0.22	0.22									
averages		0.47	0.48	0.49	0.40	0.41	0.40	0	Approx Total Tons Saved							

IP7_000276

June 1991Flyash LOI Monthly Summary

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Jun	AM	0.35	0.31	0.38	0.27	0.40	0.36									
	PM	0.33	0.44	0.40		0.32	0.32									
2-Jun	AM															
	PM															
3-Jun	AM	0.28	0.23	0.26												
	PM															
4-Jun	AM	0.27	0.32	0.35	0.34	0.25	0.28									
	PM															
5-Jun	AM	0.35	0.42	0.37	0.35	0.34	0.34									
	PM				0.23	0.19	0.21									
6-Jun	AM															
	PM															
7-Jun	AM				0.29	0.25	0.28									
	PM	0.26	0.25	0.32												
8-Jun	AM	0.28	0.25	0.27	0.31	0.37	0.36									
	PM															
9-Jun	AM	0.20	0.24	0.22	0.30	0.26	0.28									
	PM															
10-Jun	AM	0.26	0.33	0.29	0.39	0.34	0.37									
	PM				0.18	0.21	0.19									
11-Jun	AM				0.31	0.39	0.36									
	PM	0.43	0.49	0.46	0.36	0.41	0.39									
12-Jun	AM															
	PM	0.37	0.34	0.35												
13-Jun	AM															
	PM	0.35	0.26	0.31												
14-Jun	AM	0.32	0.31	0.32												
	PM	0.27	0.31	0.31	0.39	0.35	0.37									
15-Jun	AM	0.28	0.27	0.29	0.56	0.44	0.48									
	PM															
16-Jun	AM															
	PM															
17-Jun	AM				0.33	0.27	0.30									
	PM				0.33	0.20	0.27									
18-Jun	AM															
	PM	0.31	0.24	0.28	0.25	0.35	0.30									
19-Jun	AM				0.24	0.33	0.29									
	PM	0.47	0.40	0.44												
20-Jun	AM															
	PM				0.34	0.33	0.34									
21-Jun	AM															
	PM															
22-Jun	AM				0.40	0.46	0.43									
	PM															
23-Jun	AM	0.26	0.40	0.33												
	PM	0.29	0.23	0.26	0.19	0.29	0.24									
24-Jun	AM	0.43	0.40	0.41	0.35	0.34	0.35									
	PM	0.32	0.37	0.35	0.42	0.49	0.46									
25-Jun	AM				0.34	0.50	0.42									
	PM	0.55	0.49	0.52	0.40	0.50	0.45									
26-Jun	AM															
	PM	0.49	0.46	0.48												
27-Jun	AM															
	PM															
28-Jun	AM															
	PM															
29-Jun	AM															
	PM															
30-Jun	AM															
	PM															
6/31/91	AM															
	PM															
averages		0.34	0.34	0.35	0.33	0.34	0.34	0	Approx Total Tons Saved							

IP7_000277

July 1991Flyash LOI Monthly Summary

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Jul	AM	0.28	0.30	0.29	0.50	0.40	0.45									
	PM	0.40	0.32	0.38	0.42	0.46	0.44									
2-Jul	AM	0.46	0.60	0.53												
	PM	0.30	0.18	0.26	0.46	0.43	0.47									
3-Jul	AM	0.48	0.34	0.41												
	PM	0.53	0.37	0.45	0.40	0.44	0.42									
4-Jul	AM															
	PM															
5-Jul	AM															
	PM	0.26	0.19	0.23	0.35	0.39	0.37									
6-Jul	AM															
	PM															
7-Jul	AM															
	PM															
8-Jul	AM	0.54	0.36	0.45	0.26	0.31	0.29									
	PM	0.30	0.30	0.30	0.48	0.47	0.48									
9-Jul	AM	0.52	0.48	0.50	0.41	0.33	0.37									
	PM	0.40	0.42	0.47	0.42	0.45	0.44									
10-Jul	AM	0.36	0.40	0.38	0.40	0.40	0.40									
	PM	0.38	0.25	0.32	0.29	0.31	0.30									
11-Jul	AM	0.28	0.37	0.32	0.23	0.27	0.25									
	PM	0.44	0.30	0.37	0.29	0.39	0.34									
12-Jul	AM	0.55	0.46	0.46	0.32	0.48	0.39									
	PM	0.55	0.31	0.43	0.45	0.50	0.48									
13-Jul	AM	0.59	0.49	0.54	0.48	0.60	0.55									
	PM															
14-Jul	AM															
	PM															
15-Jul	AM	0.48	0.34	0.41												
	PM				0.34	0.38	0.36									
16-Jul	AM	0.38	0.34	0.34	0.31	0.30	0.34									
	PM	0.42	0.40	0.41	0.33	0.30	0.33									
17-Jul	AM				0.53	0.58	0.56									
	PM				0.49	0.45	0.47									
18-Jul	AM				0.54	0.54	0.54									
	PM				0.72	0.58	0.65									
19-Jul	AM	0.46	0.53	0.50	0.44	0.37	0.45									
	PM															
20-Jul	AM	0.25	0.38	0.41	0.36	0.36	0.36									
	PM	0.47	0.45	0.46	0.52	0.54	0.53									
21-Jul	AM															
	PM	0.44	0.44	0.44	0.45	0.38	0.42									
22-Jul	AM	0.27	0.39	0.34	0.31	0.35	0.39									
	PM															
23-Jul	AM	0.34	0.21	0.28	0.34	0.48	0.41									
	PM	0.40	0.33	0.39	0.36	0.39	0.38									
24-Jul	AM	0.62	0.39	0.51	0.50	0.47	0.49									
	PM	0.59	0.48	0.55	0.50	0.43	0.46									
25-Jul	AM	0.49	0.37	0.42	0.48	0.44	0.46									
	PM	0.46	0.43	0.45	0.52	0.56	0.54									
26-Jul	AM	0.45	0.45	0.45	0.43	0.41	0.42									
	PM	0.55	0.58	0.56	0.45	0.46	0.45									
27-Jul	AM	0.55	0.63	0.57	0.48	0.54	0.51									
	PM	0.70	0.75	0.73	0.50	0.65	0.58									
28-Jul	AM															
	PM															
29-Jul	AM	0.53	0.55	0.54												
	PM	0.61	0.65	0.63	0.40	0.57	0.49									
30-Jul	AM				0.40	0.48	0.45									
	PM	0.58	0.53	0.56	0.37	0.45	0.43									
31-Jul	AM	0.44	0.46	0.44	0.48	0.53	0.51									
	PM	0.55	0.51	0.51												
averages		0.45	0.42	0.44	0.42	0.44	0.44	0	Approx Total Tons Saved							

IP7_000278

August 1991 Flyash LOI Monthly Summary

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S. Pulverizer Unit 1	O/S. Pulverizer Unit 2
1-Aug	AM	0.49	0.49	0.49	0.47	0.55	0.51									
	PM	0.75	0.62	0.66	0.60	0.64	0.62									
2-Aug	AM	0.41	0.39	0.42	0.38	0.36	0.35									
	PM	0.55	0.62	0.62	0.23	0.43	0.37									
3-Aug	AM															
	PM															
4-Aug	AM															
	PM															
5-Aug	AM	0.51	0.46	0.59	0.50	0.56	0.53									
	PM	0.61	0.57	0.59	0.73	0.73	0.73									
6-Aug	AM	0.56	0.59	0.57	0.52	0.56	0.52									
	PM	0.58	0.54	0.56	0.59	0.60	0.59									
7-Aug	AM	0.48	0.48	0.48	0.71	0.82	0.76									
	PM	0.43	0.54	0.45	0.50	0.63	0.62									
8-Aug	AM															
	PM															
9-Aug	AM															
	PM	0.33	0.51	0.42	0.62	0.57	0.60									
10-Aug	AM	0.43	0.46	0.43	0.62	0.61	0.62									
	PM	0.48	0.48	0.48												
11-Aug	AM	0.45	0.46	0.47	0.44	0.58	0.48									
	PM															
12-Aug	AM				0.56	0.49	0.52									
	PM	0.45	0.46	0.46	0.48	0.41	0.44									
13-Aug	AM															
	PM															
14-Aug	AM	0.39	0.42	0.45	0.57	0.43	0.50									
	PM															
15-Aug	AM	0.51	0.41	0.46												
	PM	0.42	0.37	0.40	0.49	0.35	0.42									
16-Aug	AM	0.37	0.39	0.38	0.55	0.48	0.52									
	PM	0.42	0.41	0.42	0.55	0.45	0.50									
17-Aug	AM	0.53	0.55	0.53	0.65	0.67	0.66									
	PM	0.65	0.68	0.67	0.85	0.60	0.68									
18-Aug	AM	0.48	0.55	0.52	0.72	0.54	0.63									
	PM															
19-Aug	AM															
	PM	0.48	0.39	0.44	0.52	0.40	0.46									
20-Aug	AM	0.47	0.41	0.44												
	PM	0.44	0.43	0.44	0.64	0.46	0.55									
21-Aug	AM	0.46	0.51	0.49												
	PM	0.49	0.49	0.49	0.61	0.47	0.54									
22-Aug	AM	0.36	0.44	0.40												
	PM	0.41	0.44	0.43	0.53	0.49	0.51									
23-Aug	AM															
	PM	0.46	0.49	0.48	0.51	0.50	0.51									
24-Aug	AM	0.49	0.47	0.48	0.50	0.45	0.48									
	PM															
25-Aug	AM	0.40	0.40	0.40	0.45	0.36	0.41									
	PM															
26-Aug	AM	0.39	0.37	0.38	0.31	0.40	0.35									
	PM	0.39	0.38	0.38	0.34	0.39	0.37									
27-Aug	AM				0.36	0.43	0.40									
	PM	0.38	0.39	0.39	0.30	0.44	0.35									
28-Aug	AM															
	PM	0.35	0.36	0.36	0.41	0.50	0.45									
29-Aug	AM	0.35	0.33	0.34												
	PM	0.33	0.34	0.34	0.51	0.60	0.55									
30-Aug	AM	0.41	0.42	0.42												
	PM	0.41	0.44	0.48	0.51	0.56	0.54									
31-Aug	AM															
	PM	0.35	0.36	0.36	0.53	0.47	0.50									
averages		0.45	0.46	0.46	0.52	0.51	0.52	0	Approx Total Tons Saved							

IP7_000279

SEPTEMBER 1991 FLYASH LOI MONTHLY SUMMARY

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Sep	AM	0.44	0.43	0.43												
	PM															
2-Sep	AM															
	PM	0.37	0.35	0.35	0.53	0.47	0.50									
3-Sep	AM				0.45	0.43	0.44									
	PM				0.46	0.39	0.43									
4-Sep	AM															
	PM	0.50	0.48	0.49												
5-Sep	AM	0.64	0.55	0.60	0.78	0.62	0.70									
	PM	0.61	0.44	0.53	0.60	0.44	0.54									
6-Sep	AM	0.54	0.45	0.50												
	PM	0.52	0.41	0.50	0.51	0.50	0.51									
7-Sep	AM															
	PM	0.51	0.42	0.47	0.53	0.50	0.48									
8-Sep	AM															
	PM															
9-Sep	AM	0.36	0.36	0.36												
	PM	0.41	0.32	0.37	0.41	0.31	0.39									
10-Sep	AM	0.34	0.32	0.33	0.36	0.35	0.35									
	PM	0.35	0.25	0.30	0.38	0.31	0.35									
11-Sep	AM	0.30	0.29	0.30	0.33	0.28	0.31									
	PM	0.36	0.27	0.31	0.32	0.36	0.34									
12-Sep	AM				0.38	0.33	0.36									
	PM	0.37	0.38	0.37	0.48	0.39	0.44									
13-Sep	AM	0.41	0.39	0.40	0.49	0.44	0.46									
	PM															
14-Sep	AM															
	PM															
15-Sep	AM															
	PM															
16-Sep	AM				0.40	0.41	0.45									
	PM	0.50	0.47	0.49	0.40	0.32	0.37									
17-Sep	AM	0.38	0.56	0.47												
	PM															
18-Sep	AM															
	PM	0.58	0.63	0.61	0.52	0.56	0.54									
19-Sep	AM				0.37		0.37									
	PM				0.36	0.39	0.38									
20-Sep	AM															
	PM															
21-Sep	AM	0.39	0.44	0.42	0.35	0.42	0.36									
	PM				0.49	0.54	0.52									
22-Sep	AM				0.47	0.57	0.52									
	PM	0.43	0.50	0.47	0.49	0.49	0.49									
23-Sep	AM															
	PM	0.50		0.50	0.37	0.45	0.40									
24-Sep	AM				0.37	0.53	0.44									
	PM				0.44	0.56	0.50									
25-Sep	AM				0.50	0.57	0.53									
	PM				0.57	0.70	0.64									
26-Sep	AM				0.44	0.53	0.49									
	PM				0.45	0.47	0.46									
27-Sep	AM															
	PM				0.51	0.53	0.52									
28-Sep	AM															
	PM															
29-Sep	AM															
	PM															
30-Sep	AM				0.45	0.42	0.44									
	PM	0.41	0.50	0.44	0.34	0.59	0.51									
	AM															
	PM															
averages		0.44	0.42	0.44	0.45	0.46	0.46	0	Approx Total Tons Saved							

IP7_000280

OCTOBER 1991 FLYASH LOI MONTHLY SUMMARY

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Oct	AM	0.38	0.39	0.38												
	PM	0.39	0.37	0.38	0.46	0.36	0.41									
2-Oct	AM	0.39	0.38	0.39	0.49	0.37	0.43									
	PM	0.43	0.50	0.46	0.45	0.35	0.40									
3-Oct	AM	0.50	0.51	0.51	0.47	0.41	0.45									
	PM	0.46	0.44	0.45	0.53	0.43	0.47									
4-Oct	AM	0.39	0.44	0.42	0.43	0.40	0.42									
	PM	0.54	0.57	0.56	0.61	0.56	0.58									
5-Oct	AM	0.69	0.71	0.70	0.83	0.73	0.78									
	PM	0.66	0.66	0.65	0.57	0.58	0.58									
6-Oct	AM	0.53	0.64	0.58	0.60	0.61	0.61									
	PM	0.53	0.53	0.52	0.58	0.59	0.59									
7-Oct	AM	0.57	0.62	0.56	0.53	0.91	0.78									
	PM	0.52	0.51	0.51	0.43	0.73	0.62									
8-Oct	AM															
	PM	0.57	0.60	0.58												
9-Oct	AM	0.63	0.51	0.57	0.54	0.64	0.59									
	PM	0.57	0.61	0.59	0.57	0.59	0.58									
10-Oct	AM	0.48	0.56	0.52	0.54	0.52	0.53									
	PM				0.48	0.49	0.49									
11-Oct	AM				0.52	0.51	0.52									
	PM				0.43	0.51	0.47									
12-Oct	AM				0.41		0.41									
	PM				0.52	0.38	0.44									
13-Oct	AM				0.47	0.52	0.48									
	PM				0.46	0.56	0.51									
14-Oct	AM				0.52	0.51	0.52									
	PM															
15-Oct	AM	0.50	0.53	0.52												
	PM	0.50	0.43	0.47												
16-Oct	AM	0.46	0.46	0.46	0.45	0.40	0.42									
	PM															
17-Oct	AM	0.72	0.63	0.64												
	PM	0.68	0.59	0.64		0.43	0.43									
18-Oct	AM	0.66	0.63	0.65	0.40	0.37	0.38									
	PM	0.57	0.60	0.59	0.37	0.31	0.34									
19-Oct	AM	0.54	0.65	0.60	0.36	0.41	0.39									
	PM				0.68	0.91	0.81									
20-Oct	AM	0.67	0.74	0.70	0.56	0.62	0.59									
	PM	0.67	0.74	0.71	0.57	0.67	0.63									
21-Oct	AM	0.65	0.76	0.79	0.49	0.55	0.52									
	PM	0.80	0.85	0.81	0.56	0.65	0.60									
22-Oct	AM	0.80	0.71	0.76	0.57	0.71	0.63									
	PM	0.73	0.88	0.81	1.05	0.93	0.99									
23-Oct	AM	1.07	1.02	1.04	0.71	0.79	0.75									
	PM	1.01	0.95	0.98	0.74	0.86	0.80									
24-Oct	AM	0.98	0.92	0.94	0.63	0.76	0.69									
	PM	0.92	0.76	0.84	0.61	0.80	0.68									
25-Oct	AM	1.01	0.94	0.97	0.75	0.81	0.79									
	PM	0.97	0.91	0.94	0.76	0.78	0.77									
26-Oct	AM															
	PM															
27-Oct	AM	0.75	0.66	0.71												
	PM	0.63	0.56	0.57												
28-Oct	AM	0.71	0.63	0.67												
	PM	0.71	0.84	0.63												
29-Oct	AM	0.73	0.63	0.66												
	PM	0.81	0.72	0.76												
30-Oct	AM	0.90	0.96	0.93												
	PM	0.80	0.99	0.90												
31-Oct	AM	0.77	0.83	0.80												
	PM	0.62	0.69	0.64												
averages		0.66	0.66	0.66	0.55	0.59	0.57	0	Approx Total Tons Saved							

NOVEMBER 1991 FLYASH LOI MONTHLY SUMMARY

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Nov	AM	0.79	0.77	0.78	Outage											
	PM	0.80	0.65	0.72												
2-Nov	AM	0.67	0.65	0.67												
	PM	0.61	0.56	0.60												
3-Nov	AM	0.65	0.70	0.67												
	PM	0.58	0.62	0.60												
4-Nov	AM	0.51	0.56	0.54												
	PM	0.39	0.53	0.47												
5-Nov	AM	0.55	0.69	0.62												
	PM	0.71	0.80	0.74												
6-Nov	AM	0.74	0.72	0.74												
	PM	0.70	0.59	0.65												
7-Nov	AM	0.67	0.71	0.68												
	PM	0.60	0.56	0.58												
8-Nov	AM	0.83	0.76	0.79												
	PM	0.64	0.54	0.59												
9-Nov	AM	0.70	0.76	0.73												
	PM	0.65	0.65	0.65												
10-Nov	AM	0.70	0.58	0.64												
	PM	0.60	0.55	0.58												
11-Nov	AM	0.50	0.50	0.50												
	PM	0.38	0.38	0.39												
12-Nov	AM															
	PM	0.41	0.47	0.44												
13-Nov	AM	0.43	0.47	0.45												
	PM	0.41	0.46	0.44												
14-Nov	AM	0.51	0.48	0.50												
	PM	0.48	0.46	0.46												
15-Nov	AM	0.52	0.59	0.56												
	PM	0.49	0.55	0.52												
16-Nov	AM	0.51	0.63	0.57												
	PM	0.50	0.52	0.51												
17-Nov	AM	0.50	0.59	0.54												
	PM	0.58	0.74	0.66												
18-Nov	AM	0.64	0.65	0.64												
	PM	0.97	0.72	0.86												
19-Nov	AM															
	PM	0.92	0.86	0.89												
20-Nov	AM	0.82	0.85	0.85												
	PM	0.71	0.80	0.76												
21-Nov	AM	0.71	0.80	0.75												
	PM	0.70	0.80	0.75												
22-Nov	AM	0.56	0.74	0.64												
	PM	0.68	0.66	0.67												
23-Nov	AM	0.56	0.67	0.61												
	PM	0.66	0.72	0.68												
24-Nov	AM	0.52	0.69	0.59												
	PM	0.64	0.71	0.68												
25-Nov	AM	0.66	0.70	0.68												
	PM	0.56	0.55	0.55												
26-Nov	AM	0.59	0.72	0.65												
	PM	0.52	0.75	0.67												
27-Nov	AM	0.56	0.67	0.62												
	PM	0.59	0.65	0.62												
28-Nov	AM															
	PM															
29-Nov	AM	0.67	0.65	0.67												
	PM															
30-Nov	AM	0.60	0.66	0.63												
	PM	0.70	0.67	0.69												
	AM															
	PM															
averages		0.62	0.65	0.63	####	####	####	0	Approx Total Tons Saved							

IP7_000282

DECEMBER 1991 FLYASH LOI MONTHLY SUMMARY

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Dec	AM				0.83	0.64	0.71									
	PM															
2-Dec	AM				0.87	0.73	0.81									
	PM	1.18	1.09	1.14	0.85	0.70	0.77									
3-Dec	AM	1.02	1.02	0.96	1.11	0.76	0.90									
	PM				0.94	0.63	0.78									
4-Dec	AM				0.92	0.79	0.85									
	PM				0.85	0.74	0.80									
5-Dec	AM				0.96	0.84	0.90									
	PM				0.84	0.86	0.85									
6-Dec	AM	1.08	0.97	1.03	0.98	0.82	0.88									
	PM				0.92	0.69	0.80									
7-Dec	AM				0.88	0.80	0.84									
	PM				1.05	0.95	1.00									
8-Dec	AM				1.01	0.95	0.98									
	PM				1.13	1.06	1.10									
9-Dec	AM	1.06	0.99	1.03	0.97	1.03	1.00									
	PM	0.84	0.96	0.90	1.08	0.88	0.98									
10-Dec	AM	0.61	0.95	0.80	0.92	0.89	0.91									
	PM	0.84	0.94	0.89												
11-Dec	AM	0.71	0.74	0.73	0.83	0.82	0.83									
	PM	0.82	0.89	0.85	0.87	0.60	0.74									
12-Dec	AM	0.60	0.93	0.79	0.68	0.62	0.65									
	PM	0.91	1.20	1.06	0.63	0.49	0.56									
13-Dec	AM	0.78	1.03	0.90	0.78	0.63	0.71									
	PM	0.78	0.97	0.88	0.81	0.87	0.84									
14-Dec	AM	0.61	0.83	0.72	0.70	0.69	0.70									
	PM	0.61	0.78	0.70	0.64	0.61	0.63									
15-Dec	AM	0.64	0.73	0.69	0.64	0.72	0.68									
	PM	0.69	0.64	0.67	0.68	0.71	0.70									
16-Dec	AM	0.61	0.95	0.78	0.64	0.67	0.66									
	PM	0.65	0.77	0.71	0.74	0.70	0.72									
17-Dec	AM				0.80	0.66	0.73									
	PM	1.00	0.94	0.97	0.79	0.62	0.70									
18-Dec	AM				0.77	0.95	0.86									
	PM	0.88	1.05	0.97	0.95	0.86	0.91									
19-Dec	AM	0.84	0.95	0.90	0.78	0.75	0.77									
	PM	0.78	0.69	0.73	0.99	0.71	0.84									
20-Dec	AM	1.01	1.11	1.05	0.89	0.78	0.84									
	PM	0.86	0.96	0.91	1.08	0.84	0.95									
21-Dec	AM	0.82	1.09	0.95	0.87	0.78	0.82									
	PM	0.73	0.87	0.80	0.78	0.60	0.69									
22-Dec	AM				0.82	0.72	0.77									
	PM				0.80	0.59	0.70									
23-Dec	AM	0.65	0.76	0.71	0.67	0.62	0.65									
	PM	0.58	0.85	0.72	0.89	0.56	0.73									
24-Dec	AM	0.58	0.77	0.68	0.82	0.64	0.71									
	PM	0.62	0.75	0.68	0.66	0.56	0.61									
25-Dec	AM															
	PM															
26-Dec	AM				0.72	0.67	0.70									
	PM	0.63	0.79	0.71	0.94	0.64	0.79									
27-Dec	AM	0.47	0.59	0.53	0.64	0.65	0.64									
	PM	0.37	0.45	0.41	0.49	0.51	0.50									
28-Dec	AM	0.45	0.60	0.51	0.60	0.63	0.62									
	PM	0.39	0.60	0.50	0.58	0.50	0.54									
29-Dec	AM	0.37	0.49	0.43	0.59	0.57	0.58									
	PM	0.72	0.97	0.85	0.68	0.64	0.66									
30-Dec	AM	0.61	0.69	0.65	0.49	0.45	0.47									
	PM	0.64	0.73	0.69	0.65	0.60	0.63									
31-Dec	AM	0.60	0.76	0.68	0.75	0.66	0.71									
	PM	0.63	0.63	0.63	0.69	0.72	0.71									
averages		0.72	0.84	0.78	0.81	0.71	0.76	0	Approx Total Tons Saved							

January 1992 Flyash LOI Monthly Summary

1992		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Jan	AM	0.57	0.64	0.61	0.43	0.60	0.52		---	---	---	---	---	---	---	---
	PM	0.54	0.62	0.58	0.42	0.46	0.44									
2-Jan	AM	0.46	0.64	0.55	0.32	0.38	0.35		---	---	---	---	---	---	---	---
	PM	0.41	0.58	0.50	0.41	0.51	0.46									
3-Jan	AM	0.49	0.67	0.58	0.42	0.51	0.47		---	---	---	---	---	---	---	---
	PM	0.47	0.81	0.64	0.39	0.55	0.47									
4-Jan	AM	0.46	0.80	0.63	0.41	0.64	0.53		---	---	---	---	---	---	---	---
	PM	0.43		0.43	0.40	0.56	0.48									
5-Jan	AM	0.45	0.62	0.54	0.34	0.48	0.41		---	---	---	---	---	---	---	---
	PM	0.45	0.54	0.50	0.36	0.49	0.43									
6-Jan	AM	0.53	0.58	0.56	0.33	0.54	0.44		---	---	---	---	---	---	---	---
	PM	0.48	0.58	0.53	0.31	0.60	0.46									
7-Jan	AM	0.55	0.64	0.60					---	---	---	---	---	---	---	---
	PM	0.48	0.65	0.57	0.55	0.67	0.61									
8-Jan	AM	0.48	0.65	0.57	0.49	0.63	0.56		---	---	---	---	---	---	---	---
	PM	0.45	0.90	0.68	0.51	0.58	0.55									
9-Jan	AM	0.51	0.64	0.58	0.45	0.64	0.55		---	---	---	---	---	---	---	---
	PM	0.48	0.62	0.55	0.53	0.60	0.57									
10-Jan	AM	0.56	0.72	0.64	0.44	0.62	0.53		---	---	---	---	---	---	---	---
	PM	0.48	0.71	0.60	0.41	0.74	0.58									
11-Jan	AM	0.59	0.79	0.69	0.49	0.67	0.58		---	---	---	---	---	---	---	---
	PM	0.53	0.69	0.61	0.60	0.92	0.76									
12-Jan	AM	0.43	0.67	0.55	0.43	0.57	0.50		---	---	---	---	---	---	---	---
	PM	0.39	0.54	0.47	0.40	0.53	0.47									
13-Jan	AM	0.48	0.65	0.57					---	---	---	---	---	---	---	---
	PM	0.44	0.65	0.56	0.49	0.94	0.72									
14-Jan	AM				0.51	0.78	0.65		---	---	---	---	---	---	---	---
	PM	0.74	0.70	0.72	0.63	0.94	0.79									
15-Jan	AM				0.81	1.18	1.00		---	---	---	---	---	---	---	---
	PM	0.70	0.93	0.82	0.69	0.97	0.83									
16-Jan	AM	0.64	0.74	0.69	0.64	0.96	0.80		---	---	---	---	---	---	---	---
	PM	0.79	0.85	0.82	0.74	0.97	0.86									
17-Jan	AM	0.69	0.86	0.78	0.77	0.89	0.83		---	---	---	---	---	---	---	---
	PM	0.68	0.78	0.73	0.78	0.97	0.88									
18-Jan	AM	0.75	0.84	0.80	0.60	0.75	0.68		---	---	---	---	---	---	---	---
	PM	0.62	0.65	0.64	0.56	0.69	0.76									
19-Jan	AM	0.66	0.76	0.71	0.64	0.86	0.75		---	---	---	---	---	---	---	---
	PM	0.73	0.76	0.75	0.76	0.97	0.87									
20-Jan	AM	0.63	0.65	0.64	0.75	0.89	0.82		---	---	---	---	---	---	---	---
	PM	0.64	0.59	0.62	0.68	0.72	0.70									
21-Jan	AM	0.73	0.70	0.72	0.60	0.76	0.68		---	---	---	---	---	---	---	---
	PM	0.59	0.55	0.57	0.60	0.71	0.66									
22-Jan	AM	0.56	0.63	0.60	0.55	0.78	0.67		---	---	---	---	---	---	---	---
	PM	0.64	0.63	0.64	0.56	0.75	0.66									
23-Jan	AM	0.52	0.55	0.54	0.54	0.74	0.64		---	---	---	---	---	---	---	---
	PM	0.64	0.54	0.59												
24-Jan	AM	0.61	0.59	0.60	0.53	0.72	0.63		---	---	---	---	---	---	---	---
	PM	0.64	0.53	0.59	0.53	0.66	0.60									
25-Jan	AM	0.65	0.58	0.62	0.84	0.83	0.84		---	---	---	---	---	---	---	---
	PM	0.71	0.63	0.67	0.79	0.85	0.82									
26-Jan	AM	0.72	0.55	0.64	0.88	0.68	0.78		---	---	---	---	---	---	---	---
	PM	0.67	0.57	0.62	0.83	0.85	0.84									
27-Jan	AM	0.65	0.56	0.61					---	---	---	---	---	---	---	---
	PM	0.58	0.53	0.56	0.70	0.73	0.72									
28-Jan	AM	0.68	0.57	0.63					---	---	---	---	---	---	---	---
	PM	0.58	0.56	0.57	0.65	0.76	0.71									
29-Jan	AM	0.56	0.54	0.55	0.52	0.73	0.63		---	---	---	---	---	---	---	---
	PM	0.43	0.45	0.44	0.50	0.64	0.57									
30-Jan	AM	0.49	0.47	0.48					---	---	---	---	---	---	---	---
	PM	0.51	0.55	0.53												
31-Jan	AM	0.59	0.58	0.59	0.52	0.69	0.61		---	---	---	---	---	---	---	---
	PM	0.54	0.56	0.55	0.51	0.71	0.61									
averages		0.57	0.65	0.61	0.56	0.72	0.64	0	Approx Total Tons Saved							

IP7_000284

February 1992 Flyash LOI Monthly Summary

1992		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Feb	AM	0.48	0.45	0.47	0.49	0.63	0.56									
	PM	0.55	0.47	0.51	0.50	0.51	0.51									
2-Feb	AM				0.47	0.60	0.54									
	PM															
3-Feb	AM				0.44	0.62	0.53									
	PM	0.51	0.49	0.50	0.55	0.58	0.57									
4-Feb	AM	0.41	0.54	0.48												
	PM	0.46	0.55	0.51												
5-Feb	AM															
	PM															
6-Feb	AM	0.52	0.54	0.53	0.83	0.85	0.84									
	PM	0.59	0.61	0.60	0.76	0.78	0.77									
7-Feb	AM	0.53	0.65	0.59	0.81	0.83	0.82									
	PM	0.49	0.54	0.52	0.74	0.79	0.77									
8-Feb	AM	0.47	0.59	0.53	0.71	0.80	0.76									
	PM	0.47	0.51	0.49	0.68	0.67	0.68									
9-Feb	AM	0.37	0.59	0.48	0.63	0.78	0.71									
	PM				Sludge needed											
10-Feb	AM	Sludge needed			Sludge needed											
	PM	Sludge needed			Sludge needed											
11-Feb	AM	0.39	0.50	0.46	0.51	0.61	0.56									
	PM	0.40	0.45	0.43		0.79	0.79									
12-Feb	AM				0.58	0.72	0.65									
	PM	0.40	0.45	0.43	0.57	0.73	0.65									
13-Feb	AM	0.57	0.63	0.60												
	PM	0.60	0.68	0.64												
14-Feb	AM	0.60	0.54	0.57	0.60	0.76	0.68									
	PM	0.62	0.51	0.57												
15-Feb	AM	0.68	0.57	0.63	0.65	0.77	0.71									
	PM	0.69	0.47	0.58	0.76	0.75	0.76									
16-Feb	AM	0.66	0.57	0.62	0.88	0.76	0.82									
	PM	0.62	0.39	0.51	0.70	0.80	0.75									
17-Feb	AM	0.58	0.44	0.51	0.58	0.68	0.63									
	PM	0.54	0.42	0.48	0.61	0.74	0.68									
18-Feb	AM	0.51	0.41	0.46	0.44	0.60	0.52									
	PM	0.50	0.39	0.45	0.41	0.60	0.51									
19-Feb	AM	Sludge needed			Tagged Out											
	PM	0.72	0.47	0.60	Tagged Out											
20-Feb	AM	0.66	0.52	0.59	Tagged Out											
	PM	0.88	0.62	0.75	0.82	0.98	0.90									
21-Feb	AM	0.72	0.62	0.67	Tagged Out											
	PM	Tagged Out			Tagged Out											
22-Feb	AM	Tagged Out			Tagged Out											
	PM	0.77	0.91	0.84	0.77	0.91	0.84									
23-Feb	AM	Tagged Out			Tagged Out											
	PM	0.52	0.54	0.53	Tagged Out											
24-Feb	AM	Tagged Out			0.52	0.54	0.53									
	PM	Tagged Out			No Test											
25-Feb	AM	Tagged Out			No Test											
	PM	0.28	0.26	0.27	0.40	0.52	0.46									
26-Feb	AM	0.56	0.45	0.51	0.55	0.56	0.56									
	PM	0.86	0.76	0.81	0.74	0.86	0.79									
27-Feb	AM	0.60	0.53	0.57	Tagged Out											
	PM	0.60	0.58	0.59	0.61	0.80	0.71									
28-Feb	AM	0.53	0.50	0.52	No Test											
	PM	No Test			0.48	0.64	0.56									
29-Feb	AM	0.50	0.59	0.55	0.68	0.75	0.72									
	PM	0.63	0.61	0.62	0.79	0.68	0.74									
	AM															
	PM															
	AM															
	PM															
averages		0.56	0.53	0.55	0.63	0.71	0.67	0	Approx Total Tons Saved							

IP7_000285

March 1992 Flyash LOI Monthly Summary

1992		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Mar	AM	0.61	0.63	0.62	0.68	0.71	0.70									
	PM	0.63	0.44	0.54	Tagged Out											
2-Mar	AM	Tagged Out			0.57	0.74	0.66									
	PM	0.76	0.61	0.69	0.69	0.86	0.77									
3-Mar	AM	0.61	0.50	0.56	0.46	0.53	0.48									
	PM	0.60	0.58	0.59	0.59	0.64	0.62									
4-Mar	AM	Tagged Out			0.50	0.60	0.55									
	PM	0.49	0.50	0.50	0.50	0.61	0.56									
5-Mar	AM	Tagged Out			0.55	0.66	0.61									
	PM	Tagged Out			0.67	0.69	0.68									
6-Mar	AM	0.86	0.71	0.79	1.01	1.02	1.02									
	PM	0.87	0.93	0.90	1.09	0.94	1.02									
7-Mar	AM	0.68	0.67	0.68	0.84	0.96	0.90									
	PM	0.94	1.00	0.97	1.09	0.94	1.02									
8-Mar	AM	0.63	0.59	0.60	0.76	0.98	0.87									
	PM	0.71	0.61	0.66	0.77	0.89	0.83									
9-Mar	AM	0.46	0.43	0.45	0.61	0.75	0.68									
	PM	0.44	0.40	0.42	0.55	0.61	0.58									
10-Mar	AM	0.66	0.49	0.58	0.65	0.89	0.77									
	PM	0.70	0.57	0.64	0.83	0.98	0.91									
11-Mar	AM	0.73	0.57	0.65	Tagged Out											
	PM	0.81	0.65	0.73	0.75	0.78	0.77									
12-Mar	AM	0.85	0.63	0.74	Tagged Out											
	PM	0.88	0.62	0.75	0.82	0.98	0.90									
13-Mar	AM	1.03	0.53	0.78	0.44	0.69	0.57									
	PM	0.93	0.60	0.77	Tagged Out											
14-Mar	AM	0.61	0.50	0.56	0.51	0.63	0.57									
	PM	0.83	0.62	0.73	0.64	0.86	0.75									
15-Mar	AM	0.74	0.54	0.64	0.57	0.73	0.65									
	PM	0.73	0.53	0.63	0.62	0.75	0.69									
16-Mar	AM	Tagged Out			0.39	0.57	0.48									
	PM	0.76	0.72	0.74	0.67	0.80	0.74									
17-Mar	AM	0.59	0.42	0.51	Tagged Out											
	PM	0.65		0.65	0.65	0.89	0.77									
18-Mar	AM	0.60	0.44	0.52	Tagged Out											
	PM	0.70	0.49	0.60	Tagged Out											
19-Mar	AM	0.59	0.54	0.57	Tagged Out											
	PM	0.65	0.51	0.58	Tagged Out											
20-Mar	AM	0.57	0.48	0.53	Tagged Out											
	PM	0.67		0.67	0.65	0.85	0.75									
21-Mar	AM	0.72	0.55	0.64	0.62	0.71	0.67									
	PM	0.82	0.59	0.71	0.71	0.89	0.80									
22-Mar	AM	0.58	0.67	0.63	0.71	0.68	0.70									
	PM	0.95	0.57	0.76	0.67	0.75	0.71									
23-Mar	AM	0.70	0.52	0.61	0.48	0.50	0.49									
	PM	0.77	0.52	0.65	No Test											
24-Mar	AM	0.60	0.50	0.55	0.42	0.49	0.46									
	PM	0.52	0.62	0.57	0.64	0.47	0.56									
25-Mar	AM	0.84	0.59	0.72	0.52	0.64	0.58									
	PM	Tagged Out			0.69	0.65	0.67									
26-Mar	AM	1.17	0.68	0.93	0.63	0.64	0.64									
	PM	Tagged Out			Tagged Out											
27-Mar	AM	1.35	0.76	1.06	0.56	0.66	0.61									
	PM	0.87	0.51	0.69	0.56	0.49	0.53									
28-Mar	AM	0.88		0.88	No Test											
	PM	1.00	0.99	1.00	No Test											
29-Mar	AM	No Test			No Test											
	PM	No Test			No Test											
30-Mar	AM	0.74	0.58	0.66	No Test											
	PM	0.72	0.60	0.66	No Test											
31-Mar	AM	0.71	0.68	0.70	No Test											
	PM	0.86	0.70	0.78	No Test											
averages		0.74	0.59	0.67	0.65	0.74	0.70	0	Approx Total Tons Saved							

IP7_000286

April 1992 Flyash LOI Monthly Summary

1992		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Apr	AM	0.88	0.83	0.86	No Test Unit Down											
	PM	0.76	0.76	0.76	0.67	0.69	0.68									
2-Apr	AM	0.70	0.76	0.73	0.49	0.73	0.61									
	PM	0.70	0.84	0.77	0.57	0.63	0.60									
3-Apr	AM	0.72	0.72	0.72	0.39	0.55	0.47									
	PM	0.65	0.67	0.66	0.51	0.63	0.57									
4-Apr	AM	0.53	0.57	0.55	0.45	0.47	0.46									
	PM	0.47	0.55	0.51	0.27	0.42	0.35									
5-Apr	AM	0.46	0.59	0.53	0.38	0.59	0.49									
	PM	0.37	0.49	0.43	0.36	0.53	0.45									
6-Apr	AM	0.41	0.60	0.51	0.36	0.59	0.48									
	PM	0.42	0.62	0.52	0.35	0.59	0.47									
7-Apr	AM	0.46	0.54	0.50	0.31	0.47	0.39									
	PM	0.57	0.62	0.60	0.45	0.72	0.59									
8-Apr	AM	0.68	0.77	0.73	Tagged Out											
	PM	0.83	0.81	0.82	0.57	0.86	0.71									
9-Apr	AM	0.71	0.68	0.70	0.81		0.81									
	PM	Tagged Out			Tagged Out											
10-Apr	AM	0.64	0.63	0.64	0.46	0.63	0.55									
	PM	0.67	0.72	0.70	0.43	0.46	0.45									
11-Apr	AM	No Test Unit Down			0.53	0.64	0.59									
	PM	No Test Unit Down			0.57	0.66	0.62									
12-Apr	AM	No Test Unit Down			0.62	0.74	0.68									
	PM	No Test Unit Down			0.77		0.77									
13-Apr	AM	No Test Unit Down			0.69		0.69									
	PM	No Test Unit Down			0.61	0.69	0.65									
14-Apr	AM	No Test Unit Down			0.53	0.72	0.63									
	PM	No Test Unit Down			0.62	0.73	0.68									
15-Apr	AM	No Test Unit Down			Tagged Out											
	PM	No Test Unit Down			Tagged Out											
16-Apr	AM	No Test Unit Down			Tagged Out											
	PM	No Test Unit Down			0.66	0.77	0.72									
17-Apr	AM	No Test Unit Down			0.68	0.90	0.79									
	PM	No Test Unit Down			0.67	0.72	0.70									
18-Apr	AM	No Test Unit Down			0.73	0.91	0.82									
	PM	No Test Unit Down			0.64	0.89	0.77									
19-Apr	AM	No Test Unit Down			0.82	1.16	0.99									
	PM	No Test Unit Down			0.73	0.97	0.85									
20-Apr	AM	No Test Unit Down			0.52	0.90	0.71									
	PM	No Test Unit Down			0.63	1.00	0.82									
21-Apr	AM	No Test Unit Down			0.62	0.93	0.78									
	PM	No Test Unit Down			0.71	0.90	0.81									
22-Apr	AM	No Test Unit Down			0.67	0.96	0.82									
	PM	No Test Unit Down			0.50	0.82	0.66									
23-Apr	AM	No Test Unit Down			0.50	0.67	0.59									
	PM	No Test Unit Down			0.58	0.90	0.74									
24-Apr	AM	No Test Unit Down			0.58	0.80	0.69									
	PM	No Test Unit Down			0.55	0.72	0.64									
25-Apr	AM	No Test Unit Down			0.64	0.81	0.73									
	PM	No Test Unit Down			0.62	0.85	0.74									
26-Apr	AM	No Test Unit Down			0.62	0.68	0.65									
	PM	No Test Unit Down			0.60	0.80	0.70									
27-Apr	AM	No Test Unit Down			0.66	0.86	0.76									
	PM	No Test Unit Down			0.56	0.69	0.63									
28-Apr	AM	No Test Unit Down			0.50	0.55	0.53									
	PM	No Test Unit Down			0.42	0.65	0.54									
29-Apr	AM	No Test Unit Down			0.39	0.57	0.48									
	PM	No Test Unit Down			0.32	0.54	0.43									
30-Apr	AM	No Test Unit Down			0.33	0.60	0.47									
	PM	0.94	0.88	0.91	0.38	0.61	0.50									
	AM															
	PM															
averages		0.63	0.68	0.66	0.55	0.72	0.64	0	Approx Total Tons Saved							

IP7_000287

May 1992 Flyash LOI Monthly Summary

1992		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-May	AM															
	PM				0.37	0.71	0.54									
2-May	AM	0.77	0.76	0.77	0.35	0.52	0.44									
	PM				0.46	0.66	0.56									
3-May	AM	1.08	0.98	1.03												
	PM															
4-May	AM	0.96	0.74	0.85	0.46	0.73	0.60									
	PM				0.36	0.76	0.56									
5-May	AM	1.02	1.02	1.02	0.41	0.89	0.65									
	PM				0.48	0.69	0.59									
6-May	AM	1.24	0.86	1.05	0.50	0.79	0.65									
	PM				0.60	0.67	0.64									
7-May	AM	1.48	1.07	1.28												
	PM	1.34	1.08	1.21	0.64	0.75	0.70									
8-May	AM	1.33	0.91	1.12	0.64	1.10	0.87									
	PM	1.57	1.07	1.29												
9-May	AM	1.58	1.07	1.33	0.72	1.21	0.97									
	PM	1.32	1.05	1.19	0.78	1.17	0.98									
10-May	AM	1.46	0.97	1.22	0.61	1.44	1.03									
	PM	1.81	1.35	1.58	0.58	1.41	1.00									
11-May	AM	1.45	1.04	1.25	0.71	1.16	0.94									
	PM	1.30	0.92	1.11	0.69	1.15	0.92									
12-May	AM	1.11	0.80	0.96	0.60	1.10	0.85									
	PM	1.11	1.07	1.09	0.96	1.47	1.22									
13-May	AM	1.13	0.71	0.92												
	PM	1.15	0.72	0.94	0.99	1.30	1.15									
14-May	AM	1.01	0.75	0.88	0.75	1.15	0.95									
	PM	1.28	0.85	1.07	0.81	0.94	0.88									
15-May	AM	0.89	0.76	0.83												
	PM															
16-May	AM															
	PM															
17-May	AM															
	PM															
18-May	AM															
	PM				0.67	1.01	0.84									
19-May	AM															
	PM				0.85		0.85									
20-May	AM				0.40	0.55	0.48									
	PM				0.43	0.57	0.50									
21-May	AM	1.12	0.89	1.01												
	PM	1.22	0.97	1.10	0.47	0.65	0.56									
22-May	AM	0.96	0.78	0.87	0.35		0.35									
	PM				0.42	0.71	0.57									
23-May	AM				0.54	0.87	0.71									
	PM				0.57	0.94	0.76									
24-May	AM	1.04	0.64	0.84	0.58	0.99	0.79									
	PM	0.98	0.67	0.83	0.50	0.80	0.65									
25-May	AM	0.94	0.61	0.78	0.54	1.03	0.79									
	PM	1.06	0.69	0.88	0.66	1.08	0.87									
26-May	AM	1.10	0.66	0.88	0.55	1.08	0.82									
	PM	1.19	0.56	0.88		0.95	0.95									
27-May	AM	1.24	0.82	1.03												
	PM	1.22	0.74	0.98												
28-May	AM	1.02	0.88	0.95												
	PM	1.01	0.83	0.92	0.63		0.63									
29-May	AM	0.92	0.88	0.90	0.49	0.96	0.73									
	PM	0.91	0.75	0.83	0.45	0.78	0.62									
30-May	AM	0.76	0.55	0.66	0.41	0.68	0.55									
	PM	0.80	0.62	0.71	0.39	0.77	0.58									
31-May	AM	0.66	0.67	0.67	0.34	0.65	0.50									
	PM	0.71	0.50	0.61	0.36	0.69	0.53									
averages		1.13	0.84	0.98	0.56	0.92	0.73	0								

IP7_000288

June1992 Flyash LOI Monthly Summary

1992		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Jun	AM	0.68	0.61	0.66	0.39	0.68	0.54									
	PM	0.69	0.64	0.67	0.32	0.58	0.45									
2-Jun	AM	0.69	0.81	0.75	0.34	0.60	0.47									
	PM	0.75	1.01	0.88												
3-Jun	AM	0.69	0.83	0.76	0.34	0.79	0.57									
	PM	0.56	0.57	0.57	0.24	0.73	0.49									
4-Jun	AM	0.56	0.61	0.59	0.43	0.63	0.53									
	PM	0.57	0.52	0.55	0.34	0.60	0.47									
5-Jun	AM	0.69	0.46	0.58	0.30	0.45	0.38									
	PM	0.67	0.68	0.68	0.35	0.73	0.54									
6-Jun	AM	0.69	0.57	0.63	0.27	0.61	0.44									
	PM	0.79	0.59	0.69	0.28	0.65	0.47									
7-Jun	AM	0.68	0.68	0.68	0.46	0.47	0.47									
	PM	0.80	0.51	0.66	0.30	0.46	0.38									
8-Jun	AM	0.72	0.52	0.62	0.27	0.43	0.35									
	PM	0.83	0.53	0.68	0.25	0.31	0.28									
9-Jun	AM	0.84	0.65	0.75												
	PM	0.85	0.72	0.79	0.30	0.36	0.33									
10-Jun	AM				0.35	0.45	0.40									
	PM	0.99	0.81	0.90	0.31	0.46	0.39									
11-Jun	AM	1.16	0.90	1.03	0.29	0.48	0.39									
	PM	0.99	0.95	0.97	0.25	0.35	0.30									
12-Jun	AM	0.99	0.86	0.93	0.28	0.46	0.37									
	PM	0.90	0.74	0.82	0.26	0.29	0.28									
13-Jun	AM	outage			0.38	0.44	0.41									
	PM				0.32	0.46	0.39									
14-Jun	AM				0.34	0.44	0.39									
	PM				0.32	0.37	0.35									
15-Jun	AM				0.42	0.46	0.44									
	PM				0.40	0.41	0.41									
16-Jun	AM				0.33	0.44	0.39									
	PM	0.92	0.74	0.83	0.27	0.42	0.35									
17-Jun	AM	1.12	0.98	1.05	0.47	0.56	0.52									
	PM	1.06	0.98	1.02	0.46	0.63	0.55									
18-Jun	AM	1.16	1.08	1.12	0.54	0.61	0.58									
	PM	1.22	0.97	1.10	0.44	0.59	0.52									
19-Jun	AM	1.01	0.82	0.92	0.40	0.55	0.48									
	PM	1.09	0.80	0.95	0.35	0.65	0.50									
20-Jun	AM	0.66	0.73	0.70	0.40	0.54	0.47									
	PM	0.97	0.76	0.87	0.35	0.77	0.56									
21-Jun	AM	0.88	0.67	0.78	0.32	0.65	0.49									
	PM	0.94	0.68	0.81	0.34	0.60	0.47									
22-Jun	AM	1.07	0.96	1.02	0.40	0.62	0.51									
	PM	1.03	0.77	0.90	0.33	0.68	0.51									
23-Jun	AM				0.55	0.61	0.58									
	PM	0.82	0.91	0.87	0.60	0.74	0.67									
24-Jun	AM	0.77	0.80	0.79	0.52	0.62	0.57									
	PM	0.99	0.68	0.84	0.53	0.61	0.57									
25-Jun	AM	0.75	0.68	0.72	0.47	0.53	0.50									
	PM	0.67	0.67	0.67	0.45	0.50	0.48									
26-Jun	AM	0.64	0.57	0.61												
	PM	0.66	0.51	0.59	0.37	0.46	0.42									
27-Jun	AM	0.59	0.49	0.54	0.39	0.51	0.45									
	PM	0.61	0.47	0.54	0.50	0.51	0.51									
28-Jun	AM															
	PM	0.61	0.62	0.62	0.56	0.57	0.57									
29-Jun	AM	0.80	0.76	0.78	0.38	0.56	0.47									
	PM	0.80	0.67	0.74	0.43	0.58	0.51									
30-Jun	AM	0.95	0.72	0.84												
	PM	0.90	0.75	0.83	0.39	0.60	0.50									
averages		0.83	0.72	0.77	0.38	0.54	0.46									

Approx Total Tons Saved 0

July 1992 Flyash LOI Monthly Summary

1992		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Jul	AM	0.86	0.66	0.76	0.43	0.67	0.55									
	PM	0.92	0.71	0.82	0.35	0.60	0.48									
2-Jul	AM	0.75	0.69	0.72												
	PM	0.73	0.70	0.72	0.64	0.75	0.70									
3-Jul	AM	0.85	0.67	0.76	0.58	0.68	0.63									
	PM	0.84	0.73	0.79	0.51	0.70	0.61									
4-Jul	AM	0.74	0.78	0.76	0.46	0.58	0.52									
	PM															
5-Jul	AM	0.68	0.68	0.68												
	PM				0.34	0.65	0.50									
6-Jul	AM	0.65	0.72	0.69	0.40	0.52	0.46									
	PM	0.57	0.53	0.55	0.44	0.55	0.50									
7-Jul	AM				0.45	0.55	0.50									
	PM	0.58	0.52	0.55	0.35	0.41	0.38									
8-Jul	AM				0.46	0.54	0.50									
	PM	0.75	0.58	0.67	0.53	0.51	0.52									
9-Jul	AM	0.89	0.69	0.79												
	PM	0.71	0.70	0.71	0.51	0.58	0.55									
10-Jul	AM	0.85	0.88	0.87	0.64	0.69	0.67									
	PM	0.78	0.89	0.84	0.58	0.75	0.67									
11-Jul	AM	0.62	0.80	0.71	0.58	0.79	0.69									
	PM	0.63	0.77	0.70	0.60	0.64	0.62									
12-Jul	AM	0.70	0.98	0.84	0.55	0.79	0.67									
	PM	0.70	0.77	0.74	0.55	0.71	0.63									
13-Jul	AM	0.77	0.74	0.76	0.45	0.62	0.54									
	PM	0.68	0.74	0.71	0.48	0.59	0.54									
14-Jul	AM	0.59	0.62	0.61												
	PM	0.59	0.74	0.67	0.42	0.57	0.50									
15-Jul	AM				0.40	0.58	0.49									
	PM	0.74	0.50	0.62	0.42	0.39	0.41									
16-Jul	AM	0.67	0.52	0.60	0.45	0.65	0.55									
	PM	0.44	0.67	0.56	0.62	0.85	0.74									
17-Jul	AM	0.70	0.54	0.62												
	PM	0.71	0.53	0.62												
18-Jul	AM	0.60	0.67	0.64												
	PM	0.55	0.64	0.60												
19-Jul	AM	0.52	0.56	0.54												
	PM	0.52	0.51	0.52	0.71	0.73	0.72									
20-Jul	AM	0.75	0.57	0.66	0.55	0.64	0.60									
	PM															
21-Jul	AM				0.61	0.81	0.71									
	PM	0.78	0.63	0.71	0.63	0.92	0.78									
22-Jul	AM	0.64	0.59	0.62												
	PM	0.73	0.63	0.68	0.73	0.81	0.77									
23-Jul	AM	0.69	0.61	0.65	0.65	0.82	0.74									
	PM	0.73	0.60	0.67	0.58	0.81	0.70									
24-Jul	AM	0.68	0.63	0.66	0.54	0.81	0.68									
	PM	0.76	0.57	0.67	0.50	0.71	0.61									
25-Jul	AM				0.60	0.74	0.67									
	PM				0.49	0.59	0.54									
26-Jul	AM				0.65	0.85	0.75									
	PM	0.94	0.62	0.78	0.62	0.61	0.62									
27-Jul	AM	0.90	0.88	0.89	0.69	1.06	0.88									
	PM	0.89	0.79	0.84	0.71	1.01	0.86									
28-Jul	AM	0.89	0.71	0.80	0.76	0.91	0.84									
	PM	0.92	0.73	0.83	0.76	0.82	0.79									
29-Jul	AM															
	PM															
30-Jul	AM															
	PM															
31-Jul	AM															
averages		0.72	0.67	0.70	0.54	0.69	0.62									

Approx Total Tons Saved 0

August 1992 Flyash LOI Monthly Summary

1992		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Aug	AM				0.81	0.79	0.80									
	PM				0.76	0.82	0.79									
2-Aug	AM	0.62	0.47	0.55	0.85	0.81	0.83									
	PM	0.64	0.42	0.53	0.79	0.72	0.76									
3-Aug	AM	0.60	0.47	0.54	0.77	0.83	0.80									
	PM	0.76	0.47	0.62	0.84	0.93	0.89									
4-Aug	AM	0.86	0.65	0.76	0.77	0.77	0.77									
	PM	0.74	0.64	0.69	0.77	0.80	0.79									
5-Aug	AM	0.53	0.56	0.55	0.71	0.69	0.70									
	PM	0.68	0.58	0.63	0.65	0.61	0.63									
6-Aug	AM	0.71	0.52	0.62	0.78	0.86	0.82									
	PM	0.85	0.67	0.76	0.73	0.75	0.74									
7-Aug	AM	0.89	0.67	0.78												
	PM	0.78	0.76	0.77	0.70	0.90	0.80									
8-Aug	AM	0.85	0.60	0.73	0.67	0.89	0.78									
	PM	0.79	0.62	0.71	0.62	0.88	0.75									
9-Aug	AM	0.67	0.89	0.78	0.48	0.69	0.59									
	PM	0.80	0.67	0.74	0.66	0.64	0.65									
10-Aug	AM	0.93	0.78	0.86	0.78	1.14	0.96									
	PM	0.99	0.68	0.84	0.87	0.95	0.91									
11-Aug	AM															
	PM															
12-Aug	AM															
	PM															
13-Aug	AM															
	PM															
14-Aug	AM															
	PM															
15-Aug	AM															
	PM															
16-Aug	AM															
	PM															
17-Aug	AM															
	PM															
18-Aug	AM															
	PM															
19-Aug	AM															
	PM															
20-Aug	AM															
	PM															
21-Aug	AM	0.98	0.97	0.98	0.61	1.17	0.89									
	PM	1.07	1.12	1.10	0.62	1.29	0.96	0								
22-Aug	AM	1.01	0.89	0.95	0.46	1.00	0.73									
	PM	0.94	0.86	0.90	0.47	0.79	0.63	150								
23-Aug	AM	0.92	0.93	0.93	0.52	0.80	0.66									
	PM	0.92	1.05	0.99	0.47	0.88	0.68	150								
24-Aug	AM	0.97	1.07	1.02	0.41	0.88	0.65									
	PM	0.83	0.80	0.82	0.41	0.89	0.65	150								
25-Aug	AM	0.99	0.93	0.96	0.51	0.85	0.68									
	PM	0.93	1.13	1.03	0.41	0.70	0.60	100								
26-Aug	AM	0.91	0.97	0.94	0.43	0.80	0.62									
	PM	0.92	0.85	0.89	0.40	0.55	0.48	200								
27-Aug	AM				0.64	0.91	0.78									
	PM	0.88	0.77	0.83	0.55	0.68	0.62	40								
28-Aug	AM	0.82	0.54	0.68												
	PM	0.86	0.57	0.72	0.47	0.57	0.52	100								
29-Aug	AM	0.74	0.71	0.73	0.44	0.61	0.53									
	PM	0.82	0.75	0.79	0.49	0.50	0.50	200								
30-Aug	AM	0.94	0.68	0.81	0.60	0.66	0.63									
	PM	0.83	0.62	0.73	0.49	0.55	0.52	100								
31-Aug	AM				0.64	0.70	0.67									
	PM	1.06	1.02	1.04	0.66	0.77	0.71	0								
averages		0.84	0.75	0.80	0.62	0.80	0.71	1,190	Approx Total Tons Saved							

IP7_000291

September 1992 Flyash LOI Monthly Summary

1992		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Sep	AM	1.32	0.78	0.86	0.68	0.71	0.70									
	PM	0.94	0.91	0.93	0.60	0.55	0.58	200								
2-Sep	AM	1.24	0.87	1.06	0.63	0.59	0.61									
	PM	1.11	0.84	0.98	0.54	0.65	0.60	250								
3-Sep	AM	1.08	0.79	0.94	0.62	0.88	0.75									
	PM	1.09	0.74	0.92	0.70	1.09	0.90	50								
4-Sep	AM	1.08	0.64	0.86	0.61	0.78	0.70									
	PM	0.91	0.51	0.71	0.63	0.61	0.62	100								
5-Sep	AM	0.97	0.44	0.71	0.47	0.66	0.57									
	PM	0.82	0.51	0.67	0.54	0.73	0.64	200								
6-Sep	AM	0.78	0.63	0.71	0.49	0.62	0.56									
	PM	0.86	0.52	0.69	0.54	0.67	0.61	300								
7-Sep	AM	0.94	0.45	0.70	0.36	0.54	0.45									
	PM	0.83	0.46	0.65	0.40	0.45	0.43	400								
8-Sep	AM	0.88	0.58	0.73	0.34	0.59	0.47									
	PM				0.40	0.61	0.51	100								
9-Sep	AM	1.09	0.76	0.93	0.41	0.52	0.47									
	PM	1.02	0.91	0.97	0.38	0.46	0.42	250								
10-Sep	AM	1.04	0.69	0.87	0.47	0.59	0.53									
	PM	1.04	0.62	0.83	0.44	0.48	0.46	250								
11-Sep	AM	1.04	0.65	0.84	0.50	0.63	0.57									
	PM	1.00	0.69	0.85	0.60	0.71	0.66	300								
12-Sep	AM	1.18	0.84	1.01	0.68	0.79	0.74									
	PM							0								
13-Sep	AM	1.20	0.79	1.00	0.58	0.91	0.75									
	PM	1.31	0.93	1.12	0.71	1.11	0.91	0								
14-Sep	AM	1.31	0.77	1.04	0.57	0.82	0.70									
	PM	1.32	0.80	1.06	0.63	0.93	0.78	100								
15-Sep	AM	1.31	0.84	1.08												
	PM	1.29	0.79	1.04	0.46	0.72	0.59	100								
16-Sep	AM	1.13	0.69	0.91	0.56	0.86	0.71									
	PM	1.04	0.57	0.81	0.49	0.83	0.66	250								
17-Sep	AM	1.11	0.65	0.88												
	PM	0.91	0.75	0.83	0.48	0.73	0.61	150								
18-Sep	AM	0.80	0.70	0.75	0.55											
	PM	0.74	0.70	0.72	0.54	0.81	0.68	250								
19-Sep	AM	0.83	0.78	0.81	0.60	0.83	0.72									
	PM				0.46	0.81	0.64	250								
20-Sep	AM	1.00	0.92	0.96	0.64	0.92	0.78									
	PM	0.85	0.76	0.81	0.62	0.86	0.74	150								
21-Sep	AM	0.78	0.82	0.80	0.60	0.96	0.78									
	PM	0.85	0.81	0.83	0.59	1.08	0.84	200								
22-Sep	AM	0.76	0.65	0.71												
	PM	0.83	0.70	0.77	0.51	0.84	0.68	200								
23-Sep	AM	0.90	0.82	0.86												
	PM							0								
24-Sep	AM	0.75	0.84	0.80	0.58	0.98	0.78									
	PM	0.74	1.02	0.88	0.75	0.98	0.87	100								
25-Sep	AM	0.72	0.95	0.84	0.53	0.85	0.69									
	PM				0.54	0.81	0.68	100								
26-Sep	AM	0.55	0.67	0.61	0.60	0.88	0.74									
	PM	0.53	0.49	0.51	0.58	0.77	0.68	200								
27-Sep	AM	0.52	0.60	0.56	0.57	0.88	0.73									
	PM	0.50	0.58	0.54	0.56	0.73	0.65	300								
28-Sep	AM	0.63	0.57	0.60	0.48	0.73	0.61									
	PM	0.67	0.56	0.62	0.61	0.71	0.66	450								
29-Sep	AM				0.45	0.76	0.61									
	PM	0.58	0.44	0.51	0.47	0.49	0.48	500								
30-Sep	AM	0.68	0.52	0.60												
	PM							100								
	AM															
	PM															
averages		0.93	0.70	0.82	0.55	0.75	0.65	5,800	Approx Total Tons Saved							

IP7_000292

October 1992 Flyash LOI Monthly Summary

1992		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Oct	AM	0.89	0.62	0.76	0.51	0.68	0.60									
	PM	0.65	0.68	0.67	0.59	0.70	0.65	200								
2-Oct	AM	0.86	0.76	0.81												
	PM	0.96	0.73	0.85	0.48	0.59	0.54	200								
3-Oct	AM	0.91	0.80	0.86	0.41	0.62	0.52									
	PM	1.00	0.79	0.90	0.38	0.59	0.49	300								
4-Oct	AM	0.96	0.82	0.89												
	PM	1.01	0.89	0.95				0								
5-Oct	AM	0.92	0.74	0.83	0.41	0.62	0.52									
	PM	0.81	0.61	0.73	0.39	0.50	0.45	300								
6-Oct	AM		0.63	0.63	0.43	0.53	0.48									
	PM	0.74		0.74	0.41	0.50	0.46	100								
7-Oct	AM	0.83		0.83	0.46	0.57	0.52									
	PM		0.96	0.96	0.56	0.55	0.56	100								
8-Oct	AM	0.74	0.78	0.76	0.61	0.64	0.63									
	PM	0.88	0.98	0.93	0.71	0.64	0.68	0								
9-Oct	AM	0.67	0.84	0.76	0.59	0.74	0.67									
	PM	0.79	0.91	0.85	0.47	0.48	0.48	250								
10-Oct	AM	1.26	1.37	1.32	0.51	0.63	0.57									
	PM							250								
11-Oct	AM	1.54	1.36	1.45	0.35	0.58	0.48									
	PM							250								
12-Oct	AM	1.22	1.42	1.32	0.34	0.59	0.47									
	PM	1.29	1.61	1.45	0.44	0.57	0.51	400								
13-Oct	AM	1.03	1.19	1.11	0.47	0.70	0.59									
	PM	1.66	1.54	1.60	0.54	0.91	0.73	200								
14-Oct	AM	1.02	0.94	0.98	0.64	0.81	0.73									
	PM	0.79	1.12	0.96	0.52	0.79	0.66	150								
15-Oct	AM	0.83	0.96	0.90	0.44	0.78	0.61									
	PM	0.88	1.03	0.96	0.56	0.70	0.63	200								
16-Oct	AM	1.03	1.00	1.02	0.61	0.73	0.67									
	PM	0.98	1.02	1.00	0.60	0.65	0.63	250								
17-Oct	AM	0.99	0.95	0.97	0.48	0.52	0.50									
	PM							200								
18-Oct	AM	0.86	0.77	0.82	0.30	0.42	0.36									
	PM							250								
19-Oct	AM	0.73	0.83	0.78	0.37	0.55	0.46									
	PM				0.38	0.52	0.45	300								
20-Oct	AM	0.77	0.81	0.77	0.54	0.60	0.57									
	PM	0.78	0.91	0.85	0.73	0.64	0.69	100								
21-Oct	AM	0.82			0.63	0.67	0.65									
	PM	1.12	1.05	1.09	1.08	1.16	1.12	100								
22-Oct	AM		0.81	0.81	0.85	0.92	0.89									
	PM	1.39	1.26	1.33	0.84	0.86	0.85	0								
23-Oct	AM	1.04	1.04	1.04	0.55	0.78	0.67									
	PM	0.93	0.88	0.91	0.61	0.60	0.61	300								
24-Oct	AM	0.91	0.78	0.85	0.47	0.57	0.52									
	PM							300								
25-Oct	AM	0.87	0.75	0.81	0.43	0.53	0.48									
	PM							300								
26-Oct	AM	0.72	0.53	0.63	0.57	0.59	0.58									
	PM	0.71	0.56	0.64	0.43	0.58	0.51	450								
27-Oct	AM	0.65	0.49	0.57	0.38	0.49	0.44									
	PM	0.59	0.54	0.57	0.41	0.53	0.47	450								
28-Oct	AM	0.71	0.73	0.72	0.41	0.63	0.52									
	PM	0.88	0.73	0.81	0.61	0.68	0.65	300								
29-Oct	AM	0.74	1.00	0.87	0.55	0.74	0.65									
	PM	0.76	1.22	0.99	0.59	0.76	0.68	250								
30-Oct	AM	0.74	0.82	0.78	0.34	0.69	0.52									
	PM	0.91	0.82	0.87	0.68	0.78	0.73	300								
31-Oct	AM	0.73	0.95	0.84												
	PM							0								
averages		0.91	0.91	0.91	0.52	0.65	0.59	6,750	Approx Total Tons Saved							

November 1992 Flyash LOI Monthly Summary

1992		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Nov	AM	0.56	0.89	0.73												
	PM	0.57		0.57				100								
2-Nov	AM															
	PM	0.78	0.82	0.80				0								
3-Nov	AM	0.73	0.83	0.78												
	PM	0.85	1.03	0.94				0								
4-Nov	AM															
	PM	0.89	0.98	0.94				0								
5-Nov	AM															
	PM	0.73	0.86	0.80				0								
6-Nov	AM															
	PM	0.72	0.76	0.74				0								
7-Nov	AM	0.86	0.80	0.83												
	PM							0								
8-Nov	AM	0.72	0.62	0.67												
	PM							0								
9-Nov	AM															
	PM	0.61	0.50	0.56				100								
10-Nov	AM															
	PM	0.72	0.57	0.65				50								
11-Nov	AM	0.81	0.58	0.69												
	PM	0.90	0.53	0.72				100								
12-Nov	AM															
	PM	0.79	0.52	0.66				75								
13-Nov	AM	0.75	0.62	0.69												
	PM	0.87	0.63	0.75				50								
14-Nov	AM															
	PM							0								
15-Nov	AM	0.74	0.56	0.65												
	PM							75								
16-Nov	AM	0.93	0.58	0.76												
	PM	1.06	0.67	0.87				30								
17-Nov	AM															
	PM	0.73	0.55	0.64				75								
18-Nov	AM															
	PM	0.86	0.65	0.76				0								
19-Nov	AM															
	PM	0.74	0.65	0.70				0								
20-Nov	AM	0.74	0.69	0.72												
	PM	1.32	0.84	1.08				0								
21-Nov	AM	0.70	0.74	0.72												
	PM							0								
22-Nov	AM	0.80	0.61	0.71												
	PM							0								
23-Nov	AM															
	PM	0.72	0.57	0.65				50								
24-Nov	AM															
	PM	0.71	0.48	0.60				75								
25-Nov	AM	0.94	0.64	0.79												
	PM	0.85	0.54	0.70				150								
26-Nov	AM	0.76	0.49	0.63												
	PM							150								
27-Nov	AM	0.54	0.50	0.52												
	PM	0.79	0.42	0.61				200								
28-Nov	AM	0.81	0.47	0.64												
	PM		0.51	0.51				150								
29-Nov	AM	0.63	0.51	0.57	0.72	0.70	0.71									
	PM							150								
30-Nov	AM				0.69	0.76	0.73									
	PM	0.90	0.50	0.70	0.71	0.76	0.74	250								
	AM															
	PM															
averages		0.79	0.64	0.71	0.71	0.74	0.73	1,830	Approx Total Tons Saved							

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Dec-92		Flyash Monthly Summary									
			Unit 1				Unit 2				
1992		East	West	Ave		East	West	Ave	Approx tons Saved		
1-Dec	AM	0.99	0.61	0.80		0.83	1.13	0.98			
	PM	NO TEST				NO TEST					
2-Dec	AM	0.82	0.74	0.78		0.54	0.86	0.70	100		
	PM	0.78	0.86	0.82		0.74	1.01	0.88			
3-Dec	AM										
	PM										
4-Dec	AM	0.71	0.71	0.71		NO TEST					
	PM	0.77	0.76	0.77		0.72	0.74	0.73			
5-Dec	AM	0.60	0.64	0.62		0.49	0.65	0.57	100		
	PM	NO TEST				NO TEST					
6-Dec	AM	0.58	0.58	0.58		0.39	0.59	0.49	150		
	PM	NO TEST				NO TEST					
7-Dec	AM										
	PM										
8-Dec	AM	NO TEST				NO TEST					
	PM	NO TEST				0.37	0.53	0.45	250		
9-Dec	AM	NO TEST				NO TEST					
	PM	0.46	1.00	0.73		0.38	0.51	0.45	250		
10-Dec	AM	0.52	0.75	0.64		NO TEST					
	PM	0.61	TAGGED OUT			0.45	0.58	0.52	100		
11-Dec	AM	0.49	0.65	0.57		NO TEST					
	PM	0.47	0.48	0.48		0.54	0.65	0.60	200		
12-Dec	AM	0.52	0.64	0.58		0.48	0.66	0.57			
	PM	NO TEST				NO TEST					
13-Dec	AM	0.48	0.58	0.53		0.39	0.40	0.40	300		
	PM	NO TEST				NO TEST					
14-Dec	AM	0.30	0.42	0.36		0.34	0.38	0.36			
	PM	0.38	0.45	0.42		0.54	0.57	0.56	350		
15-Dec	AM	NO TEST				0.95	0.87	0.91			
	PM	0.66	0.71	0.69		NO TEST					
16-Dec	AM	NO TEST				0.79	0.73	0.76			
	PM	0.58	0.58	0.58		0.74	0.62	0.68			
17-Dec	AM	0.62	0.54	0.58		NO TEST					
	PM	0.75	0.53	0.64		0.77	0.60	0.69			
18-Dec	AM	0.72	0.46	0.59		NO TEST					
	PM	0.57	0.42	0.50		0.65	0.43	0.54	300		
19-Dec	AM	0.58	0.46	0.52		0.68	0.55	0.62	200		
	PM	NO TEST				NO TEST					
20-Dec	AM	0.44	0.38	0.41		0.60	0.36	0.48	350		
	PM	NO TEST				NO TEST					
21-Dec	AM	NO TEST				0.77	0.62	0.70			
	PM	NO TEST				NO TEST					
22-Dec	AM										
	PM										
23-Dec	AM	0.93	0.79	0.86		0.67	0.71	0.69			
	PM	0.81	0.72	0.77		0.93	0.67	0.80			
24-Dec	AM	0.60	0.63	0.62		0.68	0.40	0.54			
	PM										
25-Dec	AM										
	PM										
26-Dec	AM	0.44	0.61	0.53		0.42	0.33	0.38	300		
	PM	NO TEST				NO TEST					
27-Dec	AM	0.39	0.42	0.41		0.98	0.66	0.82	250		
	PM	NO TEST				NO TEST					
28-Dec	AM	0.62	TAGGED			0.71	0.59	0.65			
	PM	0.71	0.70	0.71		0.81	0.61	0.71			
29-Dec	AM	NO TEST				NO TEST					
	PM	NO TEST				0.61	0.41	0.51	150		
30-Dec	AM	0.71	0.74	0.73		NO TEST					
	PM	0.78	0.71	0.75		0.47	0.3	0.39	250		
31-Dec	AM	0.82	0.56	0.69		0.48	0.33	0.41	300		
	PM	0.69	0.58	0.64		0.43	0.30	0.37			
averages		0.63	0.62	0.62		0.62	0.59	0.60	3900	Total Tons Saved	

January 1993 Flyash LOI Monthly Summary

1993		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved
1-Jan	AM	0.75	0.51	0.63	0.51	0.42	0.47	350
	PM	NO TEST			NO TEST			
2-Jan	AM							
	PM							
3-Jan	AM							
	PM							
4-Jan	AM	0.64	0.56	0.60	0.65	0.58	0.62	100
	PM	0.60	0.56	0.58	0.56	0.32	0.44	
5-Jan	AM	0.53	0.41	0.47	0.56	0.34	0.45	250
	PM	0.60	0.58	0.59	0.74	0.65	0.70	
6-Jan	AM	0.56	0.43	0.50	NO TEST			100
	PM		0.57		0.69	0.58	0.64	
7-Jan	AM	0.59	0.56	0.58	0.47	0.37	0.42	300
	PM	0.59	0.56	0.58	0.46	0.39	0.43	
8-Jan	AM	0.67	0.60	0.64	0.47	0.37	0.42	300
	PM	0.67	0.61	0.64	0.51	0.38	0.45	
9-Jan	AM	0.60	0.67	0.64	0.68	0.61	0.65	
	PM	NO TEST			NO TEST			
10-Jan	AM	0.64	0.64	0.64	0.64	0.56	0.60	
	PM	NO TEST			NO TEST			
11-Jan	AM	0.50	0.49	0.50	0.42	0.34	0.38	300
	PM	0.52	0.50	0.51	0.43	0.31	0.37	
12-Jan	AM	NO TEST			NO TEST			
	PM	0.42	0.38	0.40	0.32	0.27	0.30	SILO FULL
13-Jan	AM	NO SHEET			NO SHEET			
	PM	NO SHEET			NO SHEET			
14-Jan	AM	NO TEST			NO TEST			
	PM	0.72	0.66	0.69	0.62	0.40	0.51	150
15-Jan	AM	0.73	0.73	0.73	0.61	0.50	0.56	SILO FULL
	PM	0.82	0.76	0.79	0.66	0.64	0.65	
16-Jan	AM	0.78	0.80	0.79	0.57	0.69	0.63	
	PM	NO TEST			NO TEST			
17-Jan	AM	0.67	0.66	0.67	0.58	0.56	0.57	
	PM	NO TEST			NO TEST			
18-Jan	AM	0.73	0.79	0.76	0.75	0.70	0.73	
	PM	NO TEST			NO TEST			
19-Jan	AM	0.73	0.83	0.78	NO TEST			
	PM	NO TEST			0.63	0.61	0.62	
20-Jan	AM	0.64	0.80	0.72	NO TEST			
	PM	0.66	0.84	0.75	0.52	0.64	0.58	400
21-Jan	AM	NO TEST			NO TEST			
	PM	0.58	0.82	0.70	0.43	0.42	0.43	400
22-Jan	AM	0.51	0.51	0.51	0.34	0.44	0.39	
	PM	0.66	0.80	0.73	0.39	0.46	0.43	500
23-Jan	AM	0.62	0.68	0.65	0.63	0.89	0.76	
	PM	NO TEST			NO TEST			
24-Jan	AM	0.66	0.59	0.63	0.37	0.50	0.44	300
	PM	NO TEST			NO TEST			
25-Jan	AM	NO SHEET			NO SHEET			
	PM	NO SHEET			NO SHEET			
26-Jan	AM	NO SHEET			NO SHEET			
	PM	NO SHEET			NO SHEET			
27-Jan	AM	0.66	0.70	0.68	NO TEST			
	PM	NO TEST			0.59	0.50	0.55	250
28-Jan	AM	0.63	0.57	0.60	NO TEST			
	PM	0.59	0.57	0.58	0.49	0.50	0.50	300
29-Jan	AM	0.44	0.41	0.43	0.44	0.51	0.48	500
	PM	NO TEST			NO TEST			SILO FULL
30-Jan	AM							
	PM	NO TEST			NO TEST			SILO FULL
31-Jan	AM							
	PM	NO TEST			NO TEST			SILO FULL
averages		0.63	0.62	0.63	0.54	0.50	0.52	4500 Approx Total Tons Saved

IP7_000296

February 1993 Flyash LOI Monthly Summary

1993		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave
1-Feb	AM							Full Silo						
	PM	NO TEST			NO TEST									
2-Feb	AM							Full Silo						
	PM	NO TEST			NO TEST									
3-Feb	AM	0.58	0.42	0.50	0.58	0.56	0.57	Full Silo						
	PM	NA	0.52	0.52	0.60	0.60	0.60							
4-Feb	AM	0.43	0.47	0.45	0.48	0.52	0.50	500						
	PM	0.48	0.41	0.45	0.50	0.47	0.49							
5-Feb	AM	0.46	0.40	0.43	0.33	0.41	0.37	350						
	PM	0.87	0.82	0.85	0.56	0.59	0.58							
6-Feb	AM													
	PM	NO TEST			NO TEST									
7-Feb	AM													
	PM	NO TEST			NO TEST									
8-Feb	AM													
	PM	NO TEST			NO TEST									
9-Feb	AM													
	PM	0.84	0.75	0.80	0.77	0.70	0.74							
10-Feb	AM	0.71	0.71	0.71	0.62	0.51	0.57	150						
	PM	0.65	0.74	0.70	0.67	0.47	0.57							
11-Feb	AM	0.59	0.74	0.67	0.51	0.57	0.54	100						
	PM	0.78	0.65	0.72	0.57	0.61	0.59							
12-Feb	AM	0.78	0.77	0.78	0.54	0.71	0.63							
	PM	0.72	0.63	0.67	0.59	0.57	0.58							
13-Feb	AM	0.90	0.72	0.80	0.52	0.52	0.53							
	PM													
14-Feb	AM	0.94	0.73	0.84	0.59	0.56	0.58							
	PM													
15-Feb	AM	0.63	0.59	0.61	0.35	0.28	0.32	200						
	PM	0.66	0.45	0.56	0.35	0.30	0.33	Ash to Sludge						
16-Feb	AM	0.84	0.86	0.85	0.58	0.68	0.60							
	PM	0.89	0.85	0.87	0.46	0.58	0.52	100						
17-Feb	AM	Tagged Out			0.48	0.70	0.59							
	PM	0.96	0.75	0.86	0.47	0.60	0.54	150	21	18	20	9	13	11
18-Feb	AM	0.80	0.75	0.78	Tagged Out				20	16	18			
	PM	0.87		0.87	0.34	0.43	0.39	200	21			7	8	8
19-Feb	AM	0.65	0.73	0.69	0.36	0.49	0.43							
	PM	0.98	0.75	0.87	0.42	0.49	0.46	400	21	16	19	7	9	8
20-Feb	AM	0.81	0.80	0.81	0.51	0.55	0.53					10	12	11
	PM				0.46	0.51	0.49	150				7	9	8
21-Feb	AM	0.69	0.59	0.64	0.30	0.38	0.34		19	15	17	5	7	6
	PM							400						
22-Feb	AM	0.56	0.64	0.60	0.25	0.37	0.31		14	12	13	5	6	5
	PM	No Test			0.29	0.30	0.30	350				6	7	6
23-Feb	AM	No Test			0.23	0.28	0.26					4	5	4
	PM	0.59	0.63	0.61	0.32	0.41	0.37	350	18	15	18	6	10	9
24-Feb	AM	Tagged Out			0.37	0.41	0.39					6	8	7
	PM		0.73	0.73	0.38	0.40	0.39	350		16		7	9	9
25	AM	0.63	0.57	0.60	0.48	0.58	0.53		16	12	15	10	10	10
	PM				0.46	0.48	0.47	Ash to Sludge				7	8	8
26-Feb	AM	No Test			No Test									
	PM	0.55	0.39	0.47	0.44	0.56	0.50	150	12	11	12	8	12	9
27-Feb	AM	0.43	0.36	0.40	0.23	0.34	0.29	Full Silo	11	9	12	4	6	4
	PM	No Test			No Test									
28-Feb	AM	0.50	0.41	0.46	0.39	0.38	0.39		13	11	11	7	7	7
	PM	No Test			No Test			Full Silo						
averages		0.70	0.64	0.67	0.46	0.50	0.48	3900	Approx Total Tons Saved					

March 1993 Flyash LOI Monthly Summary

1993		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Mar	AM	No Test			No Test											
	PM	0.52	0.45	0.49	0.45	0.43	0.44	Full Silo	13	12	14	8	8	8		
2-Mar	AM	Tagged Out			0.44	0.46	0.45					7	7	6		
	PM	No Test			No Test			Full Silo								
3-Mar	AM	0.77	0.58	0.68	0.30	0.32	0.31		23	22	23	6	5	5		
	PM	0.89	0.65	0.77	0.32	0.30	0.31	300	25	19	23	5	6	6		
4-Mar	AM	0.76	0.47	0.66	0.23	0.29	0.26		27	16	20	5	5	5		
	PM	No Test			0.33	0.31	0.32	350				6	6	6		
5-Mar	AM	0.73	0.96	0.85	0.32	0.42	0.37		26	27	26	7	7	7		
	PM	1.03	0.95	0.99	0.43	0.42	0.43	350	25	19	21	6	8	7		
6-Mar	AM	0.89	0.87	0.88	0.39	0.56	0.48		40	36	35	7	14	10		
	PM	No Test			No Test			150	40	36	35	7	14	10		
7-Mar	AM	0.83	0.69	0.76	0.35	0.61	0.48		30	21	26	6	13	10		
	PM	No Test			No Test			150								
8-Mar	AM	0.79	0.68	0.74	0.31	0.46	0.39		33	22	25	7	10	8		
	PM	0.82	0.45	0.64	0.35	0.44	0.40	300	30	18	21	9	10	9		
9-Mar	AM	0.63	0.59	0.61	No test				22	18	20					
	PM	0.75	0.60	0.68	0.36	0.41	0.39	300	18	14	18	8	7	7		
10-Mar	AM	0.99	0.51	0.75	0.37	0.44	0.41		34	25	27	8	10	8		
	PM	No Test			0.35	0.36	0.36	350								
11-Mar	AM	No Test			No Test											
	PM	0.89	0.65	0.77	0.37	0.35	0.36	350	38	20	24	7	7	6		
12-Mar	AM	0.82	0.57	0.70	0.35	0.38	0.37		35	27	33	7	8	8		
	PM	0.92	0.64	0.78	0.37	0.42	0.40	350	35	15	28	7	9	8		
13-Mar	AM	1.25	1.07	1.16	0.64	0.66	0.65		44	38	40	12	17	14		
	PM	No Test			No Test			0								
14-Mar	AM	0.73	0.59	0.66	0.37	0.41	0.39		25	15	19	8	10	8		
	PM	No Test			No Test			350								
15-Mar	AM	0.82	0.68	0.75	0.35	0.45	0.40		24	14	17	9	10	8		
	PM	No Test			No Test			300								
16-Mar	AM	No Test			0.48	0.64	0.56					8	11	11		
	PM	No Test			No Test			Full Silo								
17-Mar	AM	No Test			0.51	0.54	0.53					10	10	10		
	PM	1.07	0.81	0.94	0.56	0.51	0.54	350	39	25	35	11	9	10		
18-Mar	AM	0.60	0.57	0.59	0.40	0.43	0.42		20	16	18	7	8	7		
	PM	No Test			0.41	0.45	0.43	350				8	7	7		
19-Mar	AM	1.00	0.59	0.80	0.55	0.50	0.53		30	18	20	9	9	9		
	PM	0.82	0.61	0.72	0.55	0.60	0.58	300	38	18	28	7	9	8		
20-Mar	AM	0.99	0.66	0.83	0.45	0.41	0.43		41	25	34	7	6	7		
	PM	No Test			No Test			300								
21-Mar	AM	0.49	0.46	0.48	0.65	0.41	0.53		22	17	20	9				
	PM	No Test			No Test			100								
22-Mar	AM	0.73		0.73	0.28	0.23	0.26		19			5	5	5		
	PM	No Test			0.44	0.25	0.36	300				7	6	6	G	F
23-Mar	AM	0.98	0.71	0.85	0.53	0.34	0.44		22	15	18	7	6	7		
	PM	No Test			No Test			Full Silo								F
24-Mar	AM	No Test			0.64	0.58	0.61					11	9	10		
	PM	1.03	0.78	0.91	0.53	0.41	0.47	150	41	26	34	7	7	7		F
25-Mar	AM	0.83	0.85	0.84	0.51	0.44	0.48		20	15	18	9	7	7		
	PM	No Test			0.58	0.46	0.52	225				10	7	9	A	F,A
26-Mar	AM	No Test			0.77	0.46	0.62					16	10	11		
	PM	1.02	0.66	0.84	0.48	0.37	0.43	275	36	17	32	8	7	8	A	F
27-Mar	AM	1.01	0.59	0.80	0.29	0.27	0.28		34	17	28	8	9	8		
	PM	No Test			No Test			300								F
28-Mar	AM	0.82	0.46	0.64	0.50	0.56	0.48		25	8	19	10	13	10		
	PM	No Test			No Test			Full Silo								F
29-Mar	AM	No Test			No Test											
	PM	1.04	0.56	0.80	0.39	0.32	0.36	300	25	9	12	6	6	6	H	F
30-Mar	AM	0.71	0.73	0.72	No Test				16	14	17					
	PM	No Test			0.48	0.39	0.44	350				9	6	8	F	F
31-Mar	AM	0.70	0.62	0.66	Tagged Out				20	15	16					
	PM	No Test			0.51	0.43	0.47	300							F	C,F
averages		0.85	0.66	0.76	0.44	0.43	0.44	7200	Approx Total Tons Saved							

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April 1993 Flyash LOI Monthly Summary

1993		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Apr	AM	Tagged Out			0.42	0.48	0.45					7	7	7		
	PM	0.76	0.70	0.73	0.61	0.51	0.56	250	19	15	17	11	8	9	F	F
2-Apr	AM	No Test			0.47	0.44	0.46					8	7	7		
	PM	0.64	0.74	0.69	0.61	0.49	0.55	275	16	21	19	13	11	13	F	F
3-Apr	AM	0.77	0.81	0.79	0.53	0.45	0.49		17	25	20	10	8	10		
	PM	No Test			No Test			300							F	F
4-Apr	AM	No Test			0.55	0.37	0.46					14	7	9		
	PM	No Test			No Test			300							F	F
5-Apr	AM	No Test			0.55	0.40	0.48					11	8	8		
	PM	0.97	1.06	1.02	0.64	0.54	0.59	250	22	23	22	10	7	8	F	F
6-Apr	AM	0.75	0.98	0.87	0.57	0.53	0.55		21	23	21	8	9	9		
	PM	No Test			0.61	0.65	0.63	150				7	10	10	F	F
7-Apr	AM	0.77	0.79	0.78	0.56	0.49	0.53		21	20	20	10	9	9		
	PM	No Test			0.42	0.51	0.47	300				8	9	10	F	F
8-Apr	AM	No Test			No Test											
	PM	0.74	0.71	0.73	0.55	0.49	0.52	Full Silo	20	18	21	8	7	8	F	F
9-Apr	AM	No Test			0.53	0.53	0.53					10	10	10		
	PM	0.72	0.88	0.80	0.57	0.57	0.57	200	19	27	24	10	10	10	F	F
10-Apr	AM	0.65	0.74	0.70	0.49	0.40	0.45		17	18	18	9	7	8		
	PM	No Test			No Test			300								F
11-Apr	AM	No Test			No Test											
	PM	No Test			No Test											F
12-Apr	AM	No Test			No Test											
	PM	0.65	0.92	0.79	0.78	0.57	0.68	150	15	20	17	13	7	9		F
13-Apr	AM	0.65	0.99	0.82	Tagged Out				11	21	16					
	PM	No Test			0.72	0.49	0.61					11	8	11		F
14-Apr	AM	0.60	1.03	0.82	Tagged Out				11	28	18					
	PM	No Test			0.61	0.47	0.54	150				10	8	10		F
15-Apr	AM	No Test			Tagged Out											
	PM	0.83	1.06	0.95	0.60	0.50	0.55	150	17	30	27	10	8	10		F
16-Apr	AM	No Test			0.46	0.51	0.49					7	7	7		
	PM	No Test			0.49	0.47	0.48	300				8	7	7		F
17-Apr	AM	No Test														
	PM	No Test														F
18-Apr	AM	Outage			0.28	0.33	0.31					8	7	8		
	PM							300								F
19-Apr	AM	Outage			0.68	0.60	0.64					12	10	11		
	PM				0.57	0.60	0.59					8	8	8		F
20-Apr	AM	Outage			Tagged Out											
	PM				0.69	0.54	0.62					11	12	11		F
21-Apr	AM	Outage			Tagged Out											
	PM				0.81	0.62	0.72					10	12	13		F
22-Apr	AM	Outage			0.71	0.68	0.70					14	11	13		
	PM				0.69	0.71	0.70					11	11	11		F
23-Apr	AM	Outage			0.69	0.59	0.64					10	8	9		
	PM				0.52	0.49	0.51					10	8	8		F
24-Apr	AM	Outage			0.51	0.70	0.61					8	11	9		
	PM				No Test											F
25-Apr	AM	Outage			0.39	0.45	0.42					6	7	6		
	PM				No Test											F
26-Apr	AM	Outage			0.43	0.41	0.42	To Sludge				8	8	7		
	PM				0.56	0.52	0.54					8	8	8		F
27-Apr	AM	Outage			0.50	0.52	0.51					9	9	9		
	PM				0.55	0.59	0.57	150				8	10	9		F
28-Apr	AM	Outage			0.59	0.45	0.52					9	7	8		
	PM				0.59	0.45	0.52	100				9	8	9		F
29-Apr	AM	Outage			0.58	0.51	0.55					10	9	10		
	PM				0.58	0.39	0.49	150				9	9	9		F
30-Apr	AM	Outage			0.57	0.40	0.49					7	7	7		
	PM				0.57	0.35	0.48	150				8	6	8		F
averages		0.73	0.88	0.81	0.57	0.51	0.54	3925	Approx Total Tons Saved							

IP7_000299

May 1993 Flyash LOI Monthly Summary

1993		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-May	AM	Outage			0.58	0.38	0.48									
	PM							150								F
2-May	AM	Outage			0.59	0.39	0.49									
	PM							150				9	7	7		F
3-May	AM	Outage			0.56	0.33	0.44					10	7	8		
	PM				0.59	0.39	0.49	To Sludge				10	7	9		F
4-May	AM	Outage			0.68	0.66	0.67					11	9	10		
	PM				No Test			150								F
5-May	AM	Outage			0.36	0.34	0.35					9	9	9		
	PM				0.53	0.41	0.47	200				9	6	8		F
6-May	AM	Outage			0.30	0.41	0.36					8	9	9		
	PM				0.46	0.43	0.45	200				8	6	6		F,H
7-May	AM	Outage			0.29	0.37	0.33					8	6	7		
	PM				0.40	0.29	0.35	300				8	8	8		F
8-May	AM	Outage			0.40	0.34	0.37					6	5	6		
	PM				No Test			200								F
9-May	AM	Outage			0.39	0.39	0.39					7	6	7		
	PM				No Test			200								F
10-May	AM	No Test			0.46	0.42	0.44					7	7	8		
	PM	No Test						300								F
11-May	AM	No Test			0.52	0.58	0.55	Saved but				8	9	9		
	PM	No Test			No Test			no value.							E,F	C,F
12-May	AM															
	PM														H	E,F
13-May	AM															
	PM														H	F
14-May	AM	No Test			0.41	0.39	0.40	Saved but				7	7	7		
	PM	0.62	0.72	0.67	0.53	0.64	0.58	no value.	17	19	18	9	9	10	H	F
15-May	AM	No Test			No Test			Low Load								
	PM	No Test			No Test											
16-May	AM	No Test			No Test			Low Load								
	PM	No Test			No Test											
17-May	AM	No Test			Tagged Out											
	PM	0.43	0.41	0.42	0.40	0.35	0.38	700	6	9	8	6	6	6	H	F
18-May	AM	Tagged Out			Tagged Out											
	PM	0.66	0.73	0.70	0.45	0.43	0.44	200	11	17	16	7	6	6	H	F
19-May	AM	0.53	0.56	0.55	Tagged Out				9	9	9					
	PM	No Test						600				7	7	7	H	F
20-May	AM	0.59	0.56	0.58	0.47	0.38	0.43					8	6	6		
	PM	0.58	0.67	0.63	0.44	0.31	0.38	300	12	16	14	7	5	6	H	F
21-May	AM								10	14	13	7	6	7		
	PM	0.60	0.67	0.64	0.46	0.26	0.36	500	13	15	14	7	6	6	H	F
22-May	AM	0.43	0.49	0.46	0.50	0.49	0.49		9	13	10	6	6	6		
	PM	No Test			No Test			500							H	F
23-May	AM	0.48	0.54	0.51	0.42	0.31	0.37		8	11	9	6	7	7		
	PM	No Test			No Test			600							H	F
24-May	AM	Tagged Out										7	5	5		
	PM				0.67	0.44	0.56	600	10	10	10	9	8	9	H	F
25-May	AM				Tagged Out				16	16	17					
	PM	0.52	0.67	0.60	0.61	0.39	0.50	200	14	19	16	7	7	7	H	F
26-May	AM				Tagged Out				10	13	12					
	PM	0.66	0.60	0.63	0.64	0.47	0.56	300	18	15	17	8	7	7	H	F
27-May	AM	0.87	0.79	0.83	Tagged Out				17	14	15					
	PM	0.70	0.59	0.65	0.60	0.56	0.58	600	12	9	11	8	8	8	D	F
28-May	AM								11	10	11	7	7	7		
	PM	0.50	0.44	0.47	0.33	0.29	0.31	700	10	9	9	7	6	7		
29-May	AM								10	9	8	7	6	6		
	PM	0.50	0.43	0.47	0.52	0.53	0.53	500	9	8	8	7	6	6		
30-May	AM	0.64	0.58	0.61	0.34	0.45	0.40		9	8	8	7	6	6		
	PM							500								
31-May	AM	0.40	0.40	0.40	0.48	0.42	0.45	200	7	7	6	5	5	5		
	PM							Silo Full								
averages		0.57	0.58	0.58	0.48	0.41	0.45	8850	Approx Total Tons Saved							

June 1993 Flyash LOI Monthly Summary

1993		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Jun	AM	0.47		0.47	0.41	0.44	0.43		9			7	6	6		
	PM							500							F	F, G
2-Jun	AM															
	PM	0.64	0.50	0.57	0.63	0.62	0.63	400	12	7	9	10	8	9	F,G,H	F
3-Jun	AM								18	9	11					
	PM	0.98	0.63	0.81	0.61	0.63	0.62	400	21	12	18				F	F
4-Jun	AM								17	10	13	7	7	6		
	PM	0.73	0.67	0.70	0.48	0.50	0.49	350	15	12	14	8	9	8	B,F,H	F
5-Jun	AM	System Down			0.30	0.35	0.39					6	5	5		
	PM							150								
6-Jun	AM	0.42	0.48	0.45	0.33	0.39	0.36	100	9	8	7	7	6	5		
	PM							To Sludge								
7-Jun	AM								8	7	7	5	5	5		
	PM	0.38	0.50	0.44	0.29	0.33	0.31	600	9	8	8	5	5	5	F,H	F,H
8-Jun	AM	0.58	0.82	0.70	0.42	0.45	0.44		10	17	15	6	6	6		
	PM							Full Silo							A,C	F,H
9-Jun	AM				Tagged Out			Full Silo	9	16	12					
	PM	0.81	0.74	0.78	0.48	0.46	0.47	250	18	11	15	7	8	8	F,H	C,F
10-Jun	AM								10	12	10	7	6	6		
	PM	0.79	0.96	0.88	0.53	0.50	0.52	325	13	23	19	7	7	7	H	B
11-Jun	AM								16	18	16	6	7	6		
	PM	1.05	0.94	1.00	0.43	0.51	0.47	300	23	21	23	5	8	7		
12-Jun	AM	No Test			0.46	0.58	0.52					6	6	5		
	PM							200								
13-Jun	AM	0.56	0.63	0.68	0.52	0.56	0.54		13	14	13	7	7	7		
	PM							300								
14-Jun	AM	Tagged Out			Tagged Out											
	PM	0.52	0.70	0.61	0.41	0.57	0.49	400	11	19	16	6	9	7	D	E
15-Jun	AM	Tagged Out			Tagged Out											
	PM	0.80	0.79	0.80	0.53	0.74	0.64	300	16	18	16	7	15	11	D	C
16-Jun	AM	Tagged Out										9	17	13		
	PM	1.14	0.88	1.01	0.88	1.11	1.00	200	30	18	24	13	23	17	H	C
17-Jun	AM	Tagged Out										22	27	22		
	PM	Tagged Out						0								
18-Jun	AM								19	18	18	10	19	14		
	PM	0.96	0.84	0.90	0.57	0.64	0.61	300	24	18	20	9	11	11		
19-Jun	AM	0.72	0.63	0.68	0.49	0.75	0.62		15	13	15	8	13	9		
	PM							400								
20-Jun	AM	No Operator to			0.55	0.79	0.67					8	11	8		
	PM	pull Samples						300								
21-Jun	AM								15	14	15	6	7	7		
	PM	1.14	1.01	1.08	0.55	0.62	0.59	400	21	19	20	8	9	9	D	C
22-Jun	AM															
	PM	0.83	0.82	0.83	0.42	0.46	0.44	400	17	17	17	7	6	6		C
23-Jun	AM	Tagged Out										10	25	18		
	PM	1.02	0.85	0.94	0.70	0.97	0.84	200	24	19	23	10	20	15	B	
24-Jun	AM	Tagged Out										12	12	12		
	PM	1.19	0.83	1.01	0.87	0.88	0.88	400	26	18	24	13	13	13	B	D,E
25-Jun	AM	Tagged Out										9	11	11		
	PM	0.99	0.89	0.94	0.61	0.96	0.79	250	23	19	21	13	19	17		
26-Jun	AM	0.64	0.51	0.58	0.48	0.75	0.62		15	10	12	7	13	10		
	PM							200								
27-Jun	AM	0.66	0.82	0.74	0.55	0.72	0.64		12	13	13	8	10	9		
	PM							300								
28-Jun	AM								12	12	12	8	13	10		
	PM	0.77	0.93	0.85	0.52	0.57	0.55	300	12	15	14	6	9	8		
29-Jun	AM	No Test										8	9	9		
	PM	0.76	0.89	0.83	0.79	0.75	0.77	400	12	13	13	9	9	9	H	D
30-Jun	AM								8	14	10	7	7	7		
	PM	0.77	0.86	0.82	0.58	0.59	0.59	475	12	15	14	6	6	6	D	D,F
	AM															
	PM															
averages		0.78	0.76	0.77	0.53	0.63	0.58	9100	Approx Total Tons Saved							

July 1993 Flyash LOI Monthly Summary

1993		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Jul	AM								11	11	11	6	8	6		
	PM	0.67	0.75	0.71	0.50	0.41	0.46	600	12	14	12	6	5	6	C,D	A,D
2-Jul	AM								8	12	10	7	8	7		
	PM	0.70	0.85	0.78	0.62	0.71	0.67	500	12	15	13	9	9	9	D,H	C
3-Jul	AM	No Sample			No Sample											
	PM							0								
4-Jul	AM	No Sample			No Sample											
	PM							0								
5-Jul	AM	No Sample			No Sample											
	PM							0								
6-Jul	AM	Tagged Out										10	9	9	H	B
	PM	0.80	0.89	0.85	0.58	0.57	0.58	400	13	16	14	8	8	8		
7-Jul	AM	Tagged Out										8	8	7		
	PM				0.64	0.66	0.65	400				8	7	7	E,H	B,H
8-Jul	AM								11	10	9	9	8	8		
	PM	0.83	0.61	0.72	0.82	0.77	0.80	700	10	9	10	9	8	8	E,H	B,F
9-Jul	AM								18	9	14	9	9	7		
	PM	1.08	0.64	0.89	0.60	0.59	0.60	550	21	10	17	8	8	8	H	
10-Jul	AM	0.74	0.63	0.69	0.39	0.54	0.47		11	9	10	7	6	5		
	PM							700	8	9	9	5	6	5	H	
11-Jul	AM	0.50	0.71	0.61	Shutdown				9	13	10					
	PM							200							H	
12-Jul	AM															
	PM	0.88	1.06	0.97	0.54	0.51	0.53	400	14	23	19	7	7	7	B,H	B
13-Jul	AM								14	16	14	9	8	7		
	PM	0.91	1.03	0.97	0.52	0.56	0.54	500	16	19	18				G,H	B
14-Jul	AM								14	16	15	8	7	7		
	PM	0.95	0.94	0.95	0.67	0.62	0.65	500	17	17	17	9	8	8	H	B
15-Jul	AM								14	13	13	12	10	10		
	PM	0.96	0.89	0.93	0.53	0.58	0.56	500	16	15	16	7	8	7	E,H	B,C
16-Jul	AM								12	17	13	6	7	5		
	PM	1.01	1.05	1.03	0.49	0.46	0.48	500	17	20	19	5	5	5	E,H	B
17-Jul	AM	0.54	0.53	0.54	0.37	0.43	0.40		10	10	9	5	6	4		
	PM							850								B
18-Jul	AM	0.35	0.35	0.35	0.45	0.51	0.48		6	6	6	6	6	6		
	PM	Sludge required ash						400								B
19-Jul	AM															
	PM	0.52	0.57	0.55	0.45	0.40	0.43	800	10	11	11	5	5	5	A	B
20-Jul	AM															
	PM	0.82	0.63	0.73	0.44	0.40	0.42	600	16	9	14	5	5	5		
21-Jul	AM								13	10	12					
	PM	0.77	0.74	0.76	0.51	0.54	0.53	400	15	12	13	6	6	6		
22-Jul	AM									16						
	PM				0.63	0.86	0.75	200				8	15	12		
23-Jul	AM								15	17	15	7	13	9		
	PM	0.87	0.74	0.81	0.51	0.70	0.61	500	17	14	15	6	12	9		
24-Jul	AM	0.53	0.54	0.54	0.44	0.69	0.57		11	10	10	7	13	9		
	PM							800								
25-Jul	AM	0.68	0.71	0.70	0.64	0.97	0.81		11	15	13	9	20	14		
	PM							0								
26-Jul	AM								8	11	10	8	21	15		
	PM				0.64	1.00	0.82	Full Silo				9	18	15	H	G
27-Jul	AM							Full Silo	8	10	9	7	17	11		
	PM				0.33	0.81	0.57	200				7	18	15	H	G
28-Jul	AM								11	9	11					
	PM	0.57	0.65	0.61	0.39	0.70	0.55	600	9	12	11	5	16	11	E	G
29-Jul	AM	Tagged Out			Tagged Out											
	PM	Tagged Out			0.42	0.89	0.68	200				7	20	13	E	B,G
30-Jul	AM	Tagged Out										6	19	12		
	PM	0.47	0.91	0.69	0.50	0.81	0.66	400	9	27	16	6	18	12		
31-Jul	AM	0.37	0.65	0.51	0.56	0.88	0.72		8	18	12					
	PM							400								
averages		0.72	0.74	0.73	0.53	0.65	0.59	12,800	Approx Total Tons Saved							

IP7_000302

AUGUST 1993 FLYASH LOI MONTHLY SUMMARY

1991		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Aug	AM	0.39	0.48	0.41	0.43	0.58	0.51		7	13	10	7	10	8		
	PM							700								
2-Aug	AM							Silo Full				8	10	9		
	PM	0.40	0.43	0.42	0.46	0.67	0.57	600	5	6	5	5	12	8		
3-Aug	AM								7	15	10	7	12	9		
	PM	0.46	0.80	0.63	0.39	0.51	0.45	600	8	17	12	6	9	7	C,H	G
4-Aug	AM								6	13	8	6	12	10		
	PM	0.64	1.02	0.83	0.54	0.77	0.66	600	8	22	14	9	11	10	C,D	G
5-Aug	AM								7	10	8	10	15	15		
	PM	0.58	0.89	0.74	0.72	0.79	0.76	600	7	18	12	11	13	12	C	B,G
6-Aug	AM	No Test										7	8	7		
	PM	No Test			0.58	0.53	0.56	400				8	7	8	C	
7-Aug	AM	0.55	0.60	0.58	0.49	0.68	0.59		8	13	11	7	11	8		
	PM							600							C	
8-Aug	AM	0.60	0.70	0.65	0.56	0.68	0.62		11	20	17	9	13	12		
	PM							0							C	
9-Aug	AM								10	20	15	6	9	7		
	PM	0.48	0.76	0.62	0.37	0.65	0.51	400	10	19	14	6	8	11	C	H
10-Aug	AM								7	21	16	5	10	8		
	PM	0.47	0.88	0.68	0.33	0.66	0.50	Full Silo	9	24	15	4	12	8	C	E
11-Aug	AM											6	14	11		
	PM	0.66	1.16	0.91	0.39	0.48	0.44	600	9	28	19	6	9	7	C,E	E
12-Aug	AM								12	21	17	8	9	9		
	PM	Tagged Out			0.48	0.62	0.55	400				7	9	8		E
13-Aug	AM								16	18	17	8	7	8		
	PM	1.17	1.01	1.09	0.48	0.42	0.45	400	20	23	21	7	7	7		E
14-Aug	AM	0.95	1.02	0.99	0.47	0.53	0.50		18	22	20	7	8	7		
	PM							300								E
15-Aug	AM															
	PM															E
16-Aug	AM	0.65	0.60	0.63	0.39	0.38	0.39		13	11	11	5	5	5		
	PM							Full Silo							G	E
17-Aug	AM	0.98	0.98	0.98	0.47	0.57	0.52		23	23	23	7	9	7		
	PM							Full Silo							G	E
18-Aug	AM															
	PM	Tagged Out			0.50	0.54	0.52	400				7	7	7	G,H	E
19-Aug	AM									17						
	PM	0.88	0.71	0.80	0.50	0.57	0.54	400	15	17	15	7	8	7	G,H	E
20-Aug	AM								17	23	19	6	10	8		
	PM	0.85	0.98	0.91	0.50	0.60	0.55	400	16	20	18	7	10	8		E
21-Aug	AM	0.84	0.88	0.86	0.41	0.66	0.54		15	19	17	6	11	8		
	PM							400								E
22-Aug	AM	0.81	0.94	0.88	0.41	0.54	0.48		18	20	19	6	7	7		
	PM							400								E
23-Aug	AM								26	20	24	6	10	7		
	PM	1.11	0.91	1.01	0.35	0.40	0.38	400	23	19	20	6	7	6	F	E
24-Aug	AM	Tagged Out			Tagged Out											
	PM	0.94	0.98	0.96	0.51	0.88	0.70	200	18	19	18	7	12	9	F	E,F
25-Aug	AM															
	PM														F	E
26-Aug	AM	Tagged Out			Tagged Out											
	PM				0.71	0.71	0.71	400				11	10	11	B,F	D,E
27-Aug	AM											9	13	11		
	PM	1.04	1.01	1.03	0.73	0.68	0.71	400	18	16	17	13	11	10		
28-Aug	AM	0.69	0.70	0.70	0.46	0.58	0.52		13	14	13	10	10	9		
	PM							400								
29-Aug	AM	0.67	0.66	0.67	0.48	0.51	0.50		12	12	12	9	9	8		
	PM							400								
30-Aug	AM	Tagged Out										8	8	8		
	PM	0.70	0.77	0.74	0.61	0.58	0.60	400	15	16	15	8	8	8		
31-Aug	AM								19	13	17	11	17	14		
	PM	1.01	0.88	0.95	0.73	0.88	0.81	600	19	15	18	9	11	10	A,F	E,H
averages		0.74	0.83	0.79	0.50	0.61	0.56	11,400	Approx Total Tons Saved							

IP7_000303

September 1993 Flyash LOI Monthly Summary

1993		Unit 1 East	Unit 1 West	Unit 1 Ave	Unit 2 East	Unit 2 West	Unit 2 Ave	Approx tons Saved	Unit 1 Foam Index East	Unit 1 Foam Index West	Unit 1 Foam Index Ave	Unit 2 Foam Index East	Unit 2 Foam Index West	Unit 2 Foam Index Ave	O/S Pulverizer Unit 1	O/S Pulverizer Unit 2
1-Sep	AM								13			7	11	9		
	PM	1.01	0.78	0.90	0.74	0.89	0.82	500	18	12	15	10	13	11	F,H	D,H
2-Sep	AM	Tagged Out			Tagged Out											
	PM	Tagged Out			0.56	0.58	0.57	400				9	8	8	F	H
3-Sep	AM								14	15	15	8	7	8		
	PM	0.86	0.78	0.82	0.84	0.83	0.84	400	13	15	14	13	10	12		
4-Sep	AM	No Test			0.70	0.68	0.69					11	9	9		
	PM							300								
5-Sep	AM	0.59	0.75	0.67	1.03	0.78	0.91		9	13	11					
	PM							500								
6-Sep	AM	0.53	0.77	0.65	0.76	0.66	0.71		8	12	10	10	10	10		
	PM							600								
7-Sep	AM	Tagged Out										10	10	10		
	PM	0.63	0.69	0.66	0.72	0.65	0.69	500	9	11	9	10	8	10	F,H	G,H
8-Sep	AM	Tagged Out										12	14	11		
	PM	0.59	0.52	0.56	1.01	0.93	0.97	400	9	9	9	18	15	16		
9-Sep	AM				Tagged Out				10							
	PM	0.78	0.53	0.66	0.63	0.46	0.55	600	13	8	10	9	5	7		
10-Sep	AM								11	11	11	7	8	7		
	PM	0.86	0.91	0.89	0.50	0.62	0.56	400	14	16	14	6	9	7	E	A
11-Sep	AM	0.48	0.50	0.49	0.43	0.45	0.44		11	11	11	7	7	6		
	PM							600							E	A
12-Sep	AM	0.48	0.48	0.48	0.66	0.55	0.61		9	8	8	11	9	10		
	PM							500							E	A
13-Sep	AM								10	7	9	9	7	7		
	PM	0.50	0.57	0.54	0.39	0.46	0.43	500	6	8	8	6	6	6	E	A
14-Sep	AM				Tagged Out				9	10	10					
	PM	0.98	0.74	0.86	0.68	0.50	0.59	400	16	11	14	10	8	10	E,H	A,C
15-Sep	AM				Tagged Out				10	10	10					
	PM	0.75	0.88	0.82	1.28	0.72	1.00	400	10	13	12	20	9	16		
16-Sep	AM								10	7	8	10	7	8		
	PM	0.68	0.60	0.64	0.63	0.55	0.59	500	12	9	10	10	9	8		
17-Sep	AM								11	10	10	8	7	8		
	PM	0.93	0.69	0.81	0.60	0.51	0.56	500	13	8	10	8	6	7		
18-Sep	AM	0.71	0.77	0.74	0.62	0.69	0.66					8	9	9		
	PM							400								
19-Sep	AM	0.70	0.71	0.71	0.48	0.45	0.47		12	12	12	8	6	7		
	PM							400								
20-Sep	AM				Tagged Out				11	12	11					
	PM	0.67	0.90	0.79	0.43	0.44	0.44	400	11	16	14	7	6	6	E	C
21-Sep	AM								12	12	12	9	9	9		
	PM	0.60	0.68	0.64	0.80	0.60	0.70	250	8	11	9	12	7	9		C
22-Sep	AM								9	18	14	12	9	11		
	PM	0.58	0.70	0.64	0.61	0.58	0.60	200	9	14	11	8	8	8		
23-Sep	AM				Tagged Out				10	14	13					
	PM	0.44	0.50	0.47	0.74	1.33	1.04	400	5	7	6	10	15	12	E,H	C,E
24-Sep	AM								8	11	10	10	14	13		
	PM	0.37	0.49	0.43	1.03	1.07	1.05	400	7	10	10	11	14	13	E	C,E
25-Sep	AM	0.49	0.66	0.58	0.70	0.65	0.68		7	12	10	12	9	11		
	PM							300								
26-Sep	AM	0.50	0.60	0.55	0.64	0.51	0.58		7	10	9	11	8	9		
	PM							Silo Full								
27-Sep	AM	0.45	0.71	0.58	0.52	0.58	0.55		5	10	8	7	8	7		
	PM							Silo Full								
28-Sep	AM															
	PM														B	C
29-Sep	AM															
	PM	0.85	0.74	0.80	0.44	0.49	0.47	300	16	11	14	5	7	6	A,B	C
30-Sep	AM								12	17	15	8	12	10		
	PM	0.63	0.82	0.73	0.61	0.68	0.65	600	9	14	12	8	10	10		
	AM															
	PM															
averages		0.65	0.68	0.67	0.68	0.65	0.67	11,650	Approx Total Tons Saved							

IP7_000304

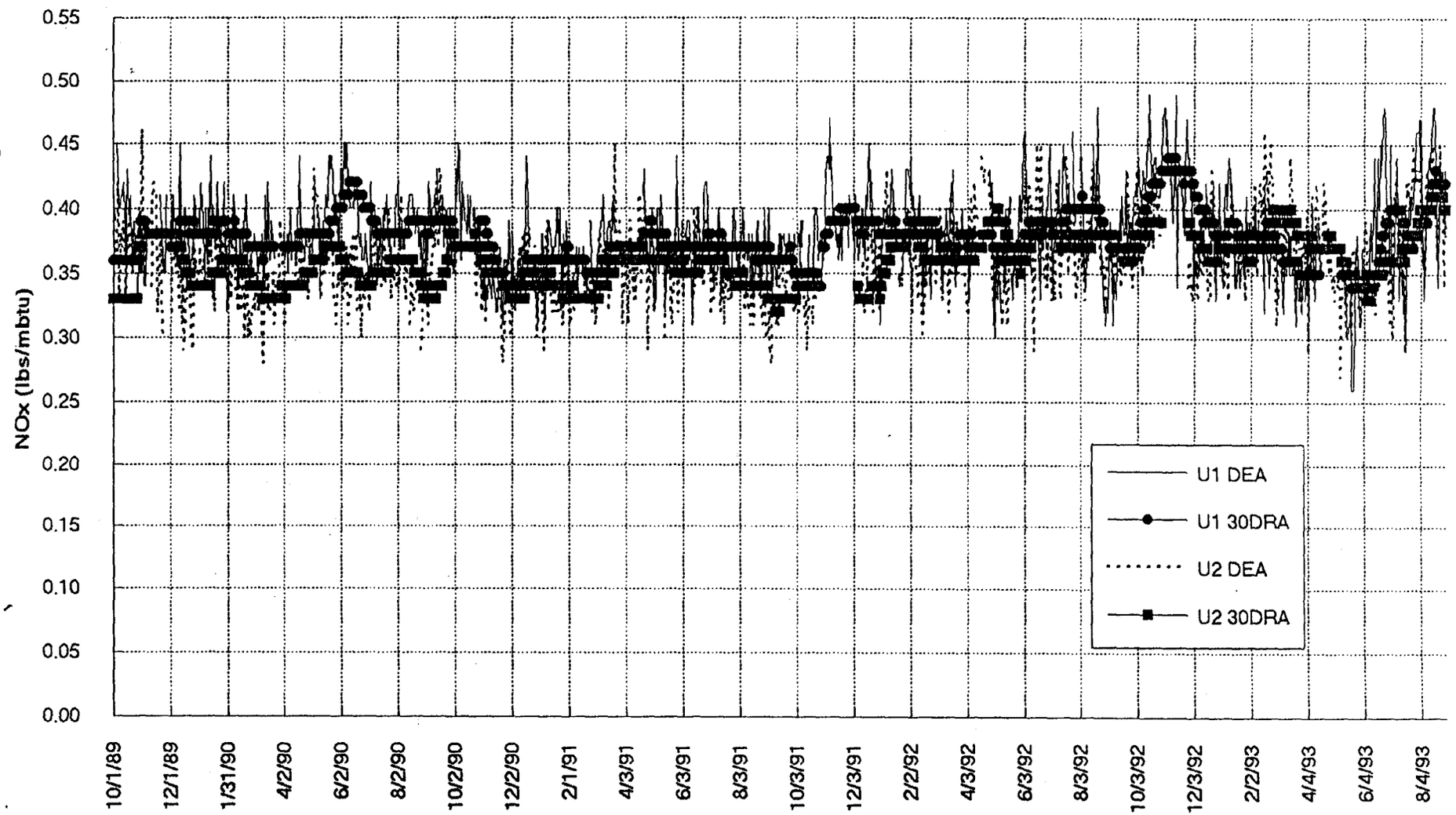
NO_x Daily Emissions Average (DEA) Summary

	Unit 1	Unit 2	Station
NO_x average (10/1/89-8/31/93)	0.380 lb/mbtu	0.361 lb/mbtu	0.370 lb/mbtu
NO_x average before modifications	0.377 lb/mbtu	0.350 lb/mbtu	0.364 lb/mbtu
NO_x average after modifications	0.385 lb/mbtu	0.374 lb/mbtu	0.379 lb/mbtu
% Change	2.1%	6.8%	4.4%

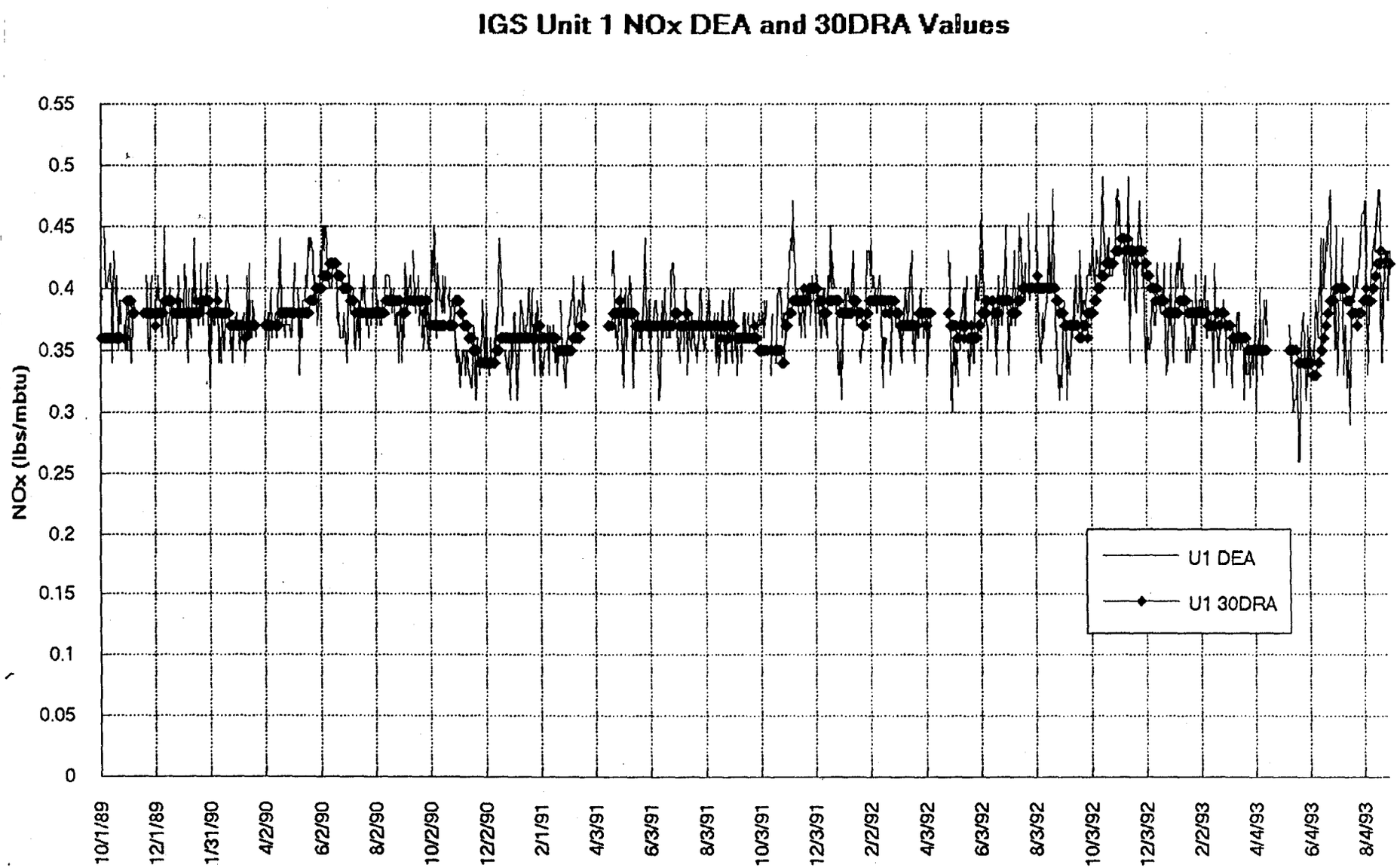
IP7_000305

IGS Unit 1 and 2	CEM NOx Values	Daily Averages and 30 Day Rolling Averages						
For 10/1/89 thru 8/31/93								
		Ave for peri	Months	Pre-outage	Months	Post-Outage	Months	% increase
		10/1/89-8/31	47.7	U1 4/10/92	30.7	U1 4/27/92	16.4	
				U2 10/25/91	25.1	U2 12/7/91	21.1	
NOx DEA	U1	0.380		0.377		0.385		2.1
	U2	0.361		0.350		0.374		6.8
	IGS	0.370		0.364		0.379		4.4
NOx 30DRA	U1	0.378		0.375		0.383		2.2
	U2	0.360		0.349		0.372		6.7
	IGS	0.369		0.362		0.378		4.4
	U1 DEA	U1 30DRA	U2 DEA	U2 30DRA				
10/1/89	0.39	0.36	0.39	0.33				
10/2/89	0.40	0.36	0.37	0.33				
10/3/89	0.39	0.36	0.37	0.33				
10/4/89			0.36	0.33				

IGS Units 1 and 2 NOX DEA and 30DRA Values

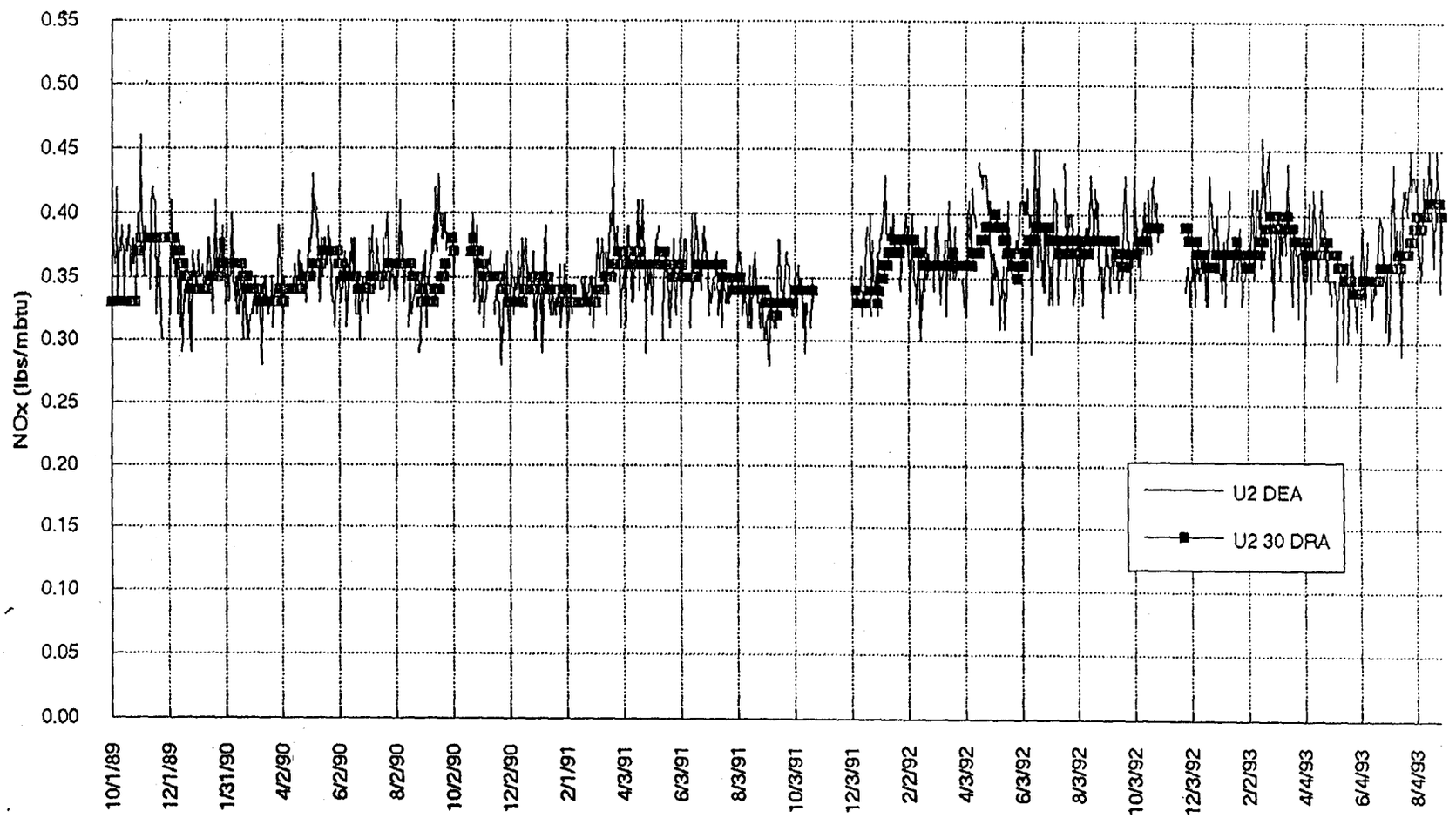


IP7_000307

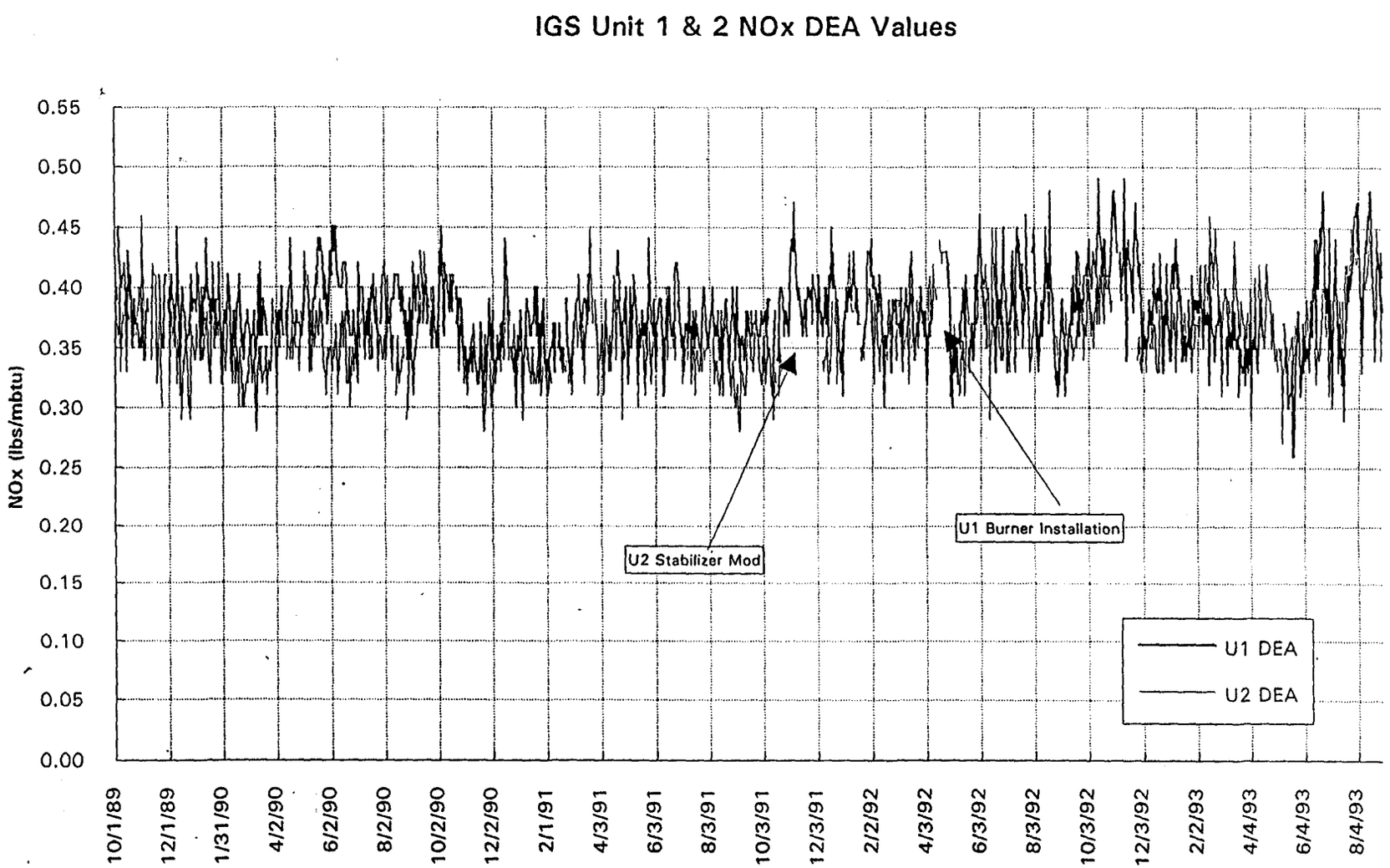

IGS Unit 1 NOx DEA and 30DRA Values
NOx (lbs/mbtu)
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
10/1/89
12/1/89
1/31/90
4/2/90
6/2/90
8/2/90
10/2/90
12/2/90
2/1/91
4/3/91
6/3/91
8/3/91
10/3/91
12/3/91
2/2/92
4/3/92
6/3/92
8/3/92
10/3/92
12/3/92
2/2/93
4/4/93
6/4/93
8/4/93
U1 DEA
U1 30DRA

IP7_000308

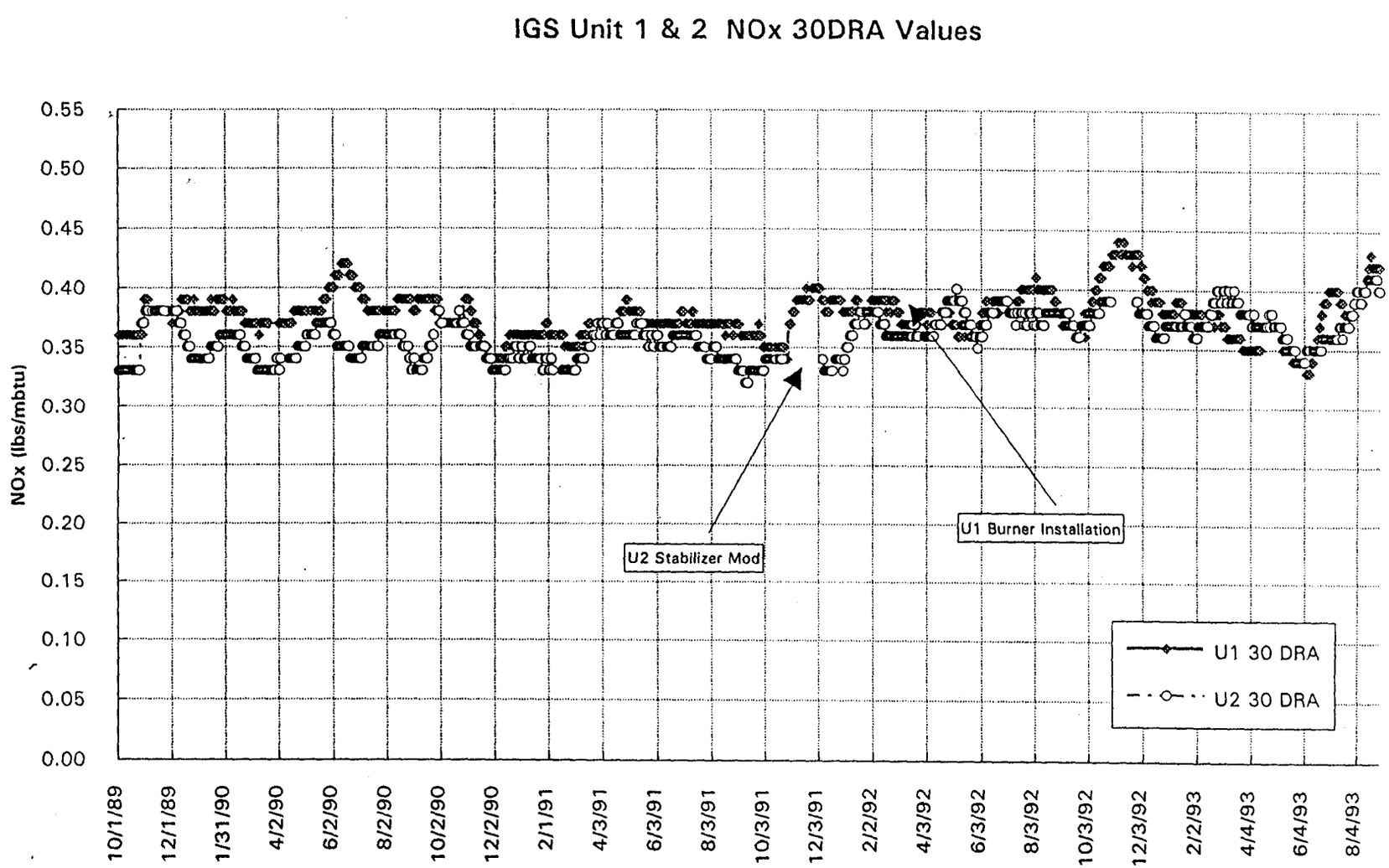
IGS Unit 2 NOx DEA and 30DRA Values



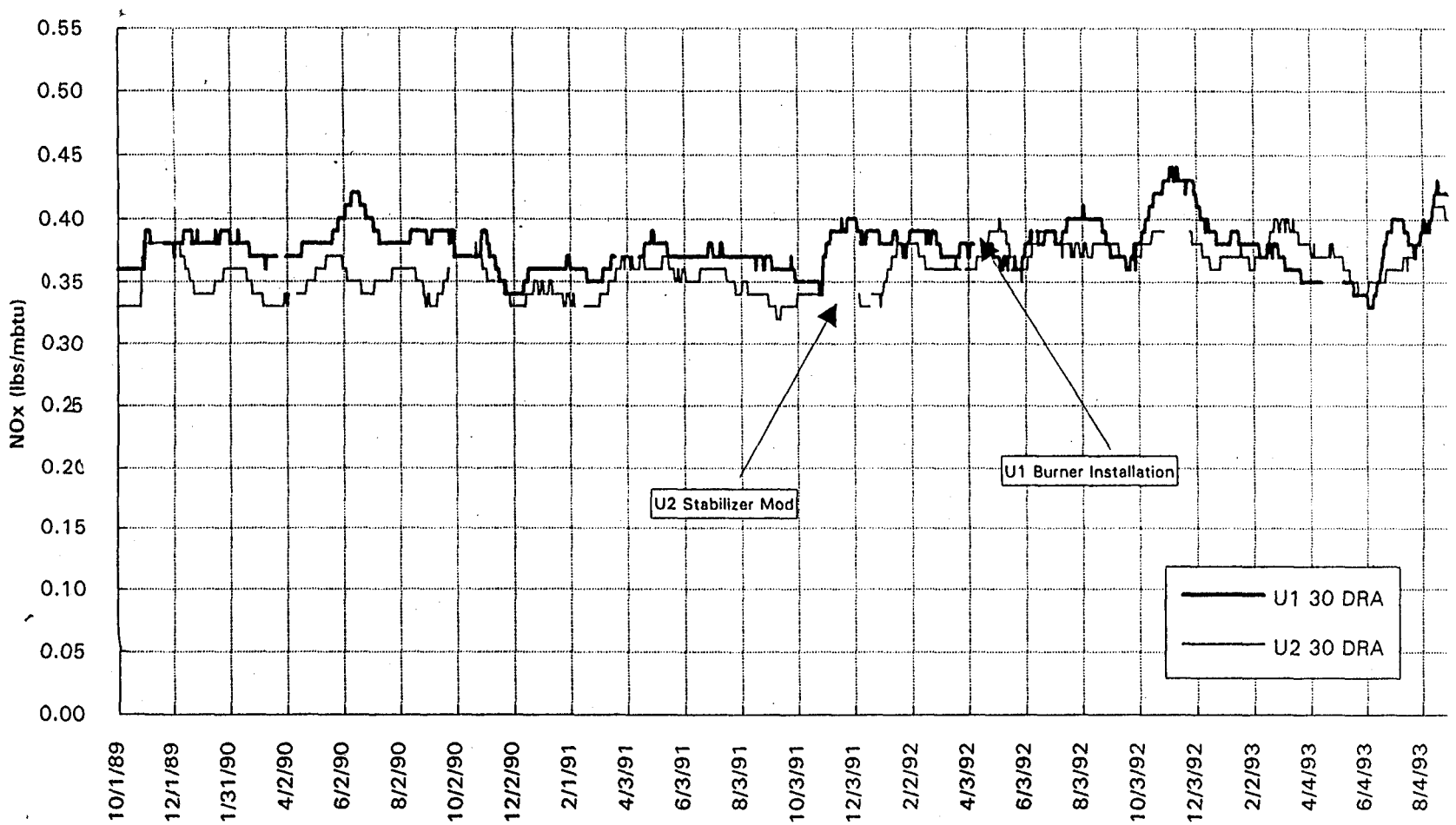
IP7_000309


IGS Unit 1 & 2 NOx DEA Values
NOx (lbs/mbtu)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
10/1/89
12/1/89
1/31/90
4/2/90
6/2/90
8/2/90
10/2/90
12/2/90
2/1/91
4/3/91
6/3/91
8/3/91
10/3/91
12/3/91
2/2/92
4/3/92
6/3/92
8/3/92
10/3/92
12/3/92
2/2/93
4/4/93
6/4/93
8/4/93
U2 Stabilizer Mod
U1 Burner Installation
U1 DEA
U2 DEA

IP7_000310


IGS Unit 1 & 2 NOx 30DRA Values
NOx (lbs/mbtu)
0.55
0.50
0.45
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
10/1/89
12/1/89
1/31/90
4/2/90
6/2/90
8/2/90
10/2/90
12/2/90
2/1/91
4/3/91
6/3/91
8/3/91
10/3/91
12/3/91
2/2/92
4/3/92
6/3/92
8/3/92
10/3/92
12/3/92
2/2/93
4/4/93
6/4/93
8/4/93
U2 Stabilizer Mod
U1 Burner Installation
U1 30 DRA
U2 30 DRA

IGS Unit 1 & 2 NOx 30DRA Values



IP7_000312

IGS Unit 1 and 2	CEM NOx Values			Daily Averages and 30 Day Rolling Averages				
For 10/1/89 thru 8/31/93								
		Ave for pe	Months	Pre-outage	Months	Post-Outag	Months	% increase
		10/1/89-8/31	47.7	U1 4/10/92	30.7	U1 4/27/92	16.4	
				U2 10/25/9	25.1	U2 12/7/91	21.1	
NOx DEA	U1	0.380		0.377		0.385		2.1
	U2	0.361		0.350		0.374		6.8
	IGS	0.370		0.364		0.379		4.4
NOx 30DR	U1	0.378		0.375		0.383		2.2
	U2	0.360		0.349		0.372		6.7
	IGS	0.369		0.362		0.378		4.4
	U1 DEA	U1 30DRA	U2 DEA	U2 30DRA				
10/1/89	0.39	0.36	0.39	0.33				
10/2/89	0.40	0.36	0.37	0.33				
10/3/89	0.39	0.36	0.37	0.33				
10/4/89			0.36	0.33				
10/5/89	0.45	0.36	0.37	0.33				
10/6/89	0.43	0.36	0.42	0.33				
10/7/89	0.40	0.36	0.33	0.33				
10/8/89	0.40	0.36	0.35	0.33				
10/9/89	0.41	0.36	0.38	0.33				
10/10/89	0.41	0.36	0.37	0.33				
10/11/89	0.42	0.36	0.39	0.33				
10/12/89	0.42	0.36	0.38	0.33				
10/13/89	0.39	0.36	0.37	0.33				
10/14/89	0.34	0.36	0.33	0.33				
10/15/89	0.39	0.36	0.36	0.33				
10/16/89	0.43	0.36	0.38	0.33				
10/17/89	0.40	0.36	0.37	0.33				
10/18/89	0.39	0.36	0.39	0.33				
10/19/89	0.41	0.36	0.39	0.33				
10/20/89	0.36	0.36	0.36	0.33				
10/21/89	0.35	0.36	0.35	0.33				
10/22/89	0.39	0.36	0.38	0.33				
10/23/89	0.39	0.36	0.36	0.33				
10/24/89	0.37	0.36	0.38	0.33				
10/25/89			0.36	0.33				
10/26/89			0.38	0.33				
10/27/89	0.37	0.36	0.38	0.37				
10/28/89	0.35	0.36	0.40	0.37				
10/29/89	0.35	0.36	0.38	0.37				
10/30/89	0.36	0.39	0.38	0.37				
10/31/89	0.35	0.39	0.42	0.37				
11/1/89	0.39	0.39	0.46	0.38				
11/2/89	0.36	0.39	0.39	0.38				
11/3/89	0.34	0.39	0.39	0.38				
11/4/89	0.34	0.39	0.35	0.38				
11/5/89	0.38	0.38	0.39	0.38				

11/6/89	0.38	0.38						
11/7/89	0.39	0.38						
11/8/89	0.38	0.38						
11/9/89			0.37	0.38				
11/10/89								
11/11/89			0.34	0.38				
11/12/89			0.41	0.38				
11/13/89			0.42	0.38				
11/14/89			0.41	0.38				
11/15/89			0.41	0.38				
11/16/89			0.41	0.38				
11/17/89			0.32	0.38				
11/18/89	0.43	0.38	0.33	0.38				
11/19/89			0.35	0.38				
11/20/89	0.41	0.38	0.38	0.38				
11/21/89	0.40	0.38	0.37	0.38				
11/22/89	0.36	0.38	0.32	0.38				
11/23/89	0.35	0.38	0.30	0.38				
11/24/89	0.36	0.38						
11/25/89	0.35	0.38						
11/26/89	0.40	0.38						
11/27/89	0.41	0.38						
11/28/89	0.41	0.38						
11/29/89								
11/30/89	0.39	0.38						
12/1/89	0.38	0.37						
12/2/89	0.40	0.38	0.32	0.38				
12/3/89	0.39	0.38	0.41	0.38				
12/4/89	0.41	0.38	0.37	0.38				
12/5/89	0.39	0.38	0.36	0.38				
12/6/89	0.39	0.38	0.37	0.38				
12/7/89	0.37	0.38	0.35	0.38				
12/8/89	0.36	0.38	0.35	0.37				
12/9/89	0.38	0.38	0.36	0.37				
12/10/89	0.40	0.38	0.32	0.37				
12/11/89	0.45	0.39	0.35	0.37				
12/12/89	0.39	0.39	0.38	0.37				
12/13/89	0.37	0.39	0.31	0.36				
12/14/89	0.37	0.39	0.35	0.36				
12/15/89	0.35	0.39	0.29	0.36				
12/16/89	0.40	0.39	0.30	0.36				
12/17/89	0.40	0.39	0.34	0.36				
12/18/89	0.38	0.39	0.33	0.35				
12/19/89	0.38	0.39	0.35	0.35				
12/20/89	0.36	0.39	0.36	0.35				
12/21/89	0.35	0.38	0.35	0.35				
12/22/89	0.36	0.38	0.34	0.35				
12/23/89	0.36	0.38	0.30	0.34				
12/24/89	0.36	0.38	0.30	0.34				
12/25/89	0.38	0.38	0.29	0.34				
12/26/89	0.41	0.39	0.37	0.34				
12/27/89	0.40	0.38	0.35	0.34				

12/28/89	0.38	0.38	0.36	0.34				
12/29/89	0.39	0.38	0.35	0.34				
12/30/89	0.39	0.38	0.34	0.34				
12/31/89	0.39	0.38	0.34	0.34				
1/1/90	0.38	0.38	0.37	0.34				
1/2/90	0.42	0.38	0.35	0.34				
1/3/90			0.35	0.34				
1/4/90	0.41	0.38	0.35	0.34				
1/5/90	0.36	0.38	0.36	0.34				
1/6/90	0.34	0.38	0.35	0.34				
1/7/90	0.40	0.38	0.34	0.34				
1/8/90	0.37	0.38	0.35	0.34				
1/9/90	0.36	0.38	0.34	0.34				
1/10/90	0.40	0.38	0.35	0.34				
1/11/90	0.39	0.38	0.38	0.34				
1/12/90	0.40	0.38	0.36	0.34				
1/13/90	0.44	0.38	0.38	0.34				
1/14/90	0.39	0.38	0.36	0.35				
1/15/90	0.40	0.39	0.33	0.35				
1/16/90	0.39	0.38	0.34	0.35				
1/17/90	0.37	0.38	0.32	0.35				
1/18/90	0.39	0.38	0.38	0.35				
1/19/90	0.38	0.38	0.37	0.35				
1/20/90	0.42	0.39	0.41	0.35				
1/21/90	0.38	0.39	0.35	0.35				
1/22/90	0.39	0.39	0.35	0.35				
1/23/90	0.37	0.39	0.38	0.35				
1/24/90	0.39	0.39	0.36	0.36				
1/25/90	0.39	0.39	0.38	0.36				
1/26/90	0.39	0.39	0.36	0.36				
1/27/90	0.42	0.39	0.39	0.36				
1/28/90	0.37	0.39	0.35	0.36				
1/29/90	0.37	0.39	0.38	0.36				
1/30/90	0.32	0.39	0.35	0.36				
1/31/90	0.34	0.38	0.32	0.36				
2/1/90	0.37	0.38	0.36	0.36				
2/2/90	0.38	0.38	0.36	0.36				
2/3/90	0.37	0.38	0.33	0.36				
2/4/90	0.37	0.38	0.34	0.36				
2/5/90	0.38	0.38	0.36	0.36				
2/6/90	0.41	0.38	0.40	0.36				
2/7/90	0.40	0.38	0.39	0.36				
2/8/90	0.40	0.39	0.35	0.36				
2/9/90	0.34	0.38	0.33	0.36				
2/10/90	0.36	0.38	0.35	0.36				
2/11/90	0.34	0.38	0.32	0.36				
2/12/90	0.38	0.38	0.35	0.36				
2/13/90	0.38	0.38	0.35	0.36				
2/14/90	0.35	0.38	0.32	0.36				
2/15/90	0.35	0.38	0.33	0.36				
2/16/90	0.38	0.38	0.35	0.36				
2/17/90	0.39	0.38	0.34	0.36				

2/18/90	0.39	0.38	0.30	0.35				
2/19/90	0.41	0.38	0.35	0.35				
2/20/90	0.38	0.38	0.34	0.35				
2/21/90	0.36	0.37	0.33	0.35				
2/22/90	0.35	0.37	0.30	0.35				
2/23/90	0.36	0.37	0.32	0.35				
2/24/90	0.34	0.37	0.30	0.34				
2/25/90	0.36	0.37	0.31	0.34				
2/26/90	0.37	0.37	0.32	0.34				
2/27/90	0.37	0.37	0.32	0.34				
2/28/90	0.38	0.37	0.33	0.34				
3/1/90	0.37	0.37	0.32	0.34				
3/2/90	0.37	0.37	0.35	0.34				
3/3/90	0.36	0.37	0.35	0.34				
3/4/90	0.35	0.37	0.35	0.34				
3/5/90	0.36	0.37	0.32	0.34				
3/6/90	0.36	0.37	0.33	0.34				
3/7/90	0.37	0.37	0.34	0.34				
3/8/90	0.38	0.37	0.34	0.33				
3/9/90	0.34	0.37	0.29	0.33				
3/10/90	0.35	0.36	0.28	0.33				
3/11/90	0.36	0.37	0.33	0.33				
3/12/90	0.41	0.37	0.34	0.33				
3/13/90	0.36	0.37	0.35	0.33				
3/14/90	0.36	0.37	0.33	0.33				
3/15/90	0.42	0.37	0.35	0.33				
3/16/90	0.36	0.37	0.32	0.33				
3/17/90	0.36	0.37	0.32	0.33				
3/18/90	0.39	0.37	0.33	0.33				
3/19/90	0.38	0.37	0.33	0.33				
3/20/90	0.38	0.37	0.33	0.33				
3/21/90	0.37	0.37	0.35	0.33				
3/22/90	0.36	0.37	0.31	0.33				
3/23/90			0.33	0.33				
3/24/90			0.34	0.33				
3/25/90			0.33	0.33				
3/26/90			0.33	0.33				
3/27/90			0.34	0.33				
3/28/90			0.39	0.33				
3/29/90			0.37	0.33				
3/30/90			0.37	0.34				
3/31/90			0.36	0.34				
4/1/90	0.38	0.37	0.34	0.34				
4/2/90	0.36	0.37	0.31	0.33				
4/3/90	0.37	0.37	0.35	0.33				
4/4/90	0.38	0.37	0.35	0.34				
4/5/90	0.35	0.37						
4/6/90	0.38	0.37						
4/7/90	0.38	0.37						
4/8/90	0.40	0.37						
4/9/90	0.36	0.37						
4/10/90	0.36	0.37						

4/11/90								
4/12/90	0.38	0.37						
4/13/90	0.36	0.37	0.34	0.34				
4/14/90	0.36	0.37	0.36	0.34				
4/15/90	0.39	0.37	0.35	0.34				
4/16/90	0.40	0.37	0.35	0.34				
4/17/90	0.40	0.37	0.34	0.34				
4/18/90	0.44	0.38	0.36	0.34				
4/19/90	0.39	0.38	0.37	0.34				
4/20/90	0.37	0.38	0.34	0.34				
4/21/90	0.37	0.38	0.36	0.34				
4/22/90	0.37	0.38	0.36	0.34				
4/23/90	0.36	0.38	0.35	0.35				
4/24/90	0.38	0.38	0.35	0.35				
4/25/90	0.37	0.38	0.35	0.35				
4/26/90	0.37	0.38	0.35	0.35				
4/27/90	0.37	0.38	0.33	0.35				
4/28/90	0.37	0.38	0.35	0.35				
4/29/90	0.36	0.38	0.38	0.35				
4/30/90	0.36	0.38	0.37	0.35				
5/1/90	0.37	0.38	0.38	0.35				
5/2/90	0.38	0.38	0.38	0.35				
5/3/90	0.39	0.38	0.40	0.36				
5/4/90	0.42	0.38	0.43	0.36				
5/5/90	0.41	0.38	0.40	0.36				
5/6/90								
5/7/90	0.40	0.38	0.41	0.36				
5/8/90	0.39	0.38	0.39	0.36				
5/9/90	0.33	0.38	0.37	0.36				
5/10/90	0.38	0.38	0.35	0.36				
5/11/90			0.33	0.36				
5/12/90	0.36	0.38	0.36	0.36				
5/13/90	0.39	0.38	0.38	0.36				
5/14/90	0.39	0.38	0.35	0.37				
5/15/90	0.39	0.38	0.36	0.37				
5/16/90	0.41	0.38	0.38	0.37				
5/17/90	0.40	0.38	0.38	0.37				
5/18/90	0.41	0.38	0.36	0.37				
5/19/90	0.44	0.38	0.36	0.37				
5/20/90	0.44	0.38	0.39	0.37				
5/21/90	0.43	0.39	0.38	0.37				
5/22/90	0.44	0.39	0.37	0.37				
5/23/90	0.43	0.39	0.38	0.37				
5/24/90	0.43	0.39	0.34	0.37				
5/25/90	0.39	0.39	0.33	0.37				
5/26/90	0.41	0.39	0.33	0.37				
5/27/90	0.40	0.40	0.31	0.37				
5/28/90	0.39	0.40	0.33	0.37				
5/29/90	0.37	0.40	0.35	0.37				
5/30/90	0.38	0.40	0.34	0.37				
5/31/90	0.40	0.40	0.35	0.37				
6/1/90	0.43	0.40	0.35	0.36				

6/2/90	0.43	0.40	0.34	0.36				
6/3/90	0.41	0.40	0.33	0.36				
6/4/90	0.45	0.41	0.35	0.36				
6/5/90	0.45	0.41	0.34	0.36				
6/6/90	0.43	0.41	0.35	0.35				
6/7/90	0.45	0.41	0.37	0.35				
6/8/90	0.45	0.41	0.35	0.35				
6/9/90	0.41	0.41	0.31	0.35				
6/10/90	0.41	0.41	0.33	0.35				
6/11/90	0.40	0.42	0.33	0.35				
6/12/90	0.40	0.42	0.37	0.35				
6/13/90	0.40	0.42	0.35	0.35				
6/14/90	0.40	0.42	0.38	0.35				
6/15/90	0.41	0.42	0.37	0.35				
6/16/90	0.42	0.42	0.35	0.35				
6/17/90	0.42	0.42	0.38	0.35				
6/18/90	0.42	0.42	0.38	0.35				
6/19/90	0.42	0.42	0.32	0.35				
6/20/90	0.38	0.41	0.32	0.35				
6/21/90	0.37	0.41	0.32	0.34				
6/22/90	0.38	0.41	0.35	0.34				
6/23/90	0.36	0.41	0.30	0.34				
6/24/90	0.36	0.41	0.32	0.34				
6/25/90	0.36	0.41	0.34	0.34				
6/26/90	0.36	0.40	0.35	0.34				
6/27/90	0.38	0.40	0.33	0.34				
6/28/90	0.37	0.40	0.35	0.34				
6/29/90	0.36	0.40	0.34	0.34				
6/30/90	0.35	0.40	0.35	0.34				
7/1/90	0.34	0.40	0.33	0.34				
7/2/90	0.37	0.40	0.32	0.34				
7/3/90	0.42	0.40	0.38	0.34				
7/4/90	0.38	0.39	0.35	0.34				
7/5/90	0.40	0.39	0.37	0.35				
7/6/90			0.37	0.35				
7/7/90	0.40	0.39	0.39	0.35				
7/8/90	0.40	0.39	0.35	0.35				
7/9/90	0.36	0.39	0.35	0.35				
7/10/90	0.35	0.38	0.34	0.35				
7/11/90	0.36	0.38	0.38	0.35				
7/12/90	0.38	0.38	0.37	0.35				
7/13/90	0.36	0.38	0.36	0.35				
7/14/90	0.39	0.38	0.36	0.35				
7/15/90	0.35	0.38	0.34	0.35				
7/16/90	0.38	0.38	0.34	0.35				
7/17/90	0.40	0.38	0.34	0.35				
7/18/90	0.39	0.38	0.38	0.35				
7/19/90	0.40	0.38	0.34	0.35				
7/20/90	0.41	0.38						
7/21/90	0.38	0.38	0.38	0.35				
7/22/90	0.37	0.38	0.39	0.35				
7/23/90	0.37	0.38	0.40	0.35				

7/24/90	0.38	0.38	0.37	0.36				
7/25/90	0.36	0.38	0.33	0.36				
7/26/90	0.36	0.38	0.35	0.36				
7/27/90			0.36	0.36				
7/28/90	0.37	0.38	0.36	0.36				
7/29/90	0.39	0.38	0.35	0.36				
7/30/90	0.41	0.38	0.34	0.36				
7/31/90	0.41	0.38	0.34	0.36				
8/1/90	0.41	0.38	0.36	0.36				
8/2/90	0.42	0.38	0.35	0.36				
8/3/90	0.37	0.38	0.34	0.36				
8/4/90	0.37	0.38	0.37	0.36				
8/5/90	0.39	0.38	0.41	0.36				
8/6/90	0.37	0.38	0.39	0.36				
8/7/90	0.37	0.38	0.38	0.36				
8/8/90	0.37	0.38	0.37	0.36				
8/9/90	0.39	0.38	0.34	0.36				
8/10/90	0.39	0.38	0.33	0.36				
8/11/90	0.39	0.38	0.36	0.36				
8/12/90	0.39	0.38	0.36	0.36				
8/13/90	0.41	0.39						
8/14/90	0.41	0.39	0.31	0.36				
8/15/90	0.41	0.39	0.33	0.36				
8/16/90	0.41	0.39	0.36	0.36				
8/17/90	0.41	0.39	0.33	0.36				
8/18/90	0.39	0.39	0.32	0.36				
8/19/90	0.40	0.39	0.33	0.35				
8/20/90	0.38	0.39	0.33	0.35				
8/21/90	0.39	0.39	0.34	0.35				
8/22/90	0.40	0.39	0.35	0.35				
8/23/90	0.37	0.39	0.34	0.35				
8/24/90	0.38	0.39						
8/25/90	0.36	0.39						
8/26/90	0.38	0.39	0.29	0.35				
8/27/90	0.34	0.39	0.30	0.34				
8/28/90	0.35	0.39	0.32	0.34				
8/29/90	0.38	0.39	0.35	0.33				
8/30/90	0.39	0.39	0.36	0.33				
8/31/90	0.34	0.38	0.35	0.33				
9/1/90	0.38	0.38	0.37	0.34				
9/2/90	0.36	0.38	0.32	0.34				
9/3/90	0.42	0.38	0.31	0.33				
9/4/90	0.41	0.38	0.35	0.33				
9/5/90	0.41	0.39	0.34	0.33				
9/6/90	0.38	0.39	0.35	0.33				
9/7/90	0.40	0.39	0.36	0.33				
9/8/90	0.40	0.39	0.37	0.33				
9/9/90	0.41	0.39	0.39	0.33				
9/10/90	0.39	0.39	0.37	0.33				
9/11/90			0.38	0.33				
9/12/90	0.43	0.39	0.42	0.34				
9/13/90	0.41	0.39	0.38	0.34				

9/14/90	0.40	0.39	0.37	0.34				
9/15/90	0.38	0.39	0.40	0.34				
9/16/90	0.40	0.39	0.43	0.34				
9/17/90	0.40	0.39	0.39	0.34				
9/18/90	0.41	0.39	0.40	0.35				
9/19/90	0.37	0.39	0.38	0.35				
9/20/90	0.39	0.39	0.40	0.35				
9/21/90			0.38	0.35				
9/22/90	0.36	0.39	0.39	0.35				
9/23/90	0.38	0.39	0.40	0.36				
9/24/90	0.35	0.39	0.37	0.36				
9/25/90	0.36	0.38						
9/26/90	0.40	0.39						
9/27/90	0.37	0.39						
9/28/90	0.36	0.39						
9/29/90	0.35	0.39						
9/30/90	0.35	0.37	0.38	0.38				
10/1/90	0.37	0.37	0.38	0.38				
10/2/90	0.38	0.37	0.35	0.37				
10/3/90	0.43	0.37	0.37	0.37				
10/4/90	0.41	0.37						
10/5/90	0.45	0.37						
10/6/90	0.44	0.37						
10/7/90	0.37	0.37						
10/8/90	0.36	0.37						
10/9/90	0.42	0.37						
10/10/90	0.41	0.37						
10/11/90	0.41	0.37						
10/12/90	0.39	0.37						
10/13/90	0.39	0.37						
10/14/90	0.38	0.37						
10/15/90	0.41	0.37						
10/16/90	0.39	0.37						
10/17/90	0.38	0.37						
10/18/90	0.41	0.37						
10/19/90								
10/20/90								
10/21/90	0.39	0.37	0.37	0.37				
10/22/90	0.40	0.37	0.40	0.37				
10/23/90	0.37	0.37	0.39	0.38				
10/24/90	0.38	0.37	0.33	0.37				
10/25/90	0.39	0.37	0.35	0.37				
10/26/90	0.39	0.37	0.37	0.37				
10/27/90	0.39	0.37	0.39	0.37				
10/28/90	0.38	0.37	0.35	0.37				
10/29/90	0.35	0.39	0.35	0.37				
10/30/90	0.34	0.39	0.32	0.36				
10/31/90	0.34	0.39	0.34	0.36				
11/1/90	0.35	0.39	0.33	0.36				
11/2/90	0.34	0.39	0.35	0.36				
11/3/90	0.32	0.39	0.31	0.36				
11/4/90	0.34	0.38	0.33	0.35				

11/5/90	0.33	0.38	0.33	0.35				
11/6/90	0.35	0.38	0.34	0.35				
11/7/90	0.35	0.37	0.34	0.35				
11/8/90	0.34	0.37	0.36	0.35				
11/9/90	0.33	0.37	0.36	0.35				
11/10/90	0.35	0.37	0.37	0.35				
11/11/90	0.35	0.37	0.35	0.35				
11/12/90	0.34	0.37						
11/13/90	0.33	0.36						
11/14/90	0.33	0.36						
11/15/90	0.32	0.36	0.32	0.35				
11/16/90	0.32	0.36	0.34	0.35				
11/17/90	0.34	0.35	0.34	0.35				
11/18/90	0.37	0.35	0.33	0.35				
11/19/90	0.36	0.35	0.33	0.35				
11/20/90	0.33	0.35	0.33	0.35				
11/21/90	0.31	0.35	0.29	0.35				
11/22/90	0.32	0.35	0.28	0.34				
11/23/90	0.36	0.35	0.30	0.34				
11/24/90	0.33	0.34	0.31	0.34				
11/25/90	0.33	0.34	0.36	0.34				
11/26/90	0.35	0.34	0.33	0.34				
11/27/90	0.36	0.34	0.34	0.34				
11/28/90	0.39	0.34	0.37	0.34				
11/29/90	0.37	0.34	0.33	0.33				
11/30/90	0.35	0.34	0.30	0.33				
12/1/90	0.34	0.34	0.31	0.33				
12/2/90	0.38	0.34	0.32	0.33				
12/3/90	0.34	0.34	0.37	0.33				
12/4/90	0.34	0.34	0.35	0.33				
12/5/90	0.33	0.34	0.32	0.33				
12/6/90	0.33	0.34	0.35	0.33				
12/7/90	0.36	0.34	0.34	0.33				
12/8/90	0.35	0.34	0.34	0.33				
12/9/90	0.34	0.34	0.34	0.33				
12/10/90	0.34	0.34	0.37	0.33				
12/11/90	0.35	0.34	0.33	0.33				
12/12/90	0.37	0.34	0.35	0.33				
12/13/90	0.35	0.35	0.35	0.33				
12/14/90	0.38	0.35	0.38	0.33				
12/15/90	0.37	0.35	0.34	0.33				
12/16/90	0.40	0.35	0.37	0.34				
12/17/90	0.44	0.35	0.37	0.34				
12/18/90	0.43	0.36	0.38	0.34				
12/19/90	0.40	0.36	0.38	0.34				
12/20/90	0.37	0.36	0.34	0.34				
12/21/90	0.38	0.36	0.34	0.34				
12/22/90								
12/23/90	0.35	0.36	0.34	0.34				
12/24/90	0.34	0.36	0.34	0.35				
12/25/90	0.34	0.36	0.35	0.35				
12/26/90	0.33	0.36	0.37	0.35				

12/27/90	0.35	0.36	0.35	0.35				
12/28/90	0.32	0.36	0.30	0.35				
12/29/90	0.31	0.36	0.30	0.34				
12/30/90	0.36	0.36	0.33	0.34				
12/31/90	0.34	0.36	0.33	0.34				
1/1/91	0.35	0.36	0.35	0.35				
1/2/91	0.38	0.36	0.35	0.35				
1/3/91	0.38	0.36	0.33	0.35				
1/4/91	0.36	0.36	0.31	0.34				
1/5/91	0.31	0.36	0.29	0.34				
1/6/91	0.32	0.36	0.32	0.34				
1/7/91	0.35	0.36	0.38	0.34				
1/8/91	0.35	0.36	0.36	0.34				
1/9/91	0.39	0.36	0.39	0.35				
1/10/91	0.39	0.36	0.34	0.35				
1/11/91	0.38	0.36	0.35	0.35				
1/12/91	0.38	0.36	0.33	0.35				
1/13/91	0.36	0.36	0.33	0.34				
1/14/91	0.36	0.36	0.32	0.34				
1/15/91	0.37	0.36	0.34	0.34				
1/16/91	0.37	0.36	0.35	0.34				
1/17/91	0.37	0.36	0.32	0.34				
1/18/91	0.40	0.36	0.33	0.34				
1/19/91	0.40	0.36	0.32	0.34				
1/20/91	0.36	0.36	0.32	0.34				
1/21/91	0.38	0.36	0.34	0.34				
1/22/91	0.40	0.36	0.34	0.34				
1/23/91	0.34	0.36	0.32	0.34				
1/24/91	0.37	0.36	0.36	0.34				
1/25/91	0.33	0.36	0.31	0.33				
1/26/91	0.38	0.36	0.32	0.33				
1/27/91	0.36	0.36	0.33	0.33				
1/28/91	0.39	0.37	0.36	0.34				
1/29/91	0.38	0.37	0.36	0.34				
1/30/91	0.34	0.37	0.33	0.34				
1/31/91	0.33	0.37	0.33	0.34				
2/1/91	0.34	0.36	0.31	0.33				
2/2/91	0.34	0.36	0.31	0.33				
2/3/91	0.33	0.36	0.32	0.33				
2/4/91	0.34	0.36	0.34	0.34				
2/5/91	0.35	0.36	0.33	0.34				
2/6/91	0.35	0.36	0.32	0.33				
2/7/91	0.35	0.36						
2/8/91	0.37	0.36						
2/9/91	0.35	0.36						
2/10/91	0.33	0.36						
2/11/91	0.37	0.36						
2/12/91								
2/13/91	0.35	0.36						
2/14/91	0.35	0.36						
2/15/91	0.37	0.36						
2/16/91	0.34	0.36	0.35	0.33				

2/17/91	0.35	0.36	0.34	0.33				
2/18/91	0.35	0.36	0.33	0.33				
2/19/91	0.33	0.35	0.33	0.33				
2/20/91	0.35	0.35	0.35	0.33				
2/21/91			0.33	0.33				
2/22/91	0.39	0.35	0.33	0.33				
2/23/91	0.39	0.35	0.34	0.33				
2/24/91	0.35	0.35	0.35	0.33				
2/25/91	0.35	0.35	0.32	0.33				
2/26/91	0.34	0.35	0.35	0.33				
2/27/91	0.33	0.35	0.33	0.33				
2/28/91	0.32	0.35	0.35	0.33				
3/1/91	0.33	0.35	0.31	0.33				
3/2/91	0.35	0.35	0.32	0.33				
3/3/91	0.37	0.35	0.35	0.33				
3/4/91	0.37	0.35	0.36	0.33				
3/5/91	0.38	0.35	0.38	0.34				
3/6/91	0.39	0.35	0.38	0.34				
3/7/91	0.39	0.35	0.35	0.34				
3/8/91	0.39	0.36	0.36	0.34				
3/9/91	0.41	0.36	0.37	0.34				
3/10/91	0.38	0.36	0.37	0.34				
3/11/91	0.36	0.36	0.38	0.34				
3/12/91	0.37	0.36	0.34	0.34				
3/13/91	0.38	0.36	0.34	0.34				
3/14/91	0.39	0.36	0.37	0.35				
3/15/91	0.39	0.36	0.32	0.35				
3/16/91	0.39	0.36	0.36	0.35				
3/17/91	0.38	0.37	0.37	0.35				
3/18/91	0.37	0.37	0.37	0.35				
3/19/91	0.40	0.37	0.40	0.35				
3/20/91	0.41	0.37	0.39	0.35				
3/21/91	0.38	0.37	0.39	0.35				
3/22/91			0.45	0.36				
3/23/91			0.40	0.36				
3/24/91			0.37	0.36				
3/25/91			0.37	0.36				
3/26/91								
3/27/91			0.39	0.36				
3/28/91			0.36	0.37				
3/29/91			0.37	0.37				
3/30/91			0.31	0.37				
3/31/91			0.34	0.36				
4/1/91			0.34	0.37				
4/2/91			0.35	0.37				
4/3/91			0.36	0.37				
4/4/91			0.37	0.37				
4/5/91			0.31	0.37				
4/6/91			0.32	0.36				
4/7/91			0.39	0.36				
4/8/91			0.39	0.37				
4/9/91			0.36	0.37				

10/91			0.35	0.36				
4/11/91			0.33	0.36				
4/12/91			0.36	0.36				
4/13/91			0.33	0.36				
4/14/91			0.35	0.36				
4/15/91			0.36	0.36				
4/16/91	0.38	0.37	0.38	0.36				
4/17/91	0.38	0.37	0.41	0.37				
4/18/91	0.38	0.37	0.41	0.37				
4/19/91			0.34	0.37				
4/20/91			0.39	0.37				
4/21/91	0.41	0.37	0.39	0.37				
4/22/91	0.43	0.38	0.38	0.36				
4/23/91	0.43	0.38	0.41	0.36				
4/24/91	0.36	0.38	0.38	0.36				
4/25/91	0.37	0.38	0.37	0.36				
4/26/91	0.36	0.38	0.29	0.36				
4/27/91	0.35	0.38	0.33	0.36				
4/28/91	0.38	0.38	0.36	0.36				
4/29/91	0.39	0.39	0.34	0.36				
4/30/91	0.37	0.39	0.35	0.36				
5/1/91	0.40	0.39	0.36	0.36				
5/2/91	0.34	0.38	0.35	0.36				
5/3/91	0.32	0.38	0.32	0.36				
5/4/91	0.33	0.38	0.35	0.36				
5/5/91	0.39	0.38	0.37	0.36				
5/6/91	0.40	0.38	0.37	0.36				
5/7/91	0.35	0.38	0.38	0.36				
5/8/91	0.37	0.38	0.38	0.36				
5/9/91	0.39	0.38	0.38	0.36				
5/10/91	0.41	0.38	0.39	0.36				
5/11/91	0.40	0.38	0.39	0.37				
5/12/91	0.39	0.38	0.39	0.37				
5/13/91	0.36	0.38						
5/14/91	0.32	0.38	0.30	0.37				
5/15/91	0.35	0.38	0.36	0.37				
5/16/91	0.37	0.38	0.36	0.37				
5/17/91	0.35	0.37	0.36	0.37				
5/18/91	0.36	0.37	0.35	0.36				
5/19/91	0.38	0.37	0.37	0.36				
5/20/91	0.36	0.37	0.36	0.36				
5/21/91	0.37	0.37	0.32	0.36				
5/22/91	0.36	0.37	0.31	0.36				
5/23/91	0.37	0.37	0.34	0.36				
5/24/91	0.35	0.37	0.34	0.35				
5/25/91	0.38	0.37	0.36	0.35				
5/26/91	0.39	0.37	0.38	0.35				
5/27/91	0.44	0.37	0.35	0.36				
5/28/91	0.40	0.37	0.33	0.36				
5/29/91	0.37	0.37	0.32	0.35				
5/30/91	0.37	0.37	0.35	0.35				
5/31/91	0.36	0.37	0.35	0.35				

6/1/91	0.39	0.37	0.38	0.36				
6/2/91	0.36	0.37	0.34	0.36				
6/3/91	0.35	0.37	0.33	0.36				
6/4/91	0.37	0.37	0.34	0.36				
6/5/91	0.37	0.37	0.35	0.35				
6/6/91	0.38	0.37	0.38	0.35				
6/7/91	0.39	0.37	0.38	0.35				
6/8/91	0.39	0.37	0.38	0.35				
6/9/91	0.39	0.37	0.36	0.35				
6/10/91	0.37	0.37	0.36	0.35				
6/11/91	0.35	0.37						
6/12/91	0.31	0.37						
6/13/91	0.32	0.37	0.31	0.35				
6/14/91	0.37	0.37	0.36	0.35				
6/15/91	0.39	0.37	0.40	0.35				
6/16/91	0.36	0.37	0.34	0.35				
6/17/91	0.37	0.37	0.36	0.35				
6/18/91	0.40	0.37	0.40	0.35				
6/19/91	0.40	0.37	0.38	0.35				
6/20/91	0.36	0.37	0.39	0.36				
6/21/91	0.36	0.37	0.38	0.36				
6/22/91	0.36	0.37	0.35	0.36				
6/23/91	0.37	0.37	0.35	0.36				
6/24/91	0.36	0.37	0.36	0.36				
6/25/91	0.41	0.37	0.34	0.36				
6/26/91	0.42	0.37	0.38	0.36				
6/27/91	0.42	0.37	0.39	0.36				
6/28/91	0.42	0.37	0.38	0.36				
6/29/91	0.40	0.38	0.38	0.36				
6/30/91	0.37	0.38	0.36	0.36				
7/1/91	0.37	0.38	0.37	0.36				
7/2/91	0.35	0.38	0.36	0.36				
7/3/91	0.36	0.38	0.32	0.36				
7/4/91	0.35	0.37	0.34	0.36				
7/5/91	0.34	0.37	0.33	0.36				
7/6/91	0.37	0.37	0.34	0.36				
7/7/91	0.37	0.37	0.35	0.36				
7/8/91	0.37	0.37	0.35	0.36				
7/9/91	0.35	0.37	0.34	0.36				
7/10/91	0.39	0.37	0.36	0.36				
7/11/91	0.40	0.37	0.37	0.36				
7/12/91	0.38	0.38	0.36	0.36				
7/13/91	0.33	0.38	0.32	0.36				
7/14/91	0.35	0.38	0.34	0.36				
7/15/91	0.38	0.37	0.33	0.36				
7/16/91	0.36	0.37	0.36	0.36				
7/17/91	0.35	0.37	0.31	0.36				
7/18/91	0.38	0.37	0.35	0.35				
7/19/91	0.36	0.37	0.34	0.35				
7/20/91	0.37	0.37	0.35	0.35				
7/21/91	0.36	0.37	0.33	0.35				
7/22/91	0.35	0.37	0.33	0.35				

7/23/91	0.35	0.37	0.35	0.35				
7/24/91	0.34	0.37	0.33	0.35				
7/25/91	0.36	0.37	0.33	0.35				
7/26/91	0.39	0.37	0.34	0.35				
7/27/91	0.40	0.37	0.35	0.35				
7/28/91	0.40	0.37	0.34	0.34				
7/29/91	0.38	0.37	0.35	0.34				
7/30/91	0.36	0.37	0.35	0.34				
7/31/91	0.36	0.37	0.35	0.34				
8/1/91	0.35	0.37	0.35	0.34				
8/2/91	0.36	0.37	0.37	0.34				
8/3/91	0.37	0.37	0.36	0.34				
8/4/91	0.38	0.37	0.37	0.35				
8/5/91	0.38	0.37	0.37	0.35				
8/6/91	0.40	0.37	0.37	0.35				
8/7/91	0.38	0.37	0.35	0.35				
8/8/91	0.36	0.37	0.32	0.35				
8/9/91	0.37	0.37	0.34	0.35				
8/10/91	0.36	0.37	0.33	0.34				
8/11/91	0.36	0.37	0.34	0.34				
8/12/91	0.38	0.37	0.32	0.34				
8/13/91	0.35	0.37	0.32	0.34				
8/14/91	0.34	0.37	0.31	0.34				
8/15/91	0.35	0.37	0.33	0.34				
8/16/91	0.38	0.37	0.36	0.34				
8/17/91	0.33	0.37	0.31	0.34				
8/18/91	0.34	0.37	0.31	0.34				
8/19/91	0.36	0.36	0.36	0.34				
8/20/91	0.38	0.37	0.36	0.34				
8/21/91	0.39	0.37	0.37	0.34				
8/22/91	0.39	0.37	0.36	0.34				
8/23/91	0.36	0.37	0.34	0.34				
8/24/91	0.34	0.37	0.33	0.34				
8/25/91	0.36	0.37	0.34	0.34				
8/26/91	0.34	0.37	0.32	0.34				
8/27/91	0.37	0.36	0.31	0.34				
8/28/91	0.38	0.36	0.33	0.34				
8/29/91	0.40	0.37	0.34	0.34				
8/30/91	0.37	0.37	0.32	0.34				
8/31/91	0.35	0.37	0.30	0.34				
9/1/91	0.34	0.37	0.30	0.34				
9/2/91	0.39	0.37	0.31	0.33				
9/3/91	0.40	0.37	0.32	0.33				
9/4/91	0.35	0.37	0.29	0.33				
9/5/91	0.36	0.36	0.28	0.33				
9/6/91	0.33	0.36	0.28	0.33				
9/7/91	0.35	0.36	0.34	0.33				
9/8/91	0.36	0.36	0.33	0.33				
9/9/91	0.36	0.36	0.33	0.33				
9/10/91	0.35	0.36	0.32	0.32				
9/11/91	0.34	0.36	0.31	0.32				
9/12/91	0.35	0.36	0.32	0.32				

9/13/91	0.38	0.36	0.31	0.32				
9/14/91	0.36	0.36	0.34	0.32				
9/15/91	0.38	0.36	0.38	0.33				
9/16/91	0.37	0.36	0.36	0.33				
9/17/91	0.36	0.36	0.38	0.33				
9/18/91			0.34	0.33				
9/19/91	0.38	0.36	0.34	0.33				
9/20/91	0.36	0.36	0.34	0.33				
9/21/91	0.37	0.36	0.33	0.33				
9/22/91	0.37	0.36	0.35	0.33				
9/23/91	0.37	0.36	0.37	0.33				
9/24/91	0.38	0.36	0.37	0.33				
9/25/91	0.37	0.36	0.36	0.33				
9/26/91	0.36	0.37	0.36	0.33				
9/27/91	0.36	0.36	0.36	0.33				
9/28/91	0.36	0.36	0.33	0.33				
9/29/91	0.36	0.36	0.33	0.33				
9/30/91	0.38	0.35	0.32	0.33				
10/1/91	0.37	0.35	0.32	0.33				
10/2/91	0.37	0.35	0.34	0.33				
10/3/91	0.37	0.35	0.36	0.34				
10/4/91	0.38	0.35	0.35	0.34				
10/5/91	0.38	0.35	0.32	0.34				
10/6/91	0.36	0.35	0.33	0.34				
10/7/91	0.39	0.35	0.36	0.34				
10/8/91	0.37	0.35	0.34	0.34				
10/9/91	0.39	0.35	0.35	0.34				
10/10/91	0.39	0.35	0.35	0.34				
10/11/91			0.32	0.34				
10/12/91			0.31	0.34				
10/13/91			0.33	0.34				
10/14/91	0.33	0.35	0.29	0.34				
10/15/91	0.36	0.35	0.32	0.34				
10/16/91	0.38	0.35	0.33	0.34				
10/17/91			0.32	0.34				
10/18/91	0.34	0.35						
10/19/91	0.34	0.35	0.32	0.34				
10/20/91	0.35	0.35	0.31	0.34				
10/21/91	0.39	0.35	0.34	0.34				
10/22/91	0.40	0.35	0.35	0.34				
10/23/91	0.40	0.35	0.33	0.34				
10/24/91	0.40	0.35						
10/25/91	0.39	0.35						
10/26/91	0.36	0.34						
10/27/91	0.38	0.34						
10/28/91	0.37	0.34						
10/29/91	0.38	0.34						
10/30/91	0.37	0.37						
10/31/91	0.36	0.37						
11/1/91	0.37	0.37						
11/2/91	0.40	0.37						
11/3/91	0.42	0.38						

11/4/91	0.44	0.38						
11/5/91	0.44	0.38						
11/6/91	0.43	0.38						
11/7/91	0.47	0.39						
11/8/91	0.43	0.39						
11/9/91	0.44	0.39						
11/10/91	0.40	0.39						
11/11/91	0.39	0.39						
11/12/91	0.40	0.39						
11/13/91	0.39	0.39						
11/14/91	0.37	0.39						
11/15/91	0.38	0.39						
11/16/91	0.36	0.39						
11/17/91	0.37	0.39						
11/18/91	0.39	0.39						
11/19/91	0.38	0.40						
11/20/91	0.36	0.39						
11/21/91	0.39	0.39						
11/22/91	0.40	0.39						
11/23/91	0.40	0.39						
11/24/91	0.39	0.39						
11/25/91	0.39	0.40						
11/26/91	0.40	0.40						
11/27/91	0.37	0.40						
11/28/91	0.41	0.40						
11/29/91	0.40	0.40						
11/30/91	0.40	0.40						
12/1/91	0.38	0.40						
12/2/91	0.39	0.40						
12/3/91	0.36	0.40						
12/4/91	0.41	0.40						
12/5/91	0.41	0.40						
12/6/91	0.37	0.39						
12/7/91	0.38	0.39						
12/8/91	0.36	0.39	0.34	0.34				
12/9/91	0.37	0.39	0.33	0.33				
12/10/91	0.38	0.38	0.34	0.33				
12/11/91	0.40	0.39	0.34	0.33				
12/12/91	0.37	0.38	0.35	0.33				
12/13/91	0.40	0.38	0.36	0.33				
12/14/91	0.37	0.38	0.32	0.33				
12/15/91	0.36	0.38	0.32	0.33				
12/16/91	0.41	0.39	0.34	0.33				
12/17/91	0.40	0.39	0.33	0.33				
12/18/91	0.41	0.39	0.36	0.33				
12/19/91	0.45	0.39	0.39	0.33				
12/20/91	0.40	0.39						
12/21/91	0.43	0.39						
12/22/91	0.41	0.39	0.37	0.34				
12/23/91	0.40	0.39	0.40	0.34				
12/24/91			0.32	0.34				
12/25/91	0.39	0.39	0.36	0.34				

12/26/91	0.37	0.39	0.38	0.34				
12/27/91	0.34	0.39	0.35	0.34				
12/28/91	0.33	0.39	0.34	0.34				
12/29/91	0.33	0.39	0.35	0.34				
12/30/91	0.35	0.38	0.37	0.34				
12/31/91	0.31	0.38	0.32	0.33				
1/1/92	0.36	0.38	0.36	0.34				
1/2/92	0.38	0.38	0.38	0.34				
1/3/92	0.38	0.38	0.38	0.35				
1/4/92	0.40	0.38	0.38	0.35				
1/5/92	0.38	0.38	0.39	0.35				
1/6/92	0.39	0.38	0.40	0.35				
1/7/92	0.40	0.38	0.42	0.36				
1/8/92	0.40	0.38	0.43	0.36				
1/9/92	0.39	0.38	0.39	0.36				
1/10/92	0.39	0.38	0.38	0.36				
1/11/92	0.40	0.38	0.38	0.36				
1/12/92	0.41	0.38	0.38	0.37				
1/13/92	0.43	0.39	0.39	0.37				
1/14/92	0.41	0.39	0.38	0.37				
1/15/92	0.38	0.39	0.38	0.37				
1/16/92	0.39	0.39	0.40	0.37				
1/17/92	0.37	0.39	0.40	0.37				
1/18/92	0.38	0.38	0.37	0.38				
1/19/92			0.37	0.38				
1/20/92	0.35	0.38	0.37	0.38				
1/21/92	0.34	0.38	0.37	0.38				
1/22/92	0.35	0.38						
1/23/92	0.35	0.38	0.35	0.38				
1/24/92	0.36	0.37	0.34	0.37				
1/25/92	0.37	0.37	0.37	0.38				
1/26/92	0.37	0.37	0.37	0.38				
1/27/92	0.39	0.37	0.38	0.38				
1/28/92	0.43	0.38	0.38	0.38				
1/29/92	0.43	0.38	0.39	0.38				
1/30/92	0.43	0.38	0.40	0.38				
1/31/92	0.43	0.39	0.40	0.38				
2/1/92	0.41	0.39	0.36	0.38				
2/2/92	0.44	0.39	0.39	0.38				
2/3/92	0.40	0.39	0.34	0.38				
2/4/92	0.41	0.39	0.32	0.38				
2/5/92	0.41	0.39	0.39	0.38				
2/6/92	0.39	0.39	0.40	0.38				
2/7/92	0.40	0.39	0.38	0.38				
2/8/92	0.38	0.39	0.35	0.38				
2/9/92	0.38	0.39	0.35	0.38				
2/10/92	0.40	0.39	0.33	0.37				
2/11/92	0.41	0.39	0.35	0.37				
2/12/92	0.40	0.39	0.36	0.37				
2/13/92	0.37	0.39	0.38	0.37				
2/14/92	0.35	0.39	0.32	0.37				
2/15/92	0.32	0.39	0.30	0.37				

2/16/92	0.36	0.39	0.32	0.37				
2/17/92	0.36	0.39	0.33	0.36				
2/18/92	0.35	0.38	0.35	0.36				
2/19/92	0.36	0.39	0.34	0.36				
2/20/92			0.39	0.36				
2/21/92		0.39	0.39	0.36				
2/22/92	0.35	0.38	0.35	0.36				
2/23/92	0.33	0.38	0.36	0.36				
2/24/92	0.34	0.39	0.37	0.36				
2/25/92	0.39	0.39	0.36	0.36				
2/26/92	0.38	0.39	0.36	0.36				
2/27/92			0.36	0.36				
2/28/92	0.39	0.39	0.36	0.36				
2/29/92	0.37	0.38	0.34	0.36				
3/1/92	0.37	0.38	0.39	0.36				
3/2/92	0.37	0.38	0.39	0.36				
3/3/92	0.37	0.38	0.39	0.36				
3/4/92	0.36	0.38	0.36	0.36				
3/5/92	0.38	0.37	0.40	0.36				
3/6/92	0.35	0.37	0.36	0.36				
3/7/92	0.34	0.37	0.33	0.36				
3/8/92	0.37	0.37	0.35	0.36				
3/9/92	0.38	0.37	0.35	0.36				
3/10/92	0.39	0.37	0.36	0.36				
3/11/92	0.40	0.37	0.36	0.36				
3/12/92	0.38	0.37	0.38	0.36				
3/13/92	0.38	0.37	0.34	0.36				
3/14/92	0.37	0.37	0.32	0.36				
3/15/92	0.39	0.37	0.37	0.36				
3/16/92	0.42	0.37	0.41	0.36				
3/17/92	0.41	0.37	0.35	0.36				
3/18/92	0.43	0.37	0.39	0.36				
3/19/92	0.36	0.37	0.37	0.36				
3/20/92	0.35	0.37	0.36	0.37				
3/21/92	0.34	0.37	0.35	0.37				
3/22/92	0.36	0.37	0.36	0.36				
3/23/92	0.37	0.37	0.39	0.36				
3/24/92	0.36	0.37	0.35	0.36				
3/25/92	0.36	0.38	0.37	0.36				
3/26/92	0.38	0.38						
3/27/92	0.39	0.38						
3/28/92	0.40	0.38						
3/29/92	0.37	0.38						
3/30/92	0.38	0.38						
3/31/92	0.36	0.38	0.35	0.36				
4/1/92	0.38	0.38	0.34	0.36				
4/2/92	0.38	0.38	0.33	0.36				
4/3/92	0.35	0.37	0.32	0.36				
4/4/92	0.33	0.37	0.32	0.36				
4/5/92	0.36	0.38	0.40	0.36				
4/6/92	0.37	0.38	0.40	0.36				
4/7/92	0.36	0.38	0.41	0.36				

4/8/92	0.38	0.38	0.39	0.36				
4/9/92	0.38	0.38	0.37	0.36				
4/10/92			0.38	0.36				
4/11/92			0.42	0.36				
4/12/92			0.40	0.37				
4/13/92			0.40	0.37				
4/14/92			0.39	0.37				
4/15/92			0.39	0.37				
4/16/92								
4/17/92								
4/18/92			0.44	0.37				
4/19/92			0.43	0.37				
4/20/92			0.43	0.38				
4/21/92			0.42	0.38				
4/22/92			0.43	0.38				
4/23/92			0.43	0.38				
4/24/92			0.43	0.38				
4/25/92			0.43	0.39				
4/26/92			0.43	0.39				
4/27/92	0.43	0.38	0.41	0.39				
4/28/92	0.41	0.38	0.40	0.39				
4/29/92	0.42	0.38	0.41	0.39				
4/30/92	0.31	0.37	0.33	0.39				
5/1/92	0.34	0.37	0.37	0.39				
5/2/92	0.30	0.37	0.34	0.39				
5/3/92	0.36	0.37	0.33	0.39				
5/4/92	0.36	0.37	0.37	0.39				
5/5/92	0.33	0.37	0.36	0.39				
5/6/92	0.35	0.37	0.35	0.40				
5/7/92	0.35	0.36	0.36	0.40				
5/8/92	0.32	0.36	0.35	0.39				
5/9/92			0.33	0.39				
5/10/92	0.37	0.36	0.31	0.39				
5/11/92	0.35	0.37	0.32	0.39				
5/12/92	0.38	0.37	0.35	0.39				
5/13/92	0.38	0.37	0.34	0.39				
5/14/92	0.40	0.37	0.36	0.38				
5/15/92	0.39	0.36	0.32	0.38				
5/16/92	0.36	0.37	0.31	0.38				
5/17/92	0.39	0.37	0.34	0.38				
5/18/92	0.41	0.37	0.38	0.37				
5/19/92			0.41	0.37				
5/20/92	0.35	0.36	0.37	0.37				
5/21/92	0.33	0.36	0.37	0.37				
5/22/92	0.35	0.36	0.36	0.37				
5/23/92	0.36	0.37	0.35	0.37				
5/24/92	0.37	0.36	0.37	0.36				
5/25/92	0.34	0.36	0.37	0.36				
5/26/92	0.34	0.36	0.37	0.36				
5/27/92	0.37	0.36	0.38	0.36				
5/28/92	0.41	0.36	0.38	0.36				
5/29/92	0.41	0.36	0.37	0.36				

5/30/92	0.39	0.36	0.37	0.35				
5/31/92	0.39	0.37	0.39	0.36				
6/1/92	0.42	0.37	0.41	0.36				
6/2/92	0.45	0.37	0.41	0.36				
6/3/92	0.46	0.38	0.41	0.36				
6/4/92	0.44	0.38	0.40	0.36				
6/5/92	0.42	0.38	0.41	0.36				
6/6/92	0.39	0.38	0.40	0.37				
6/7/92	0.37	0.38	0.41	0.37				
6/8/92	0.38	0.39	0.40	0.37				
6/9/92	0.39	0.38	0.42	0.37				
6/10/92	0.35	0.39	0.41	0.37				
6/11/92			0.39	0.38				
6/12/92			0.40	0.38				
6/13/92			0.29	0.38				
6/14/92			0.35	0.38				
6/15/92	0.37	0.39	0.36	0.38				
6/16/92	0.39	0.39	0.41	0.38				
6/17/92	0.39	0.38	0.45	0.38				
6/18/92	0.36	0.38	0.42	0.39				
6/19/92	0.36	0.38	0.42	0.39				
6/20/92	0.33	0.38	0.36	0.39				
6/21/92	0.38	0.38	0.45	0.39				
6/22/92	0.41	0.38	0.41	0.39				
6/23/92	0.37	0.38	0.38	0.39				
6/24/92	0.39	0.39	0.35	0.39				
6/25/92	0.39	0.39	0.35	0.39				
6/26/92	0.37	0.39	0.34	0.39				
6/27/92	0.39	0.39	0.39	0.39				
6/28/92	0.41	0.39	0.34	0.39				
6/29/92	0.41	0.39	0.39	0.39				
6/30/92	0.45	0.39	0.39	0.39				
7/1/92	0.40	0.39	0.38	0.39				
7/2/92	0.40	0.39	0.33	0.39				
7/3/92	0.33	0.39	0.36	0.39				
7/4/92	0.37	0.39	0.35	0.38				
7/5/92	0.37	0.39	0.34	0.38				
7/6/92	0.38	0.38	0.33	0.38				
7/7/92	0.37	0.38	0.40	0.38				
7/8/92	0.39	0.38	0.42	0.38				
7/9/92	0.42	0.38	0.41	0.38				
7/10/92	0.43	0.38	0.41	0.38				
7/11/92	0.37	0.38	0.34	0.38				
7/12/92	0.38	0.38	0.33	0.38				
7/13/92	0.38	0.39	0.38	0.37				
7/14/92	0.43	0.39	0.38	0.38				
7/15/92	0.45	0.39	0.36	0.38				
7/16/92	0.43	0.39						
7/17/92	0.44	0.39						
7/18/92	0.40	0.40	0.44	0.38				
7/19/92	0.41	0.40	0.43	0.38				
7/20/92	0.39	0.40	0.35	0.38				

7/21/92	0.42	0.40	0.37	0.38				
7/22/92	0.39	0.40	0.40	0.37				
7/23/92			0.38	0.38				
7/24/92			0.40	0.37				
7/25/92	0.46	0.40	0.40	0.37				
7/26/92	0.40	0.40	0.40	0.37				
7/27/92	0.39	0.40	0.38	0.38				
7/28/92	0.40	0.40	0.33	0.38				
7/29/92	0.40	0.40	0.34	0.38				
7/30/92	0.40	0.40	0.34	0.38				
7/31/92			0.36	0.38				
8/1/92	0.43	0.40	0.36	0.37				
8/2/92	0.43	0.40	0.38	0.37				
8/3/92	0.45	0.40	0.39	0.37				
8/4/92	0.41	0.41	0.35	0.38				
8/5/92	0.39	0.41	0.37	0.37				
8/6/92	0.35	0.40	0.35	0.38				
8/7/92	0.34	0.40	0.33	0.38				
8/8/92	0.34	0.40	0.35	0.38				
8/9/92	0.37	0.40	0.38	0.37				
8/10/92	0.38	0.40	0.39	0.37				
8/11/92	0.36	0.40	0.38	0.37				
8/12/92	0.37	0.40	0.39	0.37				
8/13/92	0.38	0.40	0.38	0.37				
8/14/92	0.39	0.40	0.39	0.37				
8/15/92	0.40	0.40	0.43	0.38				
8/16/92	0.45	0.40	0.43	0.38				
8/17/92	0.42	0.40	0.41	0.38				
8/18/92	0.40	0.40	0.40	0.38				
8/19/92	0.42	0.40	0.37	0.38				
8/20/92	0.40	0.40	0.39	0.38				
8/21/92	0.48	0.40	0.42	0.38				
8/22/92	0.41	0.40	0.39	0.38				
8/23/92	0.40	0.40	0.41	0.38				
8/24/92	0.37	0.40	0.35	0.38				
8/25/92	0.36	0.39	0.35	0.38				
8/26/92	0.34	0.39	0.36	0.38				
8/27/92	0.32	0.39	0.36	0.38				
8/28/92	0.33	0.39	0.36	0.38				
8/29/92	0.31	0.38	0.32	0.38				
8/30/92	0.33	0.38	0.35	0.38				
8/31/92	0.32	0.38	0.37	0.38				
9/1/92	0.36	0.38	0.38	0.38				
9/2/92	0.38	0.38	0.37	0.38				
9/3/92	0.39	0.37	0.36	0.38				
9/4/92	0.37	0.37	0.37	0.38				
9/5/92	0.36	0.37	0.35	0.38				
9/6/92	0.31	0.37	0.34	0.38				
9/7/92	0.35	0.37	0.38	0.38				
9/8/92	0.34	0.37	0.36	0.38				
9/9/92	0.33	0.37	0.35	0.38				
9/10/92	0.36	0.37	0.37	0.38				

9/11/92	0.37	0.37	0.37	0.38				
9/12/92	0.36	0.37	0.37	0.37				
9/13/92	0.38	0.37	0.35	0.37				
9/14/92	0.40	0.37	0.36	0.37				
9/15/92	0.37	0.37	0.34	0.37				
9/16/92	0.41	0.37	0.35	0.37				
9/17/92	0.38	0.37	0.35	0.37				
9/18/92	0.38	0.37	0.36	0.36				
9/19/92	0.39	0.36	0.35	0.36				
9/20/92	0.43	0.36	0.41	0.36				
9/21/92	0.39	0.36	0.41	0.36				
9/22/92	0.36	0.36	0.43	0.36				
9/23/92	0.40	0.36	0.42	0.36				
9/24/92	0.38	0.37	0.39	0.37				
9/25/92	0.39	0.37	0.37	0.37				
9/26/92	0.39	0.37	0.38	0.37				
9/27/92	0.38	0.37	0.34	0.37				
9/28/92	0.41	0.38	0.37	0.37				
9/29/92	0.41	0.36	0.36	0.37				
9/30/92	0.41	0.38	0.36	0.37				
10/1/92	0.42	0.38	0.40	0.37				
10/2/92	0.41	0.38	0.43	0.37				
10/3/92	0.42	0.38	0.41	0.37				
10/4/92	0.44	0.38	0.40	0.37				
10/5/92	0.41	0.38	0.36	0.37				
10/6/92	0.41	0.39	0.38	0.38				
10/7/92	0.40	0.39	0.37	0.38				
10/8/92	0.43	0.39	0.35	0.38				
10/9/92	0.43	0.39	0.38	0.38				
10/10/92	0.42	0.40	0.38	0.38				
10/11/92	0.42	0.40	0.40	0.38				
10/12/92	0.41	0.40	0.37	0.38				
10/13/92	0.44	0.40	0.41	0.38				
10/14/92	0.46	0.41	0.38	0.38				
10/15/92	0.49	0.41	0.37	0.38				
10/16/92	0.45	0.41	0.41	0.38				
10/17/92	0.44	0.41	0.42	0.39				
10/18/92	0.43	0.41	0.40	0.39				
10/19/92	0.41	0.42	0.38	0.39				
10/20/92	0.43	0.42	0.37	0.39				
10/21/92	0.44	0.42	0.42	0.39				
10/22/92	0.44	0.42	0.43	0.39				
10/23/92	0.41	0.42	0.40	0.39				
10/24/92	0.41	0.42	0.40	0.39				
10/25/92	0.41	0.42	0.40	0.39				
10/26/92	0.41	0.42	0.41	0.39				
10/27/92	0.41	0.42	0.38	0.39				
10/28/92	0.42	0.42	0.38	0.39				
10/29/92	0.43	0.43	0.39	0.39				
10/30/92	0.47	0.43						
10/31/92	0.48	0.43						
11/1/92	0.48	0.43						

11/2/92	0.45	0.43						
11/3/92	0.47	0.43						
11/4/92	0.44	0.43						
11/5/92	0.43	0.44						
11/6/92								
11/7/92	0.42	0.44						
11/8/92	0.43	0.44						
11/9/92	0.39	0.43						
11/10/92	0.41	0.43						
11/11/92	0.41	0.43						
11/12/92	0.45	0.44						
11/13/92	0.49	0.44						
11/14/92	0.34	0.43						
11/15/92	0.41	0.43						
11/16/92	0.43	0.43						
11/17/92	0.44	0.43						
11/18/92	0.42	0.43						
11/19/92	0.42	0.43						
11/20/92	0.40	0.43						
11/21/92	0.39	0.43						
11/22/92	0.38	0.42						
11/23/92	0.43	0.43						
11/24/92	0.46	0.43						
11/25/92	0.47	0.43						
11/26/92	0.44	0.43	0.34	0.39				
11/27/92	0.44	0.43	0.36	0.39				
11/28/92	0.41	0.43	0.36	0.39				
11/29/92	0.42	0.43	0.34	0.38				
11/30/92	0.42	0.43	0.33	0.38				
12/1/92	0.34	0.42	0.33	0.38				
12/2/92	0.34	0.42	0.37	0.38				
12/3/92	0.37	0.42	0.38	0.38				
12/4/92	0.35	0.41	0.35	0.38				
12/5/92	0.36	0.41	0.36	0.38				
12/6/92	0.35	0.41	0.33	0.38				
12/7/92	0.35	0.41	0.37	0.38				
12/8/92	0.36	0.40	0.37	0.38				
12/9/92	0.39	0.40	0.36	0.38				
12/10/92	0.39	0.40	0.35	0.37				
12/11/92	0.37	0.40	0.35	0.37				
12/12/92	0.38	0.40	0.37	0.37				
12/13/92	0.37	0.39	0.35	0.37				
12/14/92	0.39	0.40	0.37	0.37				
12/15/92	0.42	0.40	0.37	0.37				
12/16/92	0.40	0.40	0.37	0.37				
12/17/92	0.39	0.39	0.34	0.37				
12/18/92	0.38	0.39	0.33	0.36				
12/19/92	0.40	0.39	0.33	0.36				
12/20/92	0.39	0.39	0.33	0.36				
12/21/92	0.40	0.39	0.41	0.36				
12/22/92	0.39	0.39	0.43	0.36				
12/23/92	0.42	0.39	0.40	0.36				

12/24/92	0.36	0.39	0.41	0.36				
12/25/92	0.33	0.38	0.37	0.36				
12/26/92	0.34	0.38	0.38	0.36				
12/27/92	0.39	0.38	0.39	0.36				
12/28/92	0.37	0.38	0.39	0.36				
12/29/92	0.37	0.38	0.39	0.37				
12/30/92	0.42	0.38	0.40	0.37				
12/31/92	0.37	0.38	0.37	0.37				
1/1/93	0.35	0.38	0.36	0.37				
1/2/93	0.34	0.38	0.35	0.37				
1/3/93	0.36	0.38	0.36	0.37				
1/4/93	0.40	0.38	0.34	0.37				
1/5/93	0.42	0.38	0.36	0.37				
1/6/93	0.42	0.38	0.38	0.37				
1/7/93	0.40	0.38	0.37	0.37				
1/8/93	0.42	0.38	0.33	0.37				
1/9/93	0.44	0.39	0.36	0.37				
1/10/93	0.43	0.39	0.39	0.37				
1/11/93	0.40	0.39	0.39	0.37				
1/12/93	0.42	0.39	0.42	0.37				
1/13/93	0.39	0.39						
1/14/93	0.40	0.39	0.35	0.37				
1/15/93	0.34	0.39	0.35	0.37				
1/16/93	0.35	0.39	0.37	0.37				
1/17/93	0.34	0.39	0.36	0.37				
1/18/93	0.36	0.38	0.38	0.37				
1/19/93	0.36	0.38	0.37	0.37				
1/20/93	0.34	0.38	0.35	0.38				
1/21/93	0.35	0.38	0.36	0.37				
1/22/93	0.36	0.38	0.37	0.37				
1/23/93	0.39	0.38	0.39	0.37				
1/24/93	0.35	0.38	0.36	0.37				
1/25/93	0.35	0.38	0.37	0.37				
1/26/93	0.35	0.38	0.33	0.37				
1/27/93	0.41	0.38	0.35	0.37				
1/28/93	0.37	0.38	0.35	0.37				
1/29/93	0.38	0.38	0.35	0.36				
1/30/93	0.39	0.38	0.37	0.36				
1/31/93	0.39	0.38	0.37	0.36				
2/1/93	0.38	0.38	0.37	0.36				
2/2/93	0.39	0.38	0.37	0.36				
2/3/93	0.38	0.38	0.36	0.36				
2/4/93	0.38	0.38	0.37	0.37				
2/5/93	0.40	0.38	0.41	0.37				
2/6/93	0.41	0.38	0.42	0.37				
2/7/93	0.36	0.38	0.38	0.37				
2/8/93	0.36	0.38	0.35	0.37				
2/9/93	0.39	0.37	0.37	0.37				
2/10/93	0.38	0.37	0.40	0.37				
2/11/93	0.37	0.37	0.42	0.37				
2/12/93	0.37	0.37	0.42	0.37				
2/13/93	0.38	0.37	0.39	0.37				

2/14/93	0.37	0.37	0.41	0.37				
2/15/93	0.32	0.37	0.36	0.37				
2/16/93	0.42	0.37	0.46	0.38				
2/17/93	0.39	0.37	0.45	0.38				
2/18/93	0.37	0.38	0.42	0.38				
2/19/93	0.36	0.38	0.43	0.38				
2/20/93	0.36	0.38	0.40	0.39				
2/21/93	0.34	0.38	0.42	0.39				
2/22/93	0.36	0.37	0.43	0.39				
2/23/93	0.37	0.37	0.45	0.39				
2/24/93	0.37	0.38	0.42	0.39				
2/25/93	0.37	0.38	0.42	0.40				
2/26/93	0.39	0.38	0.36	0.40				
2/27/93	0.38	0.38	0.37	0.40				
2/28/93	0.38	0.38	0.33	0.40				
3/1/93	0.35	0.37	0.31	0.39				
3/2/93	0.33	0.37	0.36	0.39				
3/3/93	0.34	0.37	0.39	0.39				
3/4/93			0.39	0.40				
3/5/93	0.35	0.37	0.40	0.40				
3/6/93	0.36	0.37	0.40	0.40				
3/7/93	0.33	0.37	0.37	0.40				
3/8/93	0.32	0.36	0.35	0.39				
3/9/93	0.37	0.36	0.39	0.39				
3/10/93	0.36	0.36	0.38	0.40				
3/11/93	0.35	0.36	0.37	0.40				
3/12/93	0.36	0.36	0.39	0.40				
3/13/93	0.38	0.36	0.39	0.39				
3/14/93	0.35	0.36	0.37	0.39				
3/15/93	0.38	0.36	0.40	0.39				
3/16/93	0.38	0.36	0.44	0.39				
3/17/93	0.35	0.36	0.43	0.40				
3/18/93	0.35	0.36	0.39	0.39				
3/19/93	0.36	0.36	0.39	0.39				
3/20/93	0.35	0.36	0.36	0.39				
3/21/93	0.31	0.36	0.33	0.39				
3/22/93	0.35	0.36	0.37	0.39				
3/23/93	0.35	0.36	0.39	0.38				
3/24/93	0.33	0.36	0.38	0.38				
3/25/93	0.33	0.35	0.37	0.38				
3/26/93	0.33	0.35	0.37	0.38				
3/27/93	0.36	0.35	0.37	0.38				
3/28/93	0.32	0.35	0.32	0.38				
3/29/93	0.34	0.35	0.37	0.38				
3/30/93	0.35	0.35	0.38	0.38				
3/31/93	0.33	0.35	0.36	0.38				
4/1/93	0.34	0.35	0.35	0.38				
4/2/93	0.37	0.35	0.39	0.38				
4/3/93	0.37	0.35	0.40	0.38				
4/4/93	0.30	0.35	0.29	0.38				
4/5/93	0.35	0.35	0.37	0.37				
4/6/93	0.36	0.35	0.38	0.37				

4/7/93	0.35	0.35	0.35	0.37				
4/8/93	0.40	0.35	0.41	0.38				
4/9/93	0.35	0.35	0.35	0.37				
4/10/93	0.34	0.35	0.34	0.37				
4/11/93	0.33	0.35	0.35	0.37				
4/12/93	0.36	0.35	0.39	0.37				
4/13/93	0.39	0.35	0.42	0.37				
4/14/93	0.37	0.35	0.40	0.37				
4/15/93	0.39	0.35	0.40	0.37				
4/16/93	0.36	0.35	0.38	0.37				
4/17/93			0.36	0.37				
4/18/93			0.35	0.37				
4/19/93			0.37	0.37				
4/20/93			0.39	0.37				
4/21/93			0.42	0.37				
4/22/93			0.42	0.37				
4/23/93			0.39	0.37				
4/24/93			0.39	0.37				
4/25/93			0.39	0.38				
4/26/93			0.35	0.37				
4/27/93			0.36	0.38				
4/28/93			0.38	0.38				
4/29/93			0.36	0.38				
4/30/93			0.34	0.37				
5/1/93			0.34	0.37				
5/2/93			0.35	0.37				
5/3/93			0.33	0.37				
5/4/93								
5/5/93			0.35	0.37				
5/6/93			0.34	0.37				
5/7/93			0.35	0.37				
5/8/93			0.33	0.37				
5/9/93			0.27	0.37				
5/10/93	0.37	0.35	0.33	0.36				
5/11/93	0.37	0.35	0.34	0.36				
5/12/93	0.35	0.35	0.36	0.36				
5/13/93	0.33	0.35	0.35	0.36				
5/14/93	0.35	0.35	0.35	0.36				
5/15/93	0.30	0.35	0.30	0.36				
5/16/93	0.30	0.35	0.34	0.36				
5/17/93	0.31	0.35	0.35	0.35				
5/18/93	0.31	0.35	0.35	0.35				
5/19/93	0.32	0.35	0.36	0.35				
5/20/93	0.34	0.35	0.36	0.35				
5/21/93	0.26	0.34	0.30	0.35				
5/22/93	0.26	0.34	0.36	0.35				
5/23/93	0.26	0.34	0.37	0.35				
5/24/93	0.33	0.34	0.36	0.35				
5/25/93	0.36	0.34	0.35	0.35				
5/26/93	0.38	0.34	0.37	0.34				
5/27/93	0.38	0.34	0.35	0.34				
5/28/93	0.35	0.34	0.34	0.34				

5/29/93	0.32	0.34	0.32	0.34				
5/30/93	0.31	0.34	0.31	0.34				
5/31/93	0.33	0.34	0.35	0.34				
6/1/93	0.37	0.34	0.35	0.34				
6/2/93	0.33	0.34	0.35	0.34				
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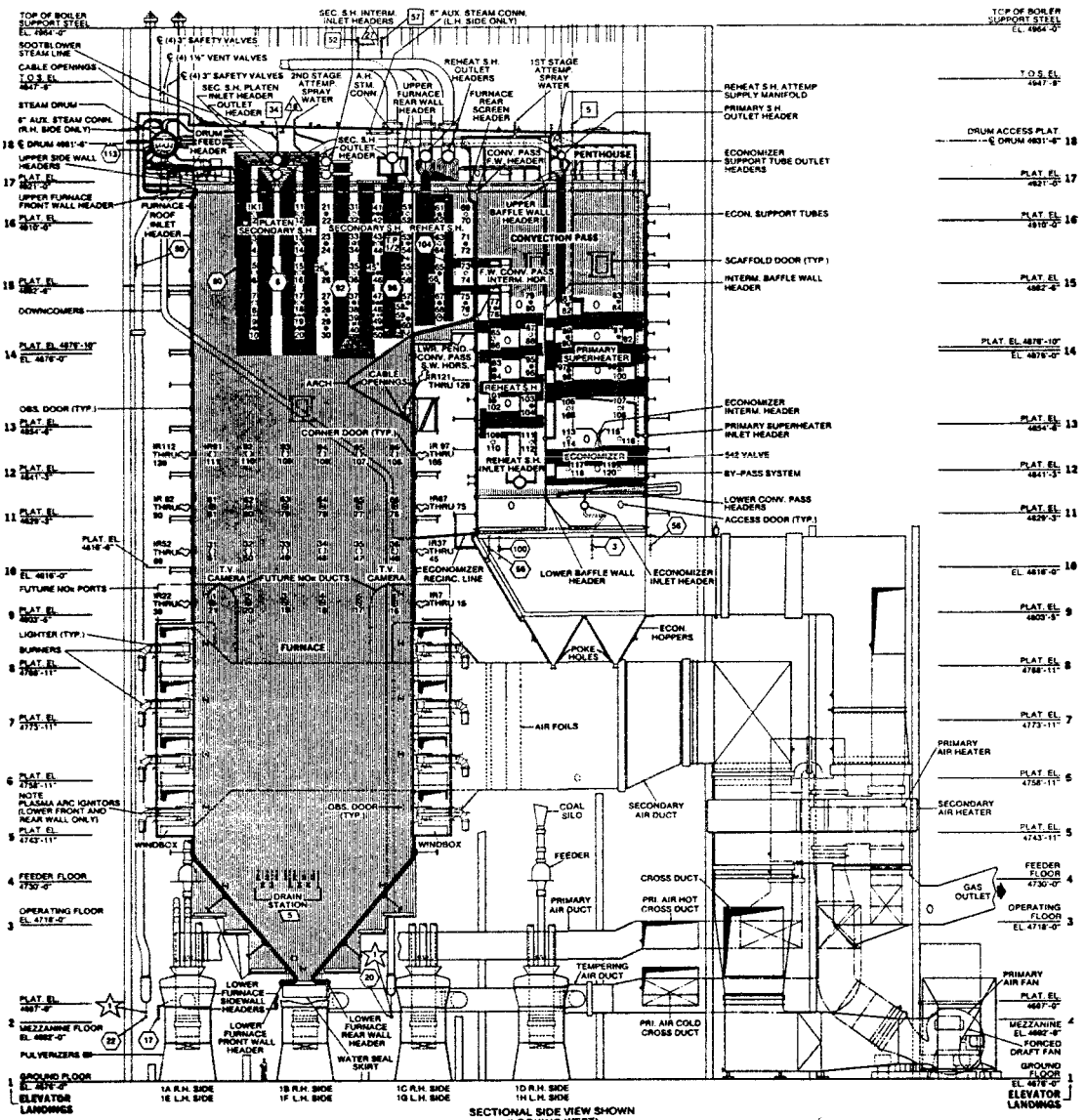
6/4/93	0.35	0.34	0.38	0.34				
6/5/93	0.34	0.34	0.39	0.34				
6/6/93	0.35	0.33	0.39	0.35				
6/7/93	0.35	0.33	0.35	0.35				
6/8/93	0.34	0.33	0.33	0.35				
6/9/93	0.37	0.33	0.34	0.35				
6/10/93	0.39	0.33	0.38	0.35				
6/11/93	0.38	0.33	0.38	0.35				
6/12/93	0.36	0.34						
6/13/93	0.40	0.34	0.35	0.35				
6/14/93	0.40	0.34	0.35	0.35				
6/15/93	0.44	0.35	0.34	0.35				
6/16/93	0.35	0.35	0.32	0.35				
6/17/93	0.39	0.35	0.34	0.35				
6/18/93	0.44	0.35	0.35	0.35				
6/19/93	0.40	0.36	0.34	0.35				
6/20/93	0.40	0.36	0.34	0.35				
6/21/93	0.45	0.37	0.36	0.35				
6/22/93	0.43	0.37	0.37	0.35				
6/23/93	0.44	0.38	0.39	0.35				
6/24/93	0.47	0.38	0.40	0.35				
6/25/93	0.48	0.38	0.40	0.36				
6/26/93	0.47	0.39	0.39	0.36				
6/27/93	0.38	0.39	0.36	0.36				
6/28/93	0.38	0.39	0.37	0.36				
6/29/93	0.40	0.39	0.37	0.36				
6/30/93	0.38	0.39	0.33	0.36				
7/1/93	0.35	0.39	0.31	0.36				
7/2/93	0.45	0.40	0.36	0.36				
7/3/93	0.37	0.40	0.35	0.36				
7/4/93	0.33	0.40	0.30	0.36				
7/5/93	0.34	0.40	0.31	0.36				
7/6/93	0.39	0.40	0.41	0.36				
7/7/93	0.39	0.40	0.40	0.36				
7/8/93	0.41	0.40	0.41	0.36				
7/9/93	0.44	0.40	0.44	0.36				
7/10/93	0.38	0.40	0.39	0.36				
7/11/93	0.33	0.40	0.36	0.36				
7/12/93	0.36	0.40	0.38	0.36				
7/13/93	0.37	0.40	0.39	0.36				
7/14/93	0.35	0.40	0.37	0.37				
7/15/93	0.32	0.39	0.34	0.37				
7/16/93	0.35	0.39	0.39	0.37				
7/17/93	0.32	0.39	0.31	0.37				
7/18/93	0.29	0.39	0.29	0.36				
7/19/93	0.35	0.39	0.40	0.37				

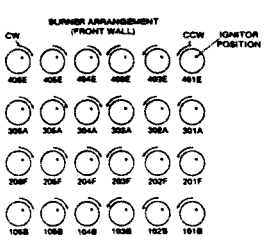
7/20/93	0.37	0.38	0.42	0.37				
7/21/93	0.38	0.38	0.41	0.37				
7/22/93	0.41	0.38	0.42	0.37				
7/23/93	0.39	0.38	0.41	0.37				
7/24/93	0.40	0.38	0.40	0.37				
7/25/93	0.41	0.38	0.42	0.37				
7/26/93	0.40	0.37	0.42	0.37				
7/27/93	0.41	0.37	0.45	0.38				
7/28/93	0.42	0.38	0.43	0.38				
7/29/93	0.43	0.38	0.42	0.38				
7/30/93	0.46	0.38	0.43	0.38				
7/31/93	0.46	0.38	0.43	0.39				
8/1/93	0.46	0.38	0.42	0.39				
8/2/93	0.47	0.39	0.42	0.39				
8/3/93	0.43	0.39	0.43	0.40				
8/4/93	0.47	0.39	0.43	0.40				
8/5/93	0.43	0.40	0.38	0.40				
8/6/93	0.38	0.39	0.36	0.40				
8/7/93	0.33	0.39	0.37	0.40				
8/8/93	0.35	0.39	0.35	0.39				
8/9/93	0.39	0.39	0.37	0.39				
8/10/93	0.41	0.39	0.43	0.40				
8/11/93	0.42	0.39	0.40	0.40				
8/12/93	0.44	0.40	0.40	0.40				
8/13/93	0.44	0.40	0.41	0.40				
8/14/93	0.43	0.40	0.41	0.40				
8/15/93	0.46	0.41	0.42	0.40				
8/16/93	0.45	0.41	0.43	0.41				
8/17/93	0.48	0.42	0.45	0.41				
8/18/93	0.48	0.42	0.41	0.41				
8/19/93	0.46	0.42	0.43	0.41				
8/20/93	0.43	0.43	0.40	0.41				
8/21/93	0.39	0.43	0.38	0.41				
8/22/93	0.34	0.42	0.36	0.41				
8/23/93	0.37	0.42	0.39	0.41				
8/24/93	0.38	0.42	0.39	0.41				
8/25/93	0.43	0.42	0.45	0.41				
8/26/93	0.42	0.42	0.43	0.41				
8/27/93	0.43	0.42	0.42	0.41				
8/28/93	0.41	0.42	0.41	0.41				
8/29/93	0.39	0.42	0.34	0.40				
8/30/93	0.43	0.42	0.40	0.40				
8/31/93	0.41	0.42	0.38	0.40				
9/1/93	0.37	0.41	0.33	0.40				
9/2/93	0.41	0.41	0.37	0.40				
9/3/93	0.42	0.41	0.36	0.39				
9/4/93	0.44	0.41	0.35	0.39				
9/5/93	0.44	0.41	0.34	0.39				
9/6/93	0.41	0.42	0.36	0.39				
9/7/93	0.44	0.42	0.37	0.39				
9/8/93	0.44	0.42	0.39	0.39				
9/9/93	0.46	0.42	0.40	0.39				

9/10/93	0.45	0.43	0.39	0.39				
9/11/93	0.47	0.43	0.36	0.39				
9/12/93	0.44	0.43	0.32	0.39				
9/13/93	0.41	0.43	0.35	0.39				
9/14/93	0.42	0.42	0.35	0.38				
9/15/93	0.49	0.43	0.36	0.38				
9/16/93	0.42	0.42	0.37	0.38				
9/17/93	0.41	0.42	0.35	0.38				
9/18/93	0.41	0.42	0.35	0.37				
9/19/93	0.38	0.42	0.35	0.37				
9/20/93	0.42	0.42	0.37	0.37				
9/21/93	0.46	0.42	0.36	0.37				
9/22/93	0.43	0.42	0.34	0.37				
9/23/93	0.43	0.43	0.35	0.37				
9/24/93	0.45	0.43	0.36	0.37				
9/25/93	0.44	0.43	0.34	0.36				
9/26/93	0.37	0.43	0.35	0.36				
9/27/93	0.39	0.42	0.35	0.36				
9/28/93	0.43	0.43	0.38	0.36				
9/29/93	0.41	0.43	0.37	0.36				
9/30/93	0.41	0.43	0.38	0.36				



SECTIONAL SIDE VIEW SHOWN (LOOKING WEST)

BURNER ARRANGEMENT (FRONT WALL)



BOILER DRAIN CONNS.

NO.	QUAN.	SIZE	
3	1	3"	ECON INLET HDR
6	1	1"	ECON DISCHARGE LINE (WEST)
8	1	1"	ECON DISCHARGE LINE (EAST)
17	1	2½"	DOWNCOMER - BLOWOFF MANIFOLD
20	1	3"	DOWNCOMER - END (WEST)
20	1	3"	DOWNCOMER - END (EAST)
22	1	3"	DOWNCOMER - SHELL (WEST)
22	1	3"	DOWNCOMER - SHELL (EAST)
22	1	3"	DOWNCOMER - SHELL (CENTER)
50	1	1"	ROOF INLET HDR
56	2	3"	LOWER CONV PASS HDR (WEST)
56	2	3"	LOWER CONV PASS HDR (EAST)
80	1	1½"	SSH PLATEN INLET HDR
92	1	1"	SSH INTERM. INLET HDR (UPPER)
92	1	1"	SSH INTERM INLET HDR (LOWER)
96	1	1½"	SSH OUTLET HDR
100	1	1½"	REHEAT INLET HDR
104	1	1½"	REHEAT OUTLET HDR (FRONT)
104	1	1½"	REHEAT OUTLET HDR (REAR)
113	1	1"	DRUM WATER GAUGE

ACID CLEANING CONNS.

NO.	QUAN.	SIZE	
1	1	5"	DOWNCOMER - END (WEST)
1	1	5"	DOWNCOMER - END (EAST)
2	1	5"	DOWNCOMER - SHELL (WEST)
2	1	5"	DOWNCOMER - SHELL (EAST)
2	1	5"	DOWNCOMER - SHELL (CENTER)

BOILER NITROGEN

NO.	QUAN.	SIZE	
18	1	1"	SEC SH PLATEN OUT HDR
27	1	1"	SEC. SH OUTLET PIPE

BOILER VENTS

NO.	QUAN.	SIZE	
5	1	1"	ECON DISCHARGE LINE (WEST)
5	1	1"	ECON DISCHARGE LINE (EAST)
34	1	1"	SSH PLATEN OUTLET HDR
35	1	1"	PSH OUTLET (WEST)
35	1	1"	PSH OUTLET (EAST)
53	1	1"	SEC. SH OUTLET PIPE
57	2	1"	REHEAT OUTLET PIPE

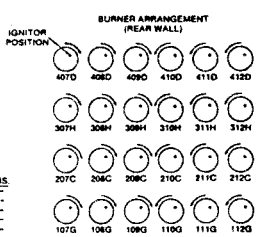
MISC. CONNS.

NO.	QUAN.	SIZE	
5	1	1½"	CONT. BLOWDOWN CONTROL (OPER. FLOOR LEVEL)

WALL TUBE DATA

DESIGNATION	NO.	OD	CTRS.
ROOF TUBES (FURN)	170	3"	6"
ROOF TUBES (CONV. PASS)	226	1¾"	4½"
FURN. FRONT WALL	339	2½"	3"
FURN. REAR WALL	339	2½"	3"
FURN. SIDE WALL	239	2½"	3"
FURN. ARCH	254	2¾"	4"
PENDANT SIDE WALL	47	1¾"	4½"
FURN. FRONT SCREEN	85	2¾"	12"
FURN. REAR SCREEN	254	2¾"	9"
CONV. PASS FRONT WALL	339	1½"	3"
CONV. PASS REAR WALL	226	1¾"	4½"
CONV. PASS SIDE WALL	121	1¾"	4½"
CONV. PASS SCREEN	110	2½"	9"
CONV. PASS BAFFLE WALL (LOWER)	339	1½"	3"
CONV. PASS BAFFLE WALL (UPPER)	339	1½"	3"
CONV. PASS BAFFLE WALL SCREEN	110	2½"	9"

BURNER ARRANGEMENT (REAR WALL)



NOTE:
(1) ODD NUMBERED IK SOOTBLOWERS (L.H. SIDE) EVEN NUMBERS (R.H. SIDE)
(2) UPPER NUMBERED IR SOOTBLOWERS (L.H. SIDE) LOWER NUMBERS (R.H. SIDE)

FUTURE IK SOOTBLOWERS
1, 2, 3, 4, 5, 6, 7, 8, 11, 12, 13, 14, 15, 16, 17, 18, 31, 32, 35, 36, 43, 44, 51, 52, 55, 56, 63, 64, 69, 70, 73, 74, 85, 86, 87, 88, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120

FUTURE IR SOOTBLOWERS
2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 31, 33, 35, 37, 39, 41, 43, 45, 47, 49, 51, 53, 55, 57, 59, 62, 64, 66, 68, 70, 72, 74, 76, 78, 80, 82, 84, 86, 88, 90, 91 THRU 120

INTERMOUNTAIN POWER PROJECT
UNIT NO. 1
LYNNDYL, UTAH

CAPACITY, LB STEAM PER HOUR 6,480,000
SUPERHEATER OUTLET PRESS., PSI.....2975
SUPERHEATER OUTLET TEMPERATURE, F 1005
REHEATER OUTLET TEMPERATURE, F 1005

BLACK & VEATCH ENGINEERS

BABCOCK & WILCOX RADIANT REHEAT BOILER

IP7_000342

BWEP 1810-6

A — FUEL AS FIRED

SAMPLES			
ANALYSES			
COAL — SOURCE — MINE			
CLASS			
GROUP			
SEAM			
DISTRICT			
COUNTY			
STATE			UTAH
SIZE		1-5/8"x0	-5/8"x0
GRINDABILITY		55	48
SURFACE MOISTURE, %			
ASH SOFT. TEMP., F (REDUCING)		2350	2215(H-W)
PROXIMATE ANALYSIS — MOISTURE, TOTAL		18.8	8.3
VOLATILE MATTER		35.5	37.1
FIXED CARBON		37.9	40.6
ASH		7.8	14.0
TOTAL		100.0	100.0

FUEL	PULV. DES WT.	RANGE PC WT.	COAL "P" WT.	PERF. COAL WT.
ULTIMATE ANALYSIS — % BY				
ASH		8.0-16.0	7.81	14.00
S		0.4- 0.7	0.93	0.55
H_2		4.3- 4.9	4.13	4.56
C		58.5-64.5	55.60	61.45
CH_4				
C_2H_4				
C_2H_6				
C_3H_8				
C_4H_{10}				
C_5H_{12}				
C_6H_{14}				
Cl		0-0.04	0.04	0.02
CO_2				
SO_2				
H_2O	12.0	7.4-9.3	18.80	8.30
N_2		1.0-1.5	0.86	1.20
O_2		9.3-10.5	11.83	9.92
TOTAL	43 GRIND		100.00	100.00
BTU/LB	10,700	0,500 to 2,100	9,962	11,010
BTU/CU FT AT 60F 30 IN.HG				

COAL "P" WILL NOT EXCEED 50% BY WT. OF A COAL MIXTURE

* NOT INCLUDING VALVES & STATIC HEAD

▲ AT PULVERIZER INLET

** INCLUDES (-1.5 INCHES WG) FOR STACK EFFECT

UTILITY BOILER PERFORMANCE SUMMARY

BY RJK APPR. [illegible] DATE 12/2/81

BABCOCK & WILCOX

P23-310-0-1S0

B — PREDICTED PERFORMANCE

STEAM LEAVING SH, M LB/HR	3965	3965	6100	6100	6600
STEAM LEAVING RH, M LB/HR	3250	3250	5000	5000	5500
AUX. STEAM M LB/HR	0	450	0	450	0
TYPE OF FUEL	PERF.COAL	PERF.COAL	PERF.COAL	PERF.COAL	PERF.COAL
LOAD CONDITION	65%	65%	100%	100%	MCR
EXCESS AIR LEAVING FURN., %	23	23	17	17	17
NO. OF BURNERS IN OPERATION	42	42	42	42	42
HEAT AVAIL. MMB/HR (FUEL & HEATED AIR)	5494	5908	7968	8374	8500
TOTAL INPUT MMB/HR (FUEL & MI. CREDITS)	5261	5662	7563	7940	8049
HEAT CREDITS, MMB/HR	6.3	6.5	7.6	7.8	7.9
FUEL INPUT MMB/HR	5255	5655	7555	7932	8040
QUANTITIES PER HR — FUEL (MCFH-NAT. GAS)	477.3	513.6	686.2	720.4	730.2
FLUE GAS ENTERING AIR MFRS.	5274	5611	7241	7600	7703
AIR TO [illegible] EQUIPMENT	4765	5064	6538	6862	6954
AIR HEATER LEAKAGE	367	378	477	498	505
PRESSURE, PSIG — STEAM AT SH OUTLET	2440	2440	2515	2515	2640
STEAM AT RH1 INLET	350	350	539	539	590
STEAM AT RH2 INLET					
PRESSURE DROP — REHEATER 1	16	16	25	28	28
REHEATER 2					
ECONOMIZER *	11	13	25	29	29
DRUM TO SH OUTLET	68	73	160	172	187
TEMPERATURE, F — STEAM — LEAVING SUPERHEATER	1005	1005	1005	1005	1005
LEAVING REHEATER 1	1005	1005	1005	1005	1005
ENTERING REHEATER 1	580	580	620	620	630
LEAVING REHEATER 2					
ENTERING REHEATER 2					
GAS — LEAVING ECONOMIZER	686	675	725	730	740
LEAVING AH (EXCL. LKG) P/S	312/276	311/277	311/286	311/289	311/294
LEAVING AH (INCL. LKG) P/S	280/267	280/268	280/276	280/279	280/280
WATER ENTERING ECONOMIZER	490	490	543	543	555
AIR — ENTERING UNIT PRI/SEC	76/62	74/63	77/64	78/65	78/65
LEAVING AIR HEATER P ▲/SEC	355/618	375/624	412/635	418/636	420/645
RESISTANCE, IN. OF WATER — GAS — FURNACE & CONVECTION BANKS	2.2	1.9	2.7	3.3	3.1
FLUES TO AH OUTLET	0.9	1.0	1.4	1.5	1.5
AIR HEATER	2.1	2.3	3.8	4.1	4.2
TOT. FROM FURNACE TO AH OUTLET	5.2	5.2	7.9	8.9	8.8
AIR — FUEL BURNERS & WINDBOX **	-0.3	0.0	1.1	1.4	1.4
DUCTS & FLOW METER	1.0	1.2	2.1	2.3	2.3
AIR HEATER	1.1	1.2	2.0	2.3	2.3
TOT. FROM AH INLET TO FURN.	1.8	2.2	5.2	6.0	6.0
HEAT LOSS-EFF., % — DRY GAS	4.92	4.84	4.84	4.86	4.98
H_2 & H_2O IN FUEL	5.14	5.14	5.15	5.15	5.16
MOISTURE IN AIR	0.07	0.07	0.07	0.07	0.07
UNBURNED COMBUSTIBLE	0.2	0.2	0.2	0.2	0.2
RADIATION	0.24	0.22	0.17	0.16	0.15
UNACC. FOR & MFRS. MARGIN	1.00	1.00	1.00	1.00	1.00
TOTAL HEAT LOSS	11.57	11.47	11.43	11.44	11.56
*GROSS EFFICIENCY OF UNIT, %	88.43	88.53	88.57	88.56	88.44
HEAT CREDITS ADJUSTMENT, %	0.01	0.01	0.01	0.01	0.01
NET EFFICIENCY A.S.M.E. PTC-4.1, %	88.44	88.54	88.58	88.57	88.45
FUEL EFFICIENCY, % (OUTPUT/FUEL INPUT)	88.55	88.65	88.67	88.66	88.54
PULVERIZER PERFORMANCE — NO. IN USE PER BOILER	4 7	5 7	6 7	6 7	6 7
TOTAL POWER, PW HP/TON MOTOR OUTPUT					
% THRU 200 U.S.S. SIEVE	71 76	72 75	71 73	71 72	70 72

PREDICTED PERFORMANCE IS BASED ON COMBUSTION AIR ENTERING UNIT WITH .0067 LB MOISTURE/LB DRY AIR, ON 25.18 IN. HG. BAROMETRIC PRESSURE, ON CONDITIONS & EQUIPMENT GIVEN ON THIS SUMMARY SHEET & ON ARRANGEMENT SHOWN ON DRAWING

C — EQUIPMENT PER UNIT

TYPE RADIANT

SIZE RBC

DESIGN PRESSURE (SH/RH) - 2975 PSIG/750 PSIG

SURFACE, SQ FT — FURNACE — WATER COOLED SCREEN (CIRCUMFERENTIAL)	
WATER COOLED (PROJECTED)	59,130
SUPERHEATER (PERIPHERAL) 54" CENTERLINE	23,244
SUPERHEATER (PERIPHERAL) 24" CENTERLINE	35,665
SUPERHEATER (PROJECTED)	4,367
TOTAL FURNACE HEATING SURFACE	122,406
CONVECTION — SATURATED (CIRCUMFERENTIAL)	13,035
SUPERHEATER (CIRCUMFERENTIAL)	279,082
REHEATER 1 (CIRCUMFERENTIAL)	300,263
REHEATER 2 (CIRCUMFERENTIAL)	
ECONOMIZER	99,902
TOTAL CONVECTION HEATING SURFACE	692,282
TOTAL FURN. & CONV. PRESSURE PART. HTG. SURF.	814,688
PROJECTED FURNACE HEATING SURFACE — TO FACE OF PLATENS (24" CENTERLINE)	87,405
TO FACE OF CONVECTION SURFACE (12" CENTERLINE)	125,510
FURNACE VOLUME, CU FT	962,055

AIR HEATER — TYPE REGENERATIVE-SECONDARY NO.2-33-1/2 VI-64

TOTAL HEATING SURFACE, SQ FT 1,047,800

TYPE: REGENERATIVE-PRIMARY NO. 2-24-1/2 VI-44

TOTAL HEATING SURFACE, SQ.FT. 135,600

FUEL BURNER — TYPE DUAL REGISTER

NO. 48 (6 BURNERS PER PULVERIZER)

PULVERIZER — TYPE MPS SIZE 89GR NO. 8

CAPACITY OF 6 PULV. IS 6600 M LB STEAM/HR BASED ON 48 GRIND 11 010 BTU COAL AT 70 % THRU 200 U.S.S. SIEVE

FOR 113 MLB COAL/PULV.-HR AT 70 % THRU 200 U.S.S. SIEVE MIN. GRIND IS 43. MAXIMUM TOTAL MOISTURE IS 12 % REQUIRING 465 F AIR

22% TOTAL MOISTURE COAL REQUIRES 540 F AIR.

STEAM TEMP. CONTROL — SUPERHEAT BY SPRAY ATTEMPERATION

REHEAT BY GAS BIASING

UNIT CONSTRUCTION & FEATURES — MEMBRANE WALL

BALANCE DRAFT

INDOOR UNIT

"AS SOLD" ARRANGEMENT

*CORRESPONDING TO ANB. METHOD PAR. 1.07 A.S.M.E. PTC-4.1

REVISIONS NO.	DESCRIPTION	BY	DATE

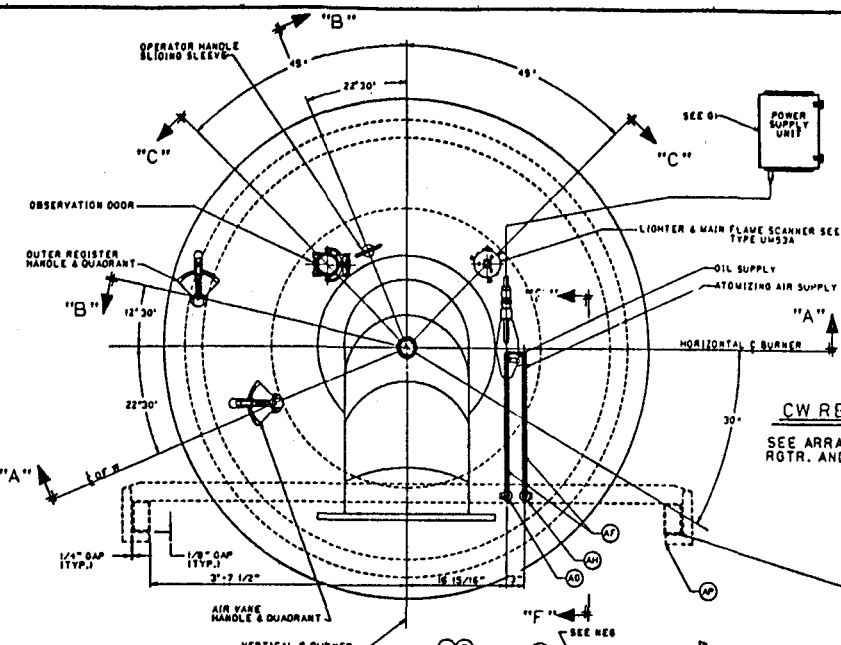
INTERMOUNTAIN POWER PROJECT

THIS SUMMARY SHEET IS THE PROPERTY OF THE BABCOCK & WILCOX COMPANY AND IS LOANED UPON CONDITION THAT IT IS NOT TO BE COPIED, IN WHOLE OR IN PART OR USED FOR FURNISHING INFORMATION TO OTHERS, OR FOR ANY OTHER PURPOSE DETRIMENTAL TO THE INTERESTS OF THE BABCOCK & WILCOX COMPANY AND IS TO BE RETURNED UPON REQUEST

IP7_000343

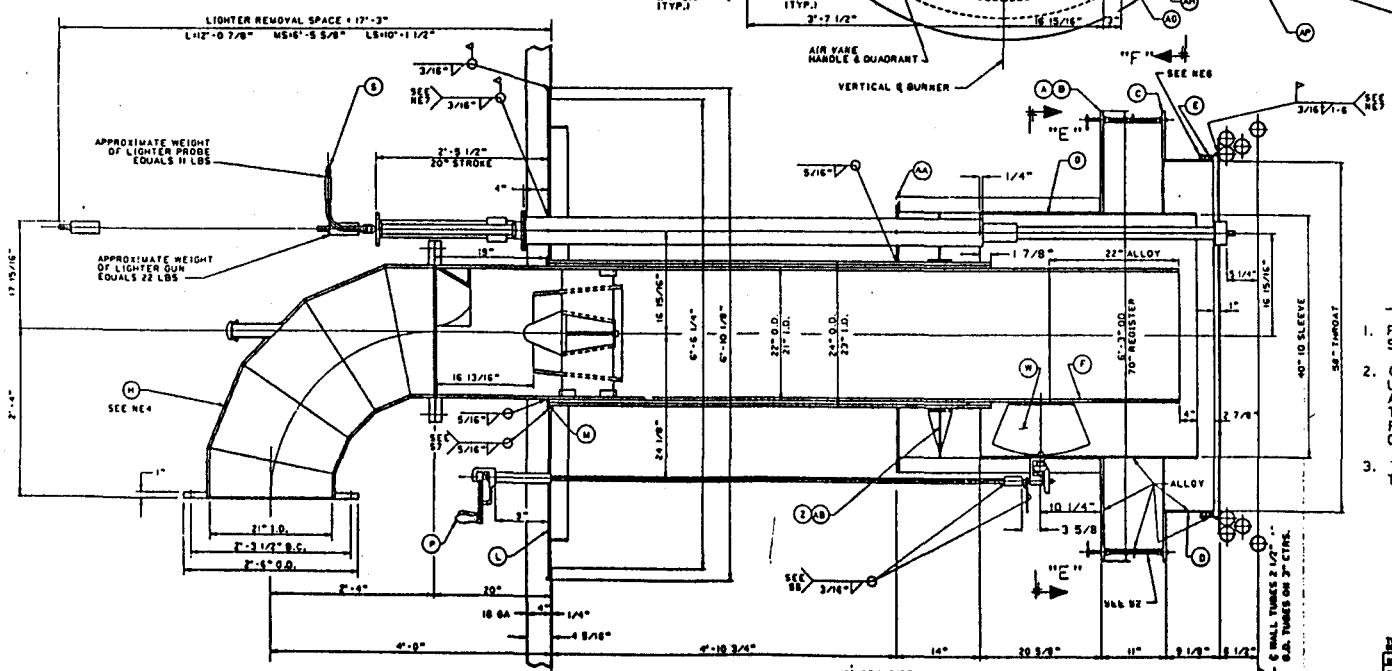
REFERENCE LIST: 36 DUAL REGISTER BURNERS 18 FRONT WALL, 18 REAR WALL				RB-614	RB-615/617
M.	DESCRIPTION	DWG.-NO.	WK-NO	QTY.	QTY.
L	INNER SLIDING SLV 70" OUTER ROTR ASSY. & CW & CCW	1971550	1 & 2	U/CW 18 CCW	24CW 24CCW
K	OUTER REGISTER FRAME CUT-OUT REAR PLATE (1965366C)	1738309	1 & 2	36	48
J	OUTER REGISTER FRAME CUT-OUT FRONT PLATE (1965367C)	1738318	1 & 2	36	48
H	THROAT SLEEVE	1968990C	2	36	48
G	THROAT SLEEVE CASING	1736148	3	36	48
F	21" DIFFUSER COAL NOZZLE ASSY "A" 10'-3 3/8"	188483C		36	48
E	INNER AIR SLEEVE	1736358	1	36	48
D	21" SEGMENTED COAL ELBOW ASSY	195591C	1	36	48
C					
B					
A	COVER PLATE	195539C	1 & 2	36	48
W	MOUNTING PLATE	167660B	1	36	48
V					
P	HANDLE & QUADRANT ASSY. (VANE) "A" 7'-3 1/8"	183366C		36	48
O	OPERATOR HANDLE ASSY (SLIDING SLV) "A" 3'-10 1/4"	188477C		36	48
N	HANDLE & QUADRANT ASSY. (OUTER REGISTER) "A" 8'-6 3/8"	183347C		36	48
S	OIL LIGHTER CFA 18 RH. 18 LH.	265375C	1 & 2	18RH 18LH	24RH 24LH
T	OBSERVATION DOOR ASSY.	2337886C		36	48
U	SCANNER SUPPORT ASSY. "A" 16'-10"	104150A	-	36	48
Y	REGISTER SUPPORT BRACKET	175491B	L343	108	144
W	AIR VANE	145549D	26	36	48
X	AIR VANE ALTERATION	1738898		180	240
Y	THREADED BAR (AIR VANE LINKAGE)	133552A		36	48
Z	INNER AIR ZONE DISK	195598C	1	36	48
AA	INNER AIR SLEEVE CUT OUT FRONT PLATE (1971550 SYM."N")	1738938	1 & 2	36	48
AB	INNER AIR ZONE DISK ALTERATION	1738928	1 & 2	36	48
AC	TEE SCRD. 1/2" 3000# SA105 3008/5362			72	96
AD	PLUG SCRD. 1/2" SQ. HD. 3000# SA105 3000/5362			72	96
AE					
AF	SUPPLY HOSE 3/8" ANACONDA BW21-1 X 57" LG. WITH GALVANIZED STEEL INTERLOCKED CONDUIT W/STYLE SHWW BOTH ENDS C.S. FITTINGS.			72	96
AG	VALVE BALL SCRD 1/2" NORCESTER 5846R-SE 600#			36	48
AH	VALVE GLOBE SCRD 1/2" VOGT 1244J			36	48
AJ					
AK	NIP. TBE 4032/5361 SA106B 1/2" SCH. 080 X 3" LG.			144	192
AL	PIPE A120 3" SCH. 040 X 6'-10" TOE NPT			36	48
AM	BUSHING SCRD 1/2" X 3/8" SA105 2916/5362			72	96
AN	UNION SCRD 1/2" 3000# SA105 2936/5362			72	96
AP	REGISTER SUPPORT BRACKET RETAINER	125865A	1	144	192
AQ	PLUG SCRD 3/4" SQ.HD. 125#			36	48

EIGHT (8) SETS OF LIGHTER MAINTENANCE TOOLS - ONE (1) SET PER BNR ROW



CW REGISTER CW VANES SHOWN

SEE ARRANGEMENT DWGS. FOR DIRECTION OF ROTR. AND VANE AIR FLOW FOR ALL BURNERS



SECTION "A-A"

5-10008

REVISIONS

1	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]

NOTES:

1. FOR LIST OF REFERENCE DRAWINGS & NOTES SEE DRAWING NO. 197002C.
2. QUANITIES INDICATED ARE FOR ONE (1) UNIT. EQUIPMENT TO BE IDENTICAL FOR ALL FOUR (4) UNITS, EXCEPT FOR PLASMA TORCH LIGHTERS WHICH ARE TO BE FURNISHED FOR THE LOWER BURNER LEVEL OF UNIT 1 ONLY. (B&W CONTRACT RB-614)
3. THIS DRAWING REPRESENTS THE UPPER THREE BNR. ELEVATIONS FRONT & REAR WALL

INTERMOUNTAIN POWER PROJECT
STEAM GENERATOR UNITS 1,2,3 & 4
PROJECT FILE 9255.62.3401
IPA CONTRACT 2010N

21-58T-40S-70R
INDOOR UNIT SUCTION FIRED

334-0616-39	RB-0614	SECTIONAL ASSEMBLY DUAL REGISTER BURNER
334-0616-39		
334-0617-39		

BABCOCK & WILCOX

294359E 6

3.3

IP7_000344

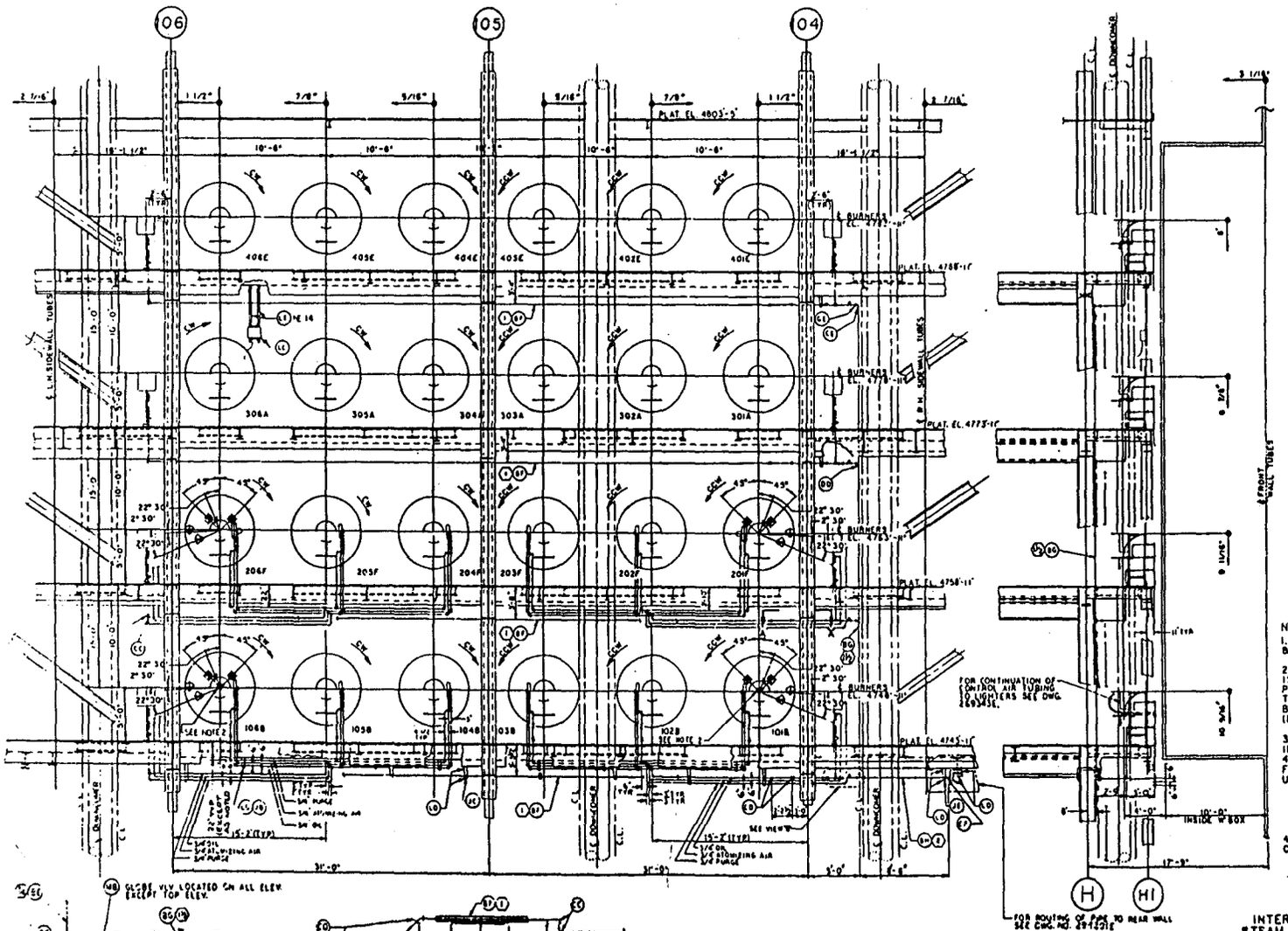


TABLE I
FLAME DETECTOR
CUSTOMER TAG NUMBERS

BURNER	ASSOCIATED FLAME DETECTOR
01 B	X'SGA-XXX-42
02 B	" - " - 43
03 B	" - " - 44
04 B	" - " - 45
05 B	" - " - 46
06 B	" - " - 47
101 F	" - " - 54
102 F	" - " - 55
203 F	" - " - 56
204 F	" - " - 57
205 F	" - " - 58
206 F	" - " - 59
301 A	" - " - 60
302 A	" - " - 61
303 A	" - " - 62
304 A	" - " - 63
305 A	" - " - 70
306 A	" - " - 71
401 E	" - " - 78
402 E	" - " - 79
403 E	" - " - 80
404 E	" - " - 81
405 E	" - " - 82
406 E	" - " - 83

NOTES:

1. FOR LIST OF REFERENCE DRAWINGS & NOTES SEE DWG NO.197002C.

2. EQUIPMENT FOR UNITS 1 THRU 4 IS TO BE IDENTICAL EXCEPT FOR PLASMA ARC IGNITERS WHICH ARE TO BE FURNISHED FOR THE LOWER BURNER LEVEL OF UNIT 1 ONLY. (B&W CONTRACT RB-614)

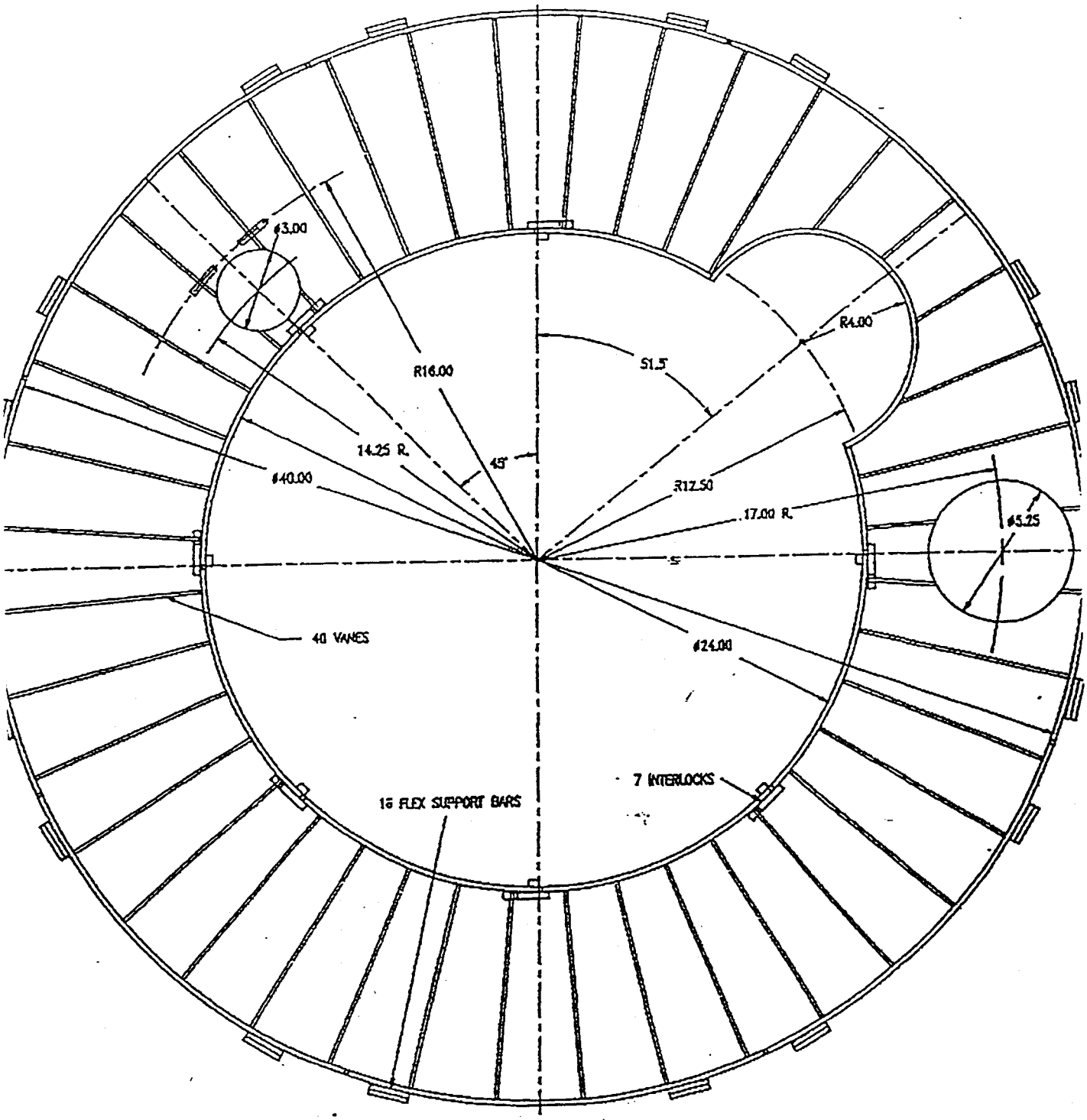
3. OWNER'S EQUIPMENT COMPONENT IDENTIFICATION IS AS INDICATED (E.G. 403E) AND IS TO BE PREFIXED AS FOLLOWS WHERE "X" IS THE ASSOCIATED UNIT NO. 1 THRU 4.

BURNER	X'SGA-BNR-
FUEL OIL IGNITER	X'SGE-IGN-
PLASMA ARC IGNITER	X'SGA-PTL-
FLAME DETECTOR	SEE TABLE I THIS DWG.

4. FIRST DIGIT OF COL ROW DESIGNATION CORRESPONDS TO UNIT NUMBER.

(100) UNIT 1 (200) UNIT 2 (300) UNIT 3 (400) UNIT 4

IP7_000345



IPP SWIRLER

Figure 47 Intermountain Power Project Swirler

MZ Coal Flame Stabilizer

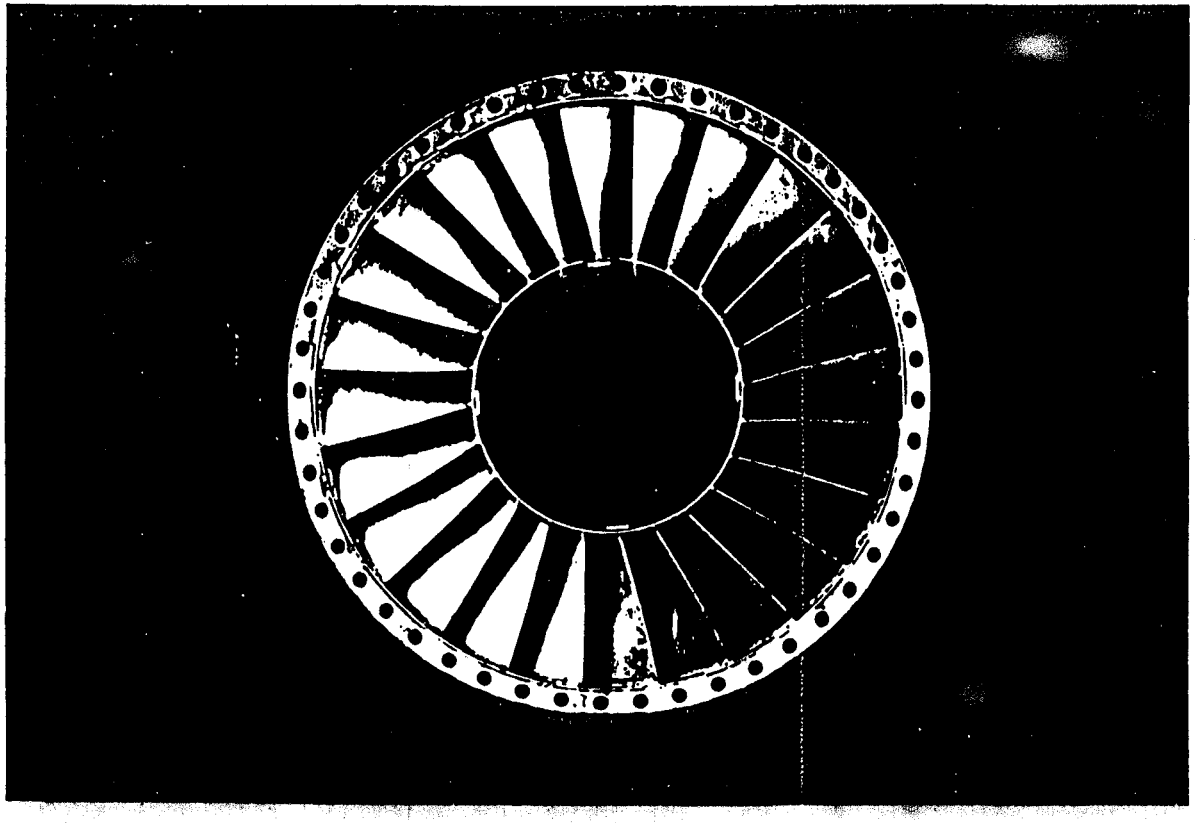


Figure 2

IP7_000347

Correct Burner Flow Pattern

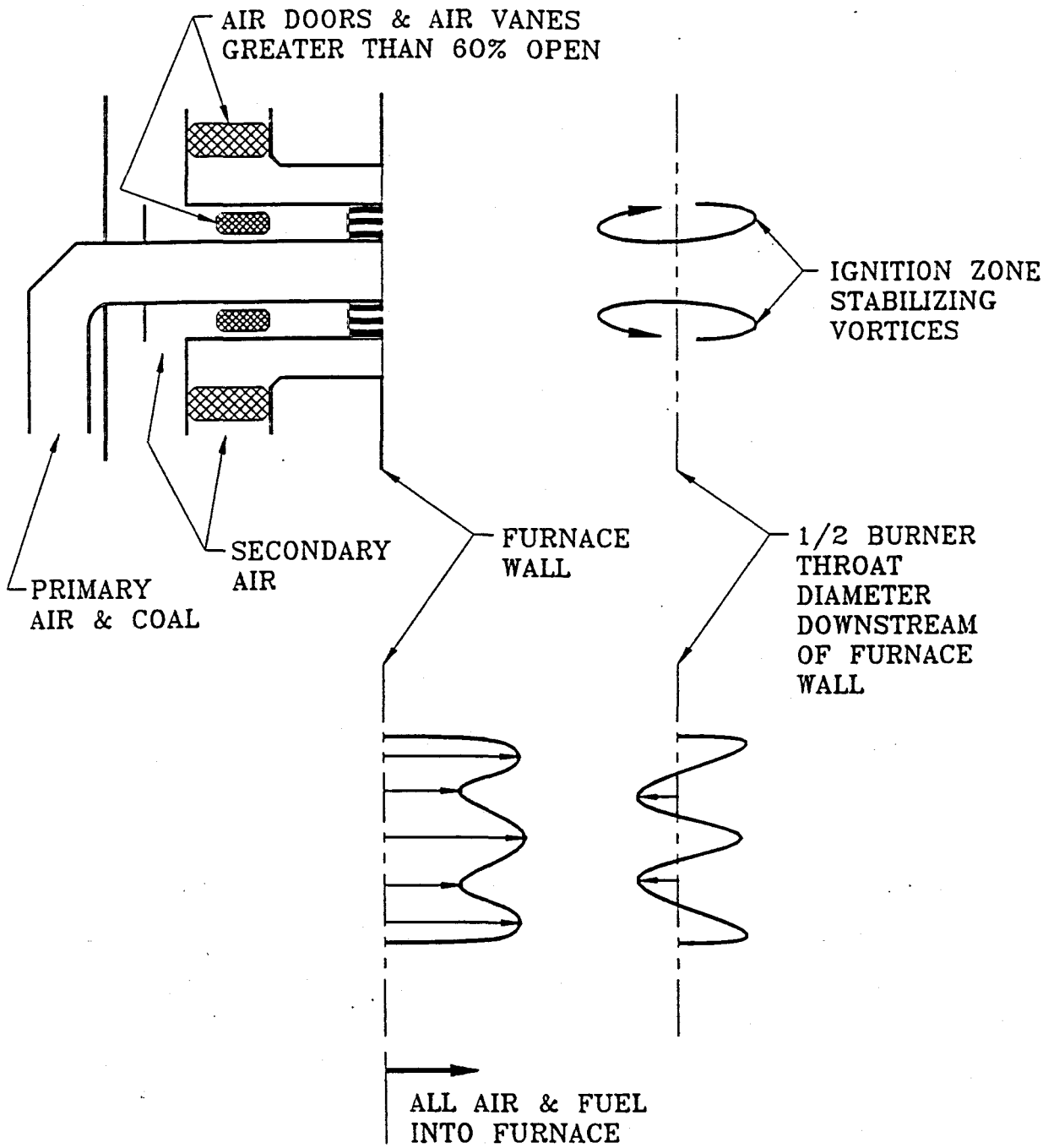


Figure 3

IP7_000348

Burner Swirl vs. Eyebrow Formation

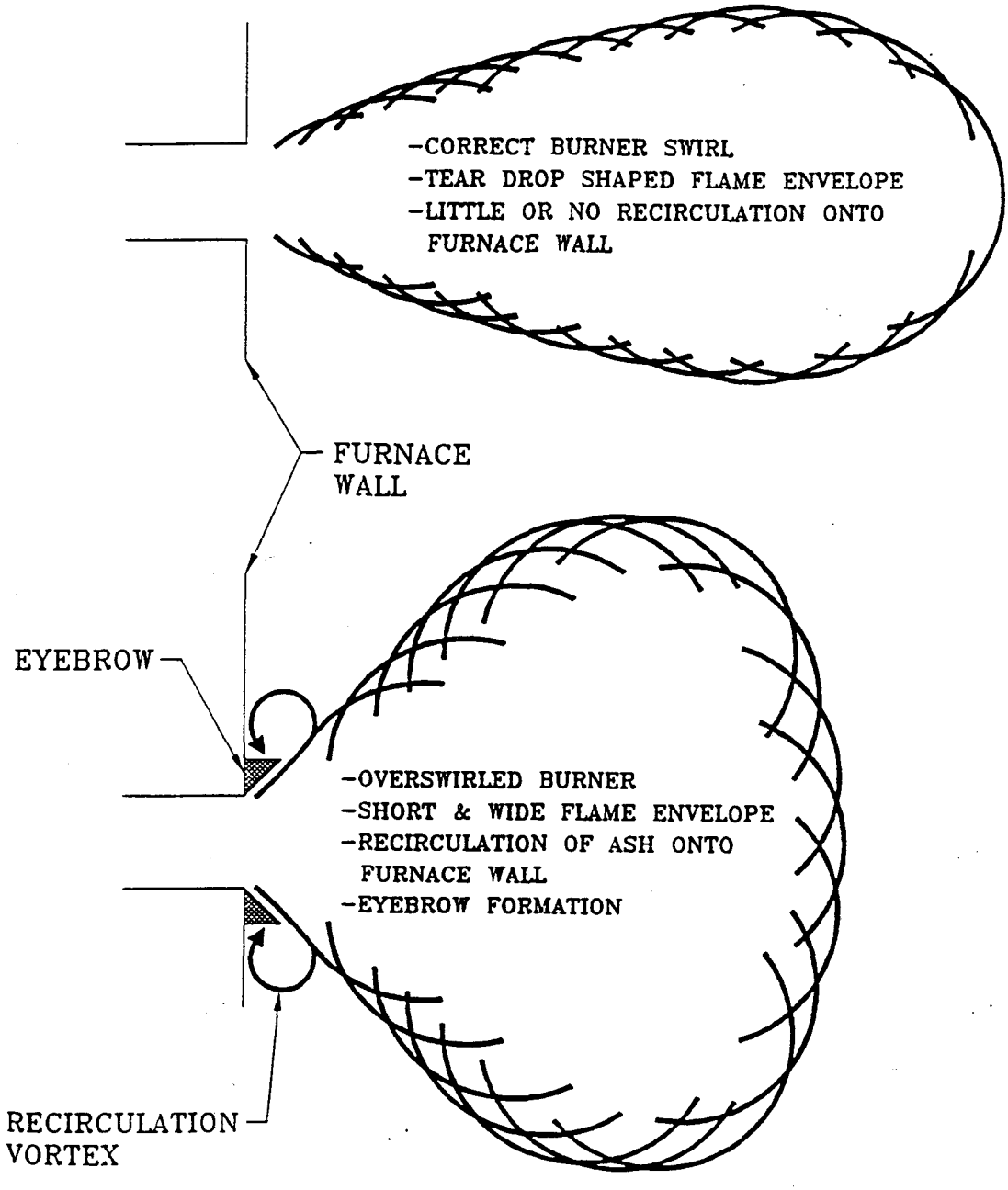
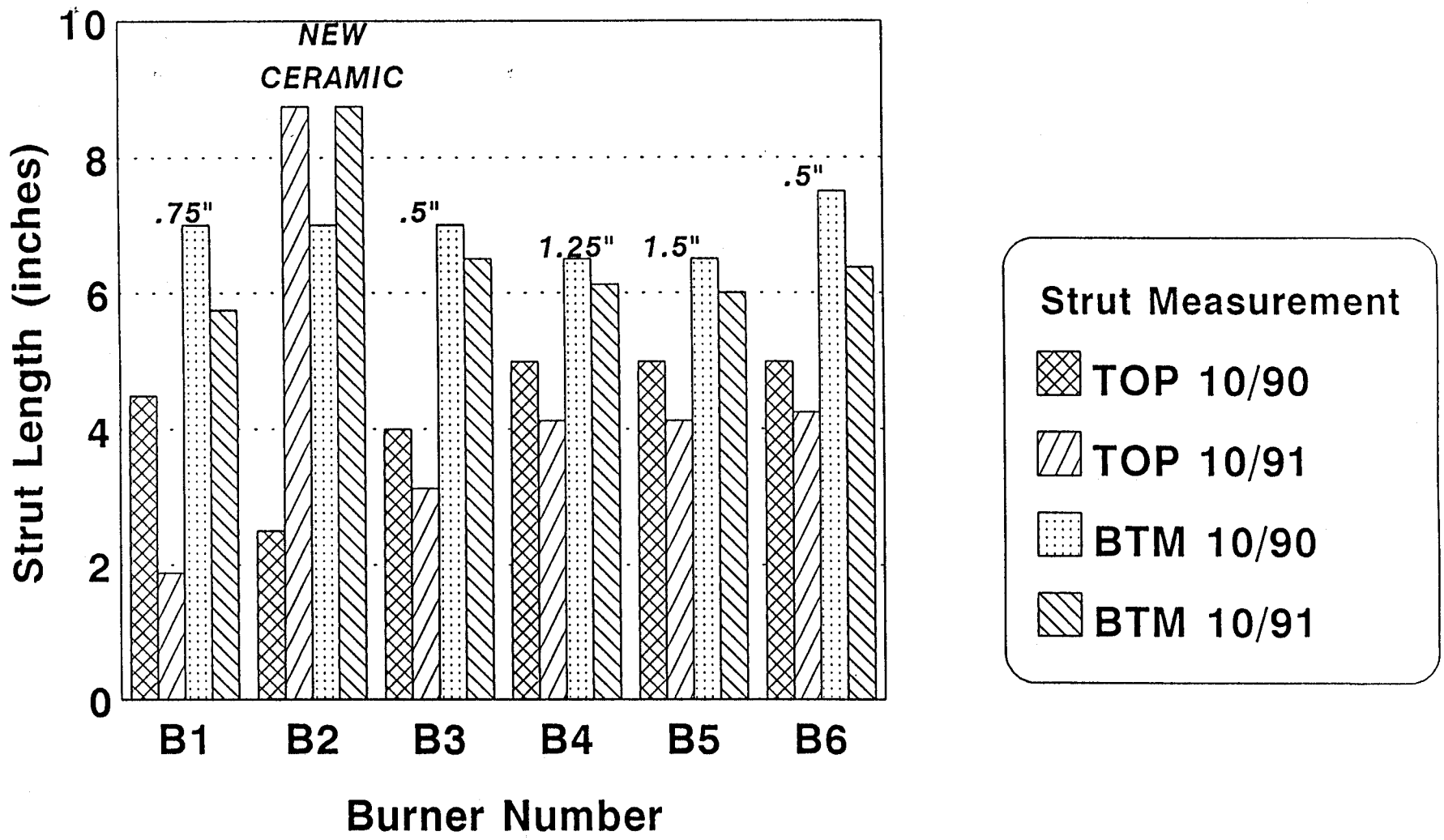


Figure 4

IP7_000349

UNIT 2 BURNER DIFFUSER MEASUREMENTS

Taken October, 1990 and October, 1991
Wear Monitoring



**Numbers above bars indicate size of hole in cone

IP7_000350

SPRING 87

TAB 16

COAL BURNER REGISTER, NOZZLES AND LIGHTERS INSPECTION

OBSERVATIONS AND WORK ACCOMPLISHED

The following items were identified by IPSC Engineering and a B&W Consultant on all coal burners and related equipment.

B&W Personnel changed out four coal nozzle assemblies that had been damaged by overheating from coal pipe fires. Several other coal pipe nozzle diffusers were replaced due to cracked supports or missing inner diffuser cones. B&W believes the coal pipe fires are attributable to coal "falling out" in the coal pipes. Although IPSC's minimum air flow velocity is well above B&W's recommendations, coal could still be falling out during special case situations such as when a mill trips under loaded conditions. The coal left in the coal pipes isn't removed during inerting and remains in the coal pipes until the mill is restarted. Another item that could be compounding the problem is higher than anticipated burner metal temperatures for out of service burners. These and other items are currently being addressed. Further information will be forwarded as more details become available.

Further overheating damage to burners was once again observed and documented during this outage. Cracked welds on the burner register front plates as well as severe overheating of carbon steel components were observed. IPSC Engineering had 30 new thermocouples installed in strategic locations on several burner register assemblies. The additional thermocouples may help IPSC convince B&W to add stainless steel to several additional areas on the burners. This would not only help eliminate the overheating problems, but could also help reduce cooling air requirements to out of service burners.

IP7_000351

BURNER ASSEMBLY RECOMMENDATIONS

During each outage, the inner parts of the burner assembly should be thoroughly inspected for excessive wear areas and also check for any missing parts. The addition of new thermocouples should be closely monitored and observations reported to IPSC Engineering. Attached is a B&W report detailing observations made during the outage and recommended corrective work to be performed at the next available time.

IP7_000352

Babcock & Wilcox
a McDermott company

To	C. A. PALMBERG - PM PROJECT MANAGEMENT - BVCB3K
From	W. E. NEWKIRK - COMBUSTION SYSTEMS - BVNO1C
Cust.	INTERMOUNTAIN POWER
Subj.	BURNER INSPECTION

BOS 6

File No. or Ref. RB-614

Date MAY 22, 1987

This letter to cover one customer and one subject only.

The writer visited Intermountain Power RB-614 to inspect the burners and report on condition of the burners. This visit was contracted by IPP to Denver Service and covered my time and expenses in full.

For the record it is noted that all failed welds, warped register plates, rope packing, reinforcing band on register, bent door shafts, and linkage was rewelded, repaired, installed, or replaced during the November 1986 outage.

My inspection results in the following condition in general. For specific condition of each burner refer to inspection sheet for each burner.

Inner Air Sleeve:

1. Many of the burners have failed welds joining the air sleeve to the outer register front plate.

2. The carbon steel reinforcing bars attaching the air sleeve to register front plate are burned up at the weld between the bar and register plate due to insufficient cooling air.

3. The air sleeve on many burners are barrel shaped and bowed due to insufficient cooling and is more severe on the two middle burners each level which had the air disk throttled. This will not affect operation.

4. Corrective repair for attachment must be made. See attached sketch.

Throat Sleeve:

1. Most of the burners have failed welds attaching throat sleeve to the register plate.

2. The throat sleeve on many burners are barrel shaped. This will not effect the functional operation of the burner.

3. Corrective repair for attachment must be made. See attached sketch.

IP7_000353

Casing:

1. The casing on many of the burners are out of round, have failed welds and are in such condition they will not retain the rope packing. A new design must be developed for these burners.

Register Front and Back Plates:

1. The register plates do not indicate further warping of the plates and are functionally sound. Although they are distorted, resulting in poor alignment of door shafts making linkage adjustment and door adjustment almost impossible. Howevcer, registers are still functional.

2. Should ot be a requirement to adjust registers on line, A device to regulate the amount of air flow to the burner can be designed to enable outer register air flow adjustment. The air doors will then be set for swirl and no further adjustment to the existing doors.

3. Welds attaching outer register to inner air sleeve will be cut free and register position will be maintained by lugs attached to inner air sleeve. This method of attachment will allow differential expansion between air sleeve and register plate. See attached sketch.

Spin Vanes:

1. The spin vanes, gears, gear shafts, and linkage are all in good condition with the exception of the burner identified on the inspection sheets. The binding of the spin vanes is due to fly ash contamination in the pivot points of the spin vane assembly.

2. Spraying the spin vane gear assemblies with penetrating oil during an outage will free up the assemblies, permitting adjustment of vanes to optimize flame and should not require further adjustment.

Inner Register Front Plate and Disk:

1. The inner register front plate and disk are in good condition and does not require any repair work.

Coal Nozzles:

1. The coal nozzles were all in good condition by visual inspection with the exception of F-4, H-6, and E-2. Which had been destroyed by nozzle fires.

2. Several burner coal nozzles indicate a short term overheat and are identified in the inspection sheets. It is my opinion the overheat is due to insufficient cooling air.

3. For improved protection from overheat, I suggest that future replacement nozzles be fabricated with longer length alloy tips.

Diffuser:

1. With the exception of diffusers that were destroyed by nozzle fires, it is

IP7_000354

Deflector:

1. The deflectors are in very good condition with very little wear evident.

Attached to this report is an inspection sheet for each burner checked to indicate the condition of each component part. A copy of these sheets was left with IPP with items highlighted that must be repaired during the May outage. Also attached are sketches of our recommended modifications listed in this report.

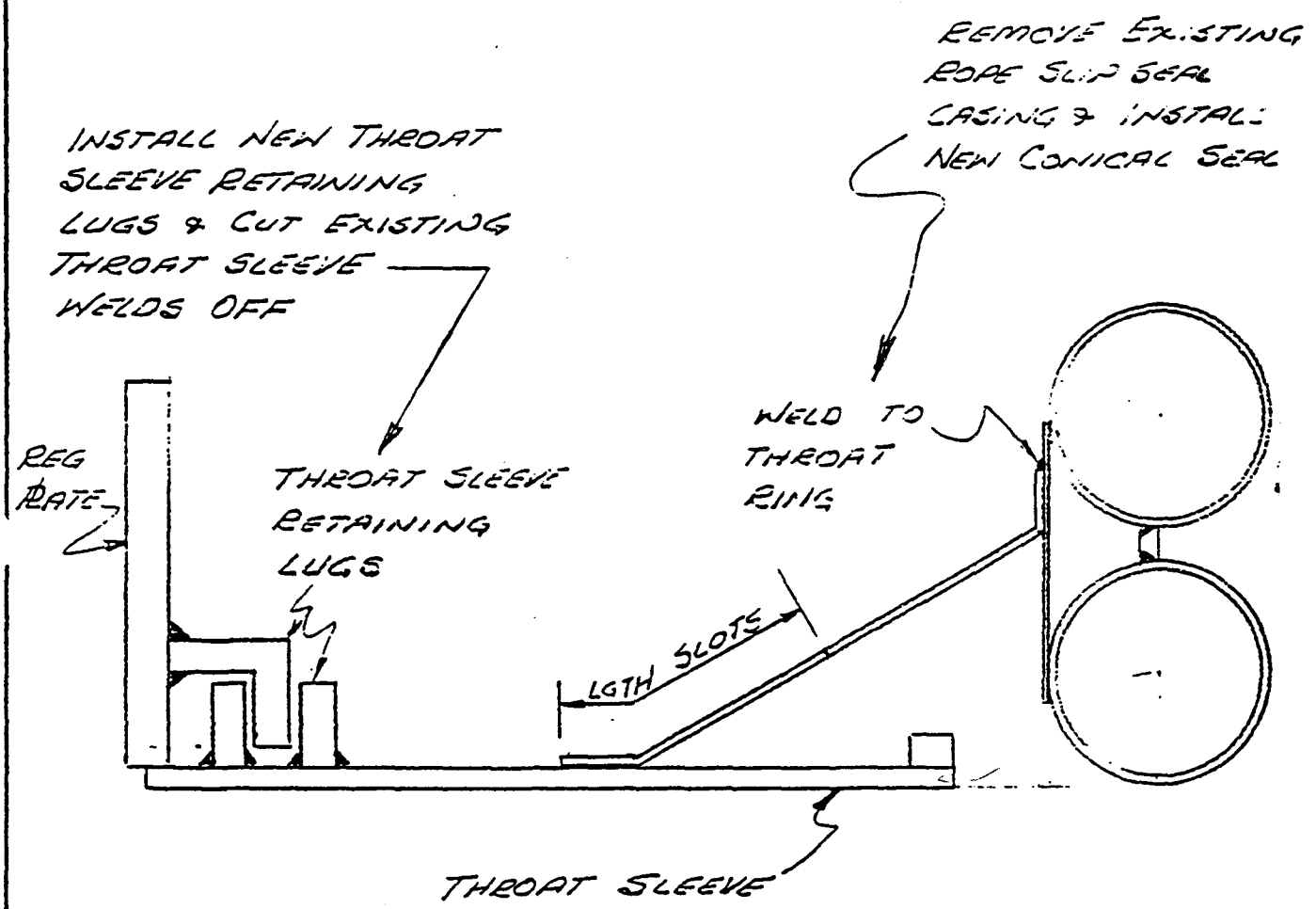
I suggest that these recommended changes be implemented on a selected pulverizer group in the October outage for evaluation for modifications to all of the burners during the Outage in February 1988.

W. E. Newkirk

W. E. Newkirk

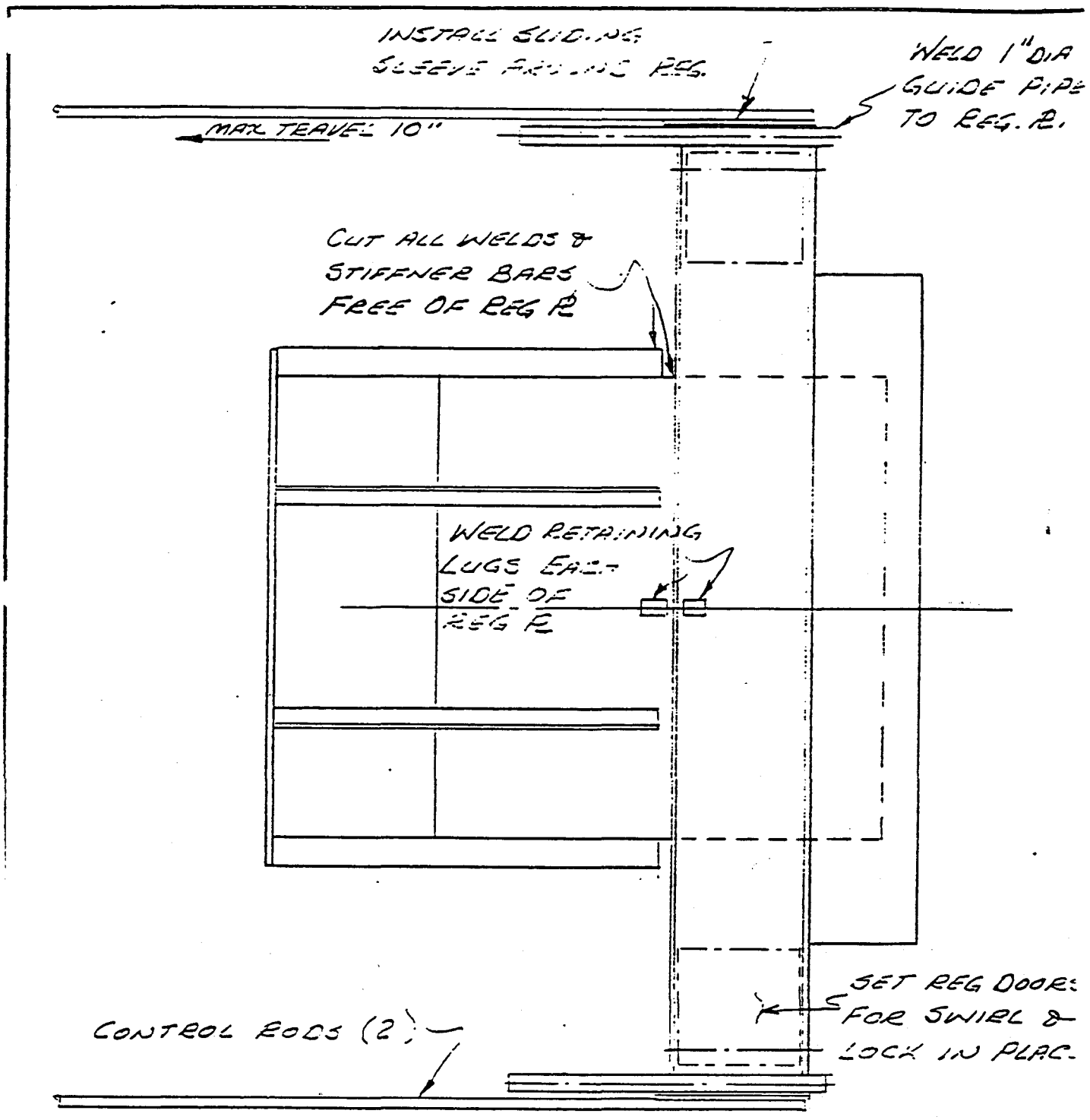
WEN009/lak
cc: P. L. Cioffi
F. J. McGinley
T. Roberts

IP7_000355



CUSTOMER INTERMOUNTAIN POWER	JOB No. RB-614
SUBJECT THROAT SLEEVE ATTACHMENTS &	

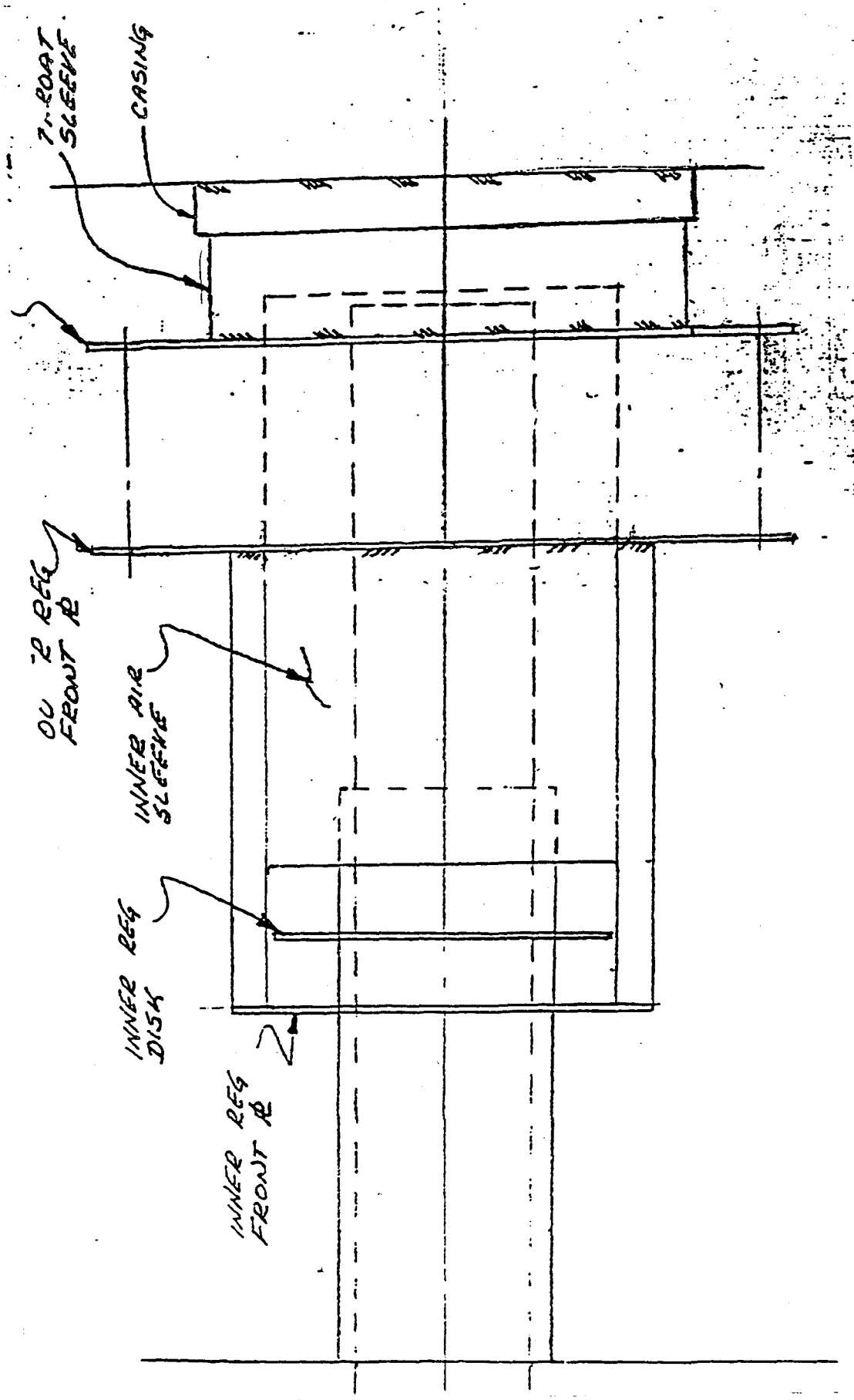
THE BABCOCK & WILCOX COMPANY



SLEEVE SHOWN IN CLOSED POSITION

CUSTOMER INTERMOUNTAIN POWER	JOB No. RB-614
SUBJECT AIR REGISTER MODIFICATION FOR	

IP7_000357



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BURNER REGISTERS - B&W Construction installed new HD registers on both the front and rear burners on level four as a trial to determine if the new register design would allow outer register adjustment while on line (Ref. Drawing 212452C). The 22 inch alloy tips on all 48 coal nozzle assemblies were replaced with a new 33 inch alloy tip. This modification will permit reduced cooling air requirements to out of service burners (Ref. Drawings 294359E, CS-072787 and 167532B). Modifications were made to the throat and inner air sleeves' attachment to the outer register frame front and rear plates. A register retaining lug and clip system replaced the previous weld attachment (Ref. Drawing 294359E, SK1, SK2 and CS-072887). This modification was made to eliminate recurring weld cracking and permit thermal expansion between sections of the burner register assembly. Attached are drawings and a description of the work performed by B&W Construction.

ECONOMIZER - B&W Construction installed eight (8) additional soot blowers in the economizer section of the boiler. This addition was implemented to address the boiler thermal performance deficiencies.

INSULATION REPAIR - Several areas requiring insulation repair were completed during the outage by B&W Construction under warranty work items. A major area of concern was the expansion joints on the secondary air ducts (Ref. Figure 1). Another area repaired during the outage was the insulation blankets on the secondary superheater outlet header located in the penthouse. Insulation on the auxiliary steam line connecting to the secondary superheater outlet header was also repaired. This area is located in the penthouse. Insulation blankets on the reheat superheater outlet headers required minor repair. Insulation repairs were completed per Insulation Detail Section 387 and 36G (Ref. Drawings 113139 and 161900).

Attached is a report written by a B&W representative describing work performed.

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STEAM GENERATOR INSPECTION - BURNERS

OBSERVATIONS AND WORK ACCOMPLISHED

Babcock and Wilcox (B&W) had contractual work responsibilities to continue to resolve problems experienced with the operation and maintenance of the burners (48 total per unit) and their related equipment. IPSC Technical Services monitored the modifications made to the burners, inspected to document ongoing status and tested after the outage to ensure adequate burner operation, flame stability and register mobility. Outage activities completed by B&W and observations made on the burners are as follows:

OUTER REGISTERS - The outer register vanes were trimmed in a trapezoidal shape to prevent biding and freezing due to thermal expansion or "oil canning" against the outer register assembly support plates. Trimming was done on all burners which included both the original and HD upgrade outer registers. The front side of the vane (closest to the water walls) was trimmed 3/4 inches on the end tapered back eight (8) inches. The back side (closest to the windbox) was trimmed (initially notched during the fall, 1987, outage) to 1 3/4 inches on the end and tapered back eight (8) inches toward and hub.

LIGHTER SHROUDS - Two missing outer thermal shrouds which go around the lighters for radiation protection were replaced due to poor attachment to the inner sleeve of the burner which resulted in attachment failure and the shrouds falling out. All other shrouds were reattached to prevent loss or drooping by welding a bar stock support bracket under the shroud. These modifications were made from the furnace side of the boiler via skyclimber.

SPIN VANE REGISTERS - Spin vane drive gear assemblies were observed showing flyash accumulation within gear preventing adjustments of the inner registers for flame stability. See photos 16 and 17. The spin vane and outer burner sleeve area also indicates ash and slag accumulation in several of the burners which prevents spin vane movement plus, it also disrupts the air flow distribution around the inner zone of the flame.

MECHANICAL STOPS - Mechanical stops were added on a trial basis to some of the outer register linkage assemblies to limit their range of motion.

BURNER THERMOCOUPLES - All bad burner thermocouples were repaired or replaced and were also verified during the outage to insure operability.

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BURNER TO WATERWALL SEAL - The burner to waterwall seal is in need of refurbishing. Seal strips need to be reattached and rope packing inserted to provide an air tight seal against the boiler frontwall.

OUTER REGISTER ASSEMBLY THERMAL EXPANSION - Design changes have previously been made to only some of the upper burner levels to allow thermal expansion without breaking structural welds or warping materials. Weld cracking is still occurring on those burners not modified. All burners not having this modification need to be upgraded to prevent structural problems from occurring.

BURNER OVERHEATING - Inspection revealed evidence of some overheating still occurring to the burners. Outer register assembly backplate supports on the HD series modifications show signs of overheat due to discoloration of the stainless steel material. Permanent warpage and bowing is still occurring on the original backplates and broken welds are also evident. NOTE: The coal nozzle tip modification cannot be inspected to determine if the material upgrade is functioning satisfactorily (alloy nipple tip extends up into burner sleeve beyond visual capabilities).

FLYASH ACCUMULATION - Accumulation of flyash has been occurring in the bottom of the windboxes on burner levels one and three. Depths are up to twelve (12) inches and require vacuuming on every outage. Investigation needs to be made as to the source, to prevent possible overloading of the windbox structural casing which separates burner levels.

WINDBOX DAMPERS - IPSC Instrument & Control and B&W stroked all windbox secondary air dampers to confirm movement, full range of motion and proper cold clearances.

COAL ON BURNERS - Coal dust, exterior to the windbox settled on the burners, lighters, scanner, etc., pose a fire hazard if not properly removed after each substantial occurrence.

RECOMMENDATIONS

DRIVE HANDLES/SLIP JOINTS ON OUTER REGISTERS (48 TOTAL) - Straighten or replace all bent drive handle rods to the outer registers. Modify each drive handle assembly with a slip joint to allow for thermal growth (drive rod is fixed at both the burner front and at the burner itself).

DRIVE HANDLES/SLIP JOINTS ON SPIN VANES - Straighten or replace all bent drive handle rods on the inner registers. Modify each drive handle with a slip joint assembly to allow for thermal growth of the burner.

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SPIN VANES/INNER REGISTER ASSEMBLIES - Sand blast all gear assemblies to remove flyash buildup. Stroke spin vanes to verify fall range of movement. Trim spin vanes around lighter shrouds and scanter tubes, if obstructing movement. Lubricate all linkages with penetrating oil.

OUTER SLEEVE/SPIN VANES - Clean out any ash or slag deposits around spin vanes in the outer burner sleeve. Investigate increasing sweep times or secondary air flow rates during pulverizer shutdown and start-up to prevent fallout or lickback.

HD OUTER REGISTERS - Modify all outer register assemblies so they are identical with one another. Remove existing HD's or upgrade all burners to HD outer registers modifications.

BURNER TO WATERWALL ROPE PACKING SEAL - Refurbish leaf seal and reinsert rope packing to provide tight seal against air and ash infiltration.

OUTER REGISTER ASSEMBLY, THERMAL EXPANSION MODIFICATION - Modify all outer register assemblies not previously upgraded, to allow for thermal growth of the outer register to prevent burner structural problems.

BURNER OVERHEATING - Investigate lowering stainless steel burner front metal temperature alarm set points from 1300° F to 1200° F by increasing the minimum cooling air flow requirements to out of service burners.

FLYASH ACCUMULATION IN WINDBOX - Flyash needs to be vacuumed out of the windboxes on every outage. Investigate cause of problem and eliminate source.

THERMOCOUPLE UPGRADE ON BURNERS - Investigate upgrading two (2) thermocouples per burner on all burners. Attach thermocouples to the backplate and on the coal nozzle tip to monitor adequate cooling temperatures and for the defection of burner line fires. Currently, every other burner is being monitored.

REGISTER DRIVE HANDLES - Replace all hexagon lockscrews on both inner and outer register drive handles (96 total). Most are either stripped, missing, immobile, filled with flyash or other debris and need to be replaced to permit adjustability.

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UNIT 1 - SPRING, 1989, OUTAGE
ENGINEERING INSPECTION REPORT

STEAM GENERATOR - BURNER INSPECTION

OBSERVATIONS AND WORK ACCOMPLISHED

Babcock and Wilcox (B&W) had contractual work responsibilities to continue to resolve outstanding problems experienced with the operation and maintenance of the burners and their related components. IPSC's Engineering Services inspected the burners to document condition, monitored the repair activities, plus tested the burners after the outage to ensure adequate burner operation, flame stability and burner register mobility.

The boiler platform was utilized during the extended outage to inspect the burner fronts from the fireside which proved to be of valuable assistance, in conjunction with the inspections conducted from the windbox. Sahn Tram, B&W Field Service Engineer, assisted with most of the burner inspections. Problems and status with the burners will also be discussed in his final boiler inspection report. Outage activities completed by B&W and IPSC Maintenance and the inspection observations made on the burners are listed below:

CONICAL COAL DIFFUSERS - The conical coal diffusers (located internal to the burner nozzle which provides dispersion of coal around the perimeter of the burner for uniform combustion) were inspected very closely for the first time during this outage. The boiler platform was used to make the fireside inspections for determining the extent of erosion and wear to the coal diffusers.

Extensive wear was found on several of the upper vertical struts which hold the conical diffuser to the outer shroud assembly. Burners 1A04 and 1A06 were the worst and had their diffuser assemblies replaced (reference Photos 1 through 3). Wear greater than 50% through the bracket was recommended for replacement. Dimensions were 3 1/2 and 4 1/2 inches respectively of metal remaining on the upper struts as compared to 8 1/2 inches when diffuser assembly is new (see Photo 4).

In addition, the conical coal diffuser for 1C06 burner was replaced due to cracking. 1A05's diffuser assembly was also replaced due to cracking from a previous on-line burner line fire.

PLASMA TORCH IGNITION SYSTEM - B&W Construction removed the plasma torch ignition system on Unit 1's bottom row burners, (Pulverizers 1B - front wall and 1G - rear wall), per contractual negotiations. This eliminates this system entirely from functional use. All related components and peripheral equipment to this system are thus disabled.

PLASMA TORCH CONICAL DIFFUSERS - The plasma torch ignition system was removed during this outage, but alterations did not include removal of the plasma torch style coal diffusers and replacement with the standard conical diffuser design.

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Inspections conducted on the bottom row burners showed extreme signs of wear to the plasma torch sleeves, PT - stye diffusers and U-bracket end supports. Reference Photos 5 through 10. B&W did repair the U-bracket supports which hold the end of the plasma torch sleeve to the outer end of the nozzle. In most cases, the U-bracket supports were worn so severe that only 1/2 to 1/8 inch of metal was remaining, plus on two of the twelve burners, the brackets were completely missing. B&W did not repair nor replace the plasma torch sleeves or diffusers.

It was determined by B&W that these items were routine wear and replacement parts should be replaced as required by IPSC during the next available maintenance outage. These alterations pertain to Unit 1 Burner Rows 1B and 1G only.

HD OUTER REGISTERS - Photos 11 through 13 show the HD outer register assembly overheat and thermal expansion damage and concerns. The HD outer registers are installed on the upper row burners, Pulverizers 1E (front wall) and 1D (rear wall). These are the only burner rows on either unit which have the modified outer register assemblies installed. The new HD assemblies have an improved style linkage mechanism for the outer register vanes which prevents most of the previous linkage binding.

The outer air register assembly, back (rear) plate on the HD registers has sheared off its retaining bolts due to thermal expansion. Permanent swelling on the inner perimeter of the register assembly prevents rebolting these sections back together.

This overheating condition is occurring although burner front operating and out-of-service temperatures are monitored and maintained below B&W's maximum allowable temperatures (1350 degrees F) for the stainless steel register assemblies.

BURNER OVERHEAT - Inspections indicate overheating and thermal expansion is an ongoing problem with the burners and their components which is steadily getting worse. Permanent warping, rippling, barreling, discoloration, flaking and thermal expansion damage is being observed on the HD and standard outer register assemblies, register vanes, drive handles, throat sleeves, inner air sleeves, casing rings, lighter shrouds and lighters (reference Photos 14 through 25 which document these conditions).

Again note, damage is occurring even though B&W operating procedures and instruction are being followed. Cooling air requirements for maintaining the burner front temperatures are being operated below B&W's limitation of 1350 degrees F.

BURNER NOZZLE 1A05 - Coal burner 1A05 had a previous detected on-line burner line fire which had been isolated from the other five burner lines prior to the beginning of the outage. Maintenance removed the coal pipe elbow for inspection of the diffuser and coal nozzle. The coal diffuser had been damaged due to the overheat condition of the fire and was replaced with the nozzle in-place. The coal nozzle pipe was inspected and determined not to have suffered sufficient damage to effect its structural integrity.

BURNER 1C04 CASING RING - During the windbox inspections, Burner 1C04 was found with the throat sleeve casing ring almost completely dropped out due to the attachment welds failing (reference Photos 27 through 29). This casing ring helps provide a seal for the outer air register assembly and throat sleeve to the waterwall front. The seal ring is intended to be packed with rope packing to provide an air tight seal. Maintenance reattached and repaired Burner 1C04's throat sleeve casing ring in its proper position (see Photo 30).

Based on examinations, broken welds are fairly common on this casing ring on all 48 of the burners. B&W Field Service noted these were not burner structural welds and that an air tight seal was not required for proper burner operation. The remaining burners were checked, but did not have the throat sleeve casing ring attachment welds repaired. See Throat Sleeve Casing Ring heading for additional information and recommendations.

THROAT SLEEVE CASING RING SEAL - The throat sleeve casing ring which is to provide an air tight seal between the outer air register and the throat sleeve assembly to the waterwall is in a greatly deteriorated condition.

There are broken welds and warping of the casing ring which has caused excessive gaps to develop between the throat sleeve and waterwall. Roper packing which is to provide the air tight seal is 90% nonexistent.

This seal is to prevent air leakage from bypassing combustion (secondary) air flow from out around the outside of the burner. It also provides a seal to prevent fly ash, coal and fuel oil from being reentrained (licked-back) back into the windbox (reference Photos 31 and 44).

B&W stated and has held in the past that they do not feel that this is a serious item of concern and that it does not pose an operational problem.

Engineering Services feels that this seal is far more critical for effective combustion and control and for maintaining oxygen tuning and balancing requirements. IPSC feels that this has been demonstrated utilizing the oxygen profile analysis.

OUTER REGISTER ASSEMBLY THERMAL EXPANSION - The outer air register was modified during a previous outage so that it was free floating (retained by clips) which allowed movement to prevent thermal expansion structure damage. Since this modification which initially had minor clearances, the inner air sleeve has moved to the point where clearances in some areas are greater than one inch (reference Photos 45 and 46). This thermal expansion problem causes additional air leakage around the air sleeve and backplate of the outer air register assembly. Note that this air is still in the outer air register zone.

INNER AIR SLEEVE ASH DEPOSITS - Photos 47 through 51 show deposits which have settled out on the outer tip of the inner air sleeve directly below the coal line nozzle. This ash consistency varies from fly ash (powdery) to slag and molten coal. How and why these deposits accumulate on the inner air sleeve is unknown. Also to what degree these deposits effect inner (spin) air flow distribution and their effect on performance in uncertain.

LIGHTERS - Lighters were found to be in extremely dirty condition with fouling and coking very evident. Overheat conditions were also noted with several of the lighter end shields swelling or barreling due to overheating. Two of these assemblies were replaced (Burners 1C03 and 1F04) due to significant damage.

Seven lighters had leaky fuel oil isolation valves which pose a fire potential and safety concern. All identified leaky valves were repaired (reference Photos 52 through 57).

LIGHTER SHROUDS - All lighter shrouds were inspected and found to be in-place. The origin of the lighter shroud recovered from the bottom ash clinker grinder by Operations could not be determined. If may possibly have come from Unit 2.

Several U-straps which hold the shroud in place against the inner air sleeve were broken due to overheating and warpage. Severe warpage of the inner air sleeve that was observed, can be attributed to overheating at the lighter shroud attachment at the outer end of the coal nozzle. This attachment weld prevents the shroud from sliding back horizontally which would allow it to fall forward out of the front U-bracket support, which has occurred in the past (reference Photos 58 through 60).

SCANNERS - Buckshot damage was found on one scanner casing due to eyebrows and clinkers on the furnace waterwalls being shot off to help prevent personal injury from falling objects during outage activities (reference Photos 61 and 62).

Grounds found on the scanner flame detection system were identified and traced out to eliminate operational problems with the scanners. A significant problem has been occurring in the past with scanners detecting flames without the burner row being inserted.

BURNER THERMOCOUPLES - Instrumentation for temperature measurement on the burner fronts were upgraded so that each burner has two thermocouples (reference Photo 11). One thermocouple was attached to the outer register backplate and the other to the coal nozzle tip (see enclosed drawings). Previously, every other burner had four thermocouples installed, but did not provide sufficient temperature measurement required of all burners.

The thermocouple addition was necessary for monitoring cooling air flow requirements to all out-of-service burners to prevent overheat conditions on an individual burner basis. Additional temperature indication will also help detection of burner line coal fires for the prevention of major equipment damage to coal nozzle, ceramic line elbow, diffuser, deflector and other burner related equipment.

OUTER REGISTER SLIP JOINT DRIVE RODS - The outer register adjustment drive rod arms were identified during a previous outage as having thermal expansion and bowing problems restricting their on-line mobility. A slip joint modification was installed by B&W on all of the outer register drive rods which allows thermal expansion to occur, but is taken up by the slip joint. This avoids the effects of thermal expansion which has been causing gear misalignment and linkage binding.

OUTER REGISTER AUXILIARY DRIVE HANDLES - The heavy duty auxiliary outer register drive arm handles were removed by B&W on all burners previously equipped with this modification. The auxiliary drive handles were determined not to have been effective in providing enhanced outer register mobility.

SPIN VANE GEAR ASSEMBLIES - Spin vane drive gear assemblies had fly ash accumulation between the gear teeth preventing adjustment of the inner air registers which is necessary for tuning and improving flame stability and quality. This ash accumulation was scraped and wire brushed off during the outage.

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WINDBOX FLY ASH ACCUMULATION - Large amounts of fly ash accumulation has been found in the bottom of the first and third burner levels mainly between the third and fourth burners. Depths of up to 16 inches were vacuumed out during the outage.

BURNER FRONT GENERAL STATUS - Photos 63 through 66 show overall burner front views taken from the fireside of the boiler platform to document general status and condition of the burners. The front wall boiler platform is shown in Photo 65. The platforms were extremely useful for the burner front inspections and for determining diffuser wear and other problems. Why the ash accumulation in these areas and not in the other windboxes is unknown.

BURNER AIR REGISTER POSITIONS - Burner outer and inner (spin) register and back plate positions were documented immediately following the start of the outage for baseline information. These positions were reviewed by B&W and revised settings were determined to set registers prior to the completion of the outage.

The burner register setups were identical to those made during Unit 2's outage. Attached is a copy of B&W's Unit 2 memorandum documenting the final burner register positions. All previous register marking indications were painted over and new baseline reference markings were made.

BURNER PERFORMANCE TESTING - Burner turndown testing was scheduled after the unit was returned to service to verify burner flame quality and stability from minimum to maximum coal feed rates. Oxygen profiles are scheduled to be conducted by B&W and IPSC to complete tuning requirements of the combustion system.

RECOMMENDATIONS

BURNER INSPECTION/THIRD PARTY CONSULTANT - Due to the findings on Unit 1 with the overheating concerns on the burners, a third party boiler/burner expert should be utilized to make recommendations for future repair on the burners.

An independent analysis would be useful in approaching B&W on resolving overheat conditions, plus addressing other issues on the burners. Recommendations should consider; determination of remaining life, estimation on cost of repairs, time schedule if major repairs are required, recommendations on cooling air requirements and burner front temperature limits, additional instrumentation and control requirements and impact on boiler performance and its effect on unit heat rate.

Potential burner experts include; Bill Newkirk, B&W retiree who was involved in the original design and addressing the initial problems with the burners, RJM Corporation who specializes in burners and combustion modeling and tuning, plus any number of companies specializing in Boiler Life Extension.

BURNER INSPECTION/BOILER PLATFORM - The burner fronts should be inspected from the fireside of the boiler on an annual basis to identify potential burner problems. The small rear wall, three man platform should be used to assist with these inspections.

Unit 2 should be inspected at the earliest opportunity to determine general status of the burners. It has not yet had a boiler fireside inspection conducted on the burners.

CONICAL COAL DIFFUSERS - A replacement or refurbishment schedule needs to be established for the conical coal diffusers either based on burner front inspections (off the fireside boiler platform) or by systematic assignment.

Possible loss of a conical coal diffuser due to erosion, wear or cracking of the holding brackets or struts should justify thorough inspection during each available outage. Unit 2 has not yet had a burner front and diffuser inspection. Diffuser loss from inside the burner would result in increased coal flow to that burner due to loss of coal nozzle restriction compounding problems, plus starving flow to the other burners. Extremely poor flame quality or possible loss of flame and potential carbon carry over into the backpass areas would pose a fire explosion hazard.

Investigate hardened alloy or ceramic overlay material around the vertical struts to the diffusers to lengthen life and speed repair of the diffuser assemblies. Install wear clips on all existing, plus all new assemblies (before installation) to prolong wear life.

In addition, investigate repositioning coal deflectors on the burner coal nozzle to prevent concentrated wear on the upper struts of the diffusers that have shown accelerated erosion.

The bottom row diffusers on both front and rear wall burners require replacement to standard diffusers (Pulverizers 1B and 1G) due to plasma torch ignition system removal (16 total). Reference heading on the Plasma Torch Conical Diffusers.

Adequate replacement parts and materials need to be on hand for diffuser replacement or refurbishing on both units. These include diffuser assemblies, replacement cones, brackets, deflectors, wear clips, ceramic patch materials (for coal pipe elbow repair), gasket materials, etc.

PLASMA TORCH CONICAL DIFFUSERS - All 12 lower row burner coal diffusers (Pulverizers 1B and 1G) need replacement due to severe erosion. Return diffusers back to the standard design conical coal diffusers (solid type) from the present plasma torch hollow style.

This process involves removal of the ceramic lined elbows and permanently removing the ceramic lined plasma torch sleeves which are attached inside the elbow. The hollow conical diffusers and U-bracket support attachment at the end of the nozzle needs to be removed. The PT-style diffuser needs to be replaced with the standard conical coal design, noting any differences between the two designs.

Any ceramic repairs required on the coal line elbows when the sleeves are removed needs to be made. Also, a steel blank off plate should be bolted over the test tap on the elbow.

PLASMA TORCH SPARE PARTS - All plasma torch ignition system spare parts in the warehouse inventory should be exchanged with B&W for standard issue wear items on the burners or for reimbursement.

Some of these parts include the coal nozzle diffusers. The plasma torch style diffuser which is of hollow design should be exchanged or modified by B&W to a solid conical style diffuser.

PLASMA TORCH IGNITION SYSTEM - The additional plasma torch ignition system related components other than just the power supply cabinets should be checked out and removed if determined a potential threat to unit availability.

The primary concern involves the Bailey Control logic and wiring to the boiler combustion control system which interfaced with the plasma torch ignition system. This should be removed to eliminate any potential logic or grounding problems from occurring in the future. The plasma torch ignition system was installed on Unit 1 burner rows B and 1G only.

HD OUTER REGISTERS - The overheat and thermal expansion problems on the HD outer register assemblies should be considered a contractual issue with B&W and negotiated with them for resolution. Some type of retaining attachment, in the interim, needs to be added to the backplate to prevent structural failure of the outer register assembly.

Dropping burner front temperature limits to 1200 degrees F on the out-of-service burners would significantly help prevent additional damage from occurring. This item needs to be addressed with B&W due to the adverse impact on reducing boiler efficiency plus, making it more difficult to obtain superheat temperatures with an upper row pulverizer out-of-service.

BURNER OVERHEAT - The burner overheating and thermal expansion damage should be considered a contract deficiency item with B&W and left to them for resolution.

Reducing cooling air flow requirements from 1350 degrees F to 1200 degrees F to out-of-service burners, should reduce further damage from occurring. Again note; increasing air flow requirements for out-of-service burners will significantly impact boiler performance. Increasing cooling air on the top level burners especially at the lower load operation with multiple burner levels out-of-service greatly increases overall secondary air flow requirements for cooling air demand, thus greatly increasing excess air and dry gas losses.

Resolution should be sought from B&W for any changes to burner front temperature limitation, so that compensation for any performance degradation resulting from these temperature changes can be adequately addressed. Also, a final excess air versus firing rate curve is required from B&W to establish final cooling air flow requirements against the number of pulverizers out-of-service.

THROAT SLEEVE CASING RINGS AND SEAL - This item should be taken up with B&W as a long term continuing contractual warranty deficiency item and put to them for final resolution and repair.

All throat sleeve casing rings should be reattached where there are any broken welds to prevent a failure similar to that on Burner 1C04. Reference Burner 1C04 Throat Ring Casing heading under Observations and Work Accomplished.

An air tight seal should be reestablished either with the original design utilizing rope packing or with an equivalent design such as a leaf spring type seal. This seal is to prevent secondary air from bypassing the burner and combustion zone and entering as casing air leakage which has adverse effects on combustion tuning and balancing.

The overheat problem on the throat sleeve casing ring could be improved by lowering the burner front temperatures on out-of-service burners. Note; previous stated concerns on lowering temperatures and their impact on boiler performance.

REGISTER HANDLES - Modify outer and inner (spin) register handles to prevent handles form vibrating and working loose form their preset positions. This problem has been attributed to several burner and scanner alarms for poor flame quality or complete lose of flames. Build up tip of handle locking latch (with a weld bead) to provide a more positive anchoring point. This item is a safety issue since it has the potential of causing flame instability and flame out condition which could lead to a possible boiler explosion.

Drill out register handles to allow installation of a paddle lock to prevent tampering of preset register positions. Order and install locks with a common key (Unit 2 already has this modification completed only on the outer register handles).

Check all hexagon set screws on the register drive handles to verify they are functional. There has been a problem in the past with these screws working out (due to vibration from the pulverizers) allowing the register handles to move. Also, some of these screw holes have been stripped or the set screws are bound or locked up. Drill and retap those screws that have problems so that all registers are functional for future combustion tuning requirements.

OUTER REGISTER MECHANICAL STOPS - The outer register drive assemblies need mechanical stops installed. This will prevent over stroking of the register damper linkage which causes immobility of the register in a locked open position.

BURNER FLAME SIGHTGLASSES - The inspection or observation port sightglasses located at the burner front need to be cleaned, during an outage, to maintain their clarity for visual inspection on verifying and troubleshooting fuel oil and coal flames.

SPIN VANE GEAR ASSEMBLIES - Inspect and clean any fly ash accumulation between the gear teeth assemblies of the spin vane (inner air) registers. This accumulation prevents problems while the unit is on line. The fly ash accumulation can be scraped and wire brushed off.

BURNER THERMOCOUPLE UPGRADE - Complete external hookup of the temperature measurements for the burner fronts from the junction box on the windbox to the information computer FIO. Reformat existing Foxboro 1A screens to represent all (48) burners with outer register backplate and coal nozzle tip temperatures only. Note; this item will be covered by a Construction Modification Package (CMP).

This upgrade was necessary for monitoring cooling air flow requirements to out-of-service burners by providing more information on overheat conditions, plus for the detection of burner line coal fires on any of the burner lines.

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Unit 2 needs the same thermocouple modification made to the burners. Currently, only every other burner has any temperature indication. See enclosed drawing markups for thermocouple locations.

BURNER FRONT TEMPERATURE ALARMS - Investigate lowering stainless steel burner front temperature alarm limits from 1350 degrees F to 1200 degrees F. In an attempt to keep the burners from overheating and burning up, increase minimum cooling air flow requirements to the out-of-service burners. As previously discussed, this will significantly reduce boiler efficiency.

By increasing burner cooling air flow requirements, the secondary air requirements increase which in turn increases the dry gas loss out the stack, increases the air leakage losses (since the additional air is not combustion air), plus also increases FD and ID fan horsepower requirements.

In addition, with the upper burner rows out-of-service, it is difficult to make main steam temperatures. The additional cooling (leakage) air enters and acts as blanketing air over the secondary superheat platens (although this is an excellent NO_x reduction technique). At lower loads, this problem compounds itself because with multiple pulverizers out-of-service, that much additional cooling air flow is required.

LIGHTER SHROUDS - Inspect lighter shrouds from the fireside of boiler off the boiler platform in future outage inspections to repair or replace any broken U-straps and attachment welds. This is to prevent shrouds from falling out into the fireside of the boiler.

Increasing cooling air requirements to out-of-service burners will also reduce overheating conditions on the shrouds, attachments and on the inner air sleeve.

LIGHTERS - Maintain original weekly Preventative Maintenance Program on the lighters and sparkers to ensure adequate lighter availability and reliability. Also, during each and every outage all lighters should be PM'd due to their heavy reliance and usage on start-up after an outage. The availability of lighters and sparkers are critical on maintaining unit start-up schedules.

Entire lighter assemblies should be pulled annually for checkout and cleaning. Cooling air flow holes should be checked and cleaned to ensure adequate cooling. Fuel oil valves should be repaired if any evidence of oil leakage is occurring on the lighter assemblies.

SCANNERS - Care must be taken when shooting off eyebrows and slag on furnace walls with a shotgun (on unit shutdowns prior to an outage) to prevent damage to scanners and lighters.

Scanners should be PM'd annually during available maintenance outages. Grounding problems with the scanners need to be resolved to eliminate scanner malfunctions (flame detection without burner group inserted). This item should be given top priority and handled as a safety issue.

INNER AIR SLEEVE ASH DEPOSITS - Investigate increasing windbox duct pressures on both in-service and out-of-service burner rows to increase velocities across the spin vanes to prevent ash deposits and fallout from occurring on the tip of the inner air sleeves.

WINDBOX FLY ASH ACCUMULATION - Vacuum fly ash accumulations in the bottom of the burner windboxes during maintenance outages. Typically, problems exist on the first and third burner levels (Pulverizers 1B, 1G, 1A and 1H) between the second and fourth burners. Also, investigate the cause and resolve the problem.

COAL DUST ON BURNERS - Coal dust, exterior to the windbox on the burner fronts that settles out on the coal nozzles, elbows, lighters, sparkers, scanners, burner lines, etc., poses an extreme fire hazard and should be cleaned up thoroughly during each available outage. Locate and repair all sources of coal leaks during these outages. Most coal leaks are at coupling locations along the coal burner lines.

INNER AND OUTER REGISTERS - Verify during major outages that all outer and inner (spin vane) air registers are moveable and in proper working condition. Inspect all linkages and gear assemblies and stroke to verify movement. Also, clean any ash or slag deposits accumulated around the spin vanes located in the inner air sleeve which may disrupt air flow and impair flame stability.

BURNER AIR REGISTER SETTINGS - Immediately following outage shutdowns, when the windboxes are accessible for inspections (prior to any burner work activities), document the inner (spin vane), outer and backplate air register positions. This information will be used to determine if any changes have been made while the unit was on-line and if potential problems have developed because of these outage.

Investigate elevating windbox pressures to two to three inches water column (positive) by pinching down the inner, outer and backplate registers. This should increase velocities through the registers and help prevent ash and slag accumulations on the inner air sleeve. Hopefully, this will also improve the overall combustion and oxygen profiles and balancing.

After all outage work activities on the burners are complete, reset and verify final register position settings. Document these final settings and mark with ink pen the outer register handle positions if different from previous settings.

BURNER PERFORMANCE AND COMBUSTION TESTING - Conduct burner/pulverizer turndown testing immediately following outages to verify flame stability and balancing through each feeders load range. Also check out scanner setup and alignments and resolve any instability or sighting problems. Oxygen profiles should also be conducted shortly thereafter to ensure all combustion and burner performance requirements have been met.

SECONDARY AIR FOIL CHECKS - The I&C Department, on an annual basis, should conduct an air leak test on the secondary air foils to verify there is not a leakage problem in the instrumentation lines that could effect combustion air flow measurement and control.

WINDBOX DAMPER CHECKOUT - I&C should also stroke all secondary air windbox dampers annually to confirm proper linkage alignment, damper position indication (checked with angle finder), cold clearance settings and full range of motion.

PRIMARY AIR FLOW CALIBRATION AND CHECKOUT - Annual checks should also be made during outages on the primary air flow averaging probes and instrumentation lines. Air pressure checks from the probes to the instrumentation cabinets would verify that no leakage points exist.

Calibrations should also be made (annually) on the primary air flow transmitters to verify proper air flow velocities through the pulverizer and coal burner lines. The calibration checks, utilizing a fechheimer probe and VPAS (velocity/pressure averaging analyzer), should be done with the unit on line. Engineering Services has the necessary equipment to conduct the calibrations.

COMPARTMENTALIZED AIR FLOW MEASUREMENT - Compartmentalized windbox secondary air flow measurement should still be investigated as having merit in monitoring, controlling and balancing combustion and cooling air requirements to the burners.

An industrial grade hot wire anemometer such as the Kurtz EVA system could have application for this situation. We would like to recommend a system set up on a trial basis on a top row rear burner level on Unit 1 (where the HD outer air registers are installed) to determine the effectiveness of such a system.

BURNER PRINTS UPDATED - B&W needs to supply updated prints on the final burner assemblies showing all modifications. These items include in part; burner nozzle tip modifications, lighter shroud assembly modifications, thermocouple placement, HD outer register upgrade, register drive handle slip joints, outer register linkage stops, inner and outer register handle paddle lock attachment, thermal expansion modification for outer air sleeve assembly, recommended final register position set up, etc.

IP7_000376

INTERMOUNTAIN POWER SERVICE CORPORATION

Engineering Test and Inspection Sheet

Equipment Burners and Windbox Unit # 2 Test/Inspect. Date Oct. 27-28, 1991

Inspector Cecil James Responsible Engineer (Initials) _____

Item or Test	Observations/Comments	Recommendations
Extensive modifications performed this outage to all Unit 2 burners include: 1) Remove 7 inches from the inner air sleeve tip 2) Remove 4 inches from the lighter shroud 3) Install an inner air stabilizer provided by RJM Corporation 4) Install a shroud around the outer air register 5) Install prescribed restrictors in selected burner lines		
Modifications were implemented to improve air distribution and aerodynamics through the windboxes and burners. Stabilizers were installed to mitigate furnace gases from licking back into the burner throat area, see photos 1 - 3. Shrouds were installed to balance the air flow from burner to burner, see photo 4. RJM provided technical assistance and measuring instrumentation in the air flow balancing.		
All burner elbows, diffusers, and deflectors were removed for the air flow tests. Nozzle tip deformation was determined using a go-no go gauge to assure nozzle conformance for the stabilizer installation. Eleven nozzles were changed out for reasons stemming from severe distortion, holes at the tip, and weld seam cracking. All diffusers were measured for comparison with measurements taken the fall, 1990 Unit 2 outage. Results from the comparisons are included with this report. 37 of 48 diffusers had erosion holes in the top portion of the cone. A total of 24 diffusers were replaced.		
Twenty five burner lines received new or modified restrictor spools. Previous clean air flow tests indicated flow deviations as high as 11.2 percent. Restrictor change outs were performed to balance primary air within 5 percent. Restrictors were not made according to IPSC drawings. The restrictor exit did not have a 30 degree bevel, as recommended by B&W. Calculations found the pressure losses due to the abrupt enlargement to be negligable as compared to losses incurred with a 30 degree bevel, so the restrictors were installed in the as received condition.		
A windbox side inspection was conducted October 27 and 28, during which, the following items were examined: a. Outer air registers b. Spin Vanes/ Backplate c. Register drive linkages d. Burner casing seal e. Thermocouples f. Windbox dampers g. Scanner sight tubes		
The following information details burner defects and deficiencies found during inspections, diffuser inspection and diffuser strut (top and bottom) measurements, and restrictor modifications performed on each respective burner line.		
B1	3/4" hole in cone. Top: 1-7/8", Bottom: 5-3/4" Restrictor changed to 18" ID.	New diffuser 11/91
B2	Ceramic diffuser. Top: 8-3/4", Bottom: 8-3/4"	

IP7_000377

INTERMOUNTAIN POWER SERVICE CORPORATION

Engineering Test and Inspection Sheet

Equipment Burners and Windbox Unit # 2 Test/Inspect. Date Oct. 27-28, 1991

Inspector Cecil James Responsible Engineer (Initials) _____

Item or Test	Observations/Comments	Recommendations
B3	1/2" hole in cone. Top: 3-1/8", Bottom: 6-1/2" Restrictor changed to 18" ID.	New diffuser 11/91
B4	1-1/4" hole in cone. Top: 4-1/8", Bottom: 6-1/8"	New diffuser 11/91
B5	1-1/2" hole in cone. Top: 4-1/8", Bottom: 6"	New diffuser 11/91
B6	1/2" hole in cone. Top: 4-1/4", Bottom: 6-3/8"	
F1	1/8" hole in cone. Top: 5", Bottom: 7"	
F2	Outer register is warped, see photo 5. 3/8" hole in cone. Top: 5", Bottom: 7-1/4" Installed 20" ID restrictor.	
F3	1/4" hole in cone. Top: 3-1/2", Bottom: 6-1/4" Installed 20" ID restrictor.	New nozzle 11/91
F4	Isolation valve will not close 100 percent. See photo 6. Spin vane (7:00 position) is bent. 3/8" hole in cone. Top: 3-3/4", Bottom: 6-3/8"	Valve repaired 11/91 Spin vane replaced 11/91 New nozzle 11/91
F5	Spacer bar weld crack (10:00 position). Broken diffuser. Top: 4-1/4", Bottom: 6"	New nozzle 11/91 New diffuser 11/91
F6	1/4" hole in cone. Top: 3-3/4", Bottom: 6"	
A1	3/8" hole in cone. Top: 3-1/8", Bottom: 6-1/4" Installed new 20" ID restrictor.	New diffuser 11/91
A2	3/4" hole in cone. Top: 3-1/2", Bottom: 6-1/8" Restrictor changed to 18" ID.	
A3	Outer register vanes are seized up. Ceramic diffuser. Top: 8-5/8", Bottom: 8-3/4"	

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INTERMOUNTAIN POWER SERVICE CORPORATION

Engineering Test and Inspection Sheet

Equipment Burners and Windbox Unit # 2 Test/Inspect. Date Oct. 27-28, 1991

Inspector Cecil James Responsible Engineer (Initials) _____

Item or Test	Observations/Comments	Recommendations
A4	Spin vanes will not open 100%. 1/8" hole in cone. Top: 3-1/4", Bottom: 6-7/8" Installed new 20" ID restrictor Nozzle had split weld seam and holes at tip. See photo 7.	New nozzle 11/91
A5	Ceramic diffuser. Top: 8-5/8", Bottom: 8-5/8"	
A6	1-3/8" hole in cone. Top: 1-1/2", Bottom: 4-7/8"	New diffuser 11/91
E1	Broken cone. Top: 2-3/4", Bottom: 6-3/8" Installed new 20" ID restrictor.	New diffuser 11/91
E2	Ceramic diffuser. Top: 8-5/8", Bottom: 8-5/8"	
E3	Outer register vanes are seized up. Ceramic diffuser. Top: 8-1/2", Bottom: 8-5/8" Restrictor changed to 19" ID.	
E4	Outer register vanes are seized up. 1/2" hole in cone. Top: 3-1/4", Bottom: 5-3/4" Restrictor changed to 18" ID.	New diffuser 11/91
E5	1-1/4" hole in cone. Top: 2-1/8", Bottom: 5-5/8" Restrictor changed to 18-1/2" ID.	New diffuser 11/91 New nozzle 11/91
E6	No hole. Top: 3-3/4", Bottom: 5-7/8" Restrictor changed to 17-1/2" ID. Hole in nozzle wall adjacent to diffuser. See photo 8.	New nozzle 11/91
G1	2" hole in cone. Top: 3-1/2", Bottom: 7"	New diffuser 11/91
G2	2-3/4" hole in cone. Top: 2", Bottom: 6-7/8"	New diffuser 11/91
G3	1/2" hole in cone. Top: 3-3/4", Bottom: 6-1/4"	
G4	1/8" hole in cone. Top: 1-1/2", Bottom: 6-1/2"	New diffuser 11/91
G5	1/8" hole in cone. Top: 3-3/4", Bottom: 6-7/8" Restrictor changed to 19" ID.	

IP7_000379

INTERMOUNTAIN POWER SERVICE CORPORATION

Engineering Test and Inspection Sheet

Equipment Burners and Windbox Unit # 2 Test/Inspect. Date Oct. 27-28, 1991

Inspector Cecil James Responsible Engineer (Initials) _____

Item or Test	Observations/Comments	Recommendations
G6	Ceramic diffuser. Top: 8-5/8", Bottom: 8-5/8"	
C1	1-5/8" hole in cone. Top: 4-1/2", Bottom: 6-1/2"	New diffuser 11/91
C2	Ceramic diffuser. Top: 8-1/2", Bottom: 8-3/4"	
C3	1/8" hole in cone. Top: 6-3/8", Bottom: 6-3/4"	
C4	3/8" hole in cone. Top: 4-1/4", Bottom: 6-3/4" Installed new 20" ID restrictor.	New nozzle 11/91
C5	1/4" hole in cone. Top: 3-7/8", Bottom: 6" Installed new 20" ID restrictor.	
C6	Spin vanes are bound up. Broken diffuser. Top: 2-7/8", Bottom: 6" Nozzle wall at alloy weld joint bulged approximately 1/2". See photo 9.	New nozzle 11/91 New diffuser 11/91
H pulverizer was oos recieving new rotating throats. During which, considerable ash accumulated in the nozzle tips. See photo 10.		
H1	1" hole in cone. Top: 2-7/8", Bottom: 5" Installed new 20" restrictor.	New diffuser 11/91
H2	Broken ceramic diffuser. Top: 8-3/8", Bottom: ?	New diffuser 11/91
H3	1-1/2" hole in cone. Top: 1-3/4", Bottom: 6-3/8" Installed new 20" restrictor.	New diffuser 11/91 New nozzle 11/91
H4	1-1/4" hole in cone. Top: 4-1/4", Bottom: 5-1/2" Restrictor changed to 18" ID.	New diffuser 11/91 New nozzle 11/91
H5	1-1/2" hole in cone. Top: 3", Bottom: 6" Restrictor changed to 17-1/2" ID.	New diffuser 11/91
H6	1" hole in cone. Top: 1-3/4", Bottom: 6-1/2" Restrictor changed to 17-1/2" ID.	New diffuser 11/91
D1	Spin vane gears (12:00 position) not meshing. 1/2" hole in cone. Top: 3-1/4", Bottom: 6-3/4" Restrictor changed to 17" ID.	New diffuser 11/91

IP7_000380

INTERMOUNTAIN POWER SERVICE CORPORATION

Engineering Test and Inspection Sheet

Equipment Burners and Windbox Unit # 2 Test/Inspect. Date Oct. 27-28, 1991

Inspector Cecil James Responsible Engineer (Initials) _____

Item or Test	Observations/Comments	Recommendations
D2	3/4" hole in cone. Top: 4-1/2", Bottom: 5-1/2" Restrictor changed to 18" ID.	
D3	1/4" hole in cone. Top: 4-1/2", Bottom: 5-3/4" Restrictor changed to 18" ID.	
D4	Ceramic diffuser. Top: 8-1/2", Bottom: 8-5/8" Restrictor changed to 18-3/4" ID.	
D5	5/8" hole in cone. Top: 3-1/4", Bottom: 5-1/2" Installed new 20" ID restrictor.	New diffuser 11/91
D6	Spin vanes are bound up. Broken ceramic diffuser. Top: 8-1/2", Bottom: 8-5/8"	New nozzle 11/91 New diffuser 11/91

IP7_000381

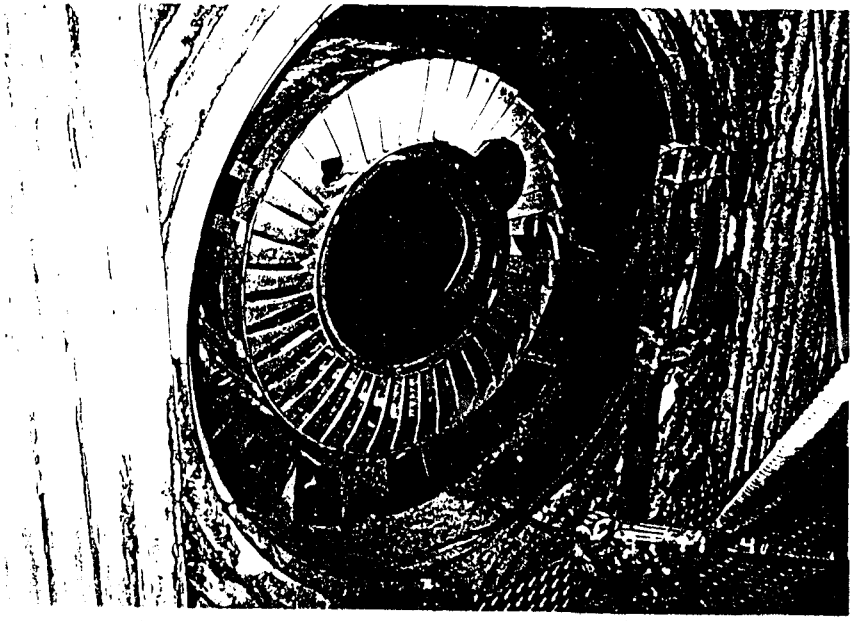


Photo #1: RJM Stabilizer.

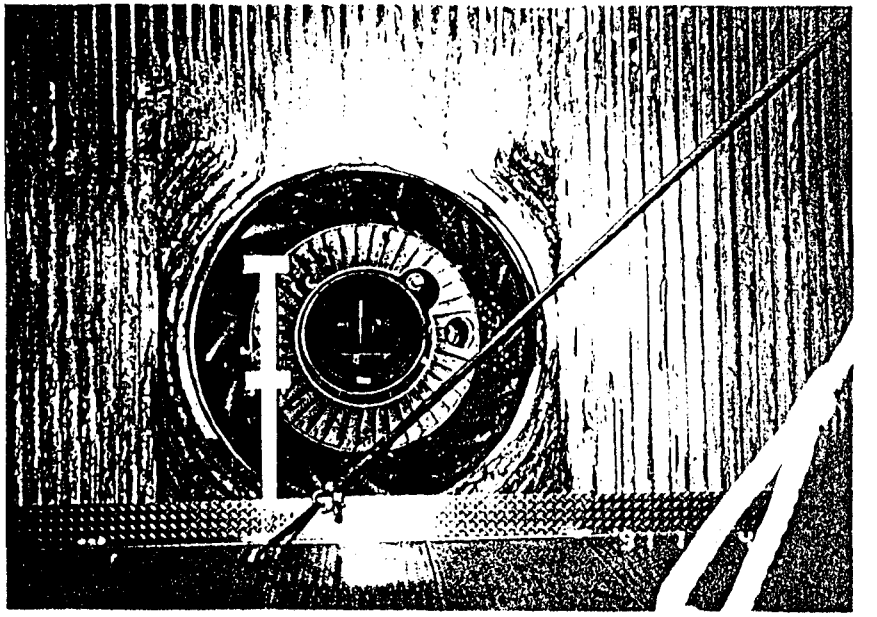


Photo #2: RJM Stabilizer.

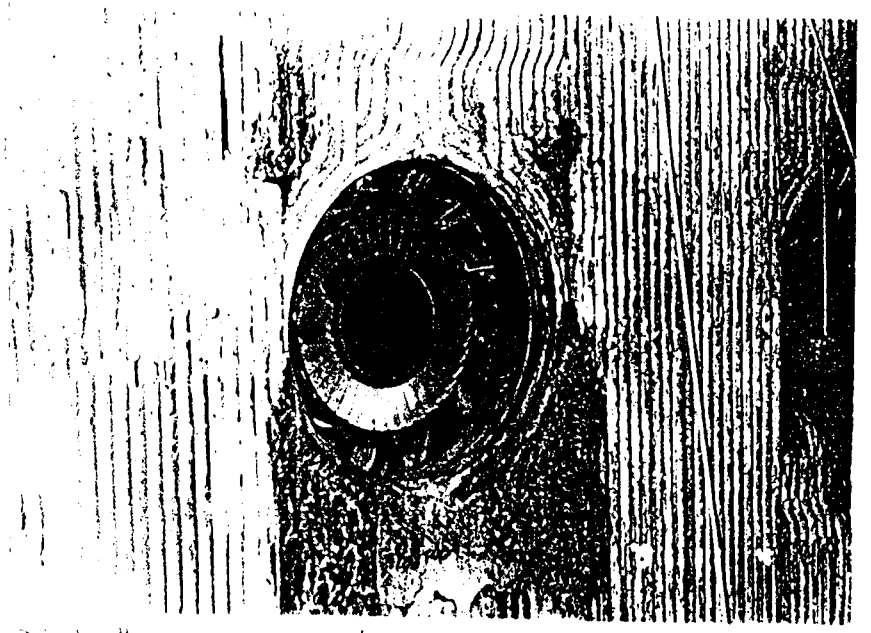


Photo #3: RJM Stabilizer.

Photo #4: Outer Air Register Shroud.

IP7_000382

Photo #5: F2 Warped Outer Register.

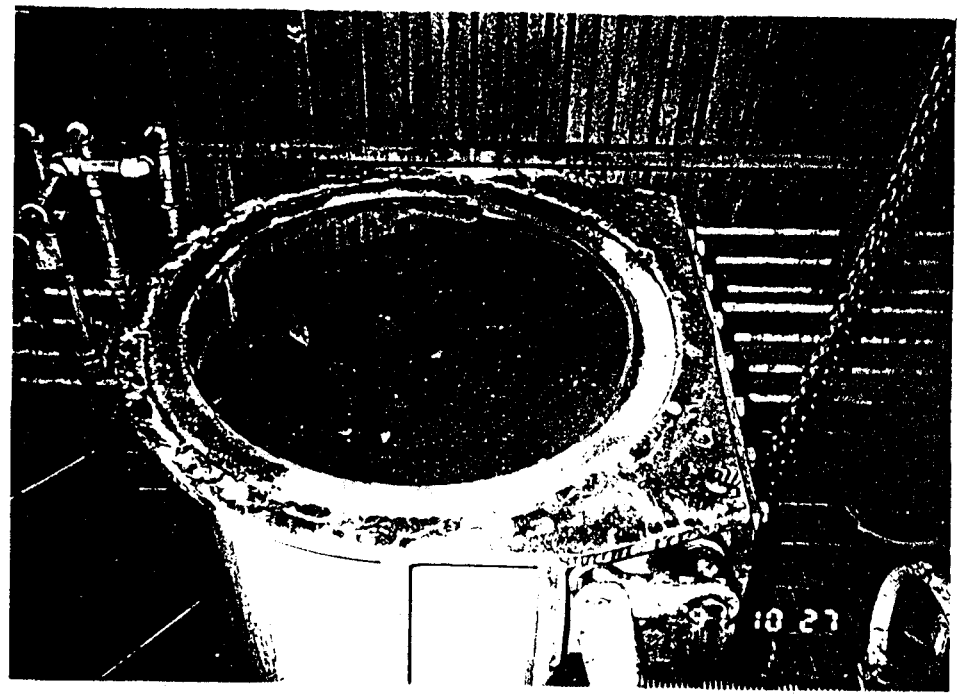
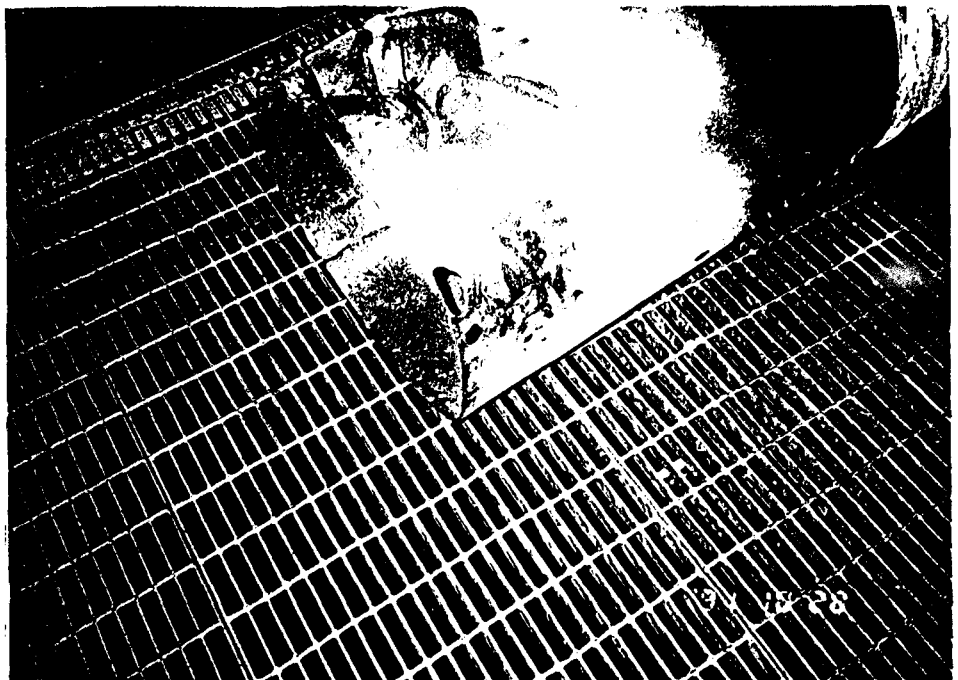
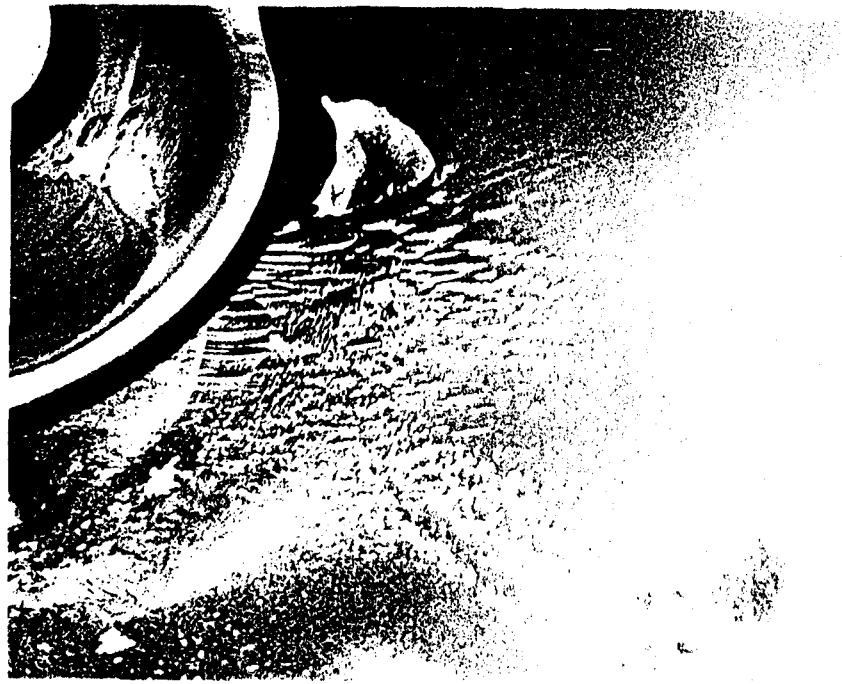


Photo #6: F4 - Isolation Gate Fails to Close 100 percent.

IP7_000383



Photo#7: A4 Nozzle tip is split and has holes.



Photo#8: E6 - Hole in nozzle wall adajacent to diffuser.

IP7_000384

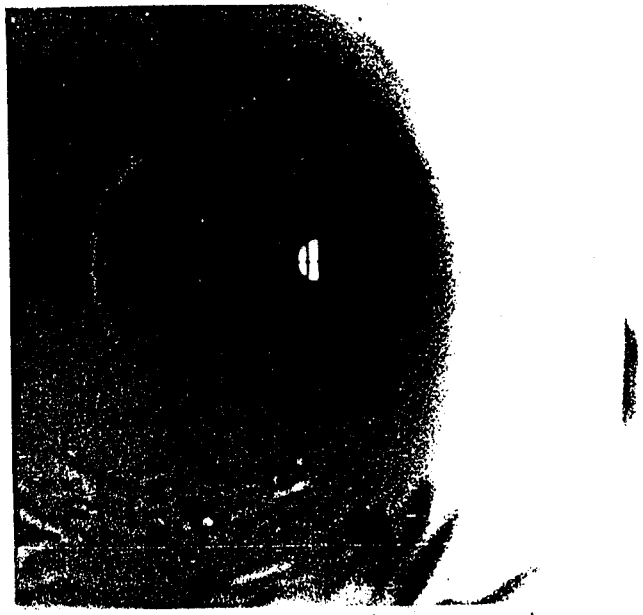


Photo #9: Nozzle wall bulges at alloy joint, C6.

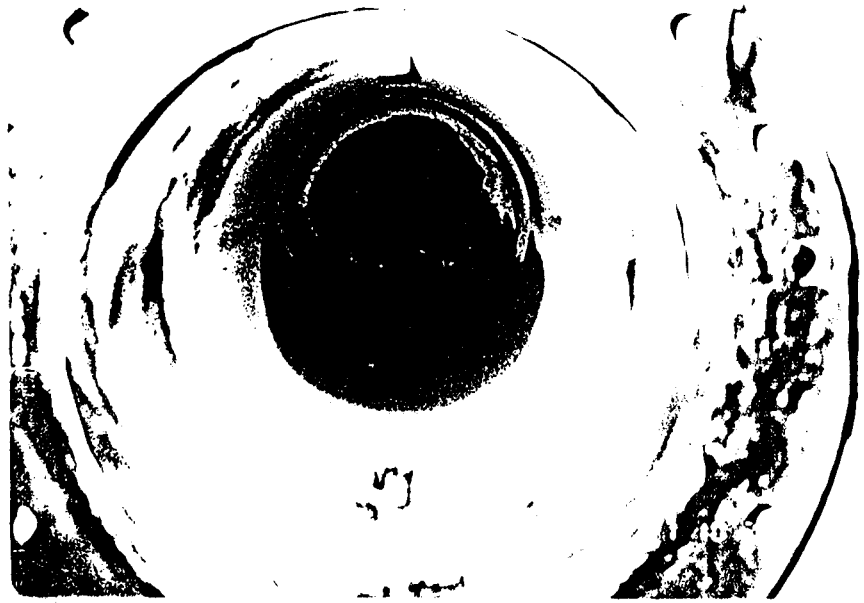


Photo #10: All H burners, Ash accumulated at nozzle tip in out of service burners.

IP7_000385

INTERMOUNTAIN POWER SERVICE CORPORATION

Engineering Test and Inspection Sheet

Equipment Burners and Windbox Unit # 1 Test/Inspect. Date April 11, 1992

Inspector Cecil James Responsible Engineer (Initials) _____

Item or Test	Observations/Comments	Recommendations
Unit 1 burner work is identified as capital project IGS91-3.		
New Burners Installed All Unit 1 burners were replaced with new B&W burners including new diffusers, deflectors, and nozzles. The new burners have the fundamental design features of the original burner design with the following exceptions: 1. The outer register back plate is segmented to allow movement as thermal stresses rise. 2. All burner parts are 309 stainless steel except the outer register front plate which is 304 stainless steel. 3. All burner parts exposed to radiant heat was designed thicker to provide more rigidity. 4. A second support channel was added to the outer register back plate and one to the outer register front plate. 5. Linkages to the outer register vanes and the inner air spin vanes are a heavy duty (HD) type. The HD type linkages used on the original burners were reliable and required little maintenance. 6. A single angle brace from the top of the outer register back plate to the burner casing was installed to prevent the outer register back plate from deforming backwards. 7. A second observation port was placed in the outer air zone. The scanners in the F row were installed in these new ports to see if flame detection could be improved.		
Old Burner Condition The original burners removed from the windboxes incurred extensive nozzle damage particularly G, B, and E burners. See photos 1 - 6. These burners never gave any indication of nozzle fires while in service and the nozzles show limited oxidation. Other burner components show little damage since the last outage.		
Flyash Accumulation in Windbox Flyash accumulation in the B, A, G, and H windboxes appear greater than normal. See photos 7 and 8.		
Burner Isolation Gates All burner isolation gates were removed for burner work. Most gates failed to retract completely from the coal path in the 100 percent open position which resulted in gate and gate-seat wear, see photos 9 and 10. The erosion on the gates prevented a complete seal when the gate was 100 percent closed, see photos 11 and 12.		
Air Flow Tests Adjustable shrouds were placed across the outer registers and back plates were tuned in conjunction with data from Air flow tests on the inner and outer secondary air zones. Results show air flow improved to ±10 percent maximum deviation from burner to burner.		

IP7_000386

INTERMOUNTAIN POWER SERVICE CORPORATION

Engineering Test and Inspection Sheet

Equipment Burner and Windbox Unit # _____ Test/Inspect. Date April 11, 1992

Inspector Cecil James Responsible Engineer (Initials) _____

Item or Test	Observations/Comments	Recommendations
Burner Line Restrictors	Certain burner line restrictors were scheduled for modification in an effort to balance primary air flow, photo 13. 23 restrictors were selected but only nine were completed. Asbestos gaskets were found in some restrictor joints, see photo 14. Since no one was prepared for an asbestos abatement procedure, the restrictors that were disassembled were re-installed in it's original location.	

Completed restrictor work was limited to the following:

Burner Line	Old Restrictor Size (ID inches)	New Restrictor Size (ID inches)
A1	21	20
A4	21	20
C4	21	19
C5	21	20
D1	17.5	18
D5	21	20
G4	18.38	18
G6	18.38	18
H3	21	20

All further restrictor work will be scheduled to coincide with future pulverizer maintenance.

IP7_000387

Photo 1: B Row Burner Deformation

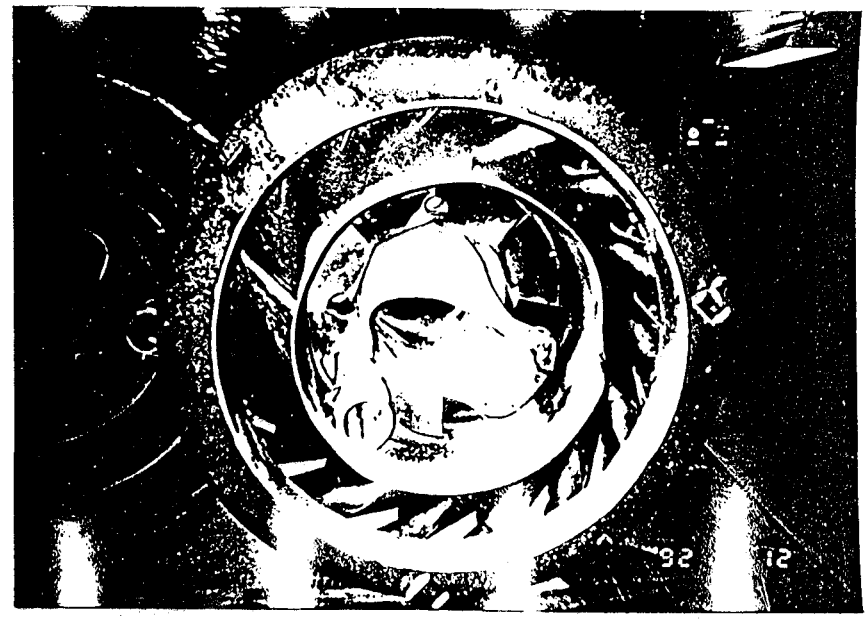


Photo 2: G Row Burner - Severe Nozzle Deformation

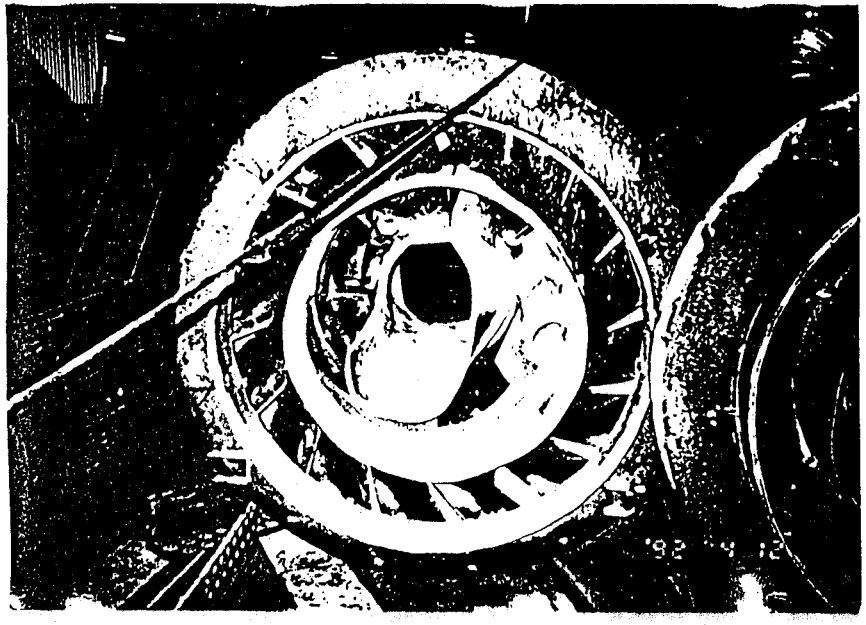


Photo 3: G Row Burner - Severe Nozzle Deformation

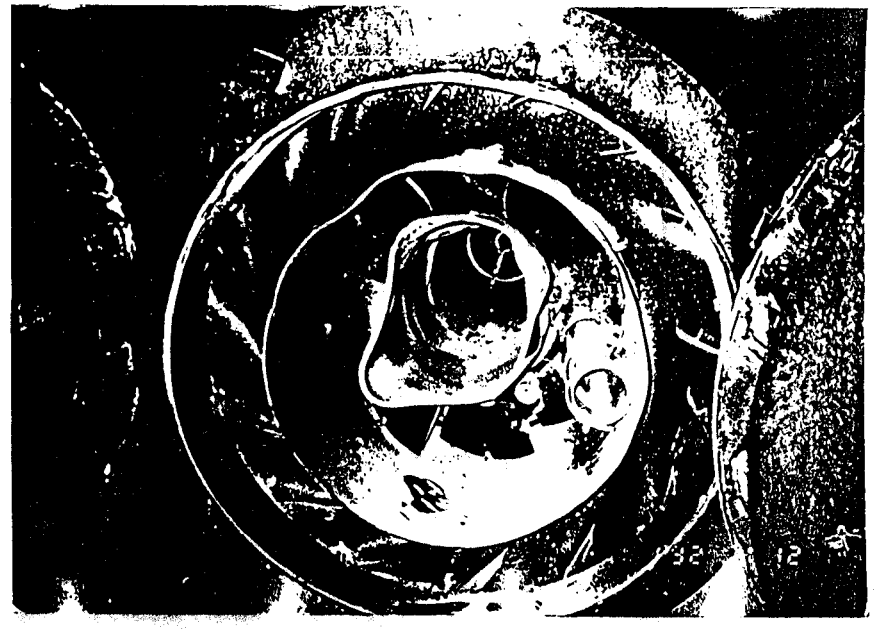


Photo 4: G Row Burner - Severe Nozzle Deformatio

IP7_000388

Photo 5: Severe Nozzle Deformation

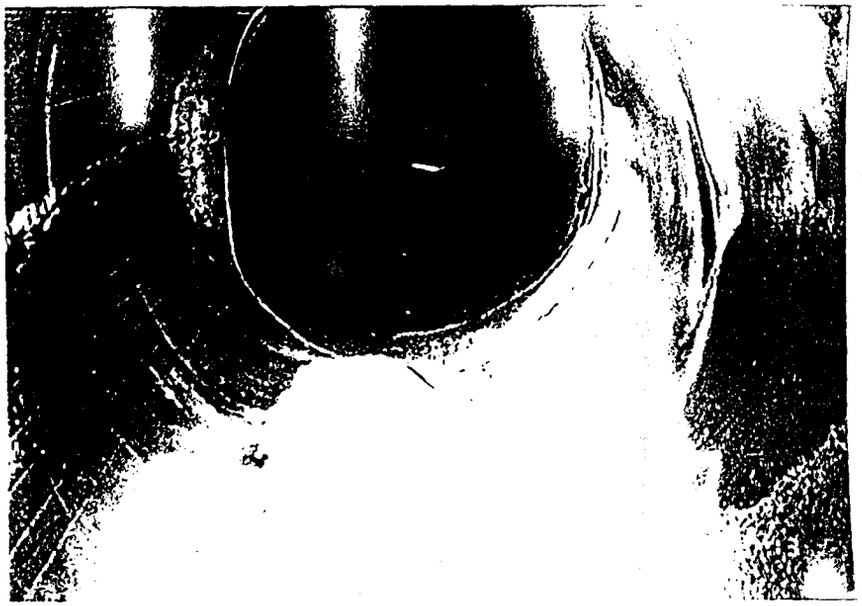


Photo 6: Severe Nozzle Deformation

Photo 7: Flyash Accumulation - A Row

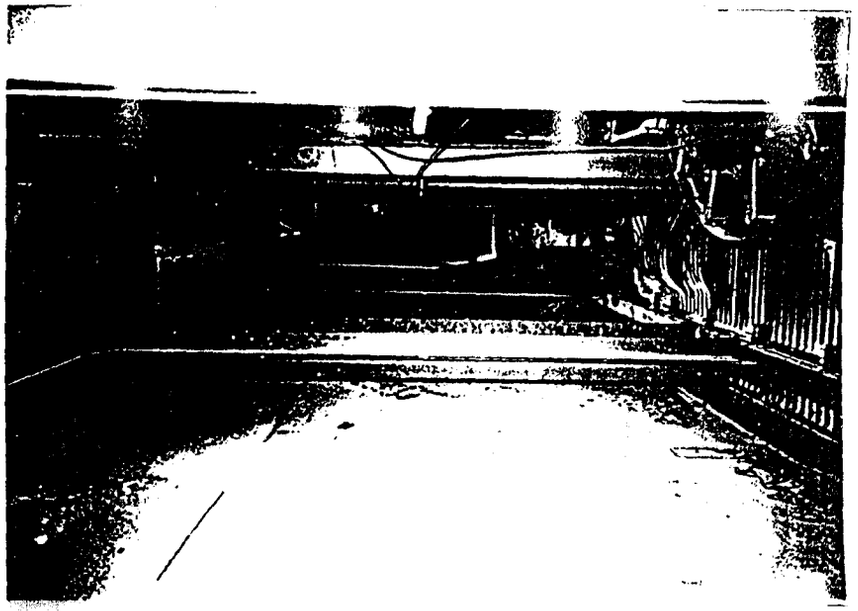


Photo 8: Flyash Accumulation - B Row

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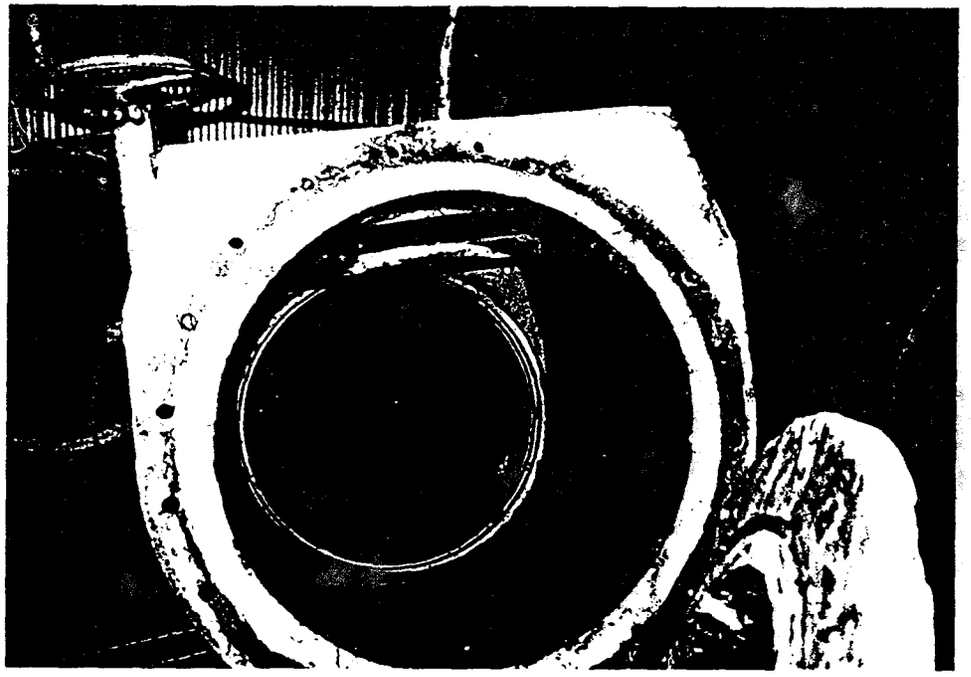


Photo 9: Isolation Valve - Gate Open But Still in Coal Path

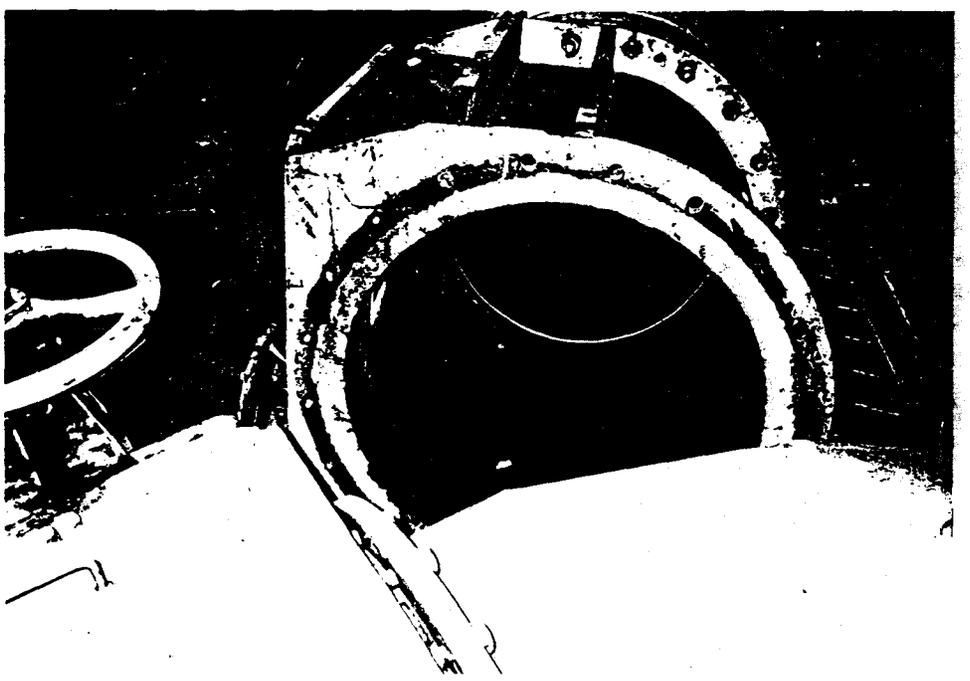


Photo 10: Isolation Valve - Gate Open But Still in Coal Path

IP7_000390

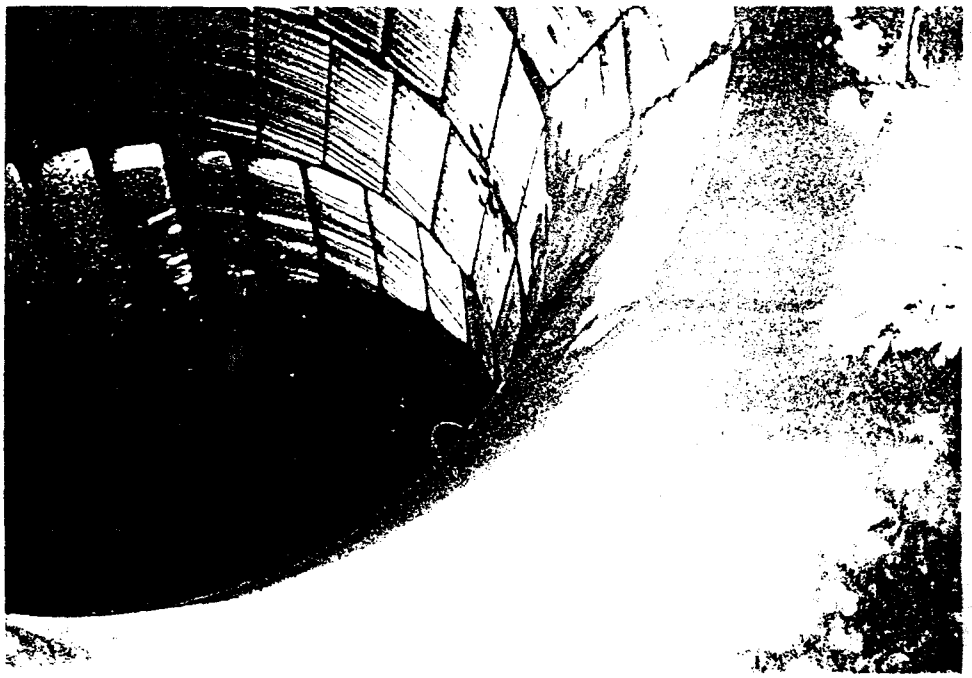


Photo 11: Isolation Valve - Gate Will Not Close Completely

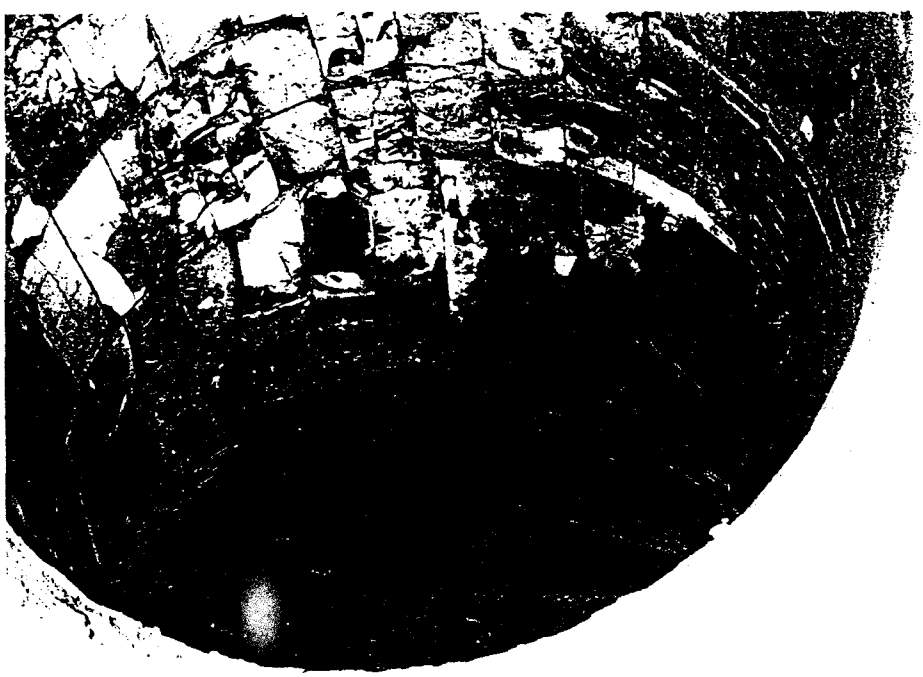


Photo 12: Isolation Valve - Gate Will Not Close Completely

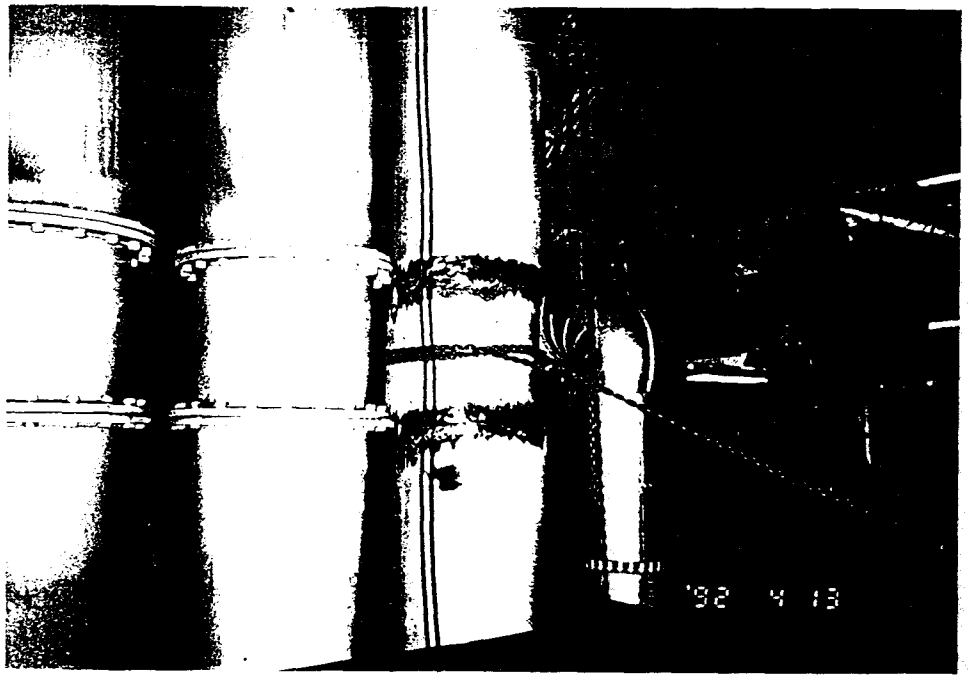


Photo 13: A1 Restrictor Installation

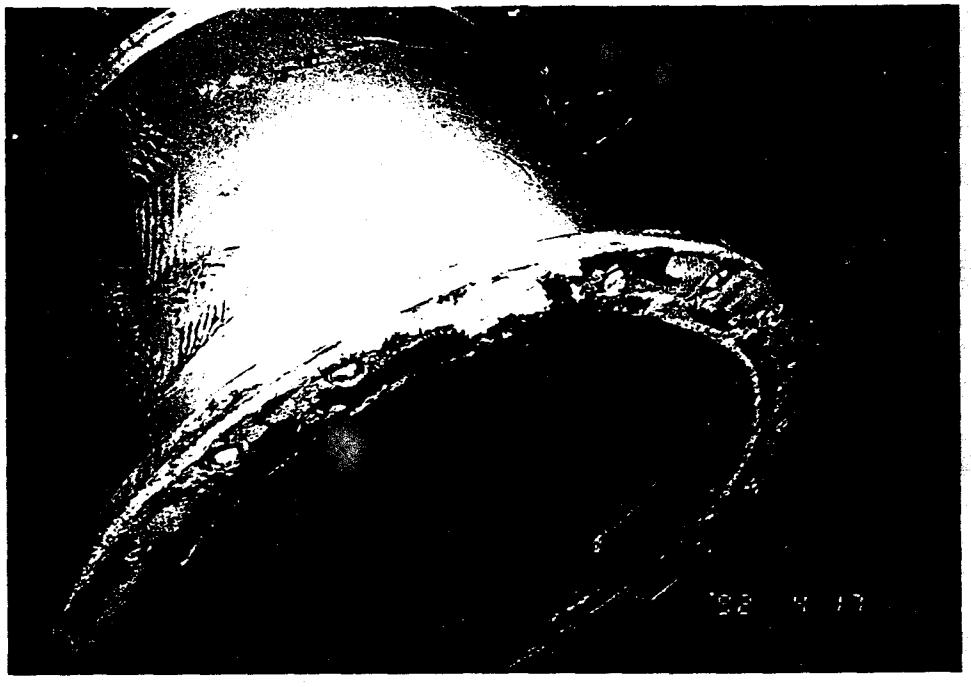


Photo 14: Asbestos Gasket - D4 Restrictor

INTERMOUNTAIN POWER SERVICE CORPORATION

Engineering Test and Inspection Sheet

Sheet ___ of ___

Equipment Burner and Windbox Unit # 2 Test/Inspection Date November 2, 1992

Inspector Garry Christensen and Cecil James Responsible Engineer (Initials) _____

Item or Test	Observations/Comments	Recommendations
All burners were inspected from the windbox side and on the fire side from the platform. The following defects and deficiencies were noted:		
B6	Small holes in the inner air sleeve just behind the back outer register plate at the 3:00 position.	Check next outage window for additional hole growth and inner air sleeve stability.
F2	The west half of the outer register has bowed back. See photo 1.	
F3	Nozzle has dropped far enough to contact the spin vanes but no the stabilizer.	Check next outage window if nozzle continues to drop and impinge on the stabilizer.
F4	The outer register has a sharp, short bow at the vane adjuster arm. See photo 2.	
A5	The nozzle has a 12 inch split at the weld seam. The nozzle has slipped behind the stabilizer's inner ring and is twisting the stabilizer as it heats and grows. See photo 3.	Nozzle replaced.
E4	The nozzle is starting to split at the weld seam.	
C6	The backplate push rod has cracked at the joint with the backplate resulting in the backplate sucking up into the inner air sleeve restricting inner air flow. See photo 4. The crack is circumferential and along the bottom half of the rod.	Rod repaired and reinforced. Install backplate hardstops on all burners so backplates will fail to a two inch air flow path.
H2	Backplate push rod failure similar to C6. The nozzle has deformed and split at the weld seam.	Rod repaired and reinforced.
H4	The nozzle tip has deformed.	
H6	The nozzle tip is starting to split at the weld seam.	
D1	Backplate push rod failure similar to C6.	Rod repaired and reinforced.

IP7_000393

← **Photo 1:** F2 burner--west half of outer register has bowed back and broken welds

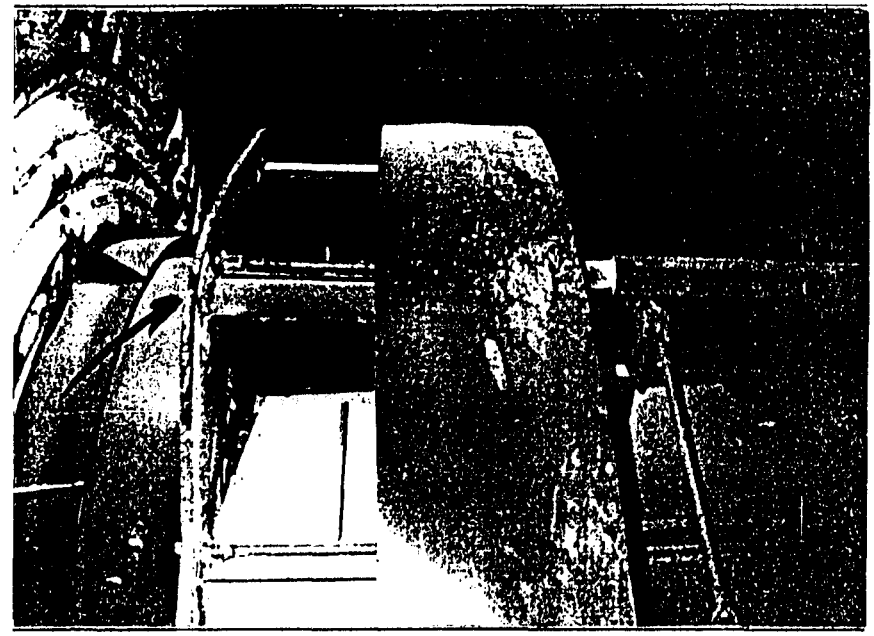


Photo 2: Joint problems in circ water return line

↓ **Photo 3:** F5 burner--split nozzle has slipped behind stabilizer's inner ring causing distortion when hot

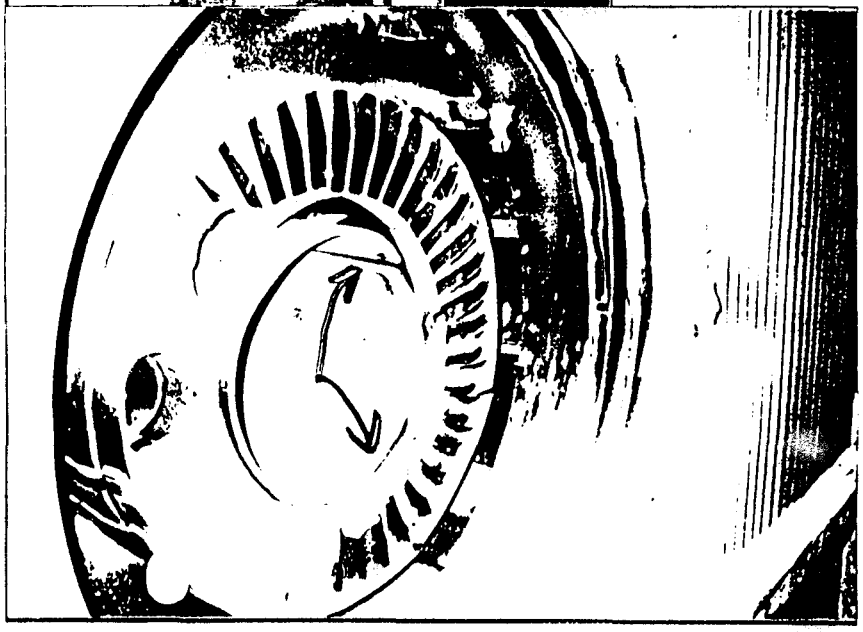
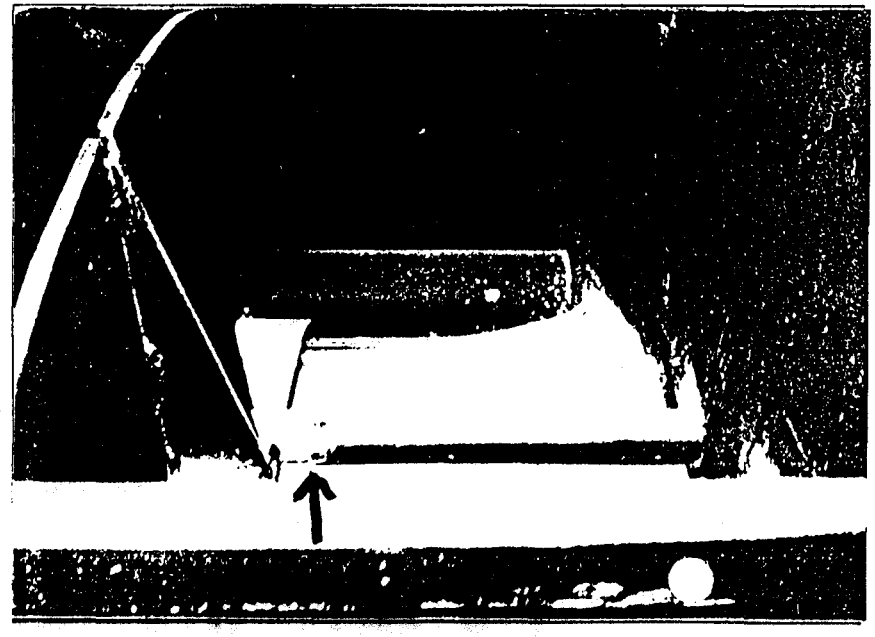


Photo 4: Erosion in return line riser to 2A tower



IP7_000394

INTERMOUNTAIN POWER SERVICE CORPORATION

Engineering Test and Inspection Sheet

Equipment Burners and Windboxes Unit # 1 Test/Inspection Date

Inspector Garry Christensen, Aaron Nissen, Cecil James Responsible Engineer (Initials)

Item or Test	Observations/Comments	Recommendations
	slightly deforming the stabilizer. Maintenance changed the nozzle and welded a clip to the stabilizer to keep the stabilizer from deforming any more.	
C5	Outer shroud found still fixed in place but loose. Re-welded by maintenance.	
D1	Throat sleeve packing rope missing. Replaced by maintenance.	
D2, D3, D4, D5, D6	Outer register seized up. Freed by maintenance.	
D4	Throat sleeve packing rope loose. Repaired by maintenance.	
D5	Throat flange has separated from the tube wall ~¼".	See photo 4.
E1	Fuel oil leak from ignitor tip.	
E3	Throat sleeve cords between clips.	See photo 5.
F2	Outer register thermocouple detached. Replaced by maintenance.	
F3	Nozzle has dropped slightly deforming the stabilizer.	See photo 6.
F6	Outer register shroud loose. Re-welded by maintenance.	
G1, G5	Outer register seized up. Freed by maintenance.	
H2	Stabilizer vanes have overheated and warped.	See photo 7.
H3	Outer register seized up. Freed by maintenance.	

This was the first inspection of the new burners since they were put in service one year ago. Their overall condition is very good. As noted above, small defect exists, the number and magnitude of problems and defects are dramatically smaller then usually experienced on Unit 1. The only outstanding problem was B2 with the catastrophically deformed nozzle tip. Ten burners had nozzles that are no longer round and two had weld splits. Both problems may possibly be resolved by using a case nozzle tip.
All burners had hard stops welded between the sliding disk and the inner air sleeve, see photo 8, to permit a minimum flow of air if the disk push fails and the disk is sucked into the inner air sleeve.

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Photo 4: D5 burner throat flange separation

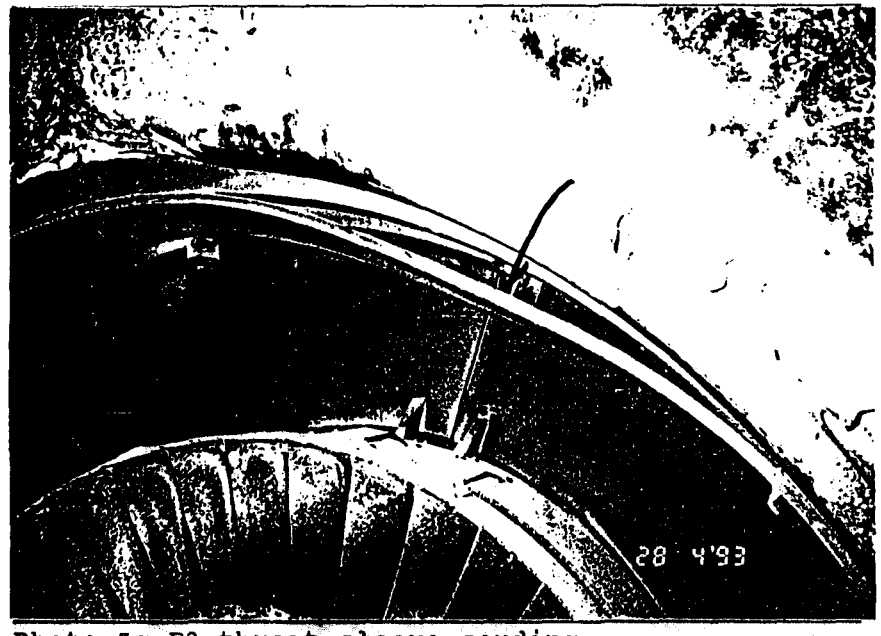


Photo 5: E3 throat sleeve cording

Photo 6: F3 nozzle has dropped onto stabilizer

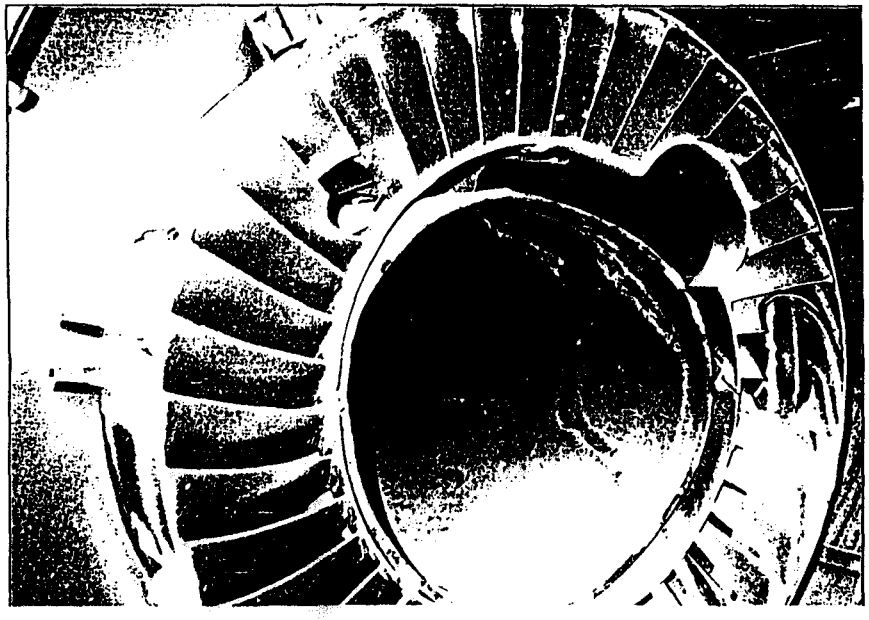
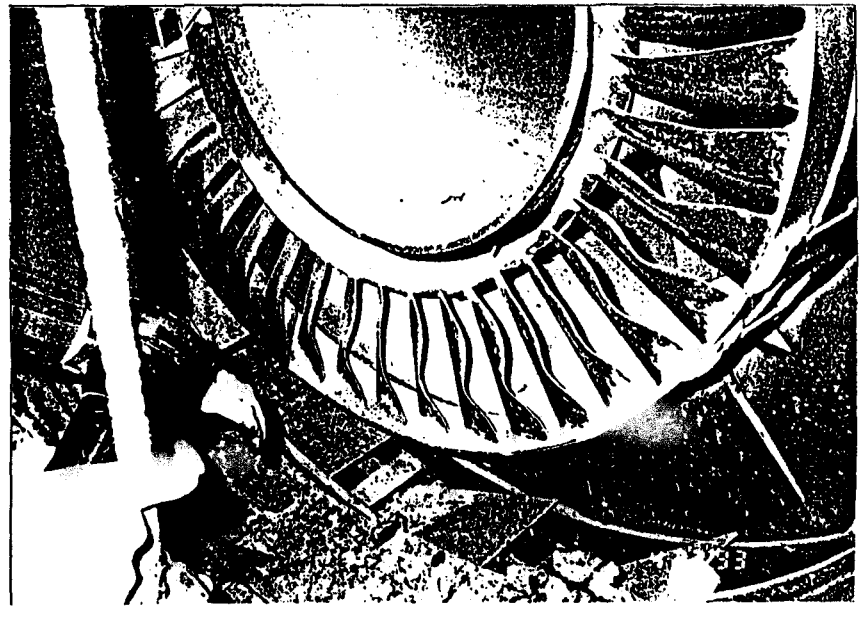


Photo 7: H2 stabilizer vanes overheated



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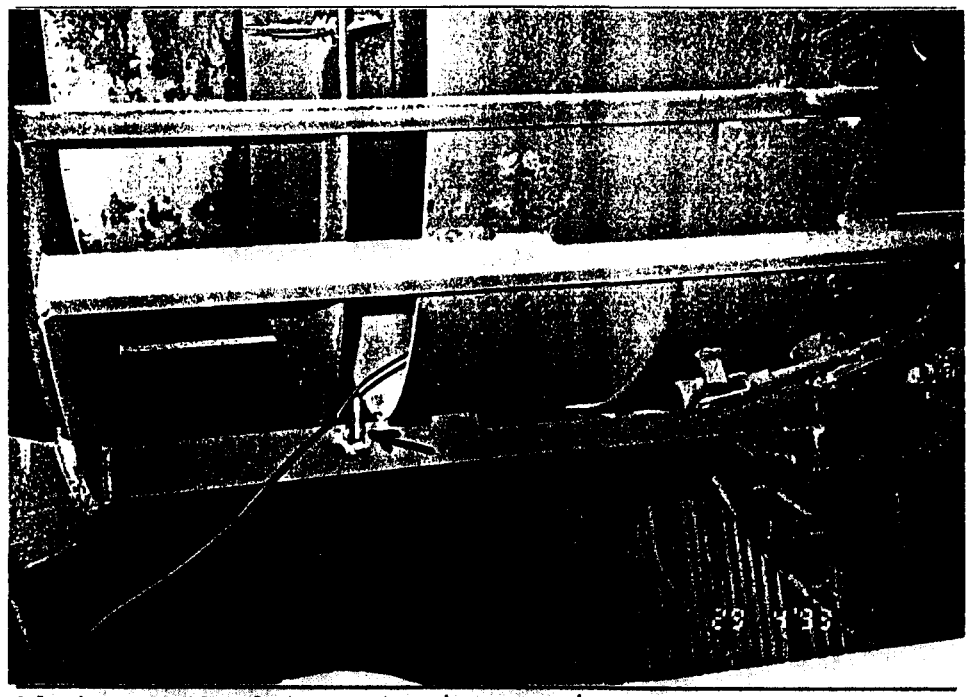

Photo 8: Hardstops to inner air zone

IP7_000397

WILLIAM E. NEWKIRK
CONSULTANT
BURNERS - COAL - OIL - GAS
LIGHTERS - OIL - GAS
41 YEARS EXPERIENCE
DESIGN ENGINEERING - MANUFACTURING
FIELD SERVICE

April 4, 1991

Cecil James
Intermountain Power Service
Corporation
Delta, Utah 84624-9546

RE: IPSC Purchase Order 91-44450

Dear Mr. James:

The writer visited IPSC on March 25, 26, 27, 1991 to inspect the burners of unit #1. I wish to advise my recommendations are based on my visual observations of the burners as found on this inspection and from past inspections of this unit. As the unit was out of service, no burner operating conditions were observed.

All 48 burners were inspected from inside each windbox compartment. Furnace side inspection was not performed. An inspection sheet for each burner is attached to this report.

The mode of failure of these burners range from warped register plates, cracked welds, shifting of burner components, separation of register plates/register doors, and coal nozzle fires. These types of failures have been occuring from the start up of these units. The primary cause of these failures are due to thermal expansion resulting from furnace radiation and poor air distribution. The 70" throat dual register burners on this contract are larger than all previous dual register applications, whereas the radiant exposure to the burner would be more severe. The size of these burners greatly exceeds previous burners manufactured by B&W, however, standard design material specifications and manufacturing procedures remained the same. These conditions

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AKRON, OHIO 44319
(216) 882-4236

coupled with the inability to know or measure air flow to the individual windbox compartment, burner destruction would be inevitable. It is apparent from the condition of the burners that air distribution in windbox compartments is unsatisfactory, especially on out of service burners. It is almost incomprehensible to believe that cooling air is being distributed equally with this size of burner, which is adjusted for in-service operation, and windbox compartment pressure negative. The center burners indicate more severe warpage, weld failures and overheat. I would like to advise that many of the original welds were of poor quality, which would fail under normal conditions.

In regard to expected remaining burner life, one must first define burner life. My definition therefore is when the as designed equipment is no longer operational as the intended design due to physical changes of the assembled device and/or it can no longer function per the intended design, the burner life is expended.

Using this criteria, I am of the opinion that on each outage one will find burners that fall into the failed catagory. As time progresses degradation of the component parts will accelerate burner failures. Therefore, if no abnormal rehabilitation repairs were made I would project remaining life to be in the range of two to five years. Average utility boiler burner life is 25 to 30 years, unless subjected to severe operating conditions. I would advise that the condition of some of the burners seen on this inspection, in a short period of time could result in a windbox fire or explosion, both of which could result in extensive material damage or possible personnel injury.

It was observed during the burner inspection, several burners have had coal nozzle fires. The probable cause is due to coal particles settling out in the nozzle due to low nozzle volocity and hot nozzles. I recommend that each coal pipe should be tested to determine if the velocities are correct and the coal pipes are balanced per B&W specifications.

The slip seal casing, although all were attached, were warped and all packing was missing, which resulted in large gaps (1"-1½") permitting air to bypass the registers. This condition should be corrected or redesigned.

The outer registers are in poor condition ranging from failed welds, separated and warped plates, oxidation of register doors, ribs and front plates. The linkage from a material standpoint is in good condition, however, movement capability is rather doubtful. I recommend that the outer registers be replaced with a redesigned linkage arrangement (H-D type) and register components with stainless steel with increased temperature and creep strength capabilities. Support design should also be improved.

The inner register will be satisfactory providing that those with damaged spin vanes and split weld seams be repaired. It is my opinion the weld seams failed on some of the inner air sleeve due to overheat, closed spin vanes restricting air flow and poor welds. The spin vanes should not be pinched down or closed for air distribution purposes. The function of the spin vane is to generate swirl of inner air zone for stable ignition. The sliding disk is used to regulate air flow.

Compartment air flow appears to be questionable on this unit. As there is no means to measure flow, I suggest a diagnostic test to determine air flow to each burner, you may want to consider using the hot wire anemometer method through the coal nozzle and cold secondary air. If new burners/registers are installed, I would consider installing a permanent device for measuring air flow to each compartment.

Fire side inspection was not made on this inspection, as the furnace scaffold was not finished.

Attached are inspection sheets for each burner and photographs of typical burner damage. Also attached is my invoice, number 003-91 for my services.

I thank you for the opportunity to work with you, should you need my assistance in the future please advise.

Sincerely,

W. E. Newkirk

William E. Newkirk

glg
enclosures

Coal Burner Condition and Estimated Remaining Life Evaluation - Intermountain Generating Station

Final Report

Prepared by:

Todd A. Melick

Todd M. Sommer

Energy & Environmental Research Corporation

Engineering Services Group

Orrville, Ohio

Prepared for:

Intermountain Power Service Corporation

Delta, Utah

August 15, 1990

1.0 INTRODUCTION

The purpose of this evaluation is to provide technical support to Intermountain Power Service Corporation (IPSC) for evaluating the existing condition and for estimating remaining life of the burners at the Intermountain Generating Station (IGS). Energy and Environmental Research Corporation was requested to perform this evaluation so that an expert unbiased opinion could be established to be used for negotiations between the Intermountain Power Project and the Original Equipment Manufacturer.

The burners have had numerous modifications, adjustments, and repairs in addition to changes in recommended operating parameters since their initial service. IPSC is concerned that the structural integrity and remaining life of the burners has been significantly affected. A burner inspection was performed on IGS Unit 1 and the results and recommendations of that inspection are included in this report.

Additionally, four alternatives (including a "Do Nothing" option) were investigated. Operational, maintenance, construction and performance criteria are included in this evaluation.

2.0 BACKGROUND INFORMATION

This section provides a description of Intermountain Generating Station Unit 1 and 2 steam generators. It also provides necessary background information concerning the start-up and operation of these Units.

2.1 IGS Unit Information

Intermountain Generating Station Units 1 and 2 are indoor, balanced draft, parallel back-end, Carolina Type Radiant Boilers provided by the Babcock & Wilcox Company (B&W). Each unit fires pulverized coal from a combination of the forty-eight high input dual-register burners arranged in four rows of six burners on both the front and rear furnace walls. The burner windboxes are compartmented with air dampers located on each end. Furnace dimensions are 85 feet wide, 60

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feet deep, and 299.5 feet from the lower wall header centerline to the drum centerline. Figure 1 illustrates the general boiler arrangement of the units.

The maximum continuous rating of each steam generator is 6,600,000 lb/hr of main steam at 2640 psig and 1005°F at the superheater outlet with reheat steam flow of 5,285,000 lb/hr at 551 psig and 1005°F with a feedwater temperature of 555°F. The "maximum capacity" load (100% - guaranteed load) for each unit is 6,100,000 lb/hr of main steam at 2510 psig and 1005°F at the superheater outlet with a reheat steam flow of 4,925,000 lb/hr at 521 psig and 1005°F with a feedwater temperature of 545°F. Main and reheat steam temperatures are controlled to 1005°F from maximum capacity down to 65% load (3,925,000 lb/hr) by a combination of gas biasing, spray attemperation, sootblowing, and excess air. The design pressures of the boiler, superheater, economizer, and reheater are 2975, 2975, 3050, and 750 psig, respectively.

The boilers are designed for cycling service and each has been constructed with a partial boiler steam by-pass system. The units can be operated in either a constant pressure, variable pressure, or hybrid pressure mode of operation. These units have typically been base-loaded units with 96-98% load capacity since commercialization, but the units should still be capable of cycling service. The burners should remain fully adjustable throughout the load range.

2.2 IGS Burner History

Unit 1 went into commercial service on May 10, 1986 and Unit 2 on July 1, 1987. Cooling air requirements for out-of-service burners were based upon final performance testing for boiler acceptance. During the first outage after start-up, physical damage to the burners was apparent. Since then the burner metal temperatures have been monitored closely, but the cooling air is still limited in order to meet boiler efficiency, main steam, and reheat steam temperature guarantees.

Approximately one year after commercial service began, each unit received new B&W Heavy Duty (H.D.) Air Registers on each upper level of burners due to complications with the original registers. The original 70" dual register burner is illustrated in Figure 2. The burner is considered "high input" by B&W because

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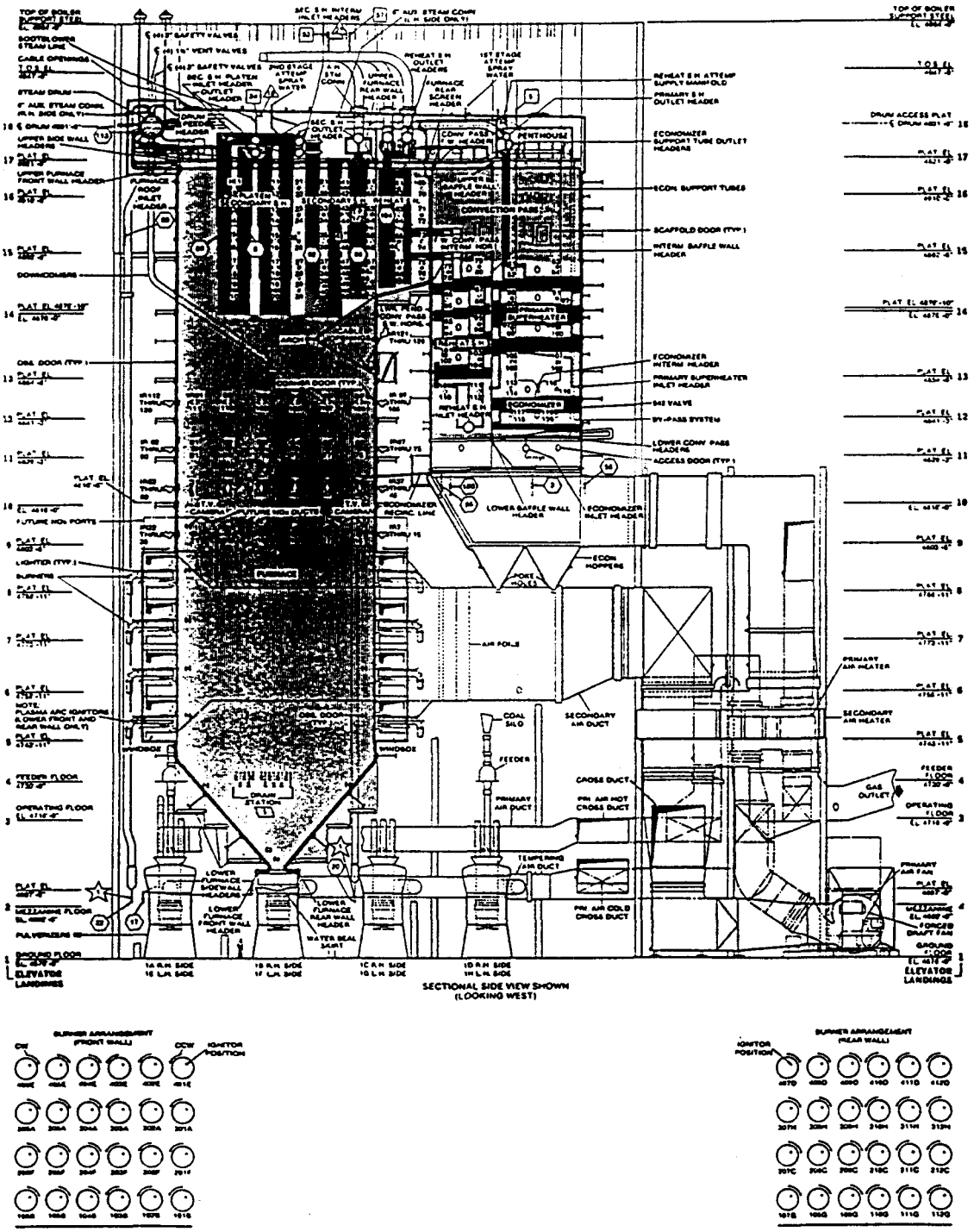
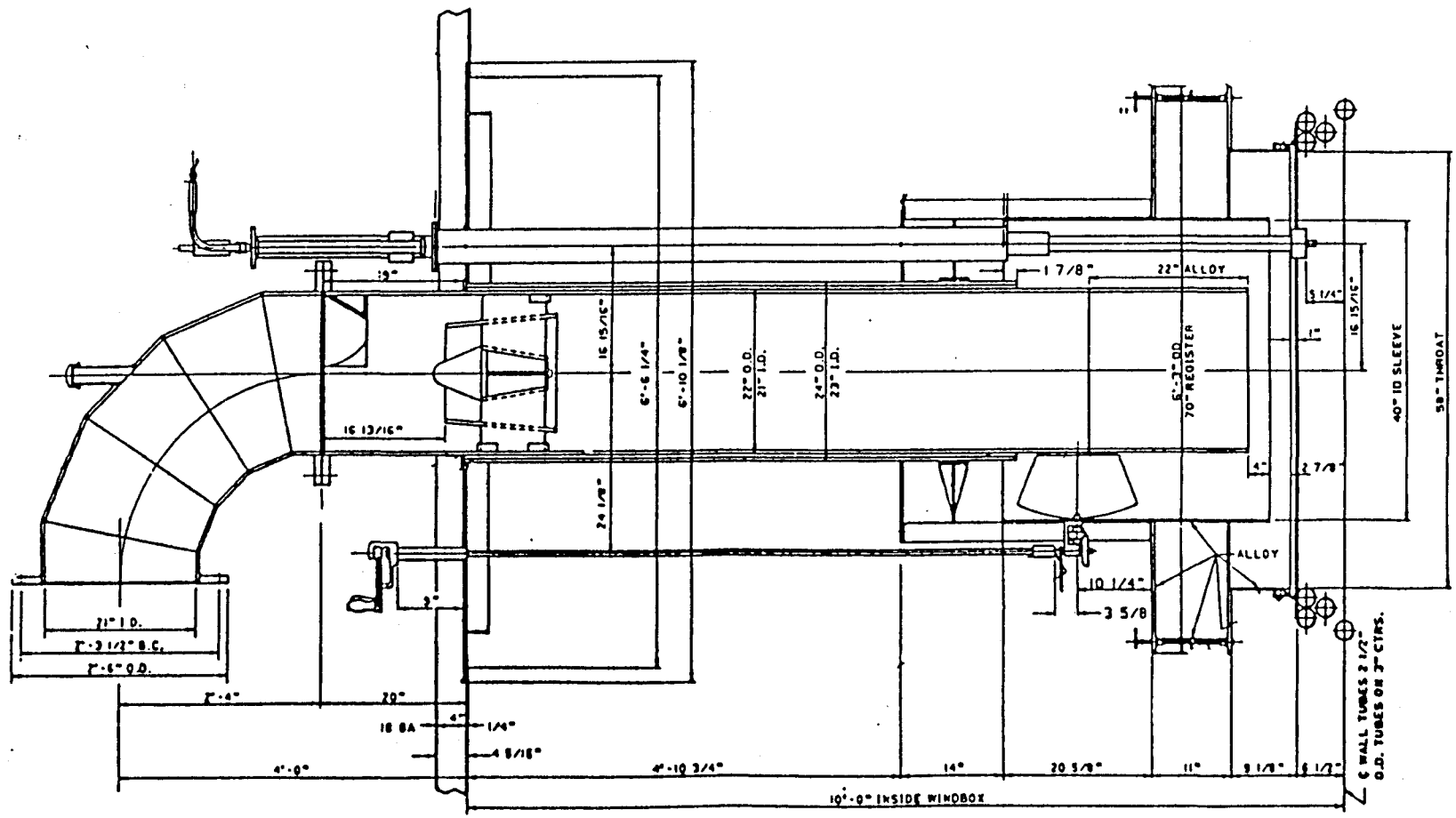


Figure 1

IP7_000405



BABCOCK & WILCOX "HIGH INPUT" DUAL REGISTER BURNER

Figure 2

IP7_000406

the design heat input and physical size were greater than all previous dual register burner applications. The H.D. type register replacement corrects some of the problems experienced with the original burner. The door shaft diameter has been increased from 1/2" to 3/4". The door shafts are fixed in place and the door rotates on the shaft. The linkage has been moved from behind the rear plate to the center of the register, and is not affected by the expansion of the rear plate. These changes have simplified the burner and have improved its operation.

2.3 Typical Utility Burners

A utility burner normally will operate for approximately 20-30 years without major component replacement. Most boilers have their own unique operating conditions, so some burners receive more severe duty than others. Wear items such as coal nozzles, diffusers, deflectors, and coal elbows do need periodic replacement. Rope packing is also a routine maintenance item as it has a tendency to disintegrate every couple of years due to heat and the grinding action caused by thermal expansion. Failure of registers, throat casings, slip seal casings, or extensive weld breakage in the first few years of operation is not typical.

The instrumentation and controls originally provided by B&W for a typical dual register burner compartmented windbox firing system would include windbox pressure, damper position, and flow measurement to each windbox compartment. However, these units do not have individual compartment air flow measurement. Actual air flow to each compartment is not measured and balanced cooling air to each burner level cannot be maintained. Air flow measurement to each compartment and a flow balancing device on each burner would be beneficial on these large burners. Individual burner flow balancing instrumentation was not previously necessary on 54" diameter dual register burners that were installed in a compartmented windbox with a design full load windbox pressure of 4 inches water gage, but may be required on IGS 70" diameter dual register burners.

Providing the correct amount of cooling air to out-of-service burners is not normally a problem. Sufficient cooling air is usually available to keep the

IP7_000407

burners cool without impacting boiler performance. Apparently, these large (70" diameter) IGS burners are requiring more cooling air than was originally anticipated.

To prevent an overheating condition on the burners, the Intermountain Power Project installed four thermocouples on every other burner to provide continuous temperature monitoring capabilities. Operating temperatures recommended by the boiler manufacturer for the out-of-service burners range up to 1350°F on the burner backplates.

3.0 BURNER INSPECTION

This section summarizes the visual observations that were made during the March 27, 1990 outage on Unit 1. It should be noted that all observations, recommendations, and conclusions are based on visual information only. No destructive or non-destructive inspection or analysis techniques were utilized as they were considered beyond the scope of inspection requested by IPSC. IPSC employees James H. Nelson, P.E., Supervising Engineer - Operations Support, Aaron Nissen, P.E., Supervising Engineer - Results, and control room operators were also interviewed to gather information concerning operating history and practices.

3.1 Physical Observations

All forty-eight burners on Unit 1 were inspected on March 27, 1990 by EER employees Todd Melick, Sr. Design Engineer and Sig Sundberg, Sr. Field Engineer. The burners were inspected from inside the windbox. A burner inspection sheet was completed for each burner to note the condition of each major component. Conditions such as warpage, exfoliation, overheating, weld breakage, and general operability were noted for each burner. Appendix A is a compilation of the individual burner inspection sheets. The following problems were apparent:

IP7_000408

1. Welds were found broken on the support bar that connects the outer air register front and back plate together. This was found on four different burners. Burner C4 (Photos #24 & 25)[1] had six of these bars broken and the back plate had subsequently warped at least 6 inches.

2. The register handle and quadrant were bolted together to prevent any adjustment so register doors could not be stroked to determine freedom of movement. The register doors were stroked a small amount (play in linkage) from the windbox. It was noted that three burners had register linkage that was locked tightly and would not move at all.

3. The register rear plate was warped (varied from 1/2" to 1") on twenty-six burners (Photos #22 & 23).

4. The register front plate was warped (Photos #18-21) on fourteen burners.

5. The burner register or the throat sleeve was misaligned with the bent tube opening of the waterwall (Photos #15-17) on eleven burners due to warpage.

6. The weld that connects the pull handle to the inner air zone disk was completely broken on one burner (Photo #28). Another inner air zone disk was cocked at an angle from vertical and was being held there by the pull handle.

7. The reinforcing bars that are welded to the outside of the inner air sleeve (Photos #26 & 27) showed signs of overheating on twenty burners. Large flakes of metal broke away from the burner with only fingertip contact. This was not caused by cutting or field alterations since it was not found on all burners. The maximum recommended working temperature of this material had undoubtedly been exceeded. Also, one burner had broken welds where the reinforcing bar attached to the inner air sleeve.

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[1]Throughout this report, references will be made to photograph numbers, for example, (Photo #1). All photographs referenced are attached in Appendix B, "INSPECTION PHOTOGRAPHS".

IP7_000409

8. The support channel connecting the register front plate to the register support bracket was bent (Photo #7) and unable to slide freely on ten burners. This was caused by insufficient clearance between the retainer and register support bracket. The bending of the support channel distributes additional stresses to the register front plate which enhances the warpage of that plate.

9. The throat sleeve and the throat sleeve casing on all forty-eight burners needed repair or replacement. B & W Construction was making these repairs during the burner inspections. The rope seal packing was virtually non-existent. This was allowing large quantities of air to escape into the furnace without flowing through the burner. Also, approximately 90% of the welds connecting the throat sleeve casing to the furnace wall (Photos #8 - 10) were broken. The casing was free to move in any direction and this caused large gaps (1-2 inches) for air leakage into the furnace. A conservative 1" gap around the burner would amount to 6.9% of the throat area.

Throat area is $(\pi)58^2 / 4 = 2642$ sq in
Air gap is $(\pi)(58)(1) = 182.2$ sq in
Percent leakage is $182.2 / 2642 = 6.9$ %

10. A general observation noted on each burner level was that the middle burners had definitely experienced higher out-of-service temperatures (due to insufficient cooling air flow) than the outside burners. This is in contrast with in service burner operation where IGS personnel feel the problem is getting enough air flow to the outer burners.

3.2 Summary of Inspection Information

The general condition of the burners at this time is considered very poor. Numerous attempts to correct the problems have left the burners looking severely mistreated. All the register doors have been cut (Photos #1 & 2) to allow door movement due to register plates overheating and becoming severely warped. A triangular section has been removed along each door side that varies from one to two inches in width, and from the door tip to almost the door shaft in length.

IP7_000410

The original clearance before modification was 5/16" from the register door edge to the register plate with a tolerance of plus 0" and minus 1/32". The register doors still have curved edges as a result of warpage before the door edges were trimmed. It appears that about 15% of the register door has been removed. Many register door shafts (Photo #3) are also bent and rotation appears difficult. The result of these modifications is a register with decreased ability to generate swirl, and a register that would have severe leakage in the closed position.

The outer air register assemblies have all been cut free from the inner air sleeve (Photo #4) so that these registers can move independently from the rest of the burner. The throat sleeve has also been cut free from the register front plate. Metal clips were installed in an attempt (Photos #5 & 6) to restrict the amount of movement between the throat sleeve and register front plate. The register is presently supported in only three locations. One is at the top of the inner sleeve, and the other two are supports from the register front plate (Photo #7) to the register support bracket. This support system promotes individual movement of the register plates which results in weld failures.

Burner component failures and the number of occurrences recorded during the Unit 1 Spring outage inspection are summarized below:

Description of Failure	Occurrences
Welds broken on register connecting bars	4
Register linkage immovable	3
Register rear plate warped	26
Register front plate warped	14
Burner misaligned with bent tube opening	11
Weld broken on pull handle to sliding disk	1
Sliding disk severely cocked	1

IP7_000411

Inner air sleeve reinforcing bars overheated	20
Support channel bent and bound	10
Throat sleeve and throat sleeve casing warpage	48

3.3 Burner Inspection Conclusions

The burner inspection revealed that the burners have received a combination of high temperatures and stresses. The excessive temperatures have severely warped the stainless steel components and exfoliation of the carbon steel exists on 20 separate burners. The burners are also improperly supported which, along with the high temperature conditions, results in permanent warpage of the burners. In an effort to correct these problems, the burners have received field modifications that have created additional stresses.

4.0 BURNER EVALUATION

4.1 Existing Burner Design

The size of the 70 inch register greatly exceeds any other previous burner register sold by B&W. The diameter of this register was increased from the previous standard size while all plate thicknesses, material specifications, and manufacturing processes remained essentially the same. This has created two problems. The burner temperatures are higher than expected even using the "normal" amount of cooling air, which can be attributed to increased radiant heat transfer through the larger furnace wall throat opening. The other problem is that higher combined (thermal, residual, bending, etc.) stresses are greater. The combination of higher stress and higher temperatures have produced the higher than expected rate of deterioration.

4.2 Metal Temperature Limitations

The majority of the stainless steel material on this burner is AISI 304. Although the maximum operating temperature (with regard to oxidation resistance) of this particular stainless steel is several hundred degrees higher, the creep strength is greatly reduced at elevated temperatures. Creep strength is the ability to resist permanent strain that increases as a function of time and

IP7_000412

temperature under stress. Depending on the information source, the creep strength of AISI 304 stainless steel is reported as approximately 9.5 KSI at 1150°F and 3 KSI at 1350°F. Figure 3 illustrates the creep strength vs. temperature relationship for 304 stainless steel. For a long term installation such as this burner, the 304 stainless material should be limited to 1150°F.

The carbide phase of carbon steel may be converted to graphite when subjected to prolonged temperatures of above 800°F. For a wear part such as the coal nozzle and non-pressure parts, the maximum temperature for carbon steel should be limited to 850°F. The thermocouple on the coal nozzle is located at the junction of the stainless and carbon steels. This thermocouple should be set to alarm at 850°F. The reinforcing bars that are welded on the outside of the inner air sleeve have definitely exceeded their allowable temperature. Large flakes of material can be picked off of the bars and the material that remains is porous and brittle.

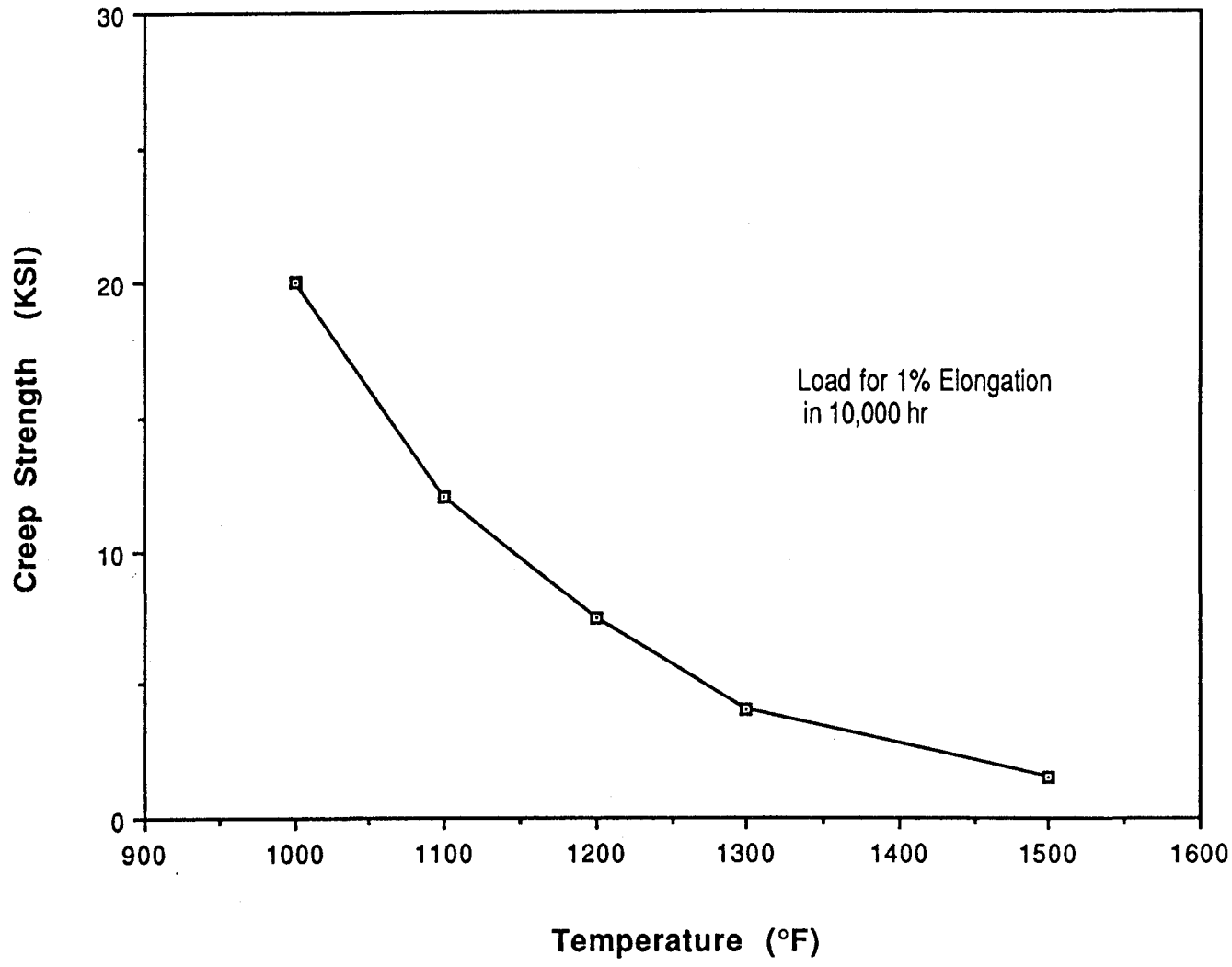
4.3 Cooling Air Requirements and Monitoring

It was apparent from the inspection that temperature variations around the burner exist during boiler operation. A thermocouple on one side of the burner may not indicate excessive temperature, but, in fact, at a different radial position around the burner the recommended temperature is being exceeded. These thermal gradients produce high thermal stresses that cause severe warpage.

Correct distribution of the cooling air to each out-of-service burner is the optimum way to reduce these temperature variations. Because cooling air flow is limited due to other boiler operating constraints, it is very important to effectively use what is available. Individual windbox compartment secondary air flow measurement would be beneficial so the flow can be balanced to each burner level.

The burners registers and sliding disk are currently adjusted for on-line operation. When the burners are taken out-of-service no adjustments to burner registers are made. The windbox pressure for in service burners is approximately 1.0 inch of water, and out-of-service windbox pressure is -.7 inch of water. Under these conditions it is difficult to imagine that the cooling air is being

IP7_000413



Creep Strength vs. Temp. for AISI 304 SST

Figure 3

IP7_000414

distributed equally. The pressure drop across the burner is simply too small (without register adjustment) to assure equal air distribution.

It was observed during the burner inspection that the burners located in the center of the windbox have experienced much higher temperatures than the outside burners. This has occurred when the burners are out-of-service and was caused by insufficient cooling air to the center burners. This phenomenon is illustrated in Figure 4, a typical printout of burner thermocouple temperature indications from Unit 1. Row H is out-of-service and burner number 3 is experiencing higher temperatures than the outer burners - which is generally the case. Also note that the secondary air damper is at 30% and not the usual 10%. The coal nozzle temperature variance is 70 to 100°F and the register plate variance is 100-140°F. These differentials will increase as the cooling air quantity is reduced. Indications are that the coal nozzle is approximately 280°F cooler when the burner is in service and the register plate is 200°F cooler. The temperatures on the throat seal fluctuate 300°F or more due to the large gaps in the slip seal casing. The thermocouple is evidently located near a large gap when a temperature of 600-800°F is reported. The air leakage through the large gaps in the slip seal casing only compounds the limited air flow problem. The air bypasses the burner and thus provides little cooling to the burner components. The air gap on the slip seal casing must be maintained at a minimum.

Pitot tubes located in the burner air stream would be one method for balancing cooling air to each burner, but it would be a difficult application on this burner. Another method would be to perform burner air flow measurements with cool secondary air flow in order to balance the flow to each burner. This could be accomplished by inserting a telescoping pitot tube assembly down the coal nozzle. Actual measurement time is small, however, all the testing must be performed with the boiler out-of-service. A significant amount of time is required to prepare the coal elbow and to perform the testing. In an iterative fashion, a register setting would be determined for each burner for out-of-service operation.

A third approach would be to provide register drives on each burner so that operators could vary register position on out-of-service burners until acceptable

IP7_000415

IGS UNIT #1

Unit Load 840 MW

	East		West	West		East	
D	(2) 598.F 1814.F 972.F 877.F	(4) 569.F 1866.F 956.F 665.F	(6) 580.F 935.F 933.F 658.F	(6) 581.F 994.F 835.F 715.F	(4) 474.F 894.F 1853.F 760.F	(2) 560.F 797.F 938.F 717.F	E
H	(1) 819.F 1118.F 985.F 1818.F	(3) 913.F 1223.F 1138.F 794.F	(5) 845.F 1083.F 1081.F 661.F	(5) 611.F 647.F 1827.F 984.F	(3) 546.F 1182.F 1132.F 879.F	(1) 589.F 1006.F 1064.F 654.F	A
C	(2) 622.F 898.F 948.F 861.F	(4) 579.F 978.F 932.F 646.F	(6) 609.F 636.F 1852.F 953.F	(6) 692.F 956.F 1818.F 924.F	(4) 610.F 1852.F 1819.F 649.F	(2) 560.F 1042.F 1006.F 761.F	F
G	(1) 562.F 969.F 916.F 966.F	(3) 551.F 1812.F 989.F 667.F	(5) 598.F 946.F 967.F 648.F	(5) 574.F 1806.F 960.F 1803.F	(3) 599.F 1807.F 1854.F 896.F	(1) 575.F 1064.F 1075.F 982.F	B

1. H Pulverizer O.O.S. with secondary air dampers at 30%.
2. All in service pulverizer feeders at 47 T.P.H.
3. All secondary air dampers on in service pulverizers at 65% position.

Notes: a. Burner number in parenthesis.

b. Description of burner temperature reading: (top to bottom)

Coal Pipe
Outer Register
Outer Register
Throat Seal

TYPICAL BURNER THERMOCOUPLE INDICATIONS
Figure 4

IP7_000416

temperature indications are achieved. This would enable the out-of-service compartment cooling air flow to be minimized at all times.

4.4 Burner Line Fires

Several burners have experienced fires back in the coal nozzle that have destroyed the nozzle tips and diffusers. Coal particles are probably settling out in the coal pipe to cause these fires. The coal nozzle velocity is in line according to the Pulverizer-Burner Coordination Curves. The concern is whether or not these velocities are maintained throughout the coal pipe. If test connections are located correctly and tests prove that these velocities are correct to each burner, then the velocity should be increased in small amounts to determine if this will eliminate the fires.

4.5 Register Controllability

The registers and sliding disk should be adjustable under all conditions. The burner should adjust so that a turndown ratio that is established by the pulverizer operating range can be accomplished. The burner should also be capable of being closed completely so that a large enough pressure drop can be created to equally distribute the cooling air. Considering the amount of trimming that has taken place on the register doors, it is questionable whether or not enough pressure drop can be created to accomplish this. Other ways of closing the register openings such as shrouds could be utilized.

The physical appearance of the registers would indicate that adjustment while in service would be impossible for approximately 50% of the burners. The severity of the warped register plates and the bent door shafts create binding that prevents any adjustment. Register adjustment during the inspection was not allowed due to the fear that the register doors would not return to their original position. Only two sliding disks appeared to be impossible to operate. The remainder of the disks were free from any binding and appeared to be in good shape.

IP7_000417

4.6 Estimated Burner Life

Considering the current burner condition and the amount of deterioration that has taken place in less than five years, the estimated remaining burner life is expected to be less than five years. It is expected that the majority of the burners will have major failures like burner C4 (Photos #24 & 25) if the burners continue to operate under the present conditions. It is estimated that $29,500 per outage will be required for labor and materials to rebuild the burners to maintain their existing poor condition. The burner failures will result primarily from register and throat deterioration.

5.0 B&W'S REPAIRS TO BURNERS

5.1 Recent Repairs

B&W field service and construction personnel were on site during the one week outage when the burners were inspected. They were replacing the slip seal casing on all 48 burners on Unit 1. These casings have been repaired or replaced on previous outages. Several (4-8) small gusset plates were being welded on the outside of the casing in an attempt to hold the casing in place. The previous casing was welded directly to the tube wall. The casing would expand from thermal expansion (1/2-5/8" on the diameter) but was limited until it broke the welds. During this time the free end of the casing would expand and the casing would resemble a 45° cone. The packing would fall out and large gaps (1-2") would appear. This new installation is at best a short term replacement, because the problem of thermal expansion is not being addressed properly. By restricting the movement, large stresses will result or the welds will break again.

The alloy section of the coal nozzle was oval on a few burners and was replaced. This was probably caused by burner line fires.

IP7_000418

5.2 Previous Repair History

In the first few years of service, many repairs were necessary on the original burners. These repairs were required due to original manufacturing deficiencies and installation errors. Since then, failures have been the result of excessive temperatures and stresses. Numerous alterations have been made in an attempt to keep the burners in an operating condition. Below is a listing of the most significant alterations.

Unit	Date	Description of Repair
1	11-86	Register plates were warped and a reinforcing band was attached to the rear plate. Numerous welds were broken and repaired.
1	5-87	Welds joining the air sleeve to the rear plate had failed. These welds were all cut free to allow differential expansion. Reinforcing bars on air sleeve were overheated. Two middle burners on each level had more severe warping due to the air disk being throttled. Thermocouples were installed by IPSC to monitor burner temperatures.
1	11-87	New HD registers were installed on front and rear walls of burner level four. The 22" alloy tip on all 48 coal nozzles was replaced with a 33" section. Retaining lugs and clips replaced the previous weld attachments on the throat and inner air sleeves.
1	3-88	The register vanes were trimmed on all registers. Lighter shrouds were re-attached.
1	1-89	Heavy duty auxiliary outer register drive arm handles were removed as they were not providing enhanced outer register mobility.

IP7_000419

2	11-87	The 22" alloy tip on all 48 nozzles was replaced with a 33" section. Retaining lugs and clips replaced the previous weld attachments on the throat and inner air sleeves. The register doors were trimmed on all burners.
2	4-88	Lighter shrouds were re-attached.
2	9-88	Slip joint modification was made on all register drive rods to allow thermal expansion to occur. The welds joining the inner air sleeve to the rear plate was cut free to allow for thermal expansion on the lower 36 burners.

6.0 ALTERNATIVES

This section itemizes four different alternatives for future burner operation. Estimated burner life and a cost summary is included for each section. New registers for all of the alternatives should be installed as a one piece design to avoid the problems that were experienced with HD registers and to return the burners to an undamaged (like-new) condition.

6.1 Continue Current Mode of Operation

If the out-of-service burners continue to operate at 1350°F the HD registers, throat sleeves and throat sleeve casings will need replacing every 5-7 years. Burner maintenance will also be required at each outage to repair broken welds and straighten warped burner components as seen on Photos #'s 24 & 25. It is estimated that labor and materials for each outage will be $29,500. This does not include normal burner maintenance. Normal burner maintenance would be minor items such as replacing the rope packing, adjusting register linkage, cleaning sprayer plates, and cleaning spin vane gears. The registers will remain adjustable for only a short period of time and balancing of cooling air to each burner will be difficult. Performance of the Unit will remain the same. Burner replacement would require approximately a four week outage

IP7_000420

depending on the size of the crew. The following cost summary is based on a quantity of 48 burners for one unit. It assumes that the work is performed in addition to other work at the site and during a scheduled outage.

Maintenance Schedule

Slip Seal Casing Materials	$10,560
Slip Seal Casing Labor	4,600
Register Repair Materials	200
Register Repair Labor	6,400
Coal Nozzle Tip Materials	2,500
Coal Nozzle Tip Labor	640
Construction Overhead, Supervision, Fee	4,600
Total Each Outage	$29,500

Cost Summary

Material Cost	$312,000
OEM Markup (assumed 100 %)	312,000
Engineering	20,000
Freight	12,000
Installation Labor & Equipment	432,000
Construction Overhead, Supervision, Fee	138,240
Major Maintenance Work ($29,500 x 2X per yr x 6 yrs)	354,000
Total (every 6 years)	$1,580,240

In order to calculate present worth, material/labor and fuel costs were escalated by 5% using the following formula:

$$S = P(1+i)^n$$

Present worth was then calculated using the following formula:

$$\text{Present Worth} = S \frac{1}{(1+i)^n}$$

$$i = 8.6\%$$

IP7_000421

The present worth for this alternative based on maintenance work of $29,500 every six months, or $59,000 per year and burner replacement every 6 years is $5,826,274.

6.2 Eight Pulverizer Operation

The burners that are in service currently operate with satisfactory temperatures. The registers average about 1000°F and the coal nozzle average is approximately 580°F. If the registers were in "like-new" condition, (this would require new HD registers, throat sleeves, and throat sleeve casings) and all 48 burners would be placed in service, the estimated burner life would be 20-30 years. Burner maintenance would be minimal since the high temperatures could be avoided. Overall boiler performance should increase slightly. Eight pulverizer operation would eliminate the need for cooling air to out-of-service burners reducing excess air requirements, thus lowering stack gas losses. Additionally, fineness would improve since feeder speeds would lower nine percent which should offset the auxiliary power requirements of the additional pulverizer. However, operating the pulverizers at less than full load could cause vibration. Increased pulverizer maintenance work would then have to be taken into consideration. This alternative has a major impact on regular on-line pulverizer overhauls which would force pulverizer work to be conducted only during maintenance outages.

The following cost summary is based on a quantity of 48 burners for one unit.

Cost Summary

Material Cost (does not include OEM markup)	$312,000
OEM Markup (assumed 100 %)	312,000
Engineering	20,000
Freight	12,000
Installation Labor and Equipment	432,000
Construction Overhead, Supervision, Fee	138,240
Total (20-30 year life)	$1,226,240

IP7_000422

The present worth for this alternative based on burner life of 25 years is $1,754,153. However, normal recommended pulverizer maintenance (3,000 and 6,000 hour) schedules would have to be omitted. While the cost impact of reduced preventative maintenance is unknown, it would undoubtedly be significant over the operating lifetime of the plant. This is not recommended as a reasonable alternative for IGS.

6.3 Increase Cooling Air Requirements

The burners should be rebuilt to like new condition (this would require new HD registers, throat sleeves, and throat sleeve casings) along with the following modifications so they can operate for 20-30 years at 1150°F. The coal nozzle thermocouple should be limited to 850°F.

1. The outer register should have additional supports. Allowing the register assembly freedom to move independent of the inner air sleeve is desirable, but the register rear plate should also be supported off of the register support bracket as is the front plate. Round edges and adequate clearances should also be incorporated into the register support bracket retainer to assure that the register assembly can expand as needed.

2. The throat sleeve casings should be redesigned to allow for the large thermal expansion. This will eliminate the extreme warpage and weld breakage.

3. The coal nozzle alloy tip length should be increased to 48 inches.

Operating at reduced temperatures will minimize burner maintenance. Boiler performance will be affected, however, by the increased cooling air flow requirements. IPSC provided the following cost evaluation information that was used for the economic analysis.

IP7_000423

Cost Evaluation Information

Unit Life (for each)	35 years
Capacity Rating (each unit)	800 MW net
Net Unit Heat Rate	9600 Btu/Kwhr
Capacity Factor	83 %
Equivalent Availability	89 %
Forced Outage Rate	2 %
Load Factor (gross)	95 %
Fuel Costs	1.45 $/MBtu
Boiler Efficiency	89.4 %
Change in out-of-service Burner Temp. versus change in Boiler Efficiency	100°F/ 1/2 %
Cost of Money	8.6 %
Operation and Maintenance Escalation	5.0 %
Fuel Escalation	5.0 %

The boiler efficiency would decrease by 1% when the out-of-service burners are maintained at 1150°F instead of 1350°F. The calculations for increased fuel costs in order to maintain current operation are shown below.

800 MW net x 83 % Capacity Factor = 664 MW
664 MW x 9600 Btu/Kwhr = 6,374.4 MBtu/hr
6,374.4 MBtu/hr x 1.45 $/MBtu = 9242 $/hr
Fuel Costs @ 89.4% Boiler Eff. = 80,967,628 $/yr

Heat to Steam = Eff_1 x Heat $Input_1$ = Eff_2 x Heat $Input_2$
(9600 Btu/Kwhr) x (89.4 %) = (X) x (88.4 %)
X = 9708.6 Btu/Kwhr
664 MW x 9708.6 Btu/Kwhr = 6,446.5 MBtu/hr
6,446.5 MBtu/hr x 1.45 $/MBtu = 9347 $/hr
Fuel Costs @ 88.4 % Boiler Eff. = 81,883,552 $/yr

Increased Fuel Costs per Boiler = 915,923 $/yr

IP7_000424

The following cost summary is based on a quantity of 48 burners for one unit.

Cost Summary

Material Cost (does not include OEM markup)	$408,000
OEM Markup (assumed 100 %)	408,000
Engineering	20,000
Freight	12,000
Installation Labor & Equipment	441,600
Construction Overhead, Supervision, Fee	141,312
Total (20-30 year life)	$1,430,912

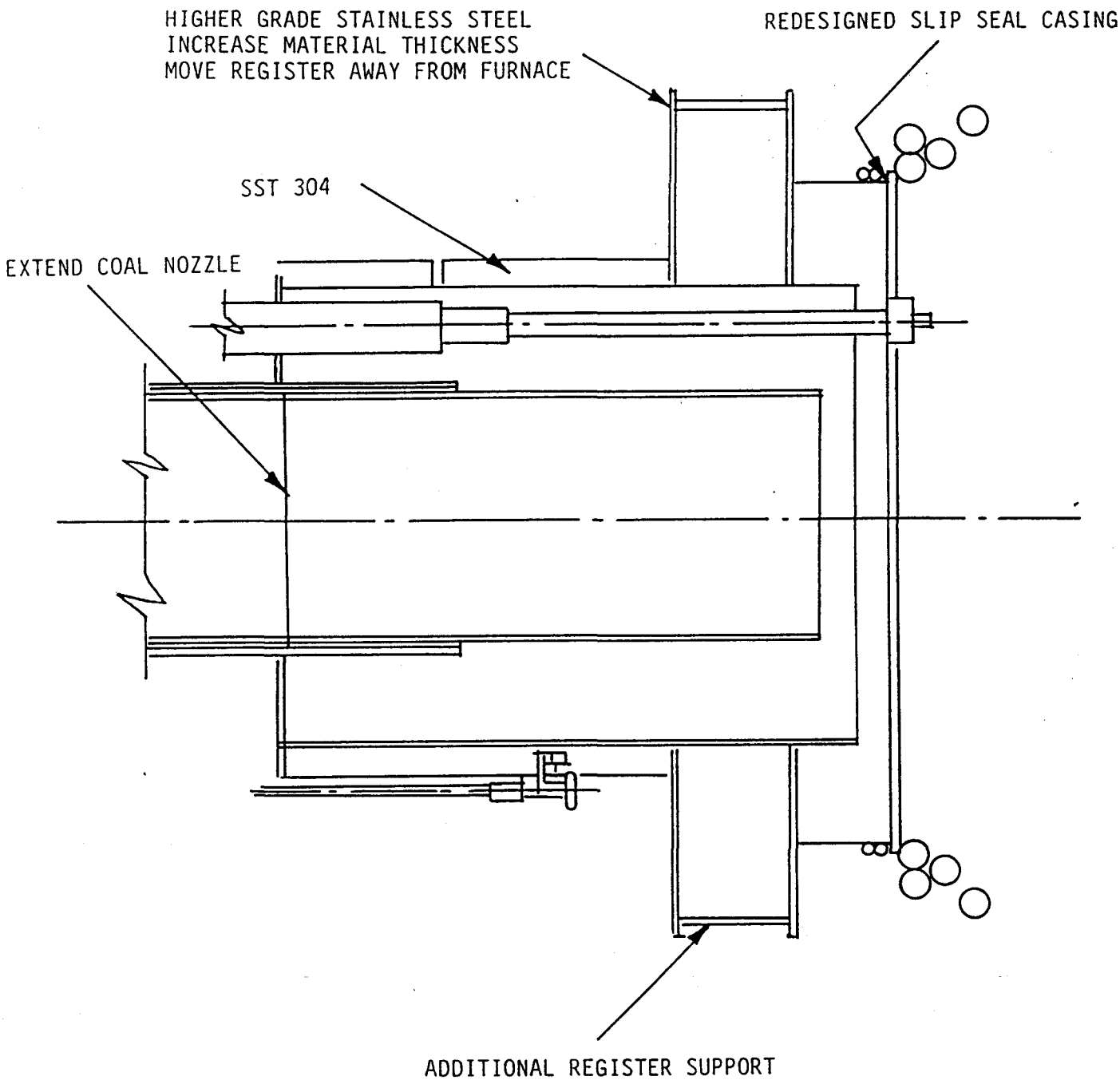
The present worth for this alternative based on burner life of 25 years is $21,186,108.

6.4 Redesign Burner

Installing burners that have been redesigned to operate at 1350°F when they are out-of-service is the fourth alternative. The advantages of this alternative are that the boiler efficiency will not be affected and the estimated burner life would be 20-30 years. The burner would remain adjustable which would allow the cooling air flow to be balanced to each of the out-of-service burners. The new burner (see Figure 5) should incorporate the following design changes:

1. The stainless steel material and plate thickness should change on several of the burner components that have failed. This is evidenced by the current HD registers that have been installed in the upper row of burners and have already been permanently warped. A higher grade of stainless steel such as AISI 309 or 310 with a low carbon content would be better suited for high temperatures and welded constructions than a 304 material. This material would provide a higher creep strength and also alleviate long term effects of weld decay (Appendix C). Material thickness would probably also need to be increased on current 309 components to overcome the high stresses that are occurring.

IP7_000425



REDESIGNED BURNER
Figure 5

IP7_000426

2. The outer register should use the HD register linkage design. This will increase the ability of the register to remain adjustable. Placing the outer register farther back from the furnace should also be considered. This would reduce the amount of heat transfer by radiation and assist in lowering the temperatures of the register back plate and doors. The disadvantage could be the reduction of swirl that is imparted to the secondary air. Considering that the existing burners have good stability while operating with low pressure drop across the burner and severely trimmed register doors, high swirl is evidently not required with the current fuel.

3. The slip seal casing should be redesigned to allow for larger thermal expansions.

4. The reinforcing bars that are welded to the outside of the inner air sleeve should be SST 304 instead of carbon steel.

5. Extension of the alloy tip on the coal nozzle would be necessary because the temperature at the carbon steel junction should be limited to 850°F. The alloy tip should be 48 inches long.

6. Both outer register plates should be supported with register support brackets. Round edges and adequate clearance should be provided on the register support bracket retainer to assure that the register assembly can expand as needed.

The following cost summary is based on a quantity of 48 burners for one unit.

IP7_000427

Cost Summary

Material Cost (does not include OEM markup)	$476,000
OEM Markup (assumed 100 %)	476,000
Engineering	40,000
Freight	12,000
Installation Labor and Equipment	411,600
Construction Overhead, Supervision, Fees	141,312
Total Cost (20-30 year life)	$1,586,912

The present worth for this alternative based on burner life of 25 years is $2,270,099.

7.0 RECOMMENDATIONS & CONCLUSIONS

The following table is a summary of the present worth for the four alternatives:

Current Mode of Operation	$5,826,274
Eight Pulverizer Operation*	$1,754,153
Increased Cooling Air	$21,186,108
Redesign Burner	$2,270,099

* Does not include maintenance considerations

7.1 Recommended Alternative

The best alternative to resolve the burner problems that are being experienced at IGS Units 1 & 2 is Alternative #4. Replace the register assemblies with the redesigned one-piece HD style and install new throat sleeve and throat sleeve casings with a new design that will operate at 1350°F. Boiler efficiency will not be affected and estimated burner life should be 20-30 years. The current condition of the existing burners warrant this change because they have a short life expectancy. The following schedule denotes the time required to get the burners installed after a purchase order release.

IP7_000428

Burner Procurement & Installation Schedule

Purchase Order Release	
Engineering	12 weeks
Material Procurement	6 weeks
Fabrication	24 weeks
Shipping	2 weeks
Installation	4 weeks
	48 weeks

7.2 Interim Solution

It is recommended that cooling air flow be increased to limit the burner temperatures to 1150°F to reduce additional damage. This will reduce the chance of a safety risk and possible forced outage due to major burner failure.

It is also recommended that IGS run all eight pulverizers whenever they are available for service. This will minimize the period of time that burners must experience the high out-of-service temperature conditions.

7.3 Instrumentation & Controls

Air flow measurement to each windbox compartment for maintaining consistent air flows and register drives for balancing air flow to out-of-service burners would be beneficial in reducing the total amount of cooling air. However, retrofit of compartment air flow measurement instrumentation and register drives would require a multi-million dollar expenditure. In addition, a significant amount of maintenance is required to keep the equipment operating. Because of the other available alternatives, additional instrumentation and controls are not recommended at this time.

IP7_000429

IPSC

BURNER MODIFICATION

PROGRAM REPORT

for

Intermountain Power Service Corporation
Rte 1, Box 864
Delta, UT 84624

Attn: Mr. Aaron Nissen
Results Supervisor

Project No. 912350
October 17, 1991
Ipscblup.rep

Ideas in progress

RJM

Prepared by

Richard J. Monro

IP7_000430

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INTRODUCTION

The IPSC boilers have been analyzed for design improvements to upgrade the durability of the coal fired burners. The existing burners experience significant mechanical stress. The inner and outer air registers and associated parts have severe thermal distortion which causes the registers to become inoperable. The aerodynamics have been examined and a swirler design made for the inner air path. Revised register settings are recommended along with an outer band to restrict inlet flow area into the outer register. The upgrade burner will have lower swirl generation in both registers. This will inhibit the tendency for gas recirculation that is evident in the existing design. The secondary air velocity with the upgrade burner aerodynamics will shape the recirculation zone to reduce NO_X formation. Structural modifications are recommended to the burner to reduce thermal stress. These incorporate a segmented outer register back plate along with radial and axial positioning means to hold the slip fit design components. Materials and thickness will remain the same as used in the existing design.

BURNER DESCRIPTION

The IPSC coal fired unit is a B&W design with 48 burners rated at 100% load for 6,100,000 lbm/hr steam leaving the superheater at 2515 psig and 1005°F. The existing burner design is shown in Figures 1 and 2 based on drawing 294361E-12. The B&W proposed design is shown on Figures 3 and 4 based on drawing SK41791E-O. A summary of the B&W proposed modification is listed in Figures 5 and 6. The recommended burner design modifications including the swirler are shown in Figure 7.

PROBLEM DESCRIPTION

The existing design problem areas are listed in Figure 8. A complete set of photos showing burner distress is in Appendix I.

The warping is caused by extreme thermal stress. Subsequent jamming of the register vanes and air slide occurs as well as relative movement which damages the rope packing air seal.

It can be seen in the photo that the inner sleeve appears distorted in the arc immediately downstream of the ignitor. It should be checked to see if any of the ignitors are firing when retracted in the burner instead of forward of the coal pipe end.

The coal pipe photos show that severe melting, resulting in egg shape ends of the pipe, is associated with coal pipe fires. In fact a photo shows that severe heat in the coal pipe elbow at the burner cover plate occurred during one fire.

AERODYNAMIC ANALYSIS

The existing burner operating conditions and register settings are shown in Figure 9. The inner air sleeve is set open 3 to 5 inches in the existing burners. Primary airflow passes with the pulverized coal. The burner secondary airflows through the outer and inner registers. Evaluation was made of the swirl number for the secondary airflow. Definition of the swirl number and its importance is listed on Figure 10. For optimum combustion and NO_x reduction, a value of 0.8 to 1.0 is desirable for the inner and outer flow. Lower outer flow swirl (.5 or less) may cause potential coal ignition problems. Higher values (approx. 1.5 or more) create over swirl, which results in an improperly sized recirculation zone and the potential of gas recirculation into the air sleeve and throat zones. The recirculation parameter is defined in Figure 11 and is a measure of

the potential for gas recirculation into the air ducts. The baseline analysis for the existing burner and settings shows the potential for hot gas ingestion, which can aggravate the thermal loading on the register parts. The recommended solution was to reduce swirl in both paths by changing register settings and using a properly designed fixed vane swirler in the inner path.

Computer output of the aerodynamic calculations is listed in Appendix II for the baseline and swirler analysis.

Baseline Analysis

The secondary airflow through the registers was evaluated at a windbox-to-furnace pressure differential of 2.0 inches of water and air inlet temperature of 650°F. The airflow is a function of register or spin vane setting angle. The outer register airflow, shown in Figure 12, is 19.1 lbm/sec at 65 degrees vane exit flow angle. The inner register airflow, shown in Figure 13, is 15.2 lbm/sec at 60 degrees vane exit flow angle, corresponding to the outer register setting. The primary airflow in the coal pipe is 10.4 lbm/sec. Total flow per burner is 44.7 lbm/sec and for the furnace with 42 burners in service is 6,760,000 lbm/hr.

The swirl number is 1.64 for the outer register, shown in Figure 14, at 65 degrees vane exit flow angle. The swirl number is 1.36 for the inner register, shown in Figure 15, at 60 degrees vane exit flow angle. Swirl number for both flows is excessive based on our experience, which will produce a combustion internal recirculation that is too large. Also, since the recirculation parameter is calculated to have a negative value, there is the potential for hot gas ingestion in the duct exit The recirculation parameter is -0.2 inch of water, shown in Figure 16, for the outer duct at 65 degrees vane exit flow angle. The recirculation parameter is -0.4 inch of water, shown in Figure 17, for the inner duct at 60 degrees vane exit flow angle.

Swirler Analysis

The approach for the aerodynamic improvement was to design a swirler to provide approximately 1/3 of the burner airflow at a swirl number of 0.85.

A swirler design was employed which uses curved vanes with axial inlet angle and exit angle variation from 40° at the hub to 65° at the tip. Mechanical design of the swirler is discussed in a later section.

The swirler is used for the inner flow, which strongly effects the shape of the combustion recirculation zone. The spin vanes of the inner register will be set full open (i.e. 0 degrees flow angle) to provide axial flow into the swirler. The outer register will be set at a lower vane exit flow angle to provide reduced swirl number.

With reduced swirl in both secondary flows, the required windbox-to-furnace differential pressure is lower than for the existing burner design and register settings. Two cases were evaluated with the swirler to obtain the same secondary airflow rates as in the existing design.

a) Pressure differential of 1.19 inch of water.

In this case the outer register vane exit flow angle was set at 56 degrees. Outer register airflow was calculated to be 19.0 lbm/sec which produces a higher than desirable swirl number of 1.13 and a positive recirculation parameter of 0.25 inch of water. The flow in the inner register with the air slide open 10 inches was calculated to be 15.5 lbm/sec. The swirler generates the design swirl number of 0.85. The recirculation parameter is positive and equal to 0.98 inches of water at the swirler hub and 1.80 inches of water at the coal pipe O.D. This case avoids negative recirculation parameter, but has a higher swirl number than necessary for the outer register airflow.

b) Pressure differential of 1.99 inch of water.

In this case the pressure differential is increased, which will help provide better burner to burner airflow uniformity. This is accomplished by putting a band around the inlet to the outer register to block approximately 50 percent of the flow area as calculated at the register air door restriction. The inner register air slide will be set less open than in case (a). The band permits setting the outer register vane exit flow angle at 50 degrees. Outer register airflow was calculated to be 1.91 lbm/sec, with a swirl number of .91 and a positive recirculation parameter of .40 inch of water. The flow in the inner register with the air slide open 5 inches was calculated to be 15.0 lbm/sec. The swirler generates the design swirl number of 0.85. The recirculation parameter is positive and equal to 1.05 inches of water at the swirler hub and 1.82 inches of water at the coal pipe O.D. This case also avoids negative recirculation parameter, but has a desirably lower value of swirl number in the outer duct. The pressure differential of 1.99 inches of water is equal to the existing baseline operating value. This case (b) is recommended and will require addition of a band on the outer air register inlet, which will restrict the open flow area to 1300 square inches (5.9" open slot width).

BURNER STRUCTURAL ANALYSIS

Test Data

The existing design of Unit 2 burners was modified and set as listed in Figure 18. Measured temperatures at full load with burners "in" and "out" of service are shown in Figure 19.

Thermal Design Conditions

The heat transfer analysis design conditions are summarized in Figure 20. In service, a maximum air side convective heat transfer coefficient (HTC) of 12 Btu/hr ft^2°F was used on the duct walls, based on velocity corresponding to 100% load airflow. Reduced (HTC) values were used in the lower velocity regions and on the surfaces exposed to the windbox. Radiation load was based on a 3200°F flame temperature and shape factors to the surfaces from mid flame position. The In-Service condition matched the measured temperature on the back plate. The Out-Of-Service conditions predicted temperatures higher than measured, which were intended to predict worst case structural loads.

Analytical Model

A finite element heat transfer and stress analysis was performed on the existing burner design, (294361E-12), the B&W proposed burner design, (SK 41791E-0), and on our recommended modified design using the COSMOS/M finite element computer program.

For the existing design, the inner sleeve, back plate, throat sleeve and front plate were modeled as an assembly using 392 axisymetric ring elements. Nodal displacements linking the front plate to the back plate were used to simulate the outer register assembly. Radiant heat flux and cooling airflows were simulated using element heat generation and surface convection coefficients. See Figure 21.

For the proposed design, only the slip-fit back plate was analyzed (using 84 axisymetric ring elements), since the unrestrained inner sleeve will be free to grow thermally and is therefore essentially stress-free. Similarly the slip-fit feature of the front plate/throat sleeve attachment relieves the thermal stress build-up between these parts so that further analysis of these parts is not required.

For the recommended modified design only the segmented back plate panels were analyzed using a 90° circular plate model consisting of 228 plane stress elements 1/2 inch thick. See Figure 22.

For the existing design and the B&W proposed design, the In-Service operating condition was evaluated based on the prescribed thermal design heat flux and airflow rates. Out-Of-Service operation was based on the full In-Service heat flux, but with the reduced (shut-down) airflow rates.

For the recommended segmented back plate design, the In-Service operating condition was evaluated based on the temperature field calculated for the proposed design. The Out-Of-Service operating condition was based on the calculated temperature field adjusted to match the maximum temperature measured for this condition.

For all cases, elastic analyses were performed. Material properties used to evaluate the designs are listed in Figures 23 through 26.

Existing Design: In-Service

The results of the heat transfer analysis are shown in Figure 27. It is seen that temperatures along the inner sleeve are generally low, but indicate a local hot spot of 875°F caused by heat flow from the back plate. A maximum temperature of 1060°F is predicted on the back plate just outboard of the inner sleeve, which is within the range 850-1220°F, measured for this condition. Low temperatures were also predicted in the throat sleeve and forward plate.

The resulting thermal growth is indicated in Figure 27A which shows the deformed finite element model, scaled for clarity, superimposed over the undeformed (room temperature) model. The radial growth of the inner sleeve is slightly greater at the back plate attachment (0.160 inch) than at either end due to the locally higher temperature at that

location. Similarly, radial growth of the back plate outer diameter is somewhat larger than that of the front plate (0.301 vs 0.245 inch), skewing the outer register connecting bars (not shown). Finally it is seen that the forward end of the throat sleeve tends to move axially (0.168 inch) as well as radially (0.221 inch), assuming no restraint from the air slip seals (not shown).

The results of the stress analysis in Figure 28 showed generally low stresses along the inner sleeve except for a high (22,000 psi) local stress concentration due to the thermal growth of the back plate. The high compressive tangential stress shown in the back plate results from the hot material near the inner radius expanding against the restraint of the colder material near the outer register. For a thin plate, this type stress field will result in a circumferential coning or buckling distortion of the plate. Fracture of the weld is expected at this stress level and temperature (see photos in Appendix I) with subsequent separation from the inner sleeve and jamming of the outer register vanes.

The stresses shown in the front plate and throat sleeve are generally low except for a moderate local stress concentration at the attachment weld. The peak stress of 7600 psi at 740°F is well within the allowable stress limits previously given in Figure 23.

The results of this analysis are summarized in Figure 29.

Existing Design: Out-Of-Service

For the Out-Of-Service analysis the high radiant heat flux of the In-Service condition was imposed in order to simulate a "worst-case" loading condition.

The heat transfer analysis shows higher temperatures throughout the design, predicting a peak temperature of 1760°F on the back plate, which far exceeds the measured temperature range of 980°F - 1285°F typical for this condition. Figure 30.

The thermal growth pattern is similar to the In-Service case, but with proportionately greater deformation values.

Based on this "worst-case" temperature field, the stress analysis, Figure 31, shows very much higher compressive tangential stresses in the back plate which would severely aggravate the circumferential coning/buckling distortion already predicted to occur during In-Service operation. Additional, and more certain, separation from the inner sleeve would, therefore, be predicted with aggravated distortion of the plate and jamming of the outer register vanes.

Fracture of the front plate/throat sleeve attachment would also be predicted.

The results of this analysis are summarized in Figure 32.

B&W Proposed Design: In-Service

For this design, a finite element analysis was performed only for the slip-fit back plate since the inner sleeve is now free to grow thermally resulting in an essentially stress-free state. A similar argument applies to the separated front plate and throat sleeve where low temperatures and stresses are now expected.

The heat transfer results, Figure 33, shows the maximum temperature on the back plate is now at the inner radius, and is 25°F hotter than the existing design due to the gap between it and the inner sleeve.

The maximum compressive stress, Figure 34, has also increased slightly resulting in a slightly stronger tangential stress field than in the existing design, and therefore the same coning/buckling behavior persists in the proposed design. Jamming of the outer register vanes is also expected.

Because coning/buckling distortion is the predicted failure mode, upgrading the material to one of higher strength will have negligible beneficial effect. Increasing the thickness from 1/2 inch to 5/8 inch will provide some, but very minor, additional resistance to buckling.

The results of this analysis are summarized in Figure 35.

Proposed Design: Out-Of-Service

This analysis gave generally similar results to the In-Service results, but again with higher temperatures and stresses, further aggravating the predicted coning/buckling distortion of the plate. See Figures 36 and 37.

The results of this analysis are summarized in Figure 38.

Recommended (RJM) Modified Design: In-Service

RJM's recommended back plate design (see Figure 39) consists of four, 90° segmented panels, slip-fitted to each other and to the inner sleeve and outer register assembly of the burner assembly, previously shown in Figure 7. Overlapping plates are shown installed between the segments to minimize airflow through the gaps. Radial support bars, two for each panel, position the panels and prevent binding of the panels during operation.

A finite element stress analysis of the four panel design was performed based on the calculated In-Service temperature field. The resulting thermal growth of these panels is shown in Figure 40. It is seen that each panel is now free to grow, and for this loading, expands 0.290 inches circumferentially at the inner radius, thereby eliminating the circumferential coning/buckling failure mode of the full plate design.

The stress results of Figure 41, shows that the edges are stress free, and that the material along the inner radius is now in tension, and effectively balanced by an adjacent compressive field. Similar tensile/compressive stress fields occur in the outer region of the plate.

Note that the calculated (elastic) stresses cannot, in practice, exceed the material's yield strength, so that the peak tensile stress is limited to 18,300 psi at this temperature. See Figure 42. Plastic straining is therefore very minor, and limited to a small region along the inner radius. Furthermore, the fixed thermal strains distributed within the panel will relax due to creep, causing a gradual reduction of the stresses throughout the panel. Residual stresses resulting from the plastic strains will also gradually disappear. Failure by low cycle fatigue or creep rupture is therefore not expected.

Recommended (RJM) Modified Design: Out-Of-Service

For the Out-Of-Service condition, the calculated temperature field was adjusted to match the maximum temperature typically measured for this condition, (1285F), plus the additional 25F predicted for the slip-fit plate.

The calculated free tangential growth at the inner radius is now 0.350 inch.

The peak (elastic) stress, again at the inner radius, as shown in Figure 43, is now limited to the material's yield strength of 16,200 psi at this temperature, resulting in additional, but still minor plastic strains around the inner radius. As for the In-Service case, creep relaxation will gradually reduce these stresses throughout the panel and the residual stresses resulting from the plastic strains will also gradually disappear.

The results of this analysis and back plate design features are summarized in Figure 44.

Structural Analysis Summary

It is concluded that, during In-Service operations, the high radial temperature gradient on the back plate of the existing design, with its associated high compressive tangential stress field, results in circumferential coning/buckling of the plate with subsequent weld failures and separation from the inner sleeve. Jamming of the outer register vanes is therefore also expected. Out-Of-Service operation further aggravates the damage.

For the B&W proposed design, the slip-fit on the back plate does not relieve the high compressive tangential stress field in the plate, so that the same (or slightly more severe) coning/buckling distortion is predicted. The slip-fit feature, however, does relieve the stresses in the inner sleeve, an well as in the front plate and throat sleeve.

It was also concluded that little, if anything, would be gained by upgrading the materials or in increasing the thicknesses of the proposed design.

It is recommended that the proposed slip-fit back plate be modified by segmenting the plate into 4 separate 90° panels so as to relieve the high tangential stress field and the associated circumferential coning/buckling distortion. Jamming of the outer register doors will then also be eliminated. To ensure free thermal growth of all four panels when installed, a tangential gap of 0.75 inch is recommended between panels, with radial gaps of 0.25 and 0.50 inch at the inner and outer radius respectively.

It is also recommended that the B&W proposed inner sleeve and slip-fit front plate/throat sleeve designs remain as proposed except for the inclusion of radial support bars.

The structural conclusion and recommendations are summarized in Figure 45.

Finally it is recommended that the same materials and thicknesses of the existing design be used through out. See Figure 46.

Swirl Nozzle Mechanical Design

The recommended Swirl Nozzle design consists of 40 vanes welded to an outer and inner shroud as shown in Figure 47. Both the outer and inner shrouds are segmented to permit free thermal growth of the assembly, thereby relieving the unit from high locked-in thermal stresses. A finite element analysis was therefore not performed since the structure is essentially free of thermal stresses.

Installation of the swirler is shown in Figure 48. Cutouts (dimensions and locations supplied by IPSC) in the swirler vanes permit clearance for the ignitor, scanner and observation port. These are mirror images for CW and CCW swirlers. The unit is attached at the outer shroud to the coal nozzle by 16 support straps, 2 per segment, to allow for free thermal growth between the (hotter) outer shroud and the (cooler) coal nozzle. Locking pins, fitted to the inner shroud, permit free radial and tangential thermal growth of the segments while constraining axial movement of the segments along the inner shroud. The swirler is constructed of high temperature stainless steel (SS310).

A summary of the swirler mechanical design features is listed in Figure 49.

CONCLUSIONS AND RECOMMENDATIONS

- Aerodynamic analysis indicates that high swirl numbers associated with the inner and outer register airflow are excessive (approximately 1.5) and have the potential for hot gas recirculation into the air cavities.

- A swirler for the inner airflow will lower and provide a constant swirl number of 0.85.

- A band (or perforated screen) is recommended for the outer register inlet to permit it to be operated at a reduced exit vane flow angle and thus reduce its swirl number.

- Structural analysis confirms that the high radial temperature gradient on the outer register back plate of the existing design with its associated high compressive tangential stress field results in circumferential coning/buckling of the plate with subsequent weld failures and separation from the inner sleeve. Jamming of the outer register vanes is therefore also expected.

- Recommended additional burner modifications are:

  - Segmented back plate panels with slip fit clips and radial positioning support.

  - Outer register vane assembly radial and axial position struts.

  - Throat sleeve with slip fit clips to register and radial position bars.

  - The separate outer ring design for the air seal will avoid radial thermal growth

problems, but the air seal stop must be modified to permit axial movement.

- The same materials and thickness of the existing design can be used with the recommended burner design modifications.

- The recommended burner design modifications and material selections are being provided by the RJM Corporation, with the understanding that the final design decision and implementation shall be the responsibility of the Intermountain Power Service Corporation and the Babcock and Wilcox Company.

NO_X PREDICTION

As a means to estimate the impact of the MZ Flame Stabilizer and recommended register settings on NO_X emissions, RJM reviewed the latest relevant literature. In that review, several items became evident to us. For dual register burners, a significant amount of swirl number optimization work has taken place in recent years. Work done by LaRue in the early 80's showing outer swirl numbers of .6 to .7 and inner swirl numbers of 1.3 to 1.4 as being recommended practice or normal operation (Figures 50 and 51). Jeremiejczyk in 1978 shows studies over a range of both swirl numbers in the inner from 0 to .75 and the outer from .4 to 1.2. Jeremiejczyk and others also found that the outer swirl number should be greater than .5 to assure ignition point and flame stability with various coal types. Current operation at IPSC has the following swirl number settings:

Inner = 1.36

Outer = 1.64

The RJM recommendations for swirl numbers are:

Inner = .84 (MZ Stabilizer)
Outer = .91

The outer swirl number is larger than RJM's experience would dictate which is heavily influenced by prior investigators and their measured ignition/flame stability limits on oil and gas units. However, the fuel volatility and swirl number interdependence indicated by Jeremiejczyk clearly indicates higher swirl numbers would be beneficial for ignition and flame stability as the relative volatility of the fuel decreases. Based on this research, RJM has adjusted IPSC's swirl numbers accordingly.

In terms of NO_X, if we use Figure 52 with the closest comparisons to current IPSC swirl settings and RJM recommendations, a lower O_2 profile is seen to exist on the centerline with lower temperatures (perhaps 20°C). Ignoring the O_2 difference (which helps the MZ stabilizer NO_X), the temperature difference would indicate perhaps as much as 14% NO_X reduction using RJM scaling factors. Obviously, an exact NO_X prediction is not possible, but at least the recommended settings and hardware will tend to drive NO_X down from current levels; perhaps as much as the calculated 14%.

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INTERMOUNTAIN POWER PROJECT EXISTING DESIGN (REF. 294361E-12)

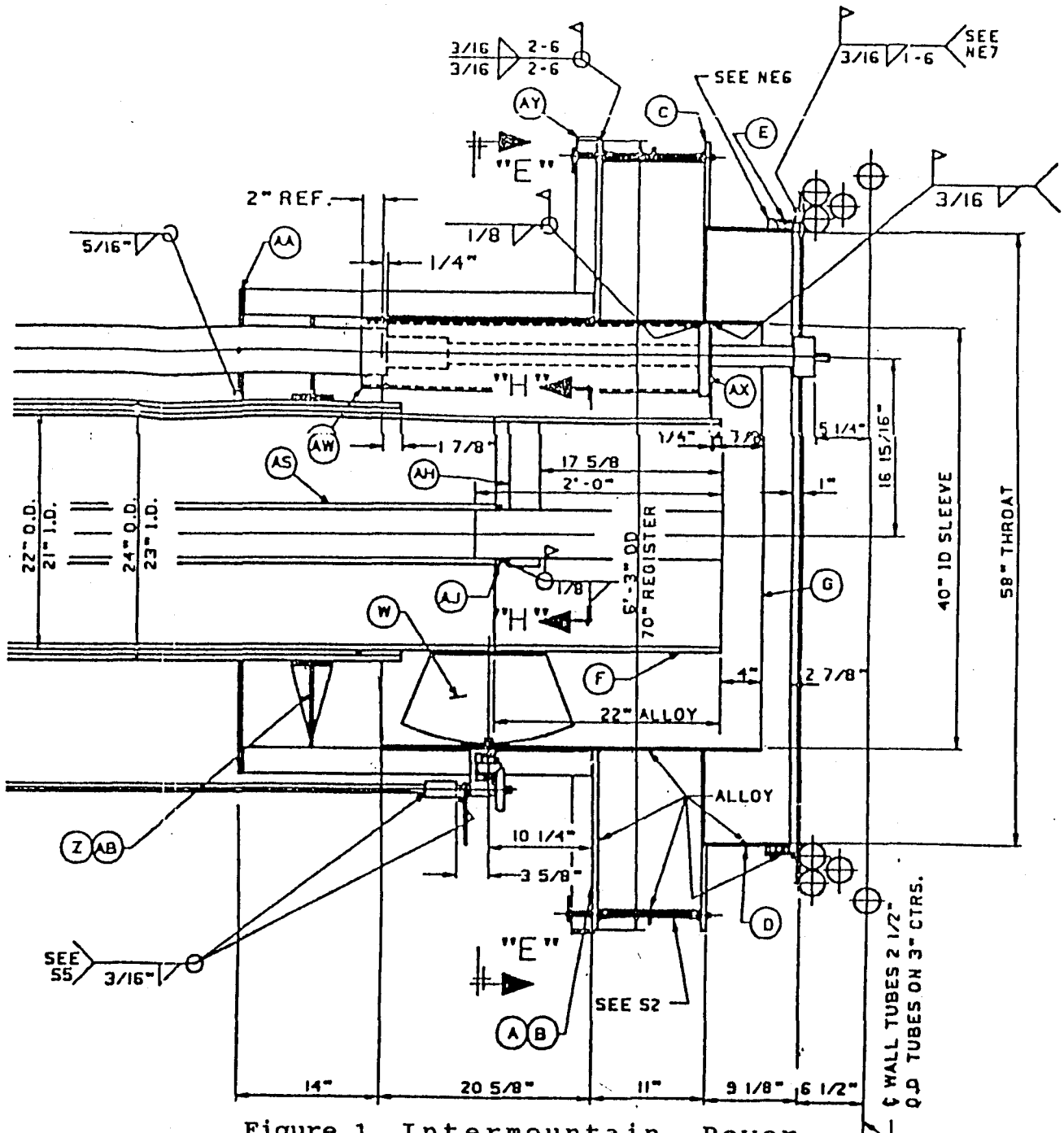


Figure 1 Intermountain Power

IP7_000452

INTERMOUNTAIN POWER PROJECT

EXISTING DESIGN
(REF. 294361E-12)

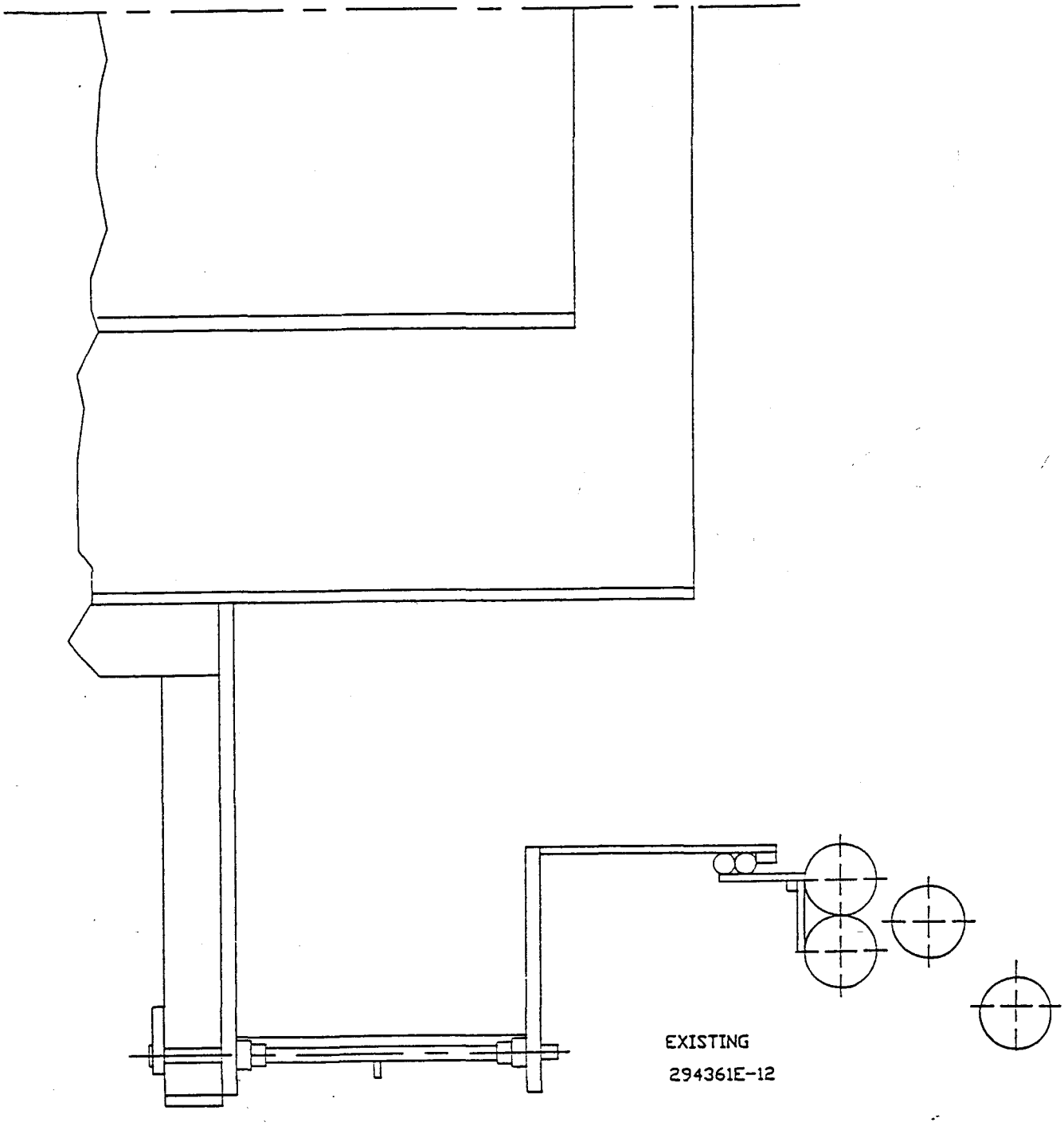
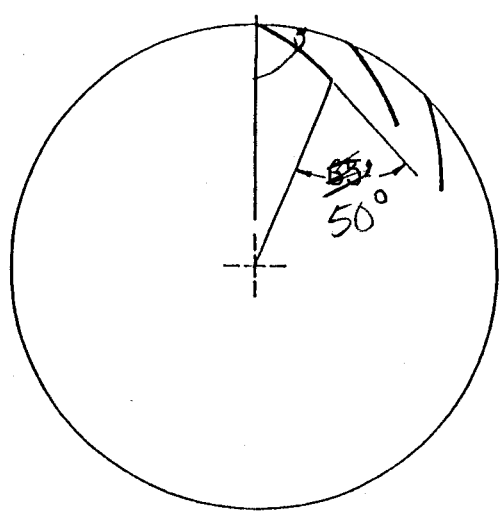


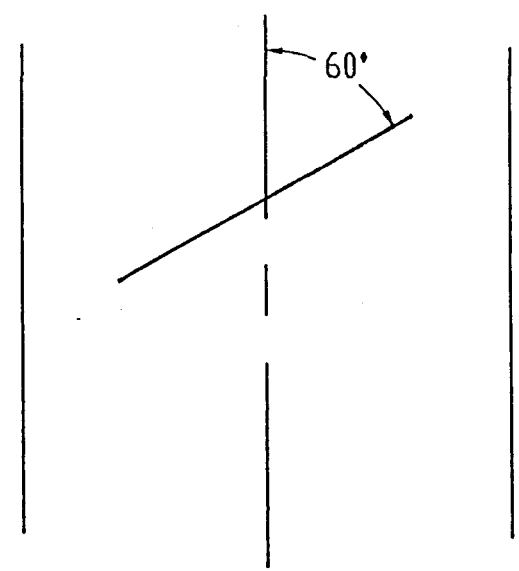
Figure 2 Intermountain Power Project - Existing Design (Expanded view)

AIR REGISTERS

- o OPERATING CONDITIONS
  - 100 PERCENT LOAD WITH 42 BURNERS
  - AIR TEMPERATURE = 650°F
  - WINDBOX TO FURNACE DIFFERENTIAL PRESSURE = 2.0 INCHES WATER
- o SETTINGS (REF. NOVEMBER 24, 1988)



OUTER REGISTER VANE
EXIT FLOW ANGLE (OFF RADIAL)



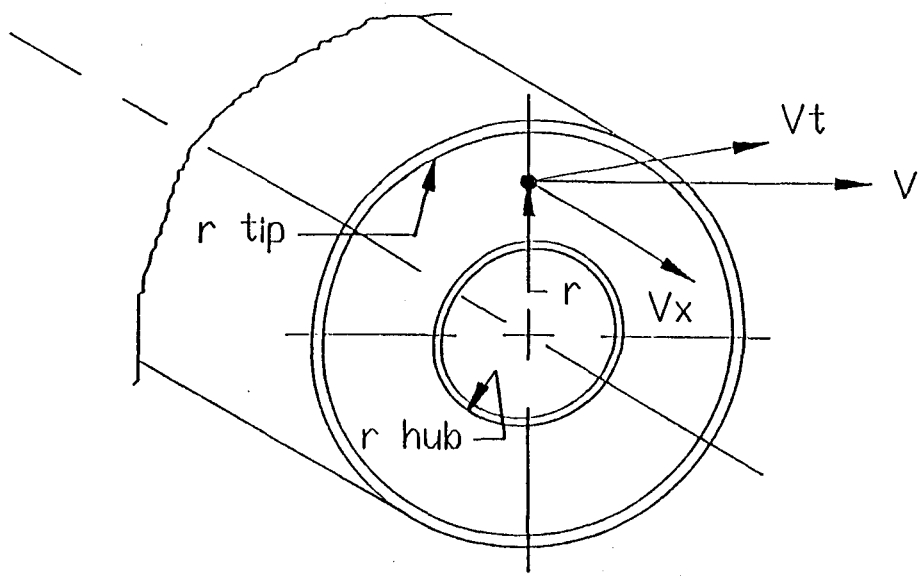
INNER SPIN VANE
EXIT FLOW ANGLE (OFF AXIAL)

IPP.AR

Figure 9 Air Registers

SWIRL NUMBER

- MEASURE OF JET TANGENTIAL TO AXIAL MOMENTUM
- DETERMINES SIZE OF COMBUSTION INTERNAL RECIRCULATION ZONE



IPP.SN(COR)

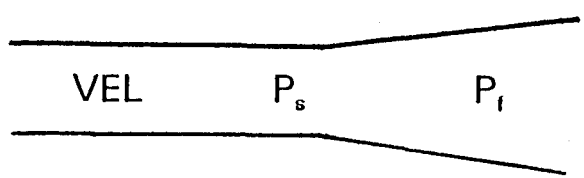
$$\text{Local Swirl No.} = \frac{rV_t}{V_x\, r_{tip}}$$

$$\text{Integrated Swirl No.} = \frac{1}{r_{tip}} \frac{\int_{r_{hub}}^{r_{tip}} rV_t \;(\rho V_x\, 2\pi r)\,dr}{\int_{r_{hub}}^{r_{tip}} V_x \;(\rho V_x\, 2\pi r)\,dr}$$

Figure 10 Swirl Number

RECIRCULATION PARAMETER

- MEASURE OF AXIAL MOMENTUM TO OVERCOME LOCAL STATIC PRESSURE TO FURNACE PRESSURE RISE
- POTENTIAL FOR RECIRCULATION EXISTS WHEN THE PARAMETER IS A NEGATIVE VALUE



$(P_s < P_f)$

RECIRCULATION PARAMETER = [(AXIAL MOMENTUM / UNIT AREA) - PRESSURE RISE]

$$\text{RECIRCULATION PARAMETER} = [(\rho V^2 / g_c) - (P_f - P_s)]$$

IPP.RP

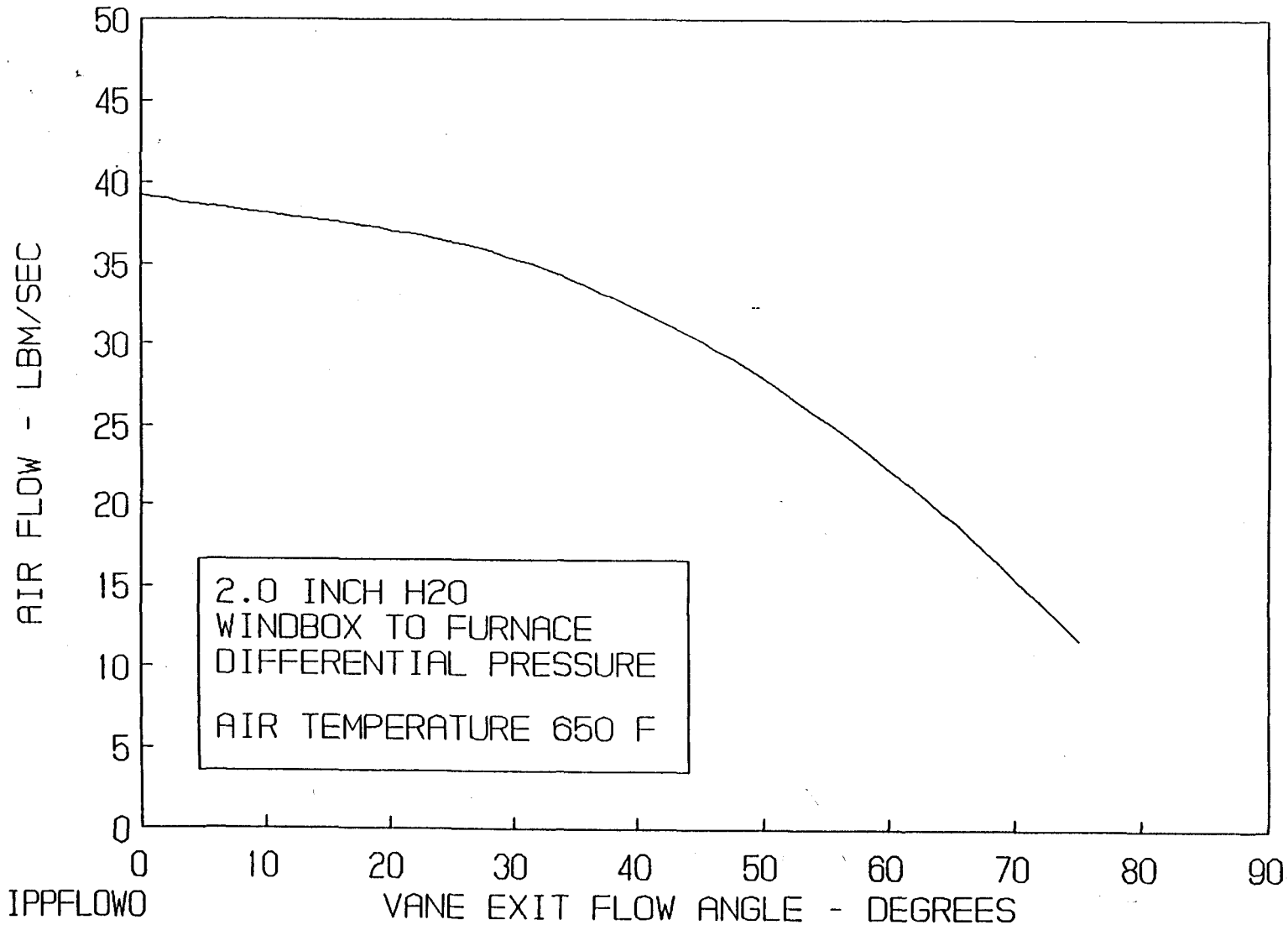
Figure 11 Recirculation Parameter

IP7_000456

INTER MOUNTAIN POWER PROJECT - UNITS 1 & 2

OUTER AIR REGISTER - EXISTING DESIGN

AIR FLOW



IPPFLOWO

Figure 12 Outer Air Register-
[redacted]sti[redacted]Des[redacted] A[redacted]Flo[redacted]

INTER MOUNTAIN POWER PROJECT - UNITS 1 & 2

INNER AIR REGISTER - EXISTING DESIGN
AIR FLOW

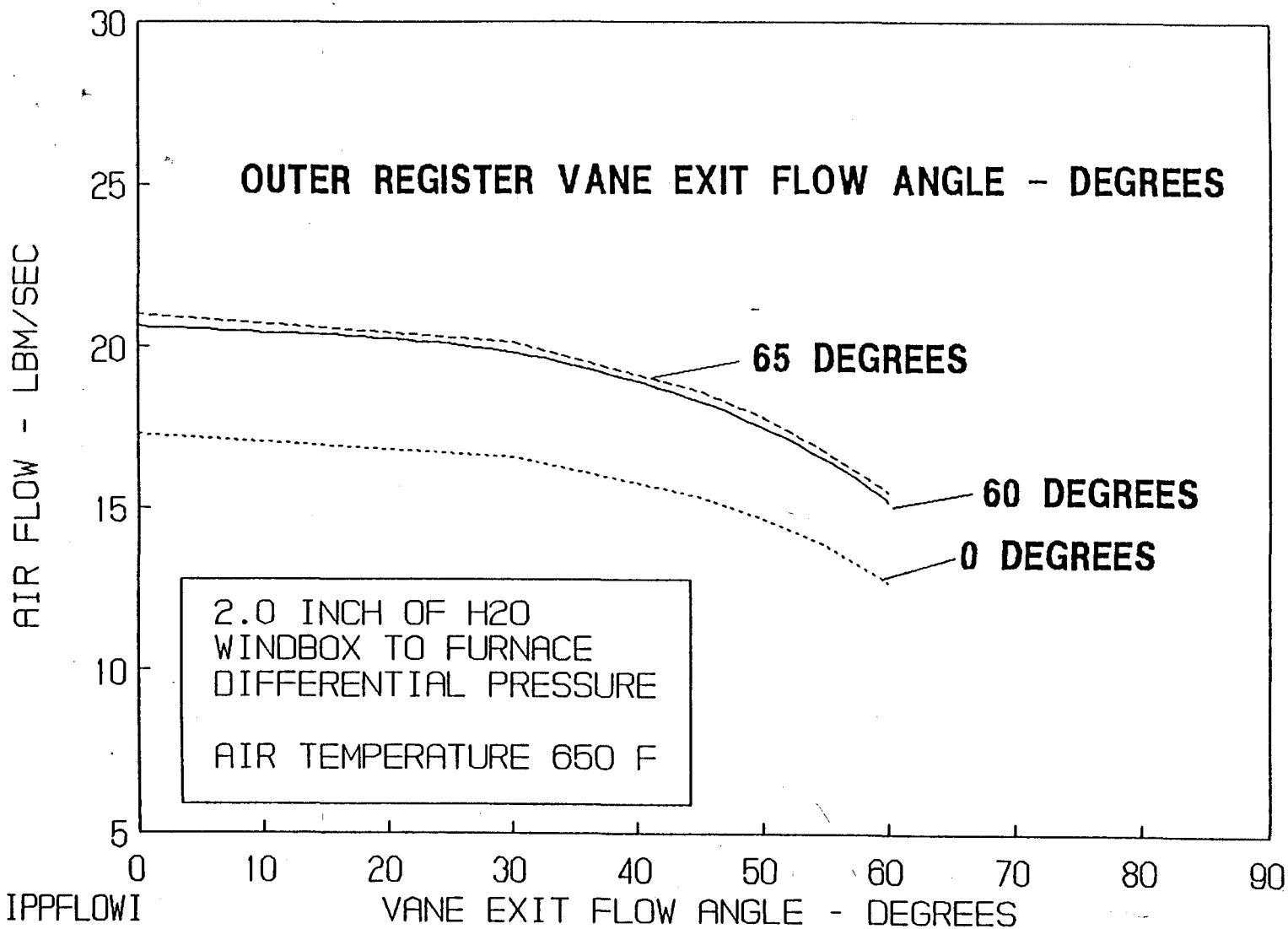


Figure 13 Inner Air Register-
Existing Design Air Flow

IP7_000458

INTER MOUNTAIN POWER PROJECT - UNITS 1 & 2

OUTER AIR REGISTER - EXISTING DESIGN

SWIRL NUMBER

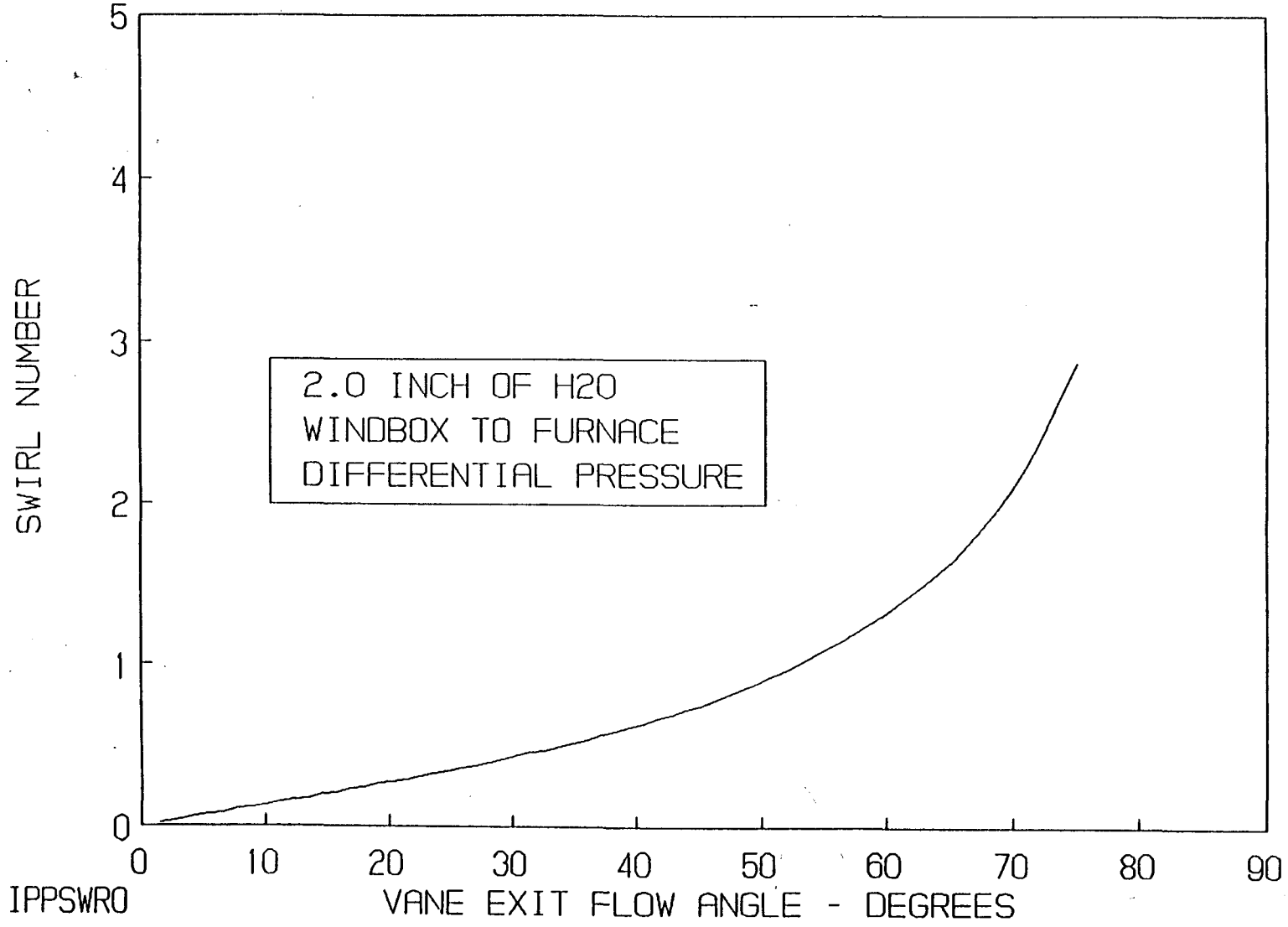


Figure 14 Outer Air Register-
[redacted]is[redacted]g [redacted]si[redacted] S[redacted]l [redacted]

IP7_000459

INTER MOUNTAIN POWER PROJECT - UNITS 1 & 2

INNER AIR REGISTER - EXISTING DESIGN
SWIRL NUMBER

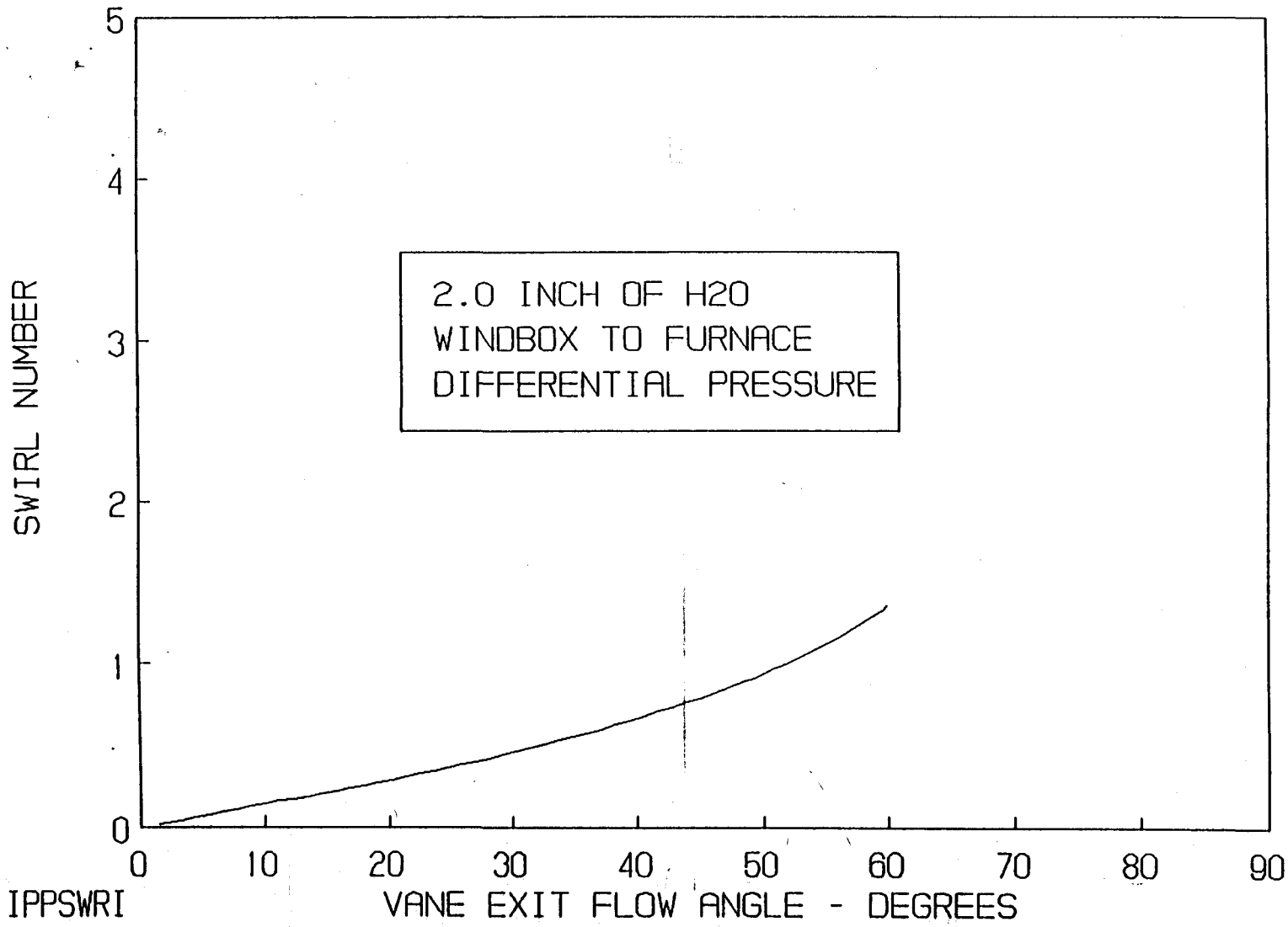
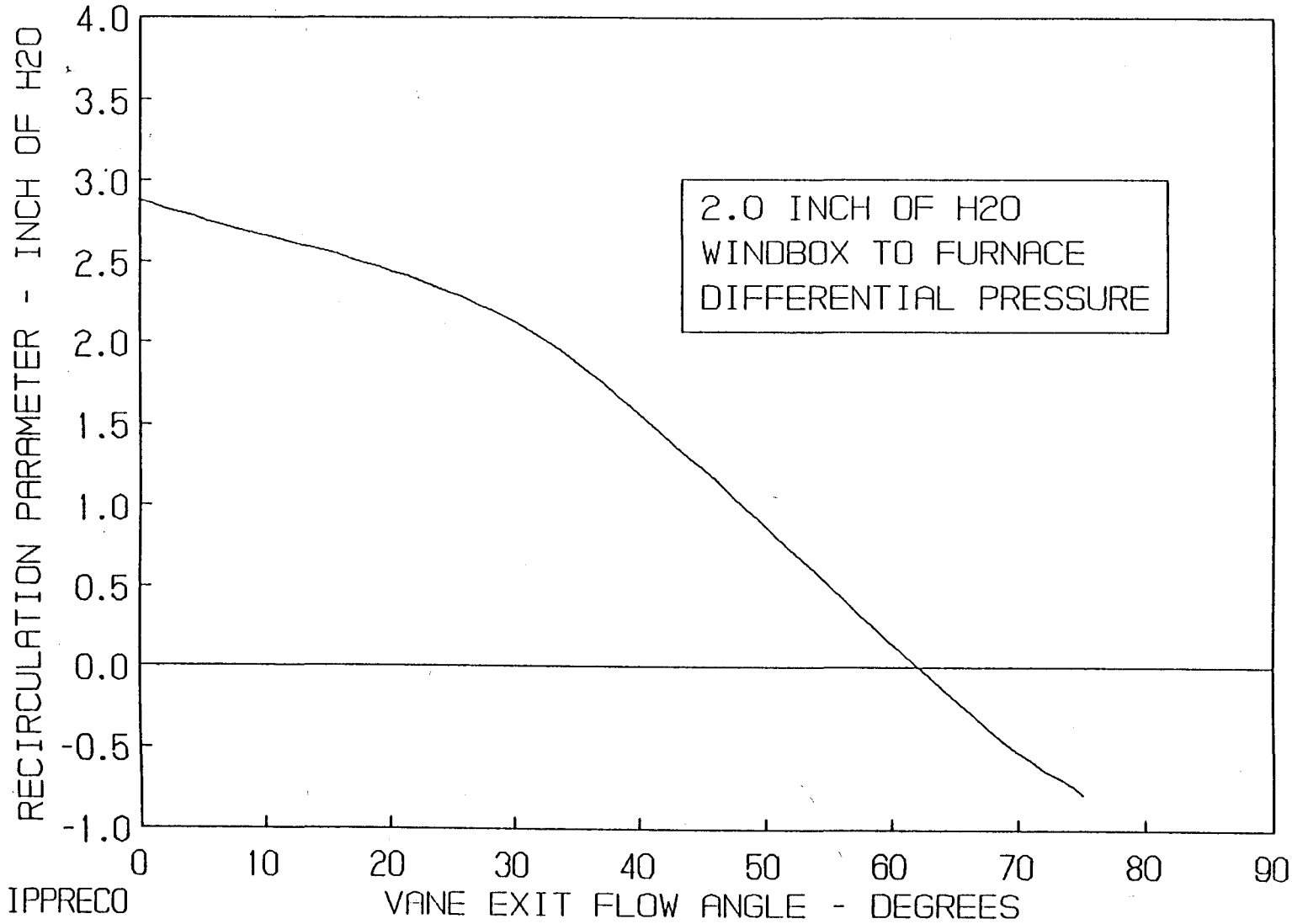


Figure 15 Inner Air Register-Existing Design Swirl

INTER MOUNTAIN POWER PROJECT - UNITS 1 & 2

OUTER AIR REGISTER - EXISTING DESIGN
RECIRCULATION PARAMETER



IPPRECO

Figure 16 Outer Air Register-
Existing Design

IP7_000461

BURNER - UNIT 2

(REF. RB-0615 - NOVEMBER 24, 1988)

BURNER MODIFICATIONS

- o EXPANSION JOINTS WERE INSTALLED ON THE OUTER REGISTER DRIVE HANDLES
- o BACKPLATES AMD FRONT PLATES OF REGISTERS WERE CUT FREE AND EXPANSION CLIPS WERE INSTALLED

BURNER SETTINGS

- o OUTER REGISTERS - 6" (DOOR STIFFENER TO DOOR - ON A PERPENDICULAR)
- o SPIN VANES - 30° (WHERE 90° IS STRAIGHT THROUGH, 0° IS CLOSED)
- o BACK PLATES - 5", 4", 3", 3", 4", 5" OPEN
- o (ALL BURNER SETTINGS HAVE BEEN LOCKED IN PLACE)

IPP.BS

Figure 18 Burner - Unit 2
(November 24, 1988)

IP7_000462

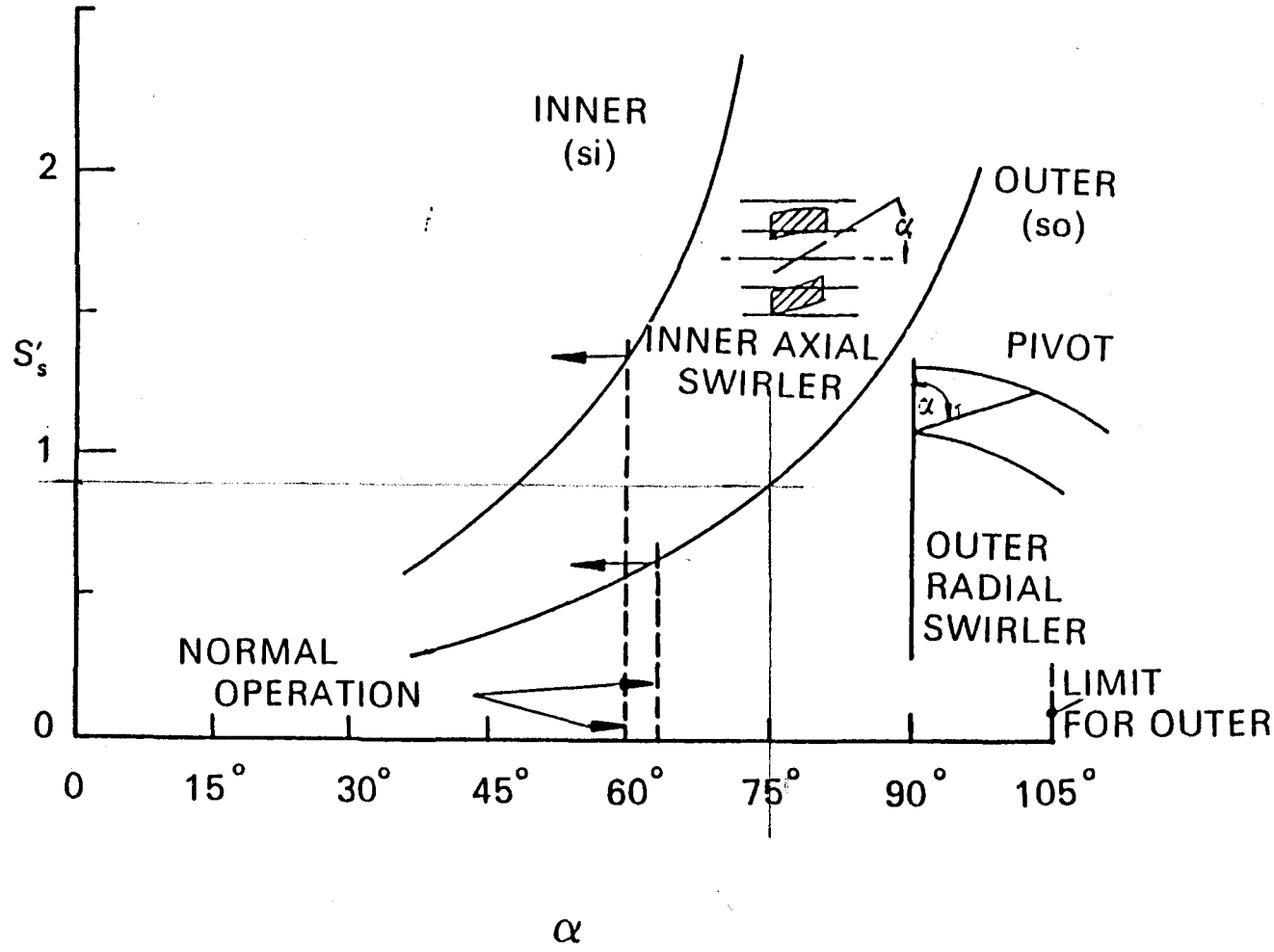


Figure 51 Swirl numbers estimated for the flows from the two registers of Figure 50

IP7_000463

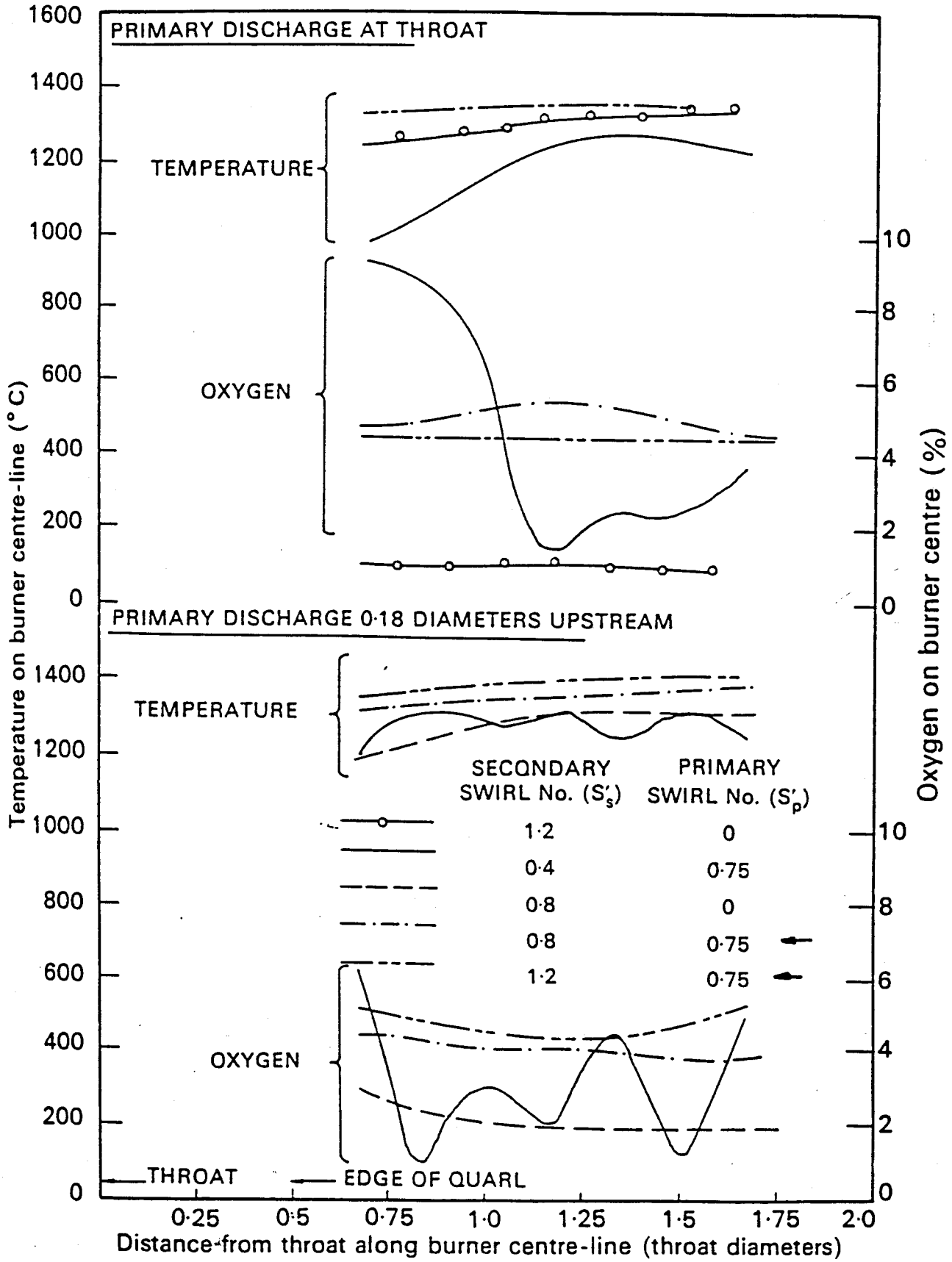


Figure 52 The effect of swirl on axial temperature and oxygen profiles. (After Jeremiejczyk (1978).)