**Topical Report** **May 2000**

# Healy Clean Coal Project

## 90-DAY COMMERCIAL OPERATION TEST AND SUSTAINED OPERATIONS REPORT: A PARTICIPANT PERSPECTIVE

**Prepared by the Alaska Industrial Development and Export Authority with contributions from 90-Day Commercial Operations Test Participants: TRW, Inc., Usibelli Coal Mine, and Stone & Webster Engineering Corporation**

**UNDER**

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# Abstract

The 90-day commercial operation test at the 50-MW Healy Clean Coal Project (HCCP) was completed on November 15, 1999. The purpose of the test was to assess the long-term commercial viability of the project. The two requirements for successful completion of the the 90-day test were: 1) that the plant generate 91,800 MWH (85% of capacity) during 90 days of continuous operation utilizing coal representative of that which will be supplied for the life of the plant and 2) that the major systems are performing in accordance with design specifications and that there is no reason why HCCP would not continue to operate on a sustained basis.

From the Alaska Industrial Development and Export Authority's (AIDEA's) perspective, the 90-day commercial operation test was a success and demonstration of the technology was successful. AIDEA believes that the plant can be considered capable of sustaining operations for 35 years after appropriate improvements are made to the coal feed system. HCCP was credited with generating 102,373 MWH of electric power equivalent to a capacity factor of 94.79% over a 90-day period. The fuel flexibility, and corresponding positive economic, and waste minimization benefits associated with the new combustor technology were demonstrated by burning 83% previously unsaleable waste coal, including fines, over the 90-day test period. This blend of run-of-mine (ROM) and waste coal is representative of coal which would be supplied for the life of the plant. In addition to achieving these results, all generation was achieved within permitted limits for emissions with the exception of short-term exceedences of sulfur dioxide ($SO_2$) and opacity that occurred during plant start-up, shut-down, and equipment repairs.

Improvements needed in the coal feed system, that are necessary to make the plant capable of sustaining operations for 35 years, are relatively minor. Remediation options to be considered are placing the fans on the clean air side, using eductors instead of fans to supply the small amount of high pressure air required, adding two small pulverizers, improving the durability of exhauster fan materials, reducing the fan blade tip speed, adjusting the air flow rates, or simply changing out the exhauster fans on a regular basis as needed.

Harris Group Inc. (HGI) was retained as an Independent Engineer to prepare the protocol for the test, to report on the results of the 90-day test, and to render an opinion on the plant's ability to operate for 35 years. HGI concluded that the major systems of the project are performing in accordance with design specifications and tolerances and could be considered commercial if the heating value of the coal burned exceeds 7200 Btu/lb. HGI also concluded that the 90-day test was inconclusive with regard to passing the 90-day test requirements set forth in the Power Sales Agreement (PSA) because they believed that the coal heating value used during the test was much higher than the design specifications and because there was "excess staffing" on-site during the test. In addition, HGI identified "problem areas," including that the coal transport system be redesigned and rebuilt.

HGI's conclusions are different from AIDEA's, but are accepted as being the "independent" opinion. AIDEA, however, believes that some of the data and assumptions used by HGI in reaching their conclusions need further analysis. Also, AIDEA believes that HGI made arbitrary interpretations of the test protocol resulting in the "inconclusive" result.

This report analyzes the data and assumptions used by HGI in reaching their conclusions. Careful review of the data will help confirm AIDEA's position that the plant is capable of

sustaining operations for 35 years with design specification coal available in the area after appropriate and cost-effective repairs to the project are completed.

In the worst case, all of the potential problem areas identified by HGI could be addressed in a relatively short time so that HGI could reach a conclusion similar to AIDEA's, that the plant is capable of sustaining operations for 35 years with design specification coal available in the area.  However, AIDEA believes that it would first be best to re-examine the issues and then agree on which of the potential problems are most cost-effective and appropriate to address based on review of the data presented in this report.

On a non-site specific basis, there is general agreement that demonstration of the new technologies, particularly the combustor technology, is fully successful and commercial.  HGI has confirmed that the new technology would be capable of sustained operations for a coal heating value as low as 7000 Btu/lb.

# 1.0 Executive Summary

A 90-day commercial operation test at the 50-MW Healy Clean Coal Project (HCCP) was completed on November 15, 1999. The purpose of the test was to assess the long-term commercial viability of the project.

The major objectives of the test were to demonstrate successful operation of the plant over a 90-day period so it could be turned over to the operator, Golden Valley Electric Association (GVEA) for long-term commercial operation. The two requirements for successful completion of the 90-day test were: 1) that the plant generate 91,800 MWH (85% of capacity) during 90 days of continuous operation utilizing coal representative of that which will be supplied for the life of the plant and 2) that the major systems are performing in accordance with design specifications and that there is no reason why HCCP would not continue to operate on a sustained basis.

From the Alaska Industrial Development and Export Authority's (AIDEA's) perspective, the 90-day commercial operation test was a success and demonstration of the technology was successful. AIDEA believes that the plant can be considered capable of sustaining operations for 35 years after appropriate improvements are made to the coal feed system. HCCP was credited with generating 102,373 MWH of electric power equivalent to a capacity factor of 94.79% over a 90-day period. The fuel flexibility, and corresponding positive economic, and waste minimization benefits associated with the new combustor technology were demonstrated by burning 83% previously unsaleable waste coal, including fines, over the 90-day test period. This blend of run-of-mine (ROM) and waste coal is representative of coal which would be supplied for the life of the plant. In addition to achieving these results, all generation was achieved within permitted limits for emissions with the exception of short-term exceedences of sulfur dioxide ($SO_2$) and opacity that occurred during plant start-up, shut-down, and equipment repairs.

Improvements needed in the coal feed system, that are necessary to make the plant capable of sustaining operations for 35 years, are relatively minor. Remediation options to be considered are placing the fans on the clean air side, using eductors instead of fans to supply the small amount of high pressure air required, adding two small pulverizers, improving the durability of exhauster fan materials, reducing the fan blade tip speed, adjusting the air flow rates, or simply changing out the exhauster fans on a regular basis as needed.

Harris Group Inc. (HGI) was retained as an Independent Engineer to prepare the 90-day test protocol (Appendix G), to report on the results of the 90-day test (Section 10), and to render an opinion on the project's ability to sustain operations for 35 years. They concluded that the major systems of the project are performing in accordance with design specifications and tolerances and could be considered commercial if the heating value of the coal burned exceeds 7200 Btu/lb. HGI also concluded that the 90-day test was inconclusive with regard to passing the 90-day test requirements set forth in the Power Sales Agreement (PSA) because they believed that the coal heating value used during the test was too high (HGI believed the test should have been run with an average coal heating value of 6950 Btu/lb. while an average 7194 Btu/lb. coal was supplied during the test) and because there was "excess staffing" on-site during the test. In addition, HGI had some recommendations for improvement, including that the coal feed system be redesigned and rebuilt.

HGI's conclusions are different from AIDEA's, but are accepted as being the "independent" opinion. AIDEA, however, believes that some of the data and assumptions used by HGI in reaching their conclusions need further analysis. Also, AIDEA believes that HGI made arbitrary interpretations of the test protocol resulting in the “inconclusive” determination.

This report analyzes the data and assumptions used by HGI in reaching their conclusions. Careful review of the data will help confirm AIDEA’s position that the plant is capable of sustaining operations for 35 years with design specification coal available in the area after appropriate and cost-effective repairs to the project are completed.

HGI made their conclusions and recommendations based on a 90-day “snapshot in time,” which is a difficult task. HGI had to extrapolate assumptions about coal supply, plant operation, and other factors that occurred during a 90-day period to a 35-year plant life. Significant uncertainty is inherent in making these types of long-term extrapolations.

In the worst case, all of the potential problem areas identified by HGI could be addressed in a relatively short time so that HGI could reach a conclusion similar to AIDEA’s, that the plant is capable of sustaining operations for 35 years with coals available in the area. However, AIDEA believes that it would first be best to re-examine HGI’s position in greater detail and then agree on which of the potential problems are most cost-effective and appropriate to address based on review of the data presented in this report.

On a non-site specific basis, there is general agreement that demonstration of the new technologies, particularly the combustor technology, is fully successful and commercial. HGI has confirmed that the new technology would be capable of sustained operations for a coal heating value as low as 7000 Btu/lb.

## 2.0 Introduction

AIDEA has constructed a nominal 50-megawatt coal-fired power generating facility at a site near Healy, Alaska. The location of the facility is on land adjacent to the existing GVEA Healy Unit No. 1 power plant. Construction of the facility was in response to the U.S. Department of Energy (DOE) Program Opportunity Notice issued in May 1989 for the Clean Coal Technology (CCT) Program. The facility, HCCP, will demonstrate new technologies and meet local power needs in an environmentally acceptable manner.

After more than five years of planning, design engineering, and permitting activities, the project celebrated its ground-breaking ceremony at Healy, Alaska on May 30, 1995. Most of the major plant equipment was delivered to the Healy site 250 miles north of Anchorage, Alaska (near Denali National Park) in 1996. This equipment included a boiler, two 350 million Btu/hr coal combustors and the associated coal and limestone feed systems, as well as a Spray Dryer Absorber System (SDA), which consisted of a single spray dryer vessel, a multi-compartment fabric filter, and an extensive slurry preparation system. Construction of the plant was completed in November 1997. Start-up commenced in July 1997. Coal-fired operations started in January 1998.

The overall objectives of the project are to demonstrate a novel power plant design which features the combined removal of nitrogen oxides ($NO_x$), sulfur dioxide ($SO_2$), and Particulate Matter (PM) using a combination of two advanced technologies, to further demonstrate reduced emission levels well below the requirements of EPA New Source Performance Standards (NSPS) for new utility coal fired units, and to meet future energy needs in an environmentally acceptable manner.

The technologies to be demonstrated in the HCCP combines the TRW Clean Coal Combustion System and the Babcock & Wilcox's (B&W)/Joy SDA System into a single, integrated, combustion/control process. The HCCP is the first utility-scale demonstration of the TRW Clean Coal Combustion System. The TRW Combustion System is designed to minimize emissions of $NO_x$, achieve very high carbon burnout, and remove the majority of flyash from the flue gas prior to the boiler. The TRW system also provides the first step of a three-step process for controlling $SO_2$ by converting limestone to flash calcined lime that subsequently absorbs $SO_2$ within the boiler. The majority of $SO_2$ is removed downstream of the boiler, using B&W's activated SDA system, which utilizes the flash calcined material (flash calcined lime + flyash) produced by the TRW system. Since most of the coal ash is removed by the combustors, the flash calcined material is rich enough in calcium content such that the SDA can be operated solely on recycled lime, eliminating the need to purchase or manufacture lime for the backend scrubbing system.

The project is owned and financed by AIDEA, and co-funded by the DOE. GVEA provided the plant operators. The plant engineer is Stone & Webster, and the coal supplier is Usibelli Coal Mine, Inc. (UCM), located adjacent to the Healy plant. According to terms of the Power Sales Agreement (PSA), GVEA will operate the new power generating facility, and purchase its net power generation from AIDEA once the plant becomes commercially operable.

This report presents results and analysis of the 90-day commercial operation test at HCCP that was completed on November 15, 1999. The purpose of the 90-day test was to assess the long-term commercial viability of the project thereby determining if the plant is commercially operable and ready for GVEA to begin power purchase according to terms of the PSA. The two requirements for successful completion of the the 90-day test were: 1) that the plant generate 91,800 MWH (85% of capacity) during 90 days of continuous operation utilizing coal representative of that which will be supplied for the life of the plant and 2) that the major systems are performing in accordance with design specifications and that there is no reason why HCCP would not continue to operate on a sustained basis.

From AIDEA's perspective, the 90-day commercial operation test was a success and demonstration of the technology was successful. AIDEA believes that the plant can be considered capable of sustaining operations for 35 years after appropriate improvements are made to the coal feed system. HCCP was credited with generating 102,373 MWH of electric power equivalent to a capacity factor of 94.79% over a 90-day period. The fuel flexibility, and corresponding positive economic, and waste minimization benefits associated with the new combustor technology were demonstrated by burning 83% previously unsaleable waste coal, including fines, over the 90-day test period. This blend of run-of-mine (ROM) and waste coal is representative of coal which would be supplied for the life of the plant. In addition to achieving these results, all generation was achieved within permitted limits for emissions with the exception of short-term exceedences of $SO_2$ and opacity that occurred during plant start-up, shut-down, and equipment repairs.

HGI was retained as an Independent Engineer to prepare the 90-day test protocol (Appendix G), to report on the results of the 90-day test (Section 10), and to render an opinion on the project's ability to sustain operations for 35 years. They concluded that the major systems of the project are performing in accordance with design specifications and tolerances and could be considered commercial if the heating value of the coal burned exceeds 7200 Btu/lb. HGI also concluded that the 90-day test was inconclusive with regard to passing the 90-day test requirements set forth in the PSA because they believed that the coal heating value used during the test was too high (HGI believed the test should have been run with an average coal heating value of 6950 Btu/lb., while an average 7194 Btu/lb. coal was supplied during the test) and because there was "excess staffing" on-site during the test. In addition, HGI had some recommendations for improvement, including that the coal feed system be redesigned and rebuilt.

There are differences between AIDEA's and HGI's position and these differences are examined in detail in this report. The HGI report and their results and recommendations are included as Section 10 of this Topical Report. Sections 1-9 of this report examine the data and assumptions used by HGI in reaching their conclusions and includes comments on and references to specific sections of the HGI report. Organizations participating in the 90-day test, TRW Inc., and UCM have also expressed views on the HGI Report in Section 11 (Appendix) of this Topical Report and in excerpts quoted in Sections 1-9.

On a non-site specific basis, there is general agreement that demonstration of the new technologies, particularly the combustor technology, is fully successful and commercial. HGI has confirmed that the new technology would be capable of sustained operations for a coal heating value as low as 7000 Btu/lb.

## 3.0 Test Protocol

A copy of the 90-day test protocol, prepared by HGI, is attached in Appendix G. Initially, the test protocol was a subject of some debate and both AIDEA and GVEA presented comments on the test protocol to HGI. With respect to coal heating value, GVEA suggested that a Btu standard of 6960 Btu/lb. +/- 100 be applied. In AIDEA's opinion, achieving a coal heating value over a +/- 200 range would be unrealistic for reasons described in this report. Ultimately, HGI prepared a test protocol, shown in Appendix G using their judgement, making changes in the ramp up rates and in the period that the plant operated in the dispatch mode. AIDEA accepted HGI's proposed target of 6950 Btu/lb and did what could reasonably be done to achieve that target. For reasons described in this report, that was unachievable.

When the test was completed, the issues of coal heating value and staffing formed the basis for HGI's final conclusions. Irrespective of the performance of the plant, AIDEA questions whether these issues are part of the original test protocol. AIDEA believes that HGI made arbitrary interpretations of the test protocol resulting in the "inconclusive" determination and that the test protocol requirements were met so that there is no basis for the inconclusive determination.

HGI deemed the test inconclusive because they believed that the coal heating value used during the test was too high (average 7194 Btu/lb. vs. 6950 Btu/lb.). The test protocol says that "the intent of the test is to demonstrate operation on a 6950 Btu mix" and that the test should be run with a "coal with characteristics equivalent to those of long-term Usibelli coal." AIDEA believes that both of these test protocol requirements were met. The test was run with a "coal with characteristics equivalent to those of long-term Usibelli coal," and successful operation of the plant was demonstrated using coal with a 6950 Btu/lb. (and lower) heating value.

AIDEA's position is that the plant was operated for extended periods during the 90-day test with a 6950 Btu/lb., or lower heating value coal and that in itself demonstrates that the plant is capable of successfully operating with 6950 Btu/lb. coal. AIDEA's position is that there is no requirement in the protocol or in any other contract documents requiring that the plant be operated on a sustained basis with 6950 Btu/lb. coal. HGI inferred that an "average 6950 Btu/lb. coal" needed to be run during the entire 90-day test based on their interpretation of design specifications, which require demonstration of operations at 6960 Btu/lb., and the coal supply contract. Although the design specifications reference 6960 Btu/lb. as a performance standard, there were no requirements to operate the plant or run the test on a sustained basis using 6960 Btu/lb. coal. With regard to the coal supply contract, 6960 Btu/lb. coal is an arbitrary target used in the coal supply contract for pricing purposes only - not for operations. It is AIDEA's understanding that HGI acknowledges that the coal heating value used during the test was representative of coals that will be used over the life of the project but was a higher than what they feel should have been used for the 90-day test.

Furthermore, AIDEA's stated intention for the 90-day test was to manage the coal pile itself, not the mining and the coal delivery. AIDEA could not control the Btu content of the coal.

HGI also deemed the test inconclusive because there was "excess staffing" on-site during the test. AIDEA's position is that staffing was not a part of the test protocol and therefore should not be part of the test criteria. HGI introduced staffing as an issue because of a court order requiring that the test be evaluated based on requirements of both the PSA, the Construction Agreement, and the reasonable expectations of parties.

## 4.0 Coal Supply

*HGI deemed the test inconclusive since it was run with an average coal heating value of 7194 Btu/lb., rather than a blend of 50% waste coal and 50% ROM coal that was estimated to result in an average coal heating value of 6950 Btu/lb.*

AIDEA's position is that it would have been virtually impossible and beyond AIDEA's control to supply the 90-day test with a blend of 50% waste coal and 50% ROM coal that would result in an average coal heating value of 6950 Btu/lb. for many reasons. These reasons are described below:

Variable coal supply and coal heating value
The coal heating value of coal delivered to the plant depends on a number of factors. The seam being mined, the coal mining technique, and the specific location within the seam being mined will all cause the ROM and waste coal heating value to vary on a daily, monthly, and yearly basis.

Waste coal, excluding fines, availability
A sufficient supply of non-fines waste coal was not available during the test period to achieve a 50/50 mix of waste and ROM coal and to lower the average coal heating value of the mixture to 6960 Btu/lb.

Variable coal heating value of waste coal
Overall, including fines 83% waste coal was used during the 90-day test. Of this 83% waste, 57.1% was fines and 42.9% was regular waste (Appendix C). When using so much waste coal, there is additional uncontrolled variability in the coal heating value of the waste and therefore the mixture. There is an extreme variability of the coal heating value of waste coal; it can range from 5000 – 9000 Btu/lb (including fines). In addition, the coal heating value of the fines normally exceeds 6960 Btu/lb.

Coal heating value of coals used over the life of the project
The attached letter (Appendix B), written by the Usibelli Coal Mines (UCM) Vice-President of Engineering, expresses concern about their ability to meet a coal heating value target on a consistent basis without additional learning experience:

> "UCM expects to be able to supply adequate low coal heating value for the plant to meet this target, but one should expect additional time getting through the learning curve before that target can be met on a consistent basis."

Additionally, in the same letter (Appendix B), UCM noted that HGI may have misunderstood what coal would be supplied over the life of the project, stating the following: "Page 6-1, 1st Paragraph. It is stated in the report that "…ROM coal from the Two Bull Ridge seam …will average approximately 6500 Btu/lb." It is likely that the UCM representative from which this statement was derived intended to say Waste coal or Waste/ROM Blend, instead of ROM coal. Coal of that quality would not fit the ROM coal criteria."

In AIDEA's opinion and based on these comments, HGI may have thought that the coal supplied over the life of the project would be lower than what is actually expected to be delivered.

It is AIDEA's understanding that HGI acknowledges that the coal heating value used during the test was representative of coals that will be used over the life of the project but was a higher quality than what they feel should have been used for the 90-day test to demonstrate sustained operations and conformance with design specifications.

Test run with coal within 3% of HGI Target

The actual average coal heating value of the coal used during the test, 7194 Btu/lb., was within approximately 3% of HGI's target of 6950 Btu/lb. It's AIDEA's view that considering the variability of the coal supply, operation within 3% of the target should be viewed as a success. It was AIDEA's understanding that due to the variable coal supply, the coal used during the test should be representative of coals used over the life of the project.

Contractual requirements to run the test on a sustained basis with 6950 Btu/lb. coal

It is AIDEA's opinion that there were no contractual requirements to run the test or the plant on a sustained basis with 6950 Btu/lb. coal or any absolute value. Although, "the test protocol called for demonstrating operation on a 6950 Btu coal..," the protocol says nothing about testing on a sustained basis, nor is it a contractually binding document. AIDEA's position is that he plant was operated at various times during the test on a 6950 Btu/lb. (or lower) mix," therefore, there is no basis for deeming the test inconclusive.

HGI inferences about test requirement

It is AIDEA's understanding that HGI inferred that 6950 Btu/lb. coal needed to be run during the test based on their interpretation of design specifications and the coal supply contract. Although the design specifications reference 6960 Btu/lb. as a performance standard, there are no requirements to operate the plant or run the test on a sustained basis using a predetermined coal quality. HGI only had to determine that the plant can operate in accordance with design specifications.

In fact, over a 15 day period during the 90-day test, the average coal properties of the coal burned were very close to the specified average "performance coal" properties (i.e. heating value of 6960 Btu/lb. and 15% ash). Since many plant performance tests are only 15 days in duration, this 15 day period demonstrated the plant's ability to meet design requirements.

With regard to the coal supply contract, 6960 Btu/lb. coal is an arbitrary target used in the coal supply contract for pricing purposes only - not for operations.

Coal supply contract

The quality of coal supplied for the test was out of AIDEA's direct control. Coal was delivered based on a long-term contract previously agreed to between GVEA and Usibelli Coal Mine. AIDEA only managed on-site blending of what was delivered. AIDEA's stated intention for the 90-day test was to manage the coal pile itself, not the mining and the coal delivery. AIDEA constantly requested that UCM lower the heating value of the coal piles; Usibelli Coal Mine tried but was unsuccessful.

Measurement of Coal Heating Value

The accuracy of measuring coal heating value by taking coals from the grab sampler is in question. The coal belt sampler was under GVEA operation, not adequately evaluated, and not maintaining consistent feed to the sampler. The controlled test and check of the coal conveyor sample cutter did not accurately reflect normal conditions that can and do vary widely. The times that GVEA coal operation personnel took grab samples, the number of times that the sampler was plugged, or the discrepancies between GVEA grab and belt samples was not addressed. Measured coal heating value determined from analysis of the coal belt sampler provided an AVERAGE heating value of the coal being delivered over an approximately 12-hour period (i.e. a 12-hour average).

Coal heating value could have been derived from the boiler loss method, which would have shown that a lower coal heating value coal was actually used throughout the test. The boiler "measured" very low heating value on many days, different from what was measured from samples taken from the sampler and coal feeder. A heat rate (NPHR) of 12,800 Btu/Kwh (per HGI's Report), when using coal with a heating value of 6105 Btu/lb. and a feed rate of 106,500 lb/hr., would produce 58 MW gross generation. Actual data shows the gross MW could not be consistently achieved; indicating that coal heating values were periodically much lower.

A significant discrepancy in coal heating value measurements was noted and documented as a part of the "Healy Clean Coal Project Demonstration Test Program Boiler Performance Testing Topical Report dated March 31, 2000." Foster Wheeler Engineering Corporation (Foster Wheeler) calculated a heating value of 7,025 Btu/lb. using a grab sample from the plant conveyor, tested in their lab, while UCM calculated a heating value of 300 Btu/lb. greater using a sample from the coal sampler. Based on that difference, Stone & Webster Engineering Corporation (Stone & Webster) recommended that "the Foster Wheeler coal analysis be used for all boiler efficiency calculations as it represents the actual fuel fired during the test." In this example coal heating value was almost 4% different measured by different parties using samples taken from different locations.

HGI was asked but did not determine the reasons for the differences among coal heating value measurements using the GVEA coal sampler, HCCP coal feeder, grab samples, and boiler heat loss methods.

Since the average coal heating value for the 90-day test, 7194 Btu/lb. (and possibly lower if derived from the boiler loss method), was within 3% of HGI's target and the design specification of 6960 Btu/lb., if the accuracy of the coal belt sampler has a 3% error bar (which is probably conservative), it can be argued that that the test was run within design specifications.

The grab samples taken at the HCCP coal feeder, which typically measured heating value of 100 to 200 Btu/lb. lower than samples taken from the open conveyor, would be most representative of coal heating value of coal actually burned due to their close proximity to the combustor

<u>Coal that should be fired during 90-day test according to Plant Design Engineer</u>
According to Stone & Webster, the plant design engineers, in order to run the plant at 50 MW (the level that the plant was run at during most of the 90-day test), Maximum Continuous Load Rating (MCR) load levels must be achieved. As noted in Appendix D, (attached letter dated December 9, 1999), "The coal to be fired (during the 90-day test) should have a heating value between the ROM (7815 Btu/lb.) and 55/45 waste/ROM (average of 6875 Btu/lb.) as specified in the TRW and Foster Wheeler specifications in order for the MCR to be reached. The low heating value resulting with a waste coal content greater than the 55/45 coal blend (or a heating value less than 6875 Btu/lb.) would not be an appropriate coal for the test purposes."

## 5.0 Coal Quality Impact on Plant Operations

*HGI concluded that the project could only be considered commercial if coal burned exceeds 7200 Btu/lb.*

AIDEA's position is that the plant ran satisfactorily while running low coal heating value coals representative of the coal supply over the life of the plant, and there is no technical (or contractual) requirement for running the plant on a sustained basis with a predetermined coal heating value as long as the range is between 6875 and 7815 Btu/lb. Key points are summarized in the following 6 sections.

**A. Combustor Operation with Low Heating Value Coal**

*HGI states in the report that there would be "slagging or plugging problems in the TRW slagging combustors with coal heating value below 7000 Btu/lb.," and that design changes would be needed for sustained operations if coal significantly below 7000 Btu/lb. is used.*

Overall performance based on combustor A
AIDEA disagrees with HGI's position based on the unit's performance. Based on the performance in combustor A, there does not appear to be any indication of excess slagging or plugging problems during operation with coal heating value between 6800 and 7000 Btu/lb., and that minor operational changes, rather than design changes, may be required for sustained operation with coals significantly below 7000 Btu/lb.

HGI is likely referring to problems in the 'B' precombustor, where a small explosion occurred. The performance of the 'B' precombustor, after the conflagration in the pulverizer, should not be taken as normal. The damage to the dampers within the coal feed system caused 'B' precombustor to receive greater coal flow than required, which resulted in a more sensitive performance. 'B' precombustor performance should be seen as equipment operating in a damaged condition and thus not considered as normal, although even the damaged 'B' combustor remained operational and the 'A' combustor was good.

Slagging and Rodding
With respect to HGI claims that slagging and rodding was excessive, these claims could not be visually verified. Written GVEA operator notes only indicate 5 days when the "A" precombustor ports required rodding more than once or twice over a 24-hour period. These 5 days correlated with changes in operating conditions during equipment start-up or malfunction. The statement in the HGI report, "At times it forms large pieces of slag which would fall off the wall and land either on the sloping wall tubes of the bottom ash hopper or in the slag ash tank…" could not be visually observed and refers to a problem that was previously solved before the 90-day test and wasn't exhibited during the 90-day test.

TRW Statement on Combustors
TRW has stated the following: ". . . based on the performance in 'A' combustor, there does not appear to be any indication of excess slagging or plugging problems during operation with coal Btu between 6800 and 7000 Btu/lb." TRW also adds that "Based on the experience gained during the Pre-Combustor Burner Characterization Tests performed during March/April 1999, it is likely that minor operational changes rather than design changes will be required for sustained operation with coals significantly below 7000 Btu/lb. This would possibly include

reduction in the Pre-Combustor coal split as well as "tuning" of Pre-Combustor and Slagging Combustor stoichiometry for lower coal heating value. The Pre-Combustor and Slagging Combustor stoichiometry could then be automated to track with inferred coal heating value."

**B. Increased ash handling**

*HGI concluded that the test was biased because of the lower ash content of the coal and that a higher ash content would have led to operational problems. According to HGI, 23% more ash would have been processed at an average coal heating value of 6960 Btu/lb, rather than 7194 Btu/lb.*

Increased ash
AIDEA's position is that the plant can run on a sustained basis using coals that have a coal heating value less than 6950 (or 6960) Btu/lb. and the corresponding higher ash contents. During HCCP's operating life and during the 90-day test period, the unit demonstrated that it operates on coal that is less than 6600 Btu/lb. without experiencing problems from increased ash. During the 90-day test, the unit ran on less than 7,000 Btu/lb coal multiple times without problems with emissions, load or ash handling capacity. On October 26 through October 30, 1999, low heating value coal was burnt in both 'A' and 'B' combustors and 'A' precombustor performed normally, without any indication of excessive slagging (i.e. no slag accumulation).

Bottom ash plugging
Bottom ash plugging did not create an operational problem during the test. It is suspected that the small amount of bridging that was discovered post-test can be eliminated with increased water agitation and more frequent use of the lower wall soot blowers.

Silica present in the high quantities of waste fines
Abrasion in the exhausters and other components that HGI attributed to ash is at least partially attributable to a high level of silica present in the high quantities of waste fines used. Based on data supplied by Usibelli Coal Mine, on a non-Btu basis, 47.4% of the coal burned during the 90-day test was waste from fines. The fines are an erosive waste product that contain significant quantities of sandstone or silica. The silica is more abrasive than clay and also increases the Ash Fusion Temperature ($T_{250}$). Since HCCP successfully fired fines, for which it was not specifically designed, this should lend credibility to its flexibility to fire a broad range of fuels and if the plant can adequately burn waste fines it can burn more ash.

Percentage of Ash for given coal quality
Based on a graph of the 90-day test data (Appendix E), the ash content is only 16.45% greater at 6960 Btu/lb. than it is at 7194 Btu/lb., not 23% higher as suggested by HGI. Therefore, HGI may have overestimated the percentage of ash at 6960 Btu/lb. and likewise the coal transport system wear and maintenance requirements.

**C. Modifications to the coal transport system**

*HGI concluded that the coal transport system from the feeder outlet to the combustor inlet must be redesigned and replaced.*

AIDEA agrees that some modifications can be made to reduce the exhauster fan wear rate or implement an alternative approach for supplying requisite pressure to the coal splitter, however, based on past performance, a complete redesign and/or system replacement from the feeder outlet to the combustor inlet may not be necessary or economic. Redesign options to be considered are placing the fans on the clean air side (Foster Wheeler has stated that this is possible), using eductors instead of fans to supply the small amount of high pressure air required, adding two small pulverizers, improving the durability of exhauster fan materials, reducing the fan blade tip speed, adjusting the air flow rates, or simply exchanging out the exhauster fans on a regular basis as needed.

TRW has agreed stating the following, "Based on the specific comments in the report and post-test observations of wear, if the exhauster fan wear rate can be reduced or an alternative approach for supplying the requisite pressure to the Coal Feed System (CFS) splitter subsystem can be developed, there does not appear to be any problem, per se, with the design of the CFS Splitter subsystem downstream of the Exhauster Fan."

**D. Use of 83% waste coal and environmental and economic benefits associated with waste minimization**

*HGI said that the test was run with only 39% waste coal.*

HGI only considered conventional waste coal as "waste." HGI failed to recognize the large volume of waste fines that were used in the test. By not distinguishing between waste fines and conventional waste coal, the fuel flexibility of HCCP, and corresponding positive economic and waste minimization benefits associated with the new technology are discounted.

There are two types of waste coal – conventional waste and fines waste. Conventional or HCCP waste is coal that is excavated along the edges of the coal seam and as a result has a lower heating value, approximately 5000 – 8000 Btu/lb. Fines waste is ground ROM coal that is too finely ground to be saleable and burned in conventional boilers. The heating value of the fines waste is similar to ROM coal, but tends to vary more (typically 6500 - 9000 Btu/lb) as a result of going through a grinding process. Also, the fines waste can also contain high quantities of silica because the small grain size of silica allows it to pass through the smallest sieves. The 90-day test was run with 83% waste coal, 57.1% waste fines and 42.9% conventional waste (Appendix C).

At this time, outside of HCCP there is no market for either type of waste coal and as a result, the materials would otherwise have no value and may have associated disposal costs if they can't be burned at HCCP. HCCP creates a market for the waste coals as well as positive economic and waste minimization benefits. Disposal costs are eliminated, a potential source of fugitive dust emissions is eliminated, and a "wasted source of energy or uneconomic resource" is utilized to create energy. By failing to recognize this, the flexibility, economic, and environmental benefits associated with the plant's ability to process a large volume of waste product is discounted.

The coal successfully burned during the 90-day test demonstrated the flexibility and the positive economic and waste minimization benefits associated with the new combustor technology.

## E. Responding to GVEA load change requirements

*HGI said that "AIDEA failed to demonstrate HCCP's abilities to follow load changes while remaining in compliance."*

There were many and varied load changes throughout the 90-day test and the unit stayed in compliance. While the time available for load change testing was limited, load changes were made in accordance with HGI directives. In any case, HCCP is a base load unit and has in emergency situations followed GVEA's requests for load changes. Page 6-26 of HGI's report, appendix 7, describes successful results of load change response testing.

## F. SDA operation and Limestone feed rates

*HGI noted that the limestone feed rate was higher than necessary, that there was some plugging of the slurry transport system, and that Spray Dryer Absorber (SDA) demonstration was not achieved.*

SDA Operation

The SDA operated very well throughout the test. Through operating experience and based on Prudent Utility Practice, atomizer change-outs must be scheduled once per month. When this preventative maintenance is done there should be no reason for (other than operator error or equipment failure) any $SO_2$ exceedances. In regards to start-up $SO_2$ exceedance, GVEA has made the decision to use high sulfur oil. Therefore, it may not be possible to prevent $SO_2$ exceedances during start-up, unless the manufacturer's recommendations to bypass the baghouse during start-up are ignored. The manufacturer of the baghouse has recommended bypassing the baghouse during start-up. Since the plant is started with fuel oil, if the baghouse was on line during start-up the oil would deposit a combustible material in the baghouse creating a fire hazard. Regulatory agencies are aware of this issue and the potential for short term exceedences during start-up.

Lower limestone feed rates

With good limestone quality and the new limestone feeder feed rate control, it is anticipated that lower limestone feed rates can be used over the long-term life of the project. During prior baghouse and SDA performance testing, the systems performed well at lower limestone feed rates. The limestone feed was higher than normal during the 90-day test because AIDEA wished to make every effort to stay in compliance, which was an HGI priority.

System plugging is not a problem

The HGI report states that some plugging of the limestone slurry feed system occurred in the transport system. In fact, there was only one transport system plug that occurred on November 10, 1999, which is a very good record for a slurry system.

## 6.0 Staffing

*HGI concluded that the 90-day test was inconclusive also due to excess staffing.*

Staffing numbers
AIDEA agrees that a larger than “normal” staff was on hand during the 90-day test, however, the increased staff was there for the following reasons:

1. The project was still in the test/construction phase during the 90-day test. On many plants undergoing similar tests, construction workforces would still be on-site and available if needed.

2. The existing Healy Unit No. 1 workforce was not available to provide assistance. Under normal circumstances, both units’ work forces would have been available.

3. Extra staff was working on a punch list of construction items remaining.

When the plant is in full production mode, AIDEA anticipates staffing somewhat lower than HGI’s recommendations. Some allowance still needs to be made for the local conditions such as extreme cold, remoteness, and proximity to a National Park. If unplanned outages occur, most utilities can call in skilled contract labor from nearby union halls. In Healy’s remote location, this is not an option. Another key consideration is that it is essential to keep generation going since there is no guaranteed reliance on an external power grid system as there may be in other plants in the lower 48 states.

On-line maintenance
The HGI statement that “on-line maintenance of critical equipment continued that would normally call for the unit shutdown" is not specific about what they refer to but is in error with “standard industry practice” and GVEA’s own operating practices for 30 years. It is reasonable and normal practice by GVEA standards to call in and keep over personnel for such operating demands as “clinker breaking, atomizer replacement, pyrite hopper cleaning, repairing the head pulley on the ash bucket conveyor and silo discharge chute battering to clear plugging.” There is nothing in the test protocol that requires the unit to be shut down for equipment problems.

## 7.0 Low-$NO_x$ Burners

HGI was of the opinion that "conversion of the combustion equipment from the existing TRW precombustor/slagging combustor system to conventional low-$NO_x$ burners will not improve the commercial viability of HCCP. In fact, if converted to conventional low-$NO_x$ burners, limitations on the coal heating value may have to be more severe in order to prevent excessive fouling of the boiler. Also, particulate emissions may increase."

While retrofitting to low-$NO_x$ burners would be technically feasible, the integral relationship between $NO_x$ emissions and carbon monoxide (CO) emissions is of great concern for operation with low-$NO_x$ burners. Also, there is some concern that there could be efficiency losses associated with low-$NO_x$ burners, in order to achieve as low a $NO_x$ output as possible. In contrast, Appendix F shows the independence of $NO_x$ emissions for HCCP to coal quality.

## 8.0 Emissions

The HGI report was focused on plant operations rather than emissions, but it is worth noting that the plant demonstrated its ability to maintain air emissions at levels below both the Air Permit limits and the New Source Performance Standards (NSPS) requirements and, furthermore, to meet most of the more stringent Demonstration Test Program (DTP) emission goals. During the test, generation was achieved within permitted limits for emissions with the exception of short term $SO_2$ and opacity exceedences that occurred during plant start-up, shut-down, and equipment repairs. Targets compared with actual results are shown in the following table and graphs.

There were no violations or exceedences of the National Pollution Discharge Elimiations System (NPDES) water disposal permit.

Low $NO_x$ and CO emissions for HCCP were obtained simultaneously. There appeared to be little relationship between $NO_x$ emissions and coal heating value. These factors enhance the flexibility of HCCP.

Table 1, below, lists the HCCP Air Emission Limits and Air Emission Goals:

Table 1

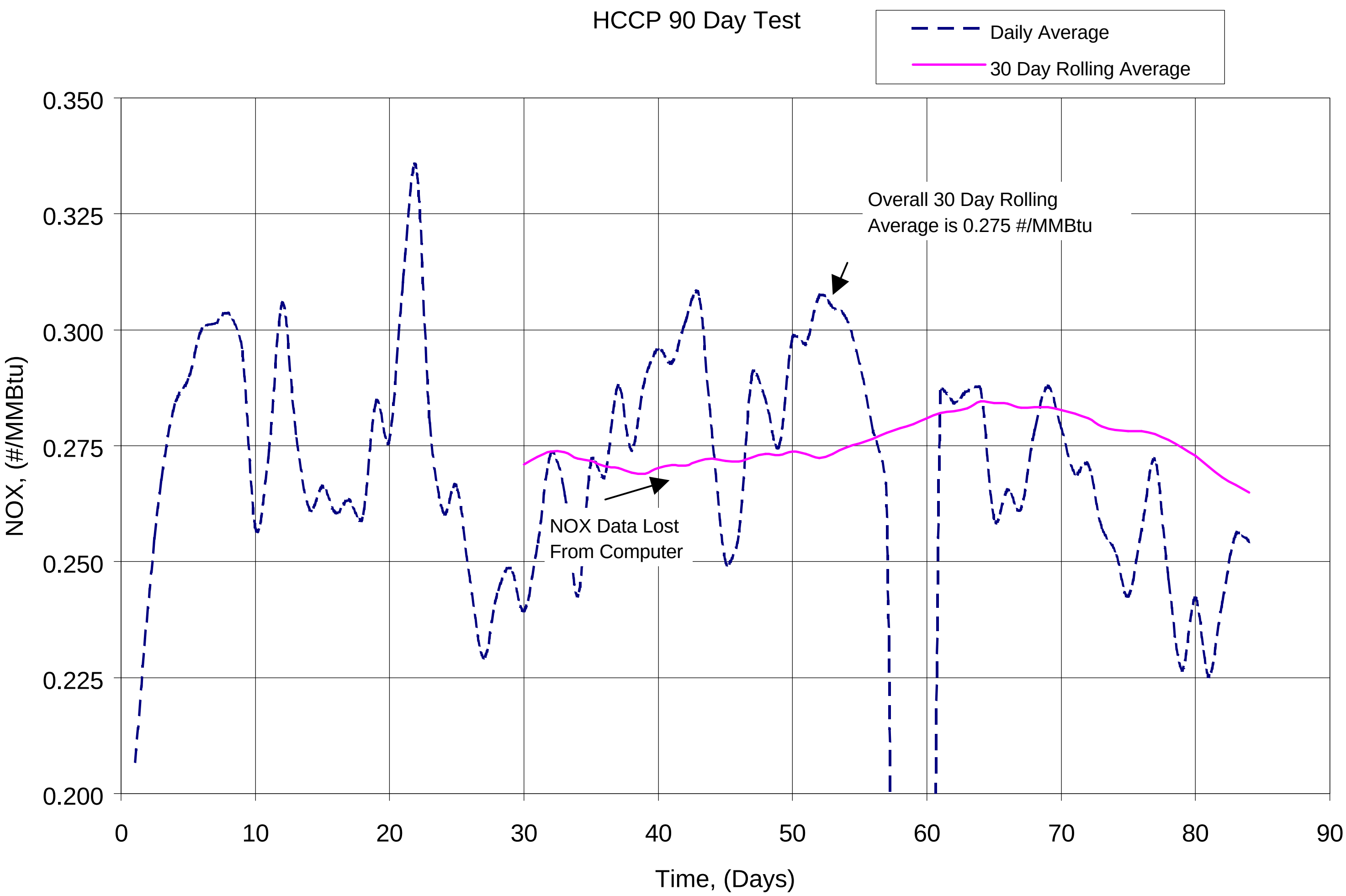
| Air Quality Permit to Operate No. 9431-AA001 Emission Limits | | | | |
|---|---|---|---|---|
| **Opacity** | **PM Emissions** [1] | **$NO_x$ Emissions** [2] | **$SO_2$ Emissions** [3] | **CO Emissions** [4] |
| 20% opacity, 3-minute average<br><br>one 6-minute period per hour of 27% opacity | 0.020 lb/MMBtu, hourly average<br><br>13.2 lbs/hr, hourly average<br><br>58 tons/yr, full load | 0.350 lb/MMBtu, 30-day rolling average<br><br>1,010 tons/yr, full load | 0.086 lb/MMBtu, annual average<br><br>0.10 lb/MMBtu, 3-hour average<br><br>65.8 lbs/hr, 3-hour average<br><br>248 tons/yr, full load | 0.20 lb/MMBtu, hourly average<br><br>202 ppm at 3.0% $O_2$<br><br>132 lbs/hr<br><br>577 tons/yr, full load |
| **NSPS Emission Limits (40CFR 60 Subpart Da)** | | | | |
| **Opacity** | **PM Emissions** | **$NO_x$ Emissions** | **$SO_2$ Emissions** | **CO Emissions** |
| 20% opacity, 6-minute average | 0.03 lb/MMBtu, hourly average<br><br>99% reduction | 0.50 lb/MMBtu | 70% removal when emissions are less than 0.60 lb/MMBtu | Dependent on HCCP ambient CO levels (no requirements listed in Subpart Da) |
| Demonstration Test Program Goals | | | | |
| Opacity | PM Emissions | **NOx Emissions** | **$SO_2$ Emissions** | **CO Emissions** |
| 20% opacity, 3-minute average | 0.015 lb/MMBtu, hourly average | 0.20 to 0.35 lb/MMBtu | 70% removal<br><br>79.6 lbs/hr maximum | < 200 ppm (dry basis) at 3.5% $O_2$<br><br>< 206 ppm at 3.0% $O_2$ |

Source: AIR EMISSION COMPLIANCE TESTING TOPICAL REPORT
1. Particulate Matter , 2. Oxides of Nitrogen , 3. Sulfur Dioxide , 4. Carbon Monoxide

Actual emissions during the 90-day test are shown in graphs on the following pages.

**Graph 1 - $NO_x$ vs. Time for 90-day test**

All $NO_x$ emissions goals and targets were met.



## Graph 2 - $SO_2$ vs. Time for 90-day test

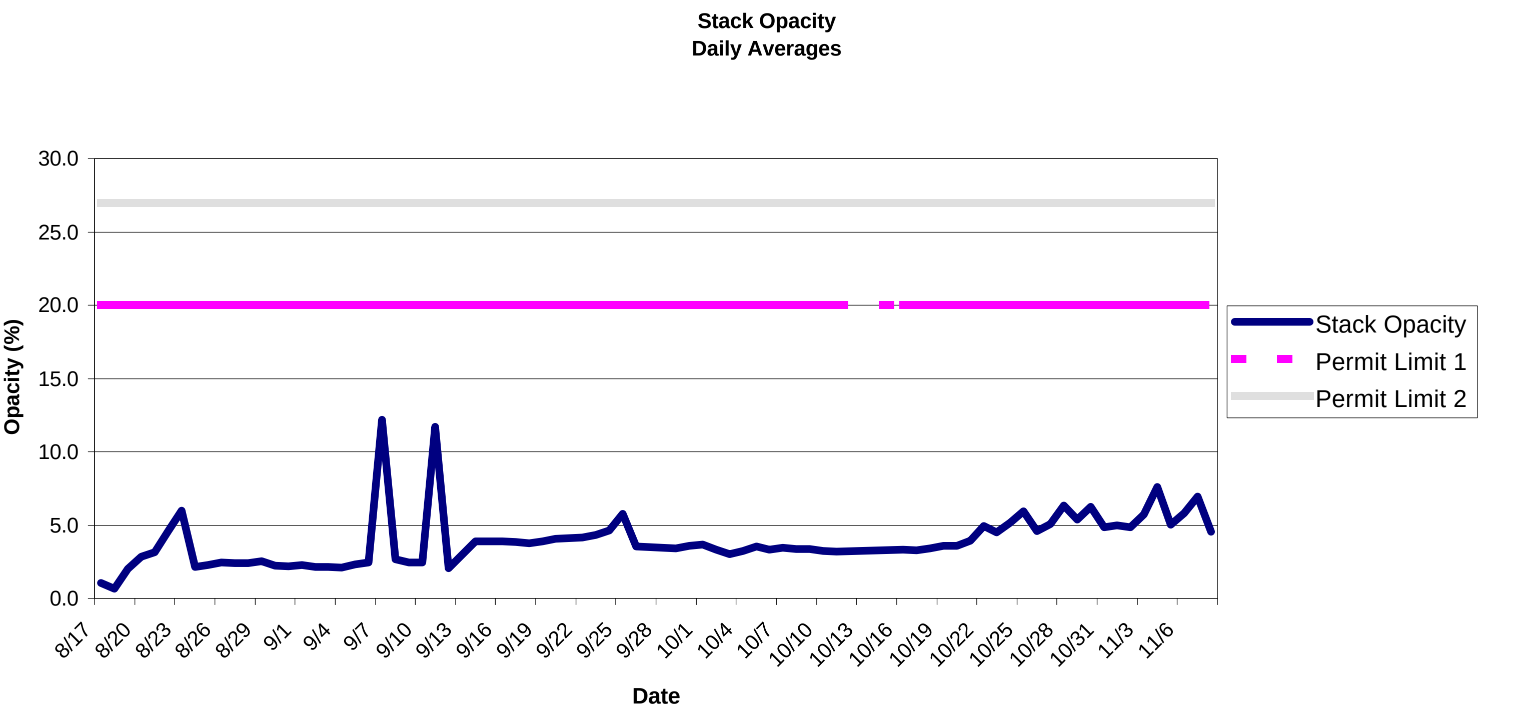
All $SO_2$ emissions goals and targets were met with the exception of short term exceedences that occurred during plant start-up, shut-down, and equipment repairs.

The graph on the following page, is Figure 7 from the attached Harris Group Inc. report.

## Graph 3 - Opacity vs. Time for 90-day test

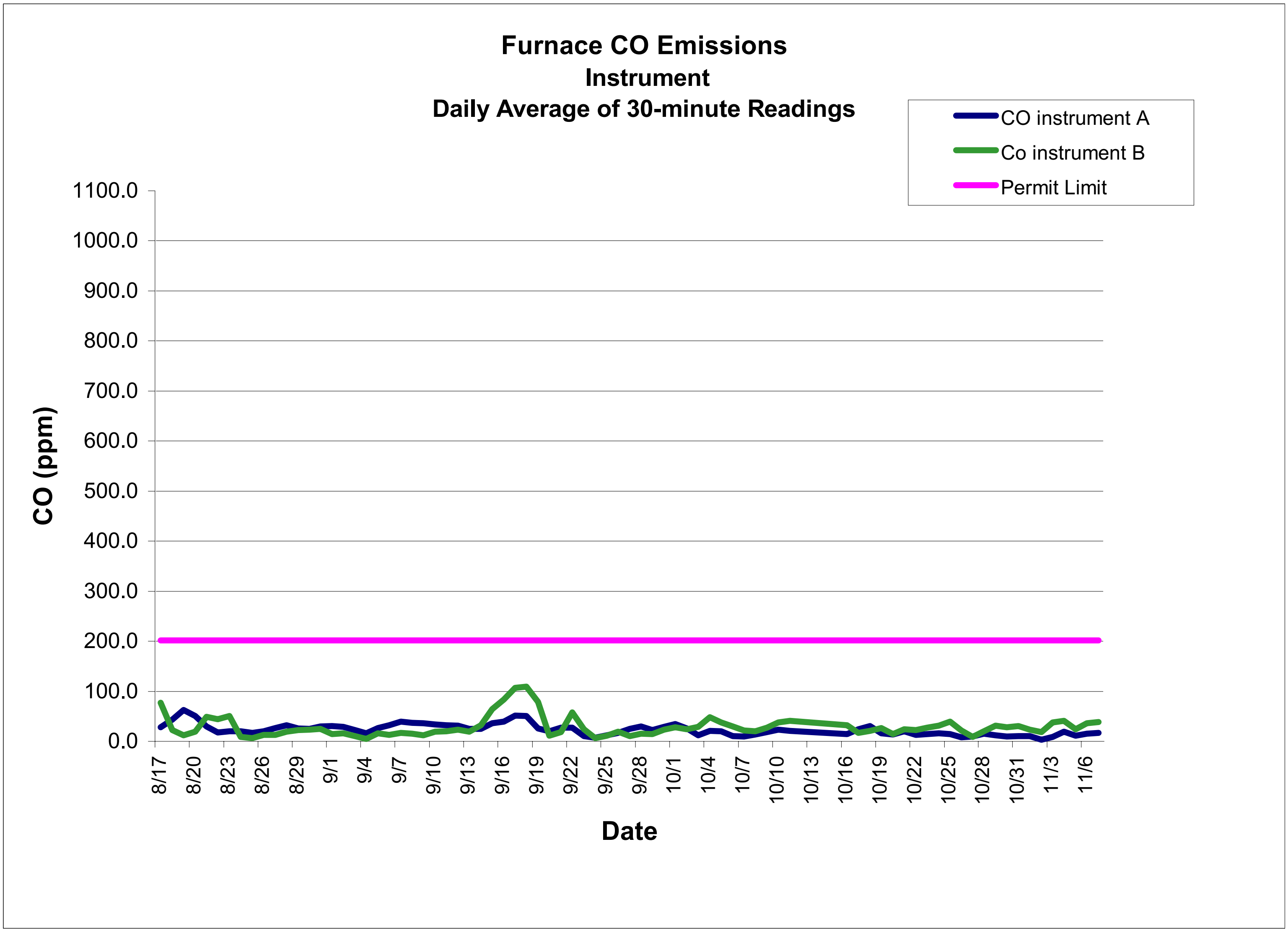
All Opacity emissions goals and targets were met. There were 2 short term exceedences that occurred as a result of a plant upset and/or start-up as previously described. These are not reflected on the graph below because the graph shows 1 day average data.

Data from the 90-day test is presented on the following graph:



### Graph 4 - CO vs. Time for 90-day test

All CO emissions goals and targets were met. Data from the 90-day test is presented on the following graph. Instrument CO data that had corresponding $O_2$ readings that were anomalous were removed from the daily average calculations.



sustaining operations for 35 years after appropriate improvements are made to the coal feed system. Key results are as follows:

- **HCCP was credited with generating 102,373 MWH of electric power at a capacity factor of 94.79% over a 90-day period.**

The PSA only required that 91,800 MWH net be generated during the 90-day test. This target was significantly exceeded. Table 1 in Section 10 (Harris Group Inc. Report) of this report, lists power generated by day during the 90-day test.

- **The 90-day test was performed with coal representative of that which would be supplied for the life of the plant and by using that coal, the flexibility, the positive economic, and waste minimization benefits associated with the new combustor technology were demonstrated.**

Analysis of the coal used in the project is as follows:

| | **Run – of - Mine (ROM) Coal** | **Waste Coal** | **Performance** |
|---|---|---|---|
| **Proximate analysis** | | | |
| Moisture, % | 26.35 | 23.87 | 25.11 |
| Ash, % | 8.20 | 25.00 | 16.60 |
| Volatile, % | 34.56 | 27.00 | 30.78 |
| Fixed, Carbon, % | 30.89 | 24.13 | 27.51 |
| Total, % | 100.00 | 100.00 | 100.00 |
| HHV, Btu/lb | 7,815 | 6,105 | 6,960 |

There are two types of waste coal – conventional waste and fines waste. Conventional or HCCP waste (described above) is coal that is excavated along the edges of the coal seam and as a result has a lower heating value, approximately 5000 – 8000 Btu/lb. Fines waste is ground ROM coal that is too finely ground to be saleable and burned in conventional boilers. The heating value of the fines waste is similar to ROM coal, but tends to vary more (typically 6500 - 9000 Btu/lb) as a result of going through a grinding process. Also, the fines waste can also contain high quantities of silica because the small grain size of silica allows it to pass through the smallest sieves.

Currently there is no market for both types of waste coal. HCCP creates a market for these otherwise unsaleable waste coals as well as positive economic and waste minimization benefits. Burning these waste coals, eliminates disposal costs, eliminates a source of fugitive dust emissions, and utilizes a “wasted source of energy or uneconomic resource” to create energy.

During the 90-day test, 83% of the total coal burned was waste coal, 57.1% waste fines and 42.9% conventional waste (Appendix C). When using so much waste coal, there is uncontrolled variability in the coal heating value of the waste and therefore the mixture. The heating value of waste coal can range from 5000 – 9000 Btu/lb (including fines). Recognizing this, the combustors are designed to burn a variety of blends - 100 percent ROM, 55 percent waste/45 percent ROM, and performance - 50 percent waste/50 percent ROM. They are also capable of burning 100 percent waste coal blends.

AIDEA's position is that by burning 83% waste coal with a heating value of 7194 Btu/lb, the test was run with a "coal with characteristics equivalent to those of long-term Usibelli coal." It is AIDEA's understanding that HGI acknowledges that the coal heating value used during the test was representative of coals that will be used over the life of the project but was a higher heating value than what they feel should have been used for the 90-day test to demonstrate sustained operations and conformance with design specifications.

It would have been virtually impossible and beyond AIDEA's control to supply the 90-day test with a blend of 50% waste coal and 50% ROM coal that would result in an average coal heating value of 6950 Btu/lb. The coal heating value of coal delivered to the plant depends on a number of factors. The seam being mined, the coal mining technique, and the specific location within the seam being mined will all cause the ROM and waste coal heating value to vary on a daily, monthly, and yearly basis. Furthermore, the accuracy of measuring coal heating value by taking coals from the grab sampler is in question.

AIDEA also believes that there is no basis for deeming the test inconclusive. HGI deemed the test inconclusive because they believed that the coal heating value used during the test was too high (average 7194 Btu/lb. vs. 6950 Btu/lb.). The test protocol says that "the intent of the test is to demonstrate operation on a 6950 Btu/lb. mix" and that the test should be run with a "coal with characteristics equivalent to those of long-term Usibelli coal." AIDEA believes that both of these test protocol requirements were met. The test was run with a "coal with characteristics equivalent to those of long-term Usibelli coal," and successful operation of the plant was demonstrated using coal with a 6950 Btu/lb. (and lower) heating value.

HGI inferred that an "average 6950 Btu/lb. coal" needed to be run during the entire 90-day test based on their interpretation of design specifications and the coal supply contract. Although the design specifications reference 6960 Btu/lb. as a performance standard, there are no requirements to operate the plant or run the test on a sustained basis using a predetermined coal quality. HGI only had to determine that the plant can operate in accordance with design specifications. AIDEA's position is that the plant was operated for extended periods during the 90-day test with a 6950 BTU/lb., or lower heating value coal and that in itself demonstrates that the plant is capable of successfully operating in accordance with design specifications. With regard to the coal supply contract, 6960 Btu/lb. coal is an arbitrary target used in the coal supply contract for pricing purposes only - not for operations. Furthermore, AIDEA's stated intention for the 90-day test was to manage the coal pile itself, not the mining and the coal delivery. AIDEA could not control the Btu content of the coal.

The actual average coal heating value of the coal used during the test, 7194 Btu/lb., was within approximately 3% of HGI's target of 6950 Btu/lb. It's also AIDEA's view that considering the variability of the coal supply and other factors, operation within 3% of the target should be viewed as a success.

Table 3 in Section 10 (Harris Group Inc. Report) of this report, lists heating value and ash data for coals used during the 90-day test.

- **All generation was achieved within permitted limits for emissions with the exception of short-term exceedences of $SO_2$ and opacity that occurred during plant start-up and equipment repairs. $NO_x$ emissions goals and targets were met.**

Emissions goals and targets for $SO_2$ were met with the exception of short-term exceedances during plant start-up, shut-down, and equipment repairs. In regards to start-up $SO_2$ exceedance, GVEA made the decision to use high sulfur oil during start-up. Therefore, it may not be possible to prevent $SO_2$ exceedances during start-up, unless the manufacturer's recommendations to bypass the baghouse during start-up are ignored. Emissions goals and targets for CO and Opacity were met.

**Summation**

Sections 1-9 of this report highlight some of the reasons why HGI's conclusions are different from AIDEA's and why AIDEA believes that HGI made an arbitrary interpretation of the test protocol to determine that the test was "inconclusive." AIDEA believes that the information provided in Sections 1-9 of this report as well as all of the 90-day test data supplied by HGI in Section 10, shows that the plant can be considered capable of sustaining operations for 35 years using design specification coal in the area after appropriate improvements are made to the coal feed system.

Improvements needed in the coal feed system, that are necessary to make the plant capable of sustaining operations for 35 years, are relatively minor. Remediation options to be considered are placing the fans on the clean air side (Foster Wheeler has stated that this is possible), using eductors instead of fans to supply the small amount of high pressure air required, adding two small pulverizers, improving the durability of exhauster fan materials, reducing the fan blade tip speed, adjusting the air flow rates, or simply changing out the exhauster fans on a regular basis as needed.

HGI made their conclusions and recommendations based on a 90-day "snapshot in time," which is a difficult task. HGI had to extrapolate assumptions about coal supply, plant operation, and other factors that occurred during a 90-day period to a 35-year plant life. Significant uncertainty is inherent in making these types of long-term extrapolations.

In the worst case, all of the potential problem areas identified by HGI could be addressed in a relatively short time so that HGI could reach a conclusion similar to AIDEA's, that the plant is capable of sustaining operations for 35 years with coals available in the area. However, AIDEA believes that it would first be best to re-examine HGI's position in greater detail and then agree on which of the potential problems are most cost-effective and appropriate to address based on review of the data presented in this report.

On a non-site specific basis, there is general agreement that demonstration of the new technologies, particularly the combustor technology, is fully successful and commercial. HGI has confirmed that the new technology would be capable of sustained operations for a coal heating value as low as 7000 Btu/lb.

# INDEPENDENT ENGINEER'S REVIEW

# OF

# HCCP 90 DAY TEST

# AND

# DETERMINATION OF SUSTAINED OPERATIONS

**HARRIS GROUP INC.**

**DECEMBER 1999**

## HCCP 90 DAY TEST COAL BTU DATA

| TEST DAY | DATE | USIBELLI LAB BTU/LB | TONS/DAY | BTU/DAY | RUNNING AVG DAY 1 TO DAY 90 BTU/LB | RUNNING AVG DAY 90 TO DAY 1 BTU/LB | FEEDERS AIDEA BTU/LB | SAMPLER AIDEA BTU/LB | SAMPLER GVEA BTU/LB |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 17-Aug | 7876 | 967.0 | 1.5232E+10 | 7876 | 7194 | 7220 | | 7773 |
| 2 | 18-Aug | 7081 | 950.4 | 1.3460E+10 | 7482 | 7186 | 6904 | 6972 | 6965 |
| 3 | 19-Aug | 7210 | 998.8 | 1.4403E+10 | 7389 | 7187 | 6852 | 7042 | 7123 |
| 4 | 20-Aug | 7111 | 1145.0 | 1.6284E+10 | 7310 | 7187 | 6796 | 6973 | 7000 |
| 5 | 21-Aug | 7324 | 1067.1 | 1.5631E+10 | 7313 | 7188 | 6794 | 7258 | 7320 |
| 6 | 22-Aug | 7054 | 945.3 | 1.3336E+10 | 7273 | 7186 | 6855 | | 7111 |
| 7 | 23-Aug | 6994 | 1040.0 | 1.4548E+10 | 7232 | 7188 | 6883 | | 7073 |
| 8 | 24-Aug | 7036 | 830.4 | 1.1685E+10 | 7212 | 7190 | 7042 | 6937 | 7054 |
| 9 | 25-Aug | 7551 | 1025.2 | 1.5483E+10 | 7250 | 7192 | 7484 | 7529 | 7614 |
| 10 | 26-Aug | 7604 | 1017.2 | 1.5470E+10 | 7286 | 7187 | 7172 | | 7566 |
| 11 | 27-Aug | 7210 | 792.8 | 1.1432E+10 | 7281 | 7182 | 6955 | | 7225 |
| 12 | 28-Aug | 7261 | 1166.0 | 1.6933E+10 | 7279 | 7182 | 6920 | | 7107 |
| 13 | 29-Aug | 7284 | 1099.4 | 1.6016E+10 | 7279 | 7180 | 7130 | | 7286 |
| 14 | 30-Aug | 7447 | 1142.7 | 1.7019E+10 | 7293 | 7179 | 7249 | | 7524 |
| 15 | 31-Aug | 7247 | 965.4 | 1.3993E+10 | 7290 | 7175 | 6866 | | 7306 |
| 16 | 1-Sep | 7445 | 1052.3 | 1.5669E+10 | 7300 | 7174 | 7178 | | 7345 |
| 17 | 2-Sep | 7301 | 1014.1 | 1.4808E+10 | 7300 | 7170 | 7137 | | 7267 |
| 18 | 3-Sep | 7132 | 890.2 | 1.2698E+10 | 7292 | 7168 | 7152 | | 7166 |
| 19 | 4-Sep | 7020 | 1082.5 | 1.5198E+10 | 7276 | 7168 | 7108 | | 7107 |
| 20 | 5-Sep | 7312 | 1230.3 | 1.7992E+10 | 7279 | 7171 | 7110 | | 7430 |
| 21 | 6-Sep | 7367 | 366.5 | 5.4000E+09 | 7280 | 7168 | | | 7473 |
| 22 | 7-Sep | 0 | 0.0 | 0.0000E+00 | 7280 | 7167 | 7168 | | |
| 23 | 8-Sep | 7420 | 695.4 | 1.0320E+10 | 7285 | 7167 | 6934 | | 7299 |
| 24 | 9-Sep | 7360 | 579.8 | 8.5347E+09 | 7287 | 7165 | 6953 | | 7277 |
| 25 | 10-Sep | 7140 | 511.4 | 7.3028E+09 | 7283 | 7163 | 7208 | | 7171 |
| 26 | 11-Sep | 7332 | 528.5 | 7.7499E+09 | 7284 | 7163 | 7081 | | 7268 |
| 27 | 12-Sep | 7374 | 1112.4 | 1.6406E+10 | 7289 | 7162 | 7028 | 7319 | 7318 |
| 28 | 13-Sep | 7386 | 1103.7 | 1.6304E+10 | 7293 | 7158 | 7121 | 7363 | 7385 |
| 29 | 14-Sep | 7540 | 976.3 | 1.4723E+10 | 7302 | 7154 | 7143 | 7218 | 7382 |

HCCP 90 DAY TEST COAL BTU DATA

| TEST DAY | DATE | USIBELLI LAB BTU/LB | TONS/DAY | BTU/DAY | RUNNING AVG DAY 1 TO DAY 90 BTU/LB | RUNNING AVG DAY 90 TO DAY 1 BTU/LB | FEEDERS AIDEA BTU/LB | SAMPLER AIDEA BTU/LB | SAMPLER GVEA BTU/LB |
|---|---|---|---|---|---|---|---|---|---|
| 30 | 15-Sep | 7318 | 1009.6 | 1.4777E+10 | 7303 | 7148 | 7003 | 7104 | 7188 |
| 31 | 16-Sep | 7202 | 1120.8 | 1.6144E+10 | 7299 | 7145 | 6797 | 7218 | 7202 |
| 32 | 17-Sep | 7201 | 1028.0 | 1.4805E+10 | 7295 | 7144 | 7112 | 7964 | 7152 |
| 33 | 18-Sep | 7331 | 1265.4 | 1.8553E+10 | 7297 | 7143 | 7256 | 7254 | 7361 |
| 34 | 19-Sep | 7264 | 1028.5 | 1.4942E+10 | 7296 | 7139 | 6980 | 7012 | 7343 |
| 35 | 20-Sep | 6994 | 571.4 | 7.9927E+09 | 7290 | 7136 | 6974 | 7142 | 7084 |
| 36 | 21-Sep | 7263 | 620.9 | 9.0192E+09 | 7290 | 7138 | 6991 | 7201 | |
| 37 | 22-Sep | 7171 | 602.0 | 8.6339E+09 | 7288 | 7136 | 7061 | 7137 | |
| 38 | 23-Sep | 7351 | 1285.6 | 1.8901E+10 | 7290 | 7136 | 7113 | 7215 | |
| 39 | 24-Sep | 7163 | 1065.1 | 1.5259E+10 | 7286 | 7131 | 7229 | 7197 | |
| 40 | 25-Sep | 7304 | 1082.3 | 1.5810E+10 | 7287 | 7130 | 7048 | 7188 | |
| 41 | 26-Sep | 7253 | 990.4 | 1.4367E+10 | 7286 | 7127 | 7220 | 7097 | |
| 42 | 27-Sep | 7111 | 1075.0 | 1.5289E+10 | 7281 | 7124 | 6865 | 7097 | |
| 43 | 28-Sep | 7230 | 335.4 | 4.8499E+09 | 7281 | 7124 | 7073 | | |
| 44 | 29-Sep | 7283 | 1341.1 | 1.9534E+10 | 7281 | 7124 | 7409 | | |
| 45 | 30-Sep | 7844 | 943.9 | 1.4808E+10 | 7293 | 7119 | 7531 | 7358 | |
| 46 | 1-Oct | 7441 | 1258.6 | 1.8730E+10 | 7298 | 7104 | 6974 | 6972 | |
| 47 | 2-Oct | 7107 | 1033.5 | 1.4690E+10 | 7293 | 7095 | 7071 | 7243 | |
| 48 | 3-Oct | 7302 | 924.1 | 1.3496E+10 | 7293 | 7095 | 7225 | 7253 | |
| 49 | 4-Oct | 7291 | 1025.8 | 1.4958E+10 | 7293 | 7090 | 7051 | 7024 | |
| 50 | 5-Oct | 7117 | 1270.7 | 1.8087E+10 | 7289 | 7085 | 6879 | 7026 | |
| 51 | 6-Oct | 7052 | 1051.7 | 1.4833E+10 | 7283 | 7084 | 6742 | 7095 | |
| 52 | 7-Oct | 7176 | 988.7 | 1.4190E+10 | 7281 | 7085 | 6818 | 7174 | |
| 53 | 8-Oct | 7288 | 1111.8 | 1.6206E+10 | 7281 | 7083 | 7118 | 7297 | |
| 54 | 9-Oct | 7266 | 1099.0 | 1.5971E+10 | 7281 | 7077 | 7075 | 7310 | |
| 55 | 10-Oct | 7345 | 957.3 | 1.4063E+10 | 7282 | 7071 | 7309 | 7336 | |
| 56 | 11-Oct | 7416 | 1095.6 | 1.6250E+10 | 7285 | 7064 | 7151 | 7207 | |
| 57 | 12-Oct | 7345 | 1085.4 | 1.5945E+10 | 7286 | 7053 | 7144 | 6881 | |
| 58 | 13-Oct | 6981 | 1116.8 | 1.5593E+10 | 7280 | 7043 | 6840 | 6753 | |
| 59 | 14-Oct | 6739 | 1023.0 | 1.3788E+10 | 7270 | 7045 | 6778 | 7178 | |
| 60 | 15-Oct | 7423 | 1119.8 | 1.6625E+10 | 7273 | 7055 | 7039 | 6960 | |
| 61 | 16-Oct | 6960 | 938.1 | 1.3058E+10 | 7268 | 7042 | 7025 | 7187 | |

HCCP 90 DAY TEST COAL BTU DATA

| TEST DAY | DATE | USIBELLI LAB BTU/LB | TONS/DAY | BTU/DAY | RUNNING AVG DAY 1 TO DAY 90 BTU/LB | RUNNING AVG DAY 90 TO DAY 1 BTU/LB | FEEDERS FEEDERS AIDEA BTU/LB | SAMPLER SAMPLER AIDEA BTU/LB | SAMPLER SAMPLER GVEA BTU/LB |
|---|---|---|---|---|---|---|---|---|---|
| 62 | 17-Oct | 7242 | 1026.8 | 1.4872E+10 | 7268 | 7044 | 7318 | 7345 | |
| 63 | 18-Oct | 7176 | 1158.9 | 1.6633E+10 | 7266 | 7037 | 6943 | 6858 | |
| 64 | 19-Oct | 7215 | 977.5 | 1.4105E+10 | 7265 | 7031 | 6937 | 7315 | |
| 65 | 20-Oct | 7388 | 800.6 | 1.1830E+10 | 7267 | 7024 | 6937 | 6965 | |
| 66 | 21-Oct | 7075 | 1504.1 | 2.1283E+10 | 7262 | 7013 | 7309 | 7242 | |
| 67 | 22-Oct | 7359 | 599.0 | 8.8161E+09 | 7263 | 7009 | 7023 | 6973 | |
| 68 | 23-Oct | 6995 | 1111.0 | 1.5543E+10 | 7259 | 7000 | 6845 | 6956 | |
| 69 | 24-Oct | 7116 | 988.9 | 1.4074E+10 | 7257 | 7000 | 6756 | | |
| 70 | 25-Oct | 6826 | 610.0 | 8.3277E+09 | 7253 | 6994 | | | |
| 71 | 26-Oct | 6994 | 1309.2 | 1.8313E+10 | 7248 | 6999 | | | |
| 72 | 27-Oct | 6963 | 1150.2 | 1.6018E+10 | 7243 | 7000 | | | |
| 73 | 28-Oct | 6830 | 1169.5 | 1.5975E+10 | 7236 | 7002 | | | |
| 74 | 29-Oct | 6658 | 1134.9 | 1.5112E+10 | 7227 | 7014 | | | |
| 75 | 30-Oct | 6833 | 961.3 | 1.3137E+10 | 7222 | 7040 | | | |
| 76 | 31-Oct | 7190 | 1136.1 | 1.6337E+10 | 7222 | 7053 | | | |
| 77 | 1-Nov | 7051 | 1096.1 | 1.5457E+10 | 7219 | 7042 | | | |
| 78 | 2-Nov | 7129 | 1045.6 | 1.4908E+10 | 7218 | 7041 | | | |
| 79 | 3-Nov | 7045 | 977.4 | 1.3772E+10 | 7216 | 7033 | | | |
| 80 | 4-Nov | 7251 | 677.1 | 9.8193E+09 | 7216 | 7032 | | | |
| 81 | 5-Nov | 6882 | 756.9 | 1.0418E+10 | 7213 | 7017 | | | |
| 82 | 6-Nov | 6806 | 765.5 | 1.0420E+10 | 7209 | 7028 | | | |
| 83 | 7-Nov | 6881 | 1164.3 | 1.6023E+10 | 7204 | 7049 | | | |
| 84 | 8-Nov | 7060 | 907.5 | 1.2814E+10 | 7203 | 7076 | | | |
| 85 | 9-Nov | 7247 | 1404.2 | 2.0352E+10 | 7203 | 7078 | | | |
| 86 | 10-Nov | 7233 | 912.0 | 1.3193E+10 | 7204 | 7029 | | | |
| 87 | 11-Nov | 7022 | 1247.6 | 1.7521E+10 | 7201 | 6981 | | | |
| 88 | 12-Nov | 6853 | 1076.2 | 1.4750E+10 | 7197 | 6962 | | | |
| 89 | 13-Nov | 7001 | 680.6 | 9.5298E+09 | 7195 | 7037 | | | |
| 90 | 14-Nov | 7064 | 884.0 | 1.2489E+10 | 7194 | 7064 | | | |

## HCCP 90 DAY TEST COAL BTU DATA

BTU/DAY CALCULATED FROM USIBELLI LAB ANALYSIS AND TONS/DAY FROM BELT SCALE

TONS/DAY DATA FROM BELT SCALE TOTALIZER READING OFF DAILY COAL LOG SHEET

RUNNING AVERAGE BTU/LB CALCULATED BY DIVIDING TOTAL BTU'S TO DATE BY TOTAL POUNDS TO DATE

| TEST DAY | DATE | USIBELLI LAB BTU/LB | TONS/DAY OF COAL | % ASH | PLUS 7000 ASH (TONS) | MINUS 7000 ASH (TONS) | PLUS 7000 ASH AVG | MINUS 7000 ASH AVG | TOTAL RUN ASH AVG |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 17-Aug | 7876 | 967.0 | 8.06 | 77.94 | | 8.06 | | 8.06 |
| 2 | 18-Aug | 7081 | 950.4 | 15.08 | 143.32 | | 11.54 | | 11.54 |
| 3 | 19-Aug | 7210 | 998.8 | 14.05 | 140.33 | | 12.40 | | 12.40 |
| 4 | 20-Aug | 7111 | 1145.0 | 14.59 | 167.06 | | 13.02 | | 13.02 |
| 5 | 21-Aug | 7324 | 1067.1 | 13.40 | 142.99 | | 13.10 | | 13.10 |
| 6 | 22-Aug | 7054 | 945.3 | 13.89 | 131.30 | | 13.22 | | 13.22 |
| 7 | 23-Aug | 6994 | 1040.0 | 13.90 | | 144.56 | | 13.90 | 13.32 |
| 8 | 24-Aug | 7036 | 830.4 | 13.54 | 112.44 | | 13.26 | | 13.34 |
| 9 | 25-Aug | 7551 | 1025.2 | 10.31 | 105.70 | | 12.88 | | 13.00 |
| 10 | 26-Aug | 7604 | 1017.2 | 10.69 | 108.74 | | 12.63 | | 12.76 |
| 11 | 27-Aug | 7210 | 792.8 | 13.34 | 105.76 | | 12.69 | | 12.80 |
| 12 | 28-Aug | 7261 | 1166.0 | 12.81 | 149.36 | | 12.70 | | 12.80 |
| 13 | 29-Aug | 7284 | 1099.4 | 12.65 | 139.07 | | 12.70 | | 12.79 |
| 14 | 30-Aug | 7447 | 1142.7 | 10.89 | 124.44 | | 12.54 | | 12.64 |
| 15 | 31-Aug | 7247 | 965.4 | 12.35 | 119.23 | | 12.53 | | 12.62 |
| 16 | 1-Sep | 7445 | 1052.3 | 11.52 | 121.22 | | 12.46 | | 12.55 |
| 17 | 2-Sep | 7301 | 1014.1 | 12.04 | 122.10 | | 12.43 | | 12.52 |
| 18 | 3-Sep | 7132 | 890.2 | 13.34 | 118.75 | | 12.48 | | 12.56 |
| 19 | 4-Sep | 7020 | 1082.5 | 14.14 | 153.07 | | 12.58 | | 12.65 |
| 20 | 5-Sep | 7312 | 1230.3 | 12.57 | 154.65 | | 12.58 | | 12.64 |
| 21 | 6-Sep | 7367 | 366.5 | 11.70 | 42.88 | | 12.56 | | 12.63 |
| 22 | 7-Sep | 0 | 0.0 | | 0.00 | | 12.56 | | 12.63 |
| 23 | 8-Sep | 7420 | 695.4 | 12.13 | 84.35 | | 12.55 | | 12.61 |
| 24 | 9-Sep | 7360 | 579.8 | 12.33 | 71.49 | | 12.54 | | 12.60 |
| 25 | 10-Sep | 7140 | 511.4 | 13.57 | 69.40 | | 12.56 | | 12.63 |
| 26 | 11-Sep | 7332 | 528.5 | 12.31 | 65.06 | | 12.56 | | 12.62 |
| 27 | 12-Sep | 7374 | 1112.4 | 13.06 | 145.28 | | 12.58 | | 12.64 |
| 28 | 13-Sep | 7386 | 1103.7 | 12.17 | 134.32 | | 12.56 | | 12.62 |
| 29 | 14-Sep | 7540 | 976.3 | 11.41 | 111.40 | | 12.52 | | 12.57 |
| 30 | 15-Sep | 7318 | 1009.6 | 11.30 | 114.08 | | 12.47 | | 12.53 |
| 31 | 16-Sep | 7202 | 1120.8 | 12.40 | 138.98 | | 12.47 | | 12.52 |
| 32 | 17-Sep | 7201 | 1028.0 | 13.01 | 133.74 | | 12.49 | | 12.54 |
| 33 | 18-Sep | 7331 | 1265.4 | 13.13 | 166.15 | | 12.52 | | 12.56 |
| 34 | 19-Sep | 7264 | 1028.5 | 12.57 | 129.28 | | 12.52 | | 12.56 |
| 35 | 20-Sep | 6994 | 571.4 | 14.00 | | 80.00 | | 13.94 | 12.59 |
| 36 | 21-Sep | 7263 | 620.9 | 12.88 | 79.97 | | 12.52 | | 12.59 |
| 37 | 22-Sep | 7171 | 602.0 | 13.19 | 79.40 | | 12.54 | | 12.60 |
| 38 | 23-Sep | 7351 | 1285.6 | 11.22 | 144.24 | | 12.49 | | 12.55 |
| 39 | 24-Sep | 7163 | 1065.1 | 13.06 | 139.10 | | 12.50 | | 12.57 |
| 40 | 25-Sep | 7304 | 1082.3 | 11.52 | 124.68 | | 12.47 | | 12.54 |
| 41 | 26-Sep | 7253 | 990.4 | 11.52 | 114.09 | | 12.45 | | 12.51 |

| TEST DAY | DATE | USIBELLI LAB BTU/LB | TONS/DAY OF COAL | % ASH | PLUS 7000 ASH (TONS) | MINUS 7000 ASH (TONS) | PLUS 7000 ASH AVG | MINUS 7000 ASH AVG | TOTAL RUN ASH AVG |
|---|---|---|---|---|---|---|---|---|---|
| 42 | 27-Sep | 7111 | 1075.0 | 12.49 | 134.27 | | 12.45 | | 12.51 |
| 43 | 28-Sep | 7230 | 335.4 | 12.38 | 41.52 | | 12.45 | | 12.51 |
| 44 | 29-Sep | 7283 | 1341.1 | 12.36 | 165.76 | | 12.45 | | 12.50 |
| 45 | 30-Sep | 7844 | 943.9 | 8.09 | 76.36 | | 12.34 | | 12.40 |
| 46 | 1-Oct | 7441 | 1258.6 | 8.75 | 110.13 | | 12.23 | | 12.30 |
| 47 | 2-Oct | 7107 | 1033.5 | 11.31 | 116.89 | | 12.21 | | 12.27 |
| 48 | 3-Oct | 7302 | 924.1 | 10.79 | 99.71 | | 12.18 | | 12.24 |
| 49 | 4-Oct | 7291 | 1025.8 | 10.14 | 104.02 | | 12.13 | | 12.20 |
| 50 | 5-Oct | 7117 | 1270.7 | 12.18 | 154.77 | | 12.13 | | 12.20 |
| 51 | 6-Oct | 7052 | 1051.7 | 14.10 | 148.29 | | 12.18 | | 12.24 |
| 52 | 7-Oct | 7176 | 988.7 | 13.46 | 133.08 | | 12.21 | | 12.26 |
| 53 | 8-Oct | 7288 | 1111.8 | 11.65 | 129.52 | | 12.19 | | 12.25 |
| 54 | 9-Oct | 7266 | 1099.0 | 11.38 | 125.07 | | 12.17 | | 12.23 |
| 55 | 10-Oct | 7345 | 957.3 | 11.06 | 105.88 | | 12.15 | | 12.21 |
| 56 | 11-Oct | 7416 | 1095.6 | 10.48 | 114.82 | | 12.12 | | 12.17 |
| 57 | 12-Oct | 7345 | 1085.4 | 11.28 | 122.43 | | 12.10 | | 12.16 |
| 58 | 13-Oct | 6981 | 1116.8 | 14.14 | | 157.92 | | 14.02 | 12.20 |
| 59 | 14-Oct | 6739 | 1023.0 | 16.04 | | 164.09 | | 14.57 | 12.26 |
| 60 | 15-Oct | 7423 | 1119.8 | 10.92 | 122.28 | | 12.08 | | 12.24 |
| 61 | 16-Oct | 6960 | 938.1 | 14.77 | | 138.56 | | 14.61 | 12.28 |
| 62 | 17-Oct | 7242 | 1026.8 | 12.79 | 131.33 | | 12.09 | | 12.29 |
| 63 | 18-Oct | 7176 | 1158.9 | 13.49 | 156.34 | | 12.12 | | 12.31 |
| 64 | 19-Oct | 7215 | 977.5 | 12.46 | 121.80 | | 12.12 | | 12.31 |
| 65 | 20-Oct | 7388 | 800.6 | 10.99 | 87.99 | | 12.11 | | 12.30 |
| 66 | 21-Oct | 7075 | 1504.1 | 14.23 | 214.03 | | 12.16 | | 12.34 |
| 67 | 22-Oct | 7359 | 599.0 | 12.33 | 73.86 | | 12.16 | | 12.34 |
| 68 | 23-Oct | 6995 | 1111.0 | 16.84 | | 187.09 | | 15.04 | 12.42 |
| 69 | 24-Oct | 7116 | 988.9 | 15.95 | 157.73 | | 12.23 | | 12.47 |
| 70 | 25-Oct | 6826 | 610.0 | 18.03 | | 109.98 | | 15.32 | 12.52 |
| 71 | 26-Oct | 6994 | 1309.2 | 17.00 | | 222.56 | | 15.61 | 12.60 |
| 72 | 27-Oct | 6963 | 1150.2 | 15.95 | | 183.46 | | 15.65 | 12.66 |
| 73 | 28-Oct | 6830 | 1169.5 | 18.51 | | 216.47 | | 15.98 | 12.76 |
| 74 | 29-Oct | 6658 | 1134.9 | 18.80 | | 213.36 | | 16.27 | 12.85 |
| 75 | 30-Oct | 6833 | 961.3 | 16.37 | | 157.36 | | 16.28 | 12.90 |
| 76 | 31-Oct | 7190 | 1136.1 | 14.30 | 162.46 | | 12.26 | | 12.92 |
| 77 | 1-Nov | 7051 | 1096.1 | 14.85 | 162.77 | | 12.31 | | 12.95 |
| 78 | 2-Nov | 7129 | 1045.6 | 13.30 | 139.06 | | 12.32 | | 12.95 |
| 79 | 3-Nov | 7045 | 977.4 | 12.70 | 124.13 | | 12.33 | | 12.95 |
| 80 | 4-Nov | 7251 | 677.1 | 11.09 | 75.09 | | 12.32 | | 12.93 |
| 81 | 5-Nov | 6882 | 756.9 | 15.17 | | 114.82 | | 16.21 | 12.95 |
| 82 | 6-Nov | 6806 | 765.5 | 15.79 | | 120.87 | | 16.19 | 12.98 |
| 83 | 7-Nov | 6881 | 1164.3 | 13.92 | | 162.07 | | 16.01 | 12.99 |
| 84 | 8-Nov | 7060 | 907.5 | 11.68 | 106.00 | | 12.31 | | 12.98 |
| 85 | 9-Nov | 7247 | 1404.2 | 10.51 | 147.58 | | 12.27 | | 12.94 |
| 86 | 10-Nov | 7233 | 912.0 | 11.81 | 107.71 | | 12.27 | | 12.93 |

| TEST DAY | DATE | USIBELLI LAB BTU/LB | TONS/DAY OF COAL | % ASH | PLUS 7000 ASH (TONS) | MINUS 7000 ASH (TONS) | PLUS 7000 ASH AVG | MINUS 7000 ASH AVG | TOTAL RUN ASH AVG |
|---|---|---|---|---|---|---|---|---|---|
| 87 | 11-Nov | 7022 | 1247.6 | 13.32 | 166.18 | | 12.28 | | 12.93 |
| 88 | 12-Nov | 6853 | 1076.2 | 13.08 | | 140.77 | | 15.81 | 12.93 |
| 89 | 13-Nov | 7001 | 680.6 | 12.20 | 83.03 | | 12.28 | | 12.93 |
| 90 | 14-Nov | 7064 | 884.0 | 11.35 | 100.33 | | 12.27 | | 12.91 |

## Appendix A

## TRW, Inc.'s Comments on Harris Group Inc. Report, February 29, 2000

TRW Space & Technology Division
Space & Electronics Group

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Redondo Beach, CA 90278
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Alaska Industrial Development and Export Authority

February 29, 2000
00.HP.RB-001

Mr. Dennis McCrohan
Deputy Director Project Development and Operations
Alaska Industrial Development and Export Authority
480 West Tudor Road
Anchorage, AK 99503-6690

Subject: TRW Comments on Harris Group, Inc., Report on HCCP 90-Day Test

Reference: HCCP 90-Day Test and Sustained Operations Report
Harris Group Inc. Project No. 60747
Dated December 29, 1999

Dear Dennis,

Attached please find TRW's comments on the Harris Group, Inc., Report on the HCCP 90-Day Test and Sustained Operations dated December 28, 1999.

Sincerely,

Ruth Braswell
TRW Project Manager
Healy Clean Coal Project

Cc: Dennis Swann, Harris Group Inc
Robert Kornosky, DOE

cc: ~~AE~~
CVH
JR
CC

## TRW Comments on the Harris Group Report

Reference: HCCP 90-Day Test and Sustained Operations Report
Harris Group Inc. Project No. 60747
Dated December 28, 1999

The key findings of the Harris Group Inc report on the "HCCP 90-Day Test and Sustained Operations" dated December 28, 1999, were summarized in the cover letter of the report and in the executive summary. Figure 1, prepared by TRW, summarizes these findings. As noted therein, the Harris Group report states that the TRW coal combustors are acceptable for the original intent and retrofit of the combustors is not warranted, the major systems are performing in accordance with design specifications and tolerances, and there is no reason that the HCCP will not operate on a sustained basis if operated and maintained according to standard utility practices and the coal remains above 7200 Btu/lb. The report also concluded that although the 90-day test met the requirements for operating continuously over a 90-day period at 50 MWe net and exceeded the specified capacity factor of 85%, the test was "biased" due to higher than specified coal Btu content (7194 Btu/lb vs 6960 Btu/lb) and excess staffing. It is further stated that if the coal used is a 50% ROM and 50% Waste Coal Blend, the coal transport system must be redesigned and rebuilt. Within the text of the report, additional details on the HCCP performance were also provided.

Contained herein are TRW's comments on the specific findings and conclusions of the Harris Group report. These comments are grouped into three separate sections: 1) Combustion System Performance, 2) Coal Feed System, and 3) Coal.

### Combustion System Performance *

In general, we agree with the majority of the conclusions of the Harris Group Report regarding the combustion system performance. As noted above, the Harris Group report concluded that the combustors were acceptable for the original intent and retrofit was not warranted. Additional comments within the text of the report included: 1) Slagging behavior of the B Precombustor appeared different than A Precombustor, with the B side performance more sensitive to coal Btu below 7000 Btu/lb, 2) The combustors were shown to operate well with coal Btu down to 7000 Btu/lb and "possibly will operate satisfactorily on coal with 200 to 300 Btu/lb less heating value if the control system is properly tuned"; 3) There was an increased amount of "rodding out of slag from scanners and combustors, especially B" during operation over the last 30 days with coal Btu from 6800 to 7000 Btu/lb, and 4) "The flame scanners should be more reliable without frequent rodding". The following information is provided to clarify some specific comments and to identify areas where our conclusions may differ somewhat from those expressed by the Harris Group.

* Combustion System refers specifically to the Combustors themselves and does not include the Coal Feed System and other support systems

PC Coal Split and Precombustor Stoichiometry:

The Precombustor coal split (percentage of total coal injected in the Precombustor) and Precombustor stoichiometry are important parameters for controlling the combustion, gas temperatures, and slagging behavior within the precombustor. During the 90-Day Test, the Precombustor operating conditions on "A" were held constant at a coal split of 34% and stoichiometry of approximately 1.4, which had been the conditions implemented beginning in April 1999. However, the Precombustor operating conditions on "B" Combustor were affected by the damage to the CFS dampers that occurred during the B Mill deflagration in September 1999. For all test operations after September 21, 1999, a significantly higher percentage of coal was directed to the "B" Precombustor, due to damage to the Precombustor and Slagging Combustor Cyclone Inlet trim dampers that could not be repaired during the September 1999 downtime. It is estimated, based on the observed positions of the CFS manual trim dampers and empirical correlations with cold flow data, that the "B" Precombustor coal split during the late September, October, and November 1999 portion of the 90-day test was 49%, with a corresponding Precombustor stoichiometry of 0.95. As the coal Btu dropped and, hence, the coal flowrate increased, the total coal flowrate to the "B" precombustor increased to unacceptable levels. This high coal flowrate to "B" Precombustor, more so than the actual coal Btu content, was probably one of the key reasons for the performance sensitivity observed on the "B" side as the coal Btu dropped.

Coal Btu Content

The report states that the combustors were shown to operate well with coal Btu down to 7000 Btu/lb. It is also suggested that the combustors could continue to perform well with coal Btu 200 Btu/lb less than this if the control system is properly tuned. It is postulated that there would be performance problems with coal Btu of "6960 $\pm$ 500" or coal "significantly less than 7000 Btu/lb" or "coal less than 6600 Btu/lb". The specific concerns related to the combustion system performance when burning these coals were identified in the report as "slagging problems" and "indications of plugging problems". There was also frequent mention of the amount of rodding out of slag from "scanners and combustors, especially B" during operation over the last 30 days with coal Btu from 6800 to 7000 Btu/lb. Further in the report, it is stated that design changes would likely be necessary for sustained operation with coal significantly below 7000 Btu/lb and greater than15% ash. TRW has the following comments:

1) Testing to date has resulted only in limited operating experience with coal Btu significantly below 7000 Btu/lb coal. Based on the experience gained during the PC Burner Characterization Tests performed during March/April 1999, it is likely that minor operational changes, rather than "design changes", will be required for sustained operation with coals significantly below 7000 Btu/lb. This would possibly include reduction in the PC coal split as well as "tuning" of PC and SC stoichiometry for lower coal Btu. The PC and SC stoichiometry could then be automated to track with inferred coal Btu.

2) As noted above, the observed high sensitivity of the B combustor performance to lower Btu coal was likely due to the higher PC coal flowrate rather than directly due to the lower coal Btu content. The B PC slagging behavior and scanner rodding history is not considered representative of "typical" behavior due to the off-nominal PC coal flowrate.
3) There was not a TRW representative on-site during the last 30 days of the 90-day test when the lower Btu coal was burned. Therefore, we do not have any first hand observations on the slagging behavior of the Precombustor with the lower Btu coal. However, based on Operator notes, it appears that there were only ~5 days out of the last 30 days of the test, during operation with the lower Btu coal, when the A PC or A SC scanner ports required rodding more than once or twice over a 24 hr period. The A PC and SC scanner rodding history (extracted from the Operator Log notes) is shown in the attached table. If scanner rodding is used as an indication of slagging behavior, then it appears that A PC did not experience any excessive slagging or plugging behavior with coal Btu between 6800 and 7000 Btu/lb.
4) Also mentioned in the report was rodding out of slag "from the combustors". It is assumed that this refers to the occasional rodding of slag from the air ports on the SC headend. It should be noted that this is a manifestation of the temporary piping configuration to duct air to the SC headend. Due to the large pressure drop thru the piping headers, there was very little operating margin and small pressure perturbations resulted in restricted air flow through the ports. Its is expected that this problem will be resolved when the permanent piping is installed.

In summary, based on the performance of the A Combustor (which was operated at typical Precombustor coal flowrates), there does not appear to be any indication of excessive slagging problems or plugging problems during operation with coal Btu between 6800 and 7000 Btu/lb.

Emission Performance

The report states that there appears to be ample opportunity to further reduce NOx emissions at HCCP by 1) reducing the SC stoichiometry from 0.80 to 0.75, 2) reducing the excess air in the boiler, and 3) relocating the NOx ports within the boiler. TRW agrees with these comments. It should also be noted that the current HCCP NOx emission levels were achieved without any specific effort by AIDEA to optimize the combustor and furnace operating conditions for NOx reduction. In general, the lowest NOx emissions were achieved at lower furnace O2 levels without any significant increase in plant CO emissions. Based on both analytical and empirical data, additional NOx reductions at HCCP can be achieved by optimizing combustor stoichiometry, and furnace air staging and O2 levels. Furthermore, the 90-day post-test inspection (and typically all previous post-test inspections during 1998 and 1999) revealed that the entire Slagging combustor was covered with a very thin slag layer from the headend to the baffle. This thin slag layer indicates that the slagging combustor is operating at a fairly high gas temperature and there is therefore a large operating margin available, in terms of lowering SC stoichiometry, without having a detrimental impact on SC slagging behavior.

Scanner Performance

There are 4 scanners located on PC and 4 scanners located on SC. The report did not distinguish between the PC and SC scanners, however, as noted above, there were statements made regarding the "abnormal" amount of operator intervention required to keep the scanners clean. The report also states that the general understanding is that the flame signal deteriorates due to "slag buildup in the combustor", even when the flame is acceptable. The amount of rodding of scanner ports was considered "unacceptable". TRW has the following comments:

- It is important to distinguish between the SC and PC scanners, the scanner locations, the type of scanners, and "A" vs "B". Due to the off-nominal PC coal split on the "B" side, the "B" scanner problems should not be considered "typical".
- As noted above, based on Operator log notes, the amount of rodding of the "A" PC scanner ports was typically 1 to 2 times per day. Even with coal Btu between 6800 and 7000, only 5 of the last 30 days had increased frequency of rodding PC scanner ports. This does not appear to be an unreasonable amount of maintenance.
- Typical rodding of A and B SC ports was also 2 to 3 times per day. It should be noted that the rodding was required most frequently on SC A at 11 o'clock and SC B at 1 o'clock (mirror image); if these ports are eliminated as scanner ports, the frequency of rodding of the 3 remaining ports would be closer to a total of 1 or 2 times per day.
- Based on the performance of the "smart scanners" installed in the PC headend, it is likely that much of the scanner rodding could be eliminated by the installation of smart scanners on other scanner ports
- It should also be noted, that the "slag buildup" which obscures the flame scanner is usually simply a local ash/slag buildup in the scanner port resulting from the ash/slag condensation on the cold air purge used to protect the scanners. This was the usual reason for the 1 or 2 scanner roddings per 24 hrs.
- In the long term, 4 scanners on the SC and 4 scanners on the PC are not required. Redundant scanners were installed for the 90-day test for two primary reasons: 1) To determine the best location for scanners for long term operation and 2) To provide a "diagnostic" to indicate possible "off-nominal" operating conditions that may be contributing to increased slagging behavior in the PC and SC, which needs to be addressed by the Operator. In particular, this is the purpose of the scanner located on the PC NOx port (referred to as PC Dot). For the long term, only 4 total scanners are probably required plus changes to the burner logic.

In summary,

1. The observed differences in slagging behavior characteristics between A Precombustor and B Precombustor during the 90-day test was due to unintentional differences in operating conditions (i.e. Precombustor coal split and stoichiometry) that were a result of damage sustained by the B CFS dampers during the B Mill

deflagration. Specifically, the B Precombustor was burning 49% of the total B coal feed rather than the desired 34% of the total coal feed. Even with these off-nominal conditions, the B Precombustor was able to sustain acceptable operation over the 90-day period.

2. Based on the performance of the A Combustor (which was operated at typical Precombustor coal flowrates), there does not appear to be any indication of "slagging problems or plugging problems" during operation with coal Btu between 6800 and 7000 Btu/lb
3. Typical rodding of the A Precombustor scanner ports was 1 to 2 times per day. This is typically due to a local ash/slag buildup in the scanner port resulting from the ash/slag condensation on the cold air purge used to protect the scanners. It is likely that much of the scanner rodding could be eliminated by the installation of smart scanners.
4. TRW agrees that there appears to be ample opportunity to further reduce NOx emissions at HCCP by 1) reducing the SC stoichiometry from 0.80 to 0.75, 2) reducing the excess air in the boiler, and 3) relocating the NOx ports within the boiler (e.g., using the OFA ports). The extremely thin slag layer within the slagging stage indicates that there is significant margin for reducing the SC stoichiometry without a detrimental impact on SC slagging behavior.

## Coal Feed System

One of the conclusions of the report is that "the coal transport system from feeder outlet to combustor inlet has to be redesigned if the coal to be supplied and burned is to be a blend of 50% ROM and 50% waste". The text of the report contains more specific comments that are primarily related to the wear exhibited on the exhauster fan blades and housing during post-test inspections and the on-line maintenance that had been required to prevent coal leaks. The report also mentions that "the area below the Splitter" on the B CFS had an area of high erosion that was caused by the damaged CFS splitter dampers. The report suggests that the CFS Splitter subsystem will be prone to accelerated wear and tear when firing high quantity of waste coal < 7000 Btu/lb. TRW has the following comments:

1) Post-test inspection of the A-side splitter, cyclone, and ductwork revealed that there was negligible, if any, wear of the abrasion-resistant tiles in this region. Tiles in the region of splitter dampers looked brand new.
2) Prior to the 90-day test, localized wear had been observed in Cyclone Impact Elbows (both SC and PC had a wear groove ~1" wide by 6" long), the SC elbows, and the Burner Inlet Scroll on both "A" and "B" side. New tiles with improved erosion-resistance were installed in the Cyclone Impact Elbows and the Burner Inlet Scroll. Post-test inspection of the B side revealed virtually no wear of the new tiles installed in the Cyclone Impact Elbows. These locations should be inspected again after another 6 months of operation, but the lack of wear following 3 months of operation is encouraging and illustrates that only minor changes are probably required to improve durability in these regions.

3) As mentioned in the report, the damage to the B CFS dampers that occurred during the deflagration of the B Mill was the primary cause of the localized erosion observed on-line and post-test in the B CFS in the region of the dampers and the inlet to the Cyclone. The deformed damper resulted in approximately 2 times the desired velocity in this region, which correlates with an approximate factor of 8 increase in wear rate. The previous fire in this region had also fractured the tiles and damaged the grout.
4) Based on the operating experience gained during the Combustor Characterization Test Series, it may not be necessary to significantly vary the PC coal split as a function of coal Btu content or load changes and, therefore, the CFS dampers could be removed and a fixed geometry could be used. Additional testing with lower Btu coal is probably necessary in order to determine the optimal fixed geometry.
5) The coal carrier air flowrate to the PC and SC during the 1998 and 1999 test operations was maintained at a level that provided significant margin above the saltation velocity. Reduction in the carrier air flowrate would reduce the wear rates in components downstream of the Cyclones.

In summary, based on post-test observations, none of the components downstream of the exhauster have been shown to have significant wear rates when burning coal with 7200 Btu/lb at nominal operating conditions (i.e. velocity). Although additional operating time with lower Btu coal is required, it is anticipated that the improved erosion-resistant tiles installed in the elbows and inlet scroll will result in acceptable wear rates. Simple changes, such as reduction in carrier air flowrates and incorporating improved erosion resistant tiles in local high wear areas will likely further improve the situation. Based on the specific comments in the report and post-test observations of wear, if the exhauster fan wear rate can be reduced or an alternative approach for supplying the requisite pressure to the CFS Splitter subsystem can be developed, there does not appear to be any problem, per se, with the design of the CFS Splitter subsystem downstream of the Exhauster Fan.

## Coal

TRW was not privy to the discussions on the coal Btu content that occurred between AIDEA, GVEA, and Harris Group during the pre-test meetings and monthly interface meetings during the test. We therefore only have general comments on this issue:

- Coal is by nature a variable fuel. In a practical sense, any coal should be defined by a range of properties rather than a single value. For example, waste coal heating value can vary between approximately 5100 and 7200 Btu/lb (with an average of ~6150 Btu/lb) and the ROM coal heating value can vary between 7500 and 8200 Btu/lb (with an average of 7850).
- Review of coal analysis data provided in the Appendix of the report indicates that a coal with an as-received coal Btu of ~ 7100 Btu/lb can have ash contents varying from 10.5% to 12%. If the moisture content is highly variable (as it is in Healy), then the variation in ash content for the same Btu coal can be even broader. Coal analysis from the 1998 and 1999 HCCP test activities show up to 14.5% ash for an as received

coal Btu of 7100 Btu/lb. It should also be noted that not only is the total ash content highly variable but the composition of the ash (i.e. quantity of Al and Si) is also variable between different coal seams.

- Experience from the 1999 HCCP test activities indicates that even with a "blended ROM / Waste Coal Pile, the blended coal composition will vary depending on the coal seam being mined, the coal mining technique, and the specific location within the seam being mined.
- Since waste coal Btu and ash content can be so variable, a 50% waste / 50% ROM coal will also be extremely variable and it is unlikely that it will coincide exactly with the "average" value from several sites, even over a 90-day period. It is most likely simply characteristic of the specific area that is being mined. To end up with the specific average would probably require operation with coal from each of the various seams that will be mined over the course of the plant operation.
- Based on the typical range of coal properties observed during the 1998 and 1999 test activities, and the typical range of coal properties included in the coal analysis data included in the appendix, waste coal Btu can vary from approximately 5100 to 7200 Btu/lb (avg of 6150 Btu/lb) and ROM coal can vary from approximately 7500 to 8200 Btu/lb (avg of 7850 Btu/lb) and a 50% waste / 50% ROM coal blend can therefore vary from 6300 to 7750 Btu/lb. Therefore, an average coal heating value of 7200 Btu/lb can be representative of 100% waste or 38% waste.
- Another variable added to the coal blend was the use of coal fines which were not included in the original plan for HCCP and were therefore not included in the original "average" coal values provided. The coal fines have a variable Btu content and are typically higher moisture. This has also affected the difference observed between the originally expected coal Btu and the actual coal Btu that would be expected.
- Review of the "performance" coal supplied by UCM to TRW during the DVT conducted at TRW's Capistrano Test Site in 1992 indicates that the coal supplied had an average coal Btu content of 6989 to 7112 Btu/lb (average of 7061 Btu/lb) with an average ash content of 11.20 to 13.25% (average of 12.3%). This lower ash content of the "performance" coal supplied by UCM in 1992 is consistent with the lower ash content of ~12.9% average for the "performance" coal supplied during the 90-day test. The fact that the average ash content of "performance" coal was approximately 11 to 13% in 1992 and again in 1999, indicates that 11 to 13% ash may be more representative of the ash content of performance coal than the 16% value used in the design specifications.
- During the 11th and 12th week of the 90-day test, the average coal heating value was 6960 Btu/lb and the average ash content was 15.16%, over this 15 day time period. Since the majority of plant performance tests are typically performed only over a 15 day time period versus the HCCP 90-day period, this 15 day period could be considered representative of a "typical plant performance test" with coal that was very close to the average "performance" coal composition.
- As noted in Steve Rosendahl's letter to Dennis McCrohan on "Plant Design Coal Basis" dated December 9, 1999, it was expected that Waste Coal would be blended with ROM coal to result in a coal blend with a heating value of at least 6875 Btu/lb; it

was not anticipated that "pure" waste coal with Btu content less than 6875 Btu/lb would be deliberately burned at HCCP

In summary, it would be difficult to run a test, even over 90-days, which will exactly match the average coal Btu expected over the next 30 years. As noted above, the "average" was a combination from several mining locations and did not include coal fines. Over a 90-day period, Usibelli would not be expected to mine from several different locations so it is unlikely if a 90-day test will ever "match" the average. However, over a 15-day time period during the 90-day test, the average coal properties were very close to the specified "average performance coal" properties. Since many plant performance tests are only 15 days in duration, this 15 day period could be considered representative of a typical power plant performance test while burning a coal with "average performance coal properties".

## Key Harris Findings

- The TRW coal combustors are "acceptable for the original intent" and a "retrofit of the combustors is not warranted".
- "The major systems are performing in accordance with design specifications and tolerances".
- "There is no reason why the HCCP will not operate on a sustained basis if operated and maintained according to standard utility practices if the coal remains above 7,200 BTU/lb".
- The 90-day test was "biased" because coal with an average of 7,194 BTU/lb was burned instead of coal that averaged 6,960 BTU/lb and the average staffing was 43 heads instead of the 26 heads in the original plan.
- "If the coal to be used is a 50% ROM and 50% Waste blend", the coal transport system "must be redesigned and rebuilt".
- During the 90-day test, 102,373 MWHrs (94.8%) were credited as generated versus a requirement of 91,800 MWHrs.
- The test period of 90 days was achieved on 15 November 1999
- "The result of burning 61% ROM coal was that ~23% less ash had to be processed during the 90 day test"
- "The TRW combustion System at the HCCP has proven that it can operate on a continuous basis for coals supplied by Usibelli down to 7,000 btu/lb and about 15% ash. For lower quality coals, design changes are most likely required for sustained operation."

Figure 1. Summary of key Harris Group findings

# Appendix B

## Usibelli Coal Mine Comments on Harris Group Inc. , March 1, 2000

USIBELLI COAL MINE, INC.
P.O. Box 1000 ■ Healy, AK 99743
(907) 683-2226 ■ fax (907) 683-2253

March 1, 2000

Mr. Dennis McCrohan
Alaska Industrial Development and Export Authority
480 West Tudor Road
Anchorage, AK 99503



Re: Healy Clean Coal Project (HCCP)

As requested, following are comments from Usibelli Coal Mine, Inc. (UCM) regarding the Harris Group Inc. (HGI) report titled *Independent Engineers Review of HCCP 90 Day Test and Determination of Sustained Operations* (the Report).

In general, HGI is to be commended for their diligence and professionalism in the monitoring of the 90 day test and the production of a report that boils the issue down to a manageable size. Subject to the following comments, the Report reached conclusions that are based upon sound logic and analysis and are in agreement with conclusions reached from UCM's observations. There are three opinions expressed in the Report which embody the essence of the HCCP's success to date.

1) Page 2-1, "*..that the major systems of the project are performing in accordance with design specifications and tolerances.*" From our observations of the start-up and testing of the HCCP, there did not appear to be an unusually high number of difficulties, most of which seemed to be solved in time for the 90 day test. The fact that the plant achieved much better than the minimum capacity factor of 85% during the test is undeniable evidence that the plant, as a whole, is functioning above design standards.

2) Page 2-1, "*..that the plant, as configured and if operated and maintained in accordance with standard utility practice, could be considered as a commercial plant which is of comparable efficiency with similar plants if coal delivered & burned remains above 7200 btu/lb.*" See comments below regarding the coal feed quality during the 90 day test. The fact that the plant achieved a heat rate significantly lower than Healy Unit 1, with better environmental performance, leans heavily towards the plant's overall commercial viability.

3) Page 10-1, "*..that conversion of the combustion equipment from the existing TRW precombustor/slagging combustor system to conventional low-NOx burners will not improve the commercial viability of HCCP.*" Our experience thus far with coal supply to Unit 1, which was retrofit with low-NOx burners in 1996, suggests that such a retrofit to HCCP will be likely to decrease its ability to burn waste coal. It also seems likely that retrofit would result in decreased environmental performance and greater difficulty in ash handling.

The Report recognizes that there are a significant number of punch list items that need to be addressed before the plant is complete. Chief among these items is the need to address the high wear rates in the mill exhauster fans. It seems that the mill exhauster problem should be solvable and therefore there is a high probability that the HCCP can and should be run commercially. The most significant criticism of the 90 day test appears to boil down to two issues discussed throughout the report and in the executive summary.

1) *A higher than target Btu value for coal burned during the test.* – The target value of 6960 Btu/lb. was derived from an assumed mixture of ROM coal and overburden. The parties involved in mining, stockpiling and handling the coal before it was burned had not previously had to put that assumption into practice for an extended period of time. UCM expects to be able to supply adequate low Btu coal for the plant to meet this target, but one should expect additional time getting through the learning curve before that target can be met on a consistent basis.

   Even though the average quality was above the target value during the 90 day test, there was a significant amount of time when the plant operated at less than target Btu value. It is my understanding that during these excursions below the target value, when combustor plugging started to occur, that the plant was able to recover and clean itself up by burning higher Btu coal for a little while. This would seem to be a perfectly acceptable means to deal with low coal quality excursions and a demonstration that the combustor technology is probably capable of burning coal at the target Btu value on a sustained basis.

   During the last month of the 90 day test, UCM stationed an observer at the GVEA coal stockpile to record the coal source for loading of the HCCP bunkers. Realizing that our data capture during any given day of operation was probably not complete (we did not have someone there 24 hours per day), the data indicates that approximately 13% of the coal feed to HCCP was ROM coal. Our understanding is that much of the reason for feeding ROM coal was to improve coal flow in the coal handling system, a flaw one could not properly attribute to the HCCP technology.

2) *Additional personnel on hand for maintenance.* Though this situation certainly tends to cloud the issue of how many people it really takes to run the plant, I believe the gravity of the uncertainty is overstated. Although Healy is perhaps a little more remote than many places, it is by no means cut off from the rest of the world and significant resources to aid in an emergency are only a phone call and a few hours away. If a loss of capacity, such as from a mill explosion, was critical to the operator, for whatever reason, then similar levels of additional personnel to repair the problem could be obtained in fairly short order by overtime from normal crew personnel or call out from Fairbanks or Anchorage.

Several items in the report need clarification. The first two points below are repeated from earlier correspondence.

1) Page 6-1, 1st Paragraph. It is stated in the report that "...ROM coal from the Two Bull Ridge seam ...will average approximately 6500 btu/lb." It is likely that the UCM representative from which this statement was derived intended to say **Waste** coal or Waste/ROM Blend, instead of ROM coal. Coal of that quality would not fit the ROM coal criteria.

2) Page 8-3, 3rd Paragraph. Regarding the rejection of rocks by UCM in coal samples prior to grinding in the laboratory. UCM has instituted the practice recommended in the December 22, 1998 report titled *Audit result for Quantity and Quality Measurements for Coal, Limestone, Fuel Oil and Ash, Harris Group Inc. Project No. 6660*. Since shortly after the audit report was released, UCM has been mathematically adjusting the BTU levels in our analysis to account for any rocks removed prior to grinding the sample, so analysis performed on 90 day test coal would be adjusted if rocks were rejected from the sample.

3) Page 5-2, 4th Paragraph. It is my understanding that some, or maybe all, of the daily tipple samples analyzed by UCM were sent to CT&E for check analysis. However, I do not believe UCM performed any analysis on the samples CT&E collected for the bias testing.

4) Section 8, Net Plant Heat Rate (NPHR). Page 8-1 defines the NPHR as the steam heat content minus the feed water heat content divided by the net turbine output. Isn't this correctly termed the turbine/generator heat rate? On page 8-4, the NPHR is defined as the fuel heat input divided by the net plant power output, which appears to be the definition actually used in any of the NPHRs quoted in the Report.

Although recommending solutions to problems with the HCCP is beyond the scope of the Report, one is left with the sense that flaws existing in the performance of major systems are relatively few and that those which are identified are solvable by conventional means. Given that the HCCP has clearly demonstrated better environmental and fuel flexibility performance than proposed retrofit technology, UCM concurs with HGI's conclusion that retrofit of the combustors themselves is not warranted at this time.

Sincerely,

Steve W. Denton
Vice President Engineering

cc: Mike Kelly, GVEA

# Appendix C

# Coal Delivered for 90-day Test

# Summary of coal sent to HCCP

8/1/99 through 11/15/99

Data supplied by UCM

| Source | Tons Wst | Tons ROM |
|---|---|---|
| Poker Fines | 3,544 | |
| Tip Fines | 1,233 | |
| EE3B Wst. | 210 | |
| RW North T/s Wst. | 500 | |
| RW5B Wst. | 87 | |
| TBR RD C1-3 Wst. | 284 | |
| TBR RD C3A Wst. | 210 | |
| E.S. Stockpile Fines | 9,243 | |
| EE2B | | 400 |
| EE3B | | 250 |
| 1-22A | | 3,607 |
| 11-21C | | 1,221 |
| Poker Fines | 23,936 | |
| RW North T/s | | 282 |
| RW4B | | 1,436 |
| RW5B | | 3,460 |
| TBR RD C1-3 | | 3,700 |
| Tip Fines | 2,366 | |
| 1-22A Wst. | 520 | |
| RW 4-Slide Wst. | 4,274 | |
| RW North T/s Wst. | 352 | |
| RW5B Wst. | 6,786 | |
| TBR RD C1-3 Wst. | 11,382 | |
| TBR RD C3A Wst. | 3,103 | |
| TBR RD C4 wst | 660 | |
| TBR RD C4-8 wst | 2,030 | |


70,755 TOTAL WASTE

14,356 TOTAL ROM

⇒ 85,111 TOTAL

TOTAL FINES 40,377 57.1%

TOTAL WASTE 30,378 42.9%

USIBELLI COAL MINE, INC.
Coal Loading Summary - Mine Mouth Power Station
for
Healy Clean Coal Project

| Assumed Heating Value | ROM | 8000 | * Calculated from assumed value for ROM and Waste. |
|---|---|---|---|
| | Waste | 6000 | |

| | # of Bucket Loads | | | | Percentage of Total | | | Heating Value BTU/lb. | |
|---|---|---|---|---|---|---|---|---|---|
| Date | Total | ROM | Blend | Waste | ROM | Blend | Waste | Average | Blend * |
| 10/19/99 | 175 | 54 | 121 | | 31% | 69% | 0% | 7215 | 6865 |
| 10/20/99 | 44 | 1 | 43 | | 2% | 98% | 0% | 7388 | 7374 |
| 10/21/99 | 191 | 41 | 150 | | 21% | 79% | 0% | 7075 | 6822 |
| 10/22/99 | 123 | 19 | 104 | | 15% | 85% | 0% | 7359 | 7242 |
| 10/23/99 | 196 | 7 | 189 | | 4% | 96% | 0% | 6995 | 6958 |
| 10/24/99 | 197 | 5 | 192 | | 3% | 97% | 0% | 7116 | 7093 |
| 10/25/99 | 98 | 0 | 98 | | 0% | 100% | 0% | 6826 | 6826 |
| 10/26/99 | 166 | 0 | 166 | | 0% | 100% | 0% | 6994 | 6994 |
| 10/27/99 | 177 | 0 | 177 | | 0% | 100% | 0% | 6963 | 6983 |
| 10/28/99 | 186 | 0 | 186 | | 0% | 100% | 0% | 6830 | 6830 |
| 10/29/99 | 164 | 0 | 164 | | 0% | 100% | 0% | 6658 | 6658 |
| 10/30/99 | 139 | 58 | 81 | | 42% | 58% | 0% | 6833 | 5997 |
| 10/31/99 | 165 | 49 | 116 | | 30% | 70% | 0% | 7190 | 6848 |
| 11/1/99 | 149 | 39 | 110 | | 26% | 74% | 0% | 7051 | 6715 |
| 11/2/99 | 136 | 42 | 94 | | 31% | 69% | 0% | 7129 | 6740 |
| 11/3/99 | 42 | 13 | 29 | | 31% | 69% | 0% | 7045 | 6617 |
| 11/4/99 | 87 | 21 | 66 | | 24% | 76% | 0% | 7251 | 7013 |
| 11/5/99 | 96 | 0 | 96 | | 0% | 100% | 0% | 6882 | 6882 |
| 11/6/99 | 79 | 16 | 63 | | 20% | 80% | 0% | 6306 | 6503 |
| 11/7/99 | 128 | 27 | 101 | | 21% | 79% | 0% | 6881 | 6582 |
| 11/8/99 | 130 | 27 | 103 | | 21% | 79% | 0% | 7060 | 6814 |
| 11/9/99 | 163 | 43 | 120 | | 26% | 74% | 0% | 7247 | 6977 |
| 11/10/99 | ###### No Coal Monitoring | | | | #VALUE! | #DIV/0! | #DIV/0! | | #VALUE! |
| 11/11/99 | 169 | 0 | 169 | | 0% | 100% | 0% | 7022 | 7022 |
| 11/12/99 | 135 | 0 | 135 | | 0% | 100% | 0% | 6853 | 6853 |
| 11/13/99 | 81 | 5 | 76 | | 6% | 94% | 0% | 7001 | 6935 |
| 11/14/99 | 133 | 0 | 133 | | 0% | 100% | 0% | 7064 | 7064 |

# Appendix D

## Letter from Stone & Webster Engineering Corporation, December 9, 1999

'keting Boston ID:617-589-2362 DEC 08'99 21:31 No.002 P.01

Post-it® Fax Note 7671

| | |
|---|---|
| To DENNIS McCROHAN | Date 12/9/99 # of pages ▸ 2 |
| Co./Dept. | From S. ROSENCAHL |
| Phone # (907)269-3025 | Co. |
| Fax # -3049 | Phone # (303)741-7273 |
| | Fax # -7040 |

**Stone & Webster**
Founded 1889

Mr. Dennis V. McCrohan
Deputy Director
Alaska Industrial Development & Export Authority
480 West Tudor
Anchorage, Alaska 99503-6690

December 9, 1999
J.O. No. 05448.01

Letter No. SA-3162

PLANT DESIGN COAL BASIS
HEALY CLEAN COAL PROJECT

As requested by AIDEA, I have reviewed the HCCP design regarding coals to be fired. The HCCP plant coal design basis is summarized in my letter to Mr. John B. Olson, Dated August 14, 1991, (SA-351) with a copy to F. Abegg. The following summarizes the design basis:

1. The HCCP design specifications for TRW's combustors and Foster Wheeler's boiler identify the analyses for Run of Mine (ROM), Performance ( a 50/50 blend of Waste and ROM coals), and Waste coal. In addition, a 55/45 blend of Waste to ROM coal is identified. While several properties in the coal's analysis define a coal, the Heating Value is useful in differentiating coals. The heating values of the specified ROM, Performance, Waste, and 55/45 coal blend are 7,815, 6,960, 6,105, and 6,875 Btu/lb respectively.

2. The design specifications require the combustors and boiler be designed to achieve full steam output referred to as the Maximum Continuous Rating (MCR) when firing either the ROM, Performance, or 55/45 coal blend. When firing the 100% Waste coal, the combustors and boiler are only required to operate continuously, no load requirement is specified. When firing 100% Waste coal, HCCP may be expected to operate at loads less than MCR.

3. The 90 day Reliability Test has a requirement to demonstrate high HCCP Capacity Factors, i.e 85%. In order to achieve this high Capacity Factor, MCR load levels must be reached and maintained. The coal to be fired should have a Heating Value between the ROM and the 55/45 coal blend as specified in the TRW and Foster Wheeler specifications in order for MCR to be reached. The low Heating Value resulting with a Waste coal content greater than in the 55/45 coal blend (or a Heating Value less than 6,875 Btu/lb) would not be an appropriate coal for the test purposes.

4. The Heating Value identified in the design specifications is 6,105 Btu/lb for the 100% Waste coal. In order to reach MCR, the Waste coal would be expected to be blended with ROM to result in a coal blend with a Heating Value of at least 6,875 Btu/lb . Also, while Usibelli's letter dated February 12, 1992 (subsequent to contracting with TRW and Foster Wheeler) identified the lowest limit of Heating Value for waste coals as 5,000 Btu/lb, this low heating value was never a design requirement for the combustor or boiler.

5. While balance of plant equipment, such as the Coal Feed and Ash Removal Systems, were designed for firing 100 percent waste coal, MCR on waste coal was not expected or guaranteed by any Project Participant due to potential combustor or boiler technology limitations.

Stone & Webster Engineers and Constructors, Inc.
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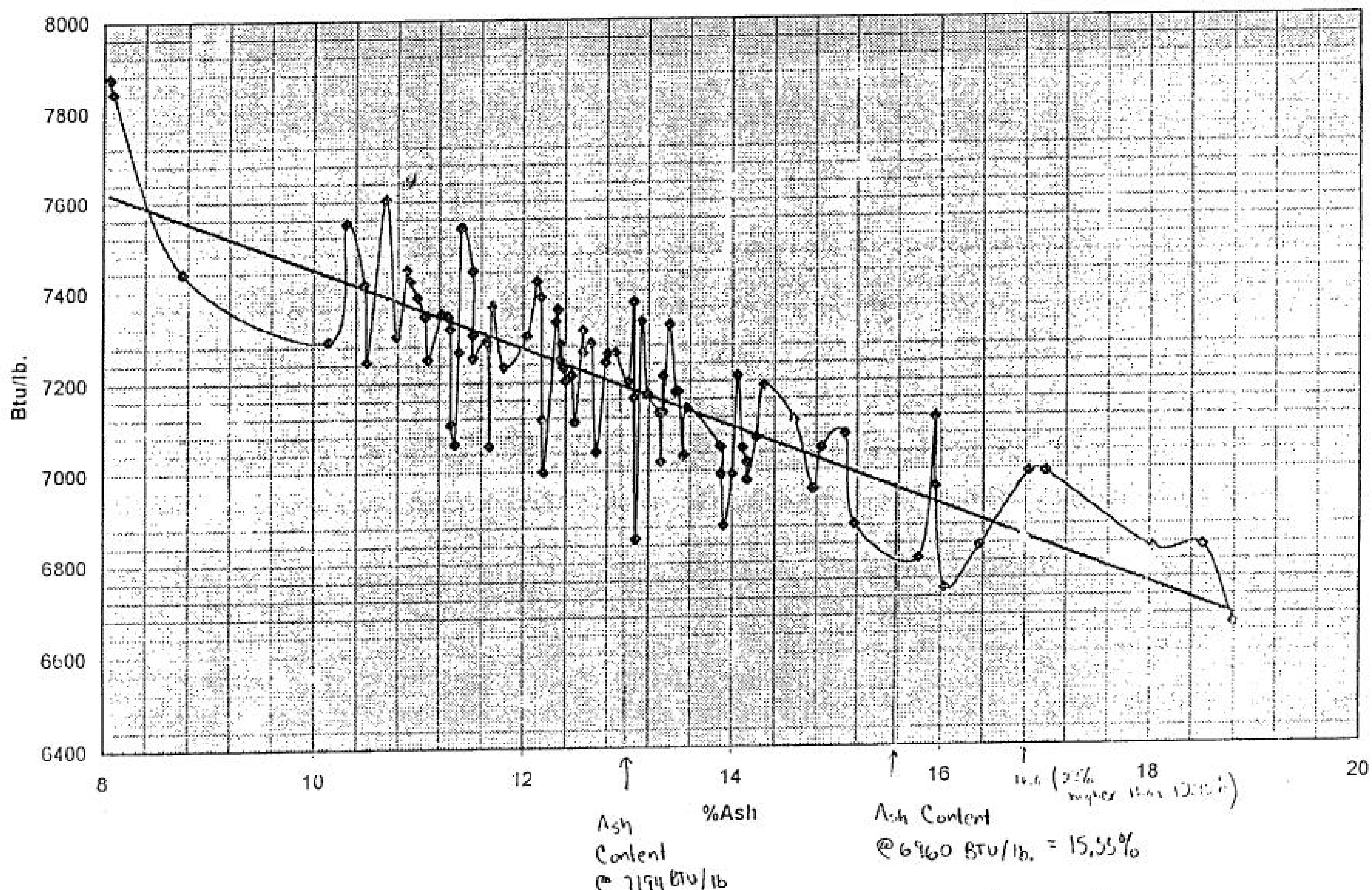
Boston, Massachusetts 02210
Phone: 617.589.5111
Fax: 617.589.2156
www.stoneweb.com

# Appendix E

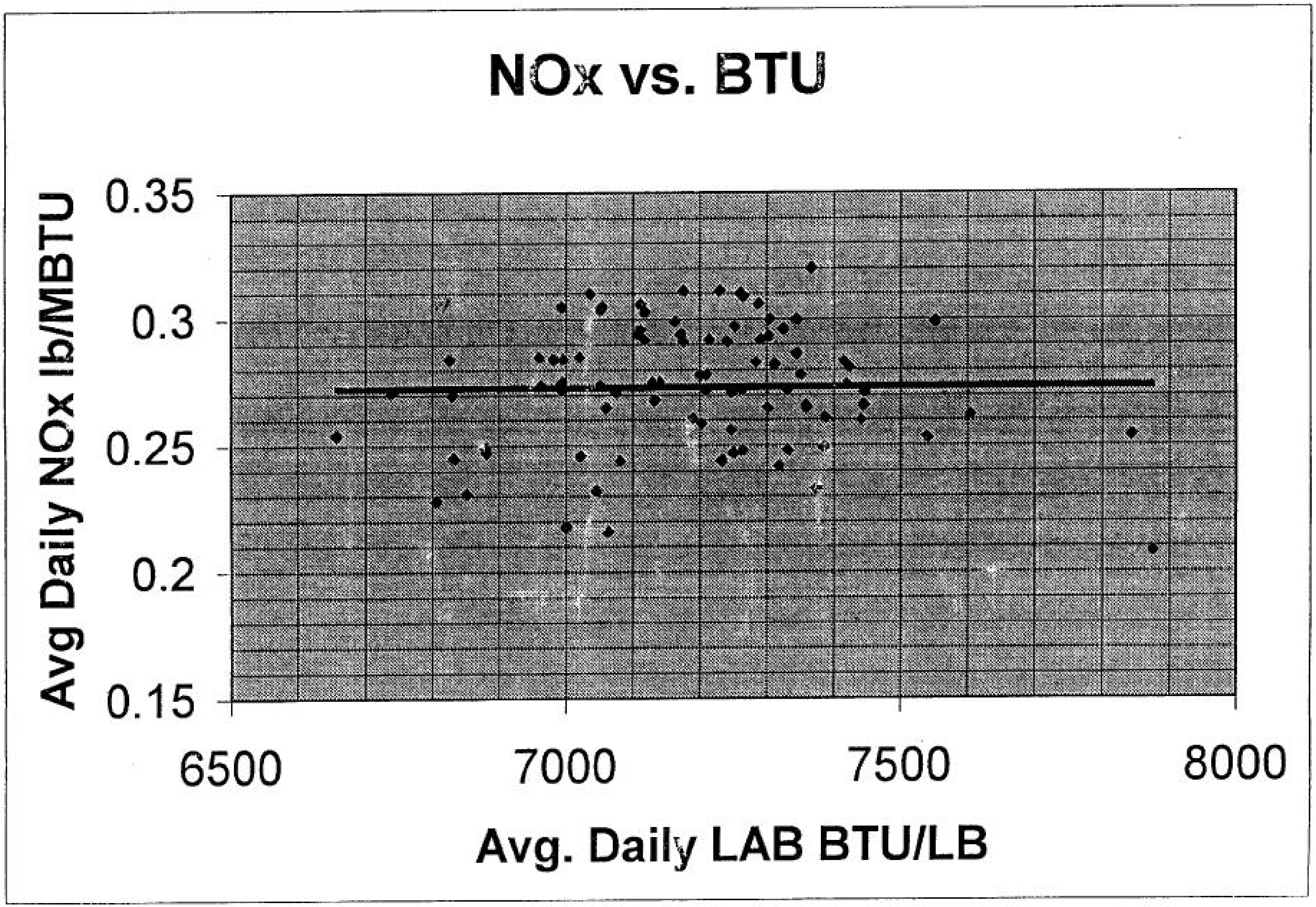
## Ash Content Graph, February 23, 2000

## HCCP 90 Test - Coal Quality



# Appendix F

## $NO_x$ vs Btu Graph, February 23, 2000


NOx vs. BTU
Avg Daily NOx lb/MBTU
0.35
0.3
0.25
0.2
0.15
6500
7000
7500
8000
Avg. Daily LAB BTU/LB

# Appendix G

# HCCP 90-day Test Protocol

# HCCP 90-DAY TEST PROTOCOL AND HCCP SUSTAINED OPERATIONS INFORMATION GATHERING

## INTRODUCTION

- PURPOSE

The purpose of the 90 Day Test is to determine the project has operated at not less than 50 megawatts, net of station service, at a capacity factor of not less than 85 percent, for a period of 90 consecutive days, using coal with characteristics equivalent to those of long-term Usibelli coal.

The purpose of the sustained operations information gathering is to observe and gather sufficient information that, as the result of independent observations of the test operations of the project and tests and inspections required by the engineers, the major systems of the project are performing in accordance with design specifications and tolerances and that the engineers know of no reason why the project will not perform on a sustained operating basis as provided under this Agreement if the project is operated, maintained, and renewed according to standard utility practices.

- GENERAL

The tests are to be run under the management and control of AIDEA. AIDEA is responsible for the operation of the facility and for the safety of the facility and personnel working in the facility.

Golden Valley may have one GVEA person and one outside contractor as observers around the clock. These observers will have access to all test data.

The GVEA person and their contractor shall have access to the plant and operations at all times. However, if AIDEA requires, they shall be escorted when not in the control room.

At AIDEA's request, the number of outside people in the control room can be limited to three (3) – GVEA, their contractor and HGI.

All access to the operators shall be through the AIDEA control room representative.

Harris Group's representative's role is that of an observer. Harris Group will rotate personnel such that a variety of disciplines are represented.

- TIMING – 90 DAY TEST

AIDEA will request a start day and time by giving three (3) day's notice. HGI will verify the plant's readiness, hold a pre-meeting and declare the actual start time which is expected to be at approximately the time requested by AIDEA.

- TIMING – SUSTAINED OPERATIONS

  The time period to be considered in evaluation of sustained operations includes the 90 Day Test, the time of the prior boiler and scrubber tests, the time of operation prior to the 90 days, plus any time operated after the 90 days and the time required after the 90 day test to physically inspect the plant.

- TEST RELATIONSHIPS

  There is no specific relationship between the two tests. The 90 Day Test provides a convenient period to gather operating data for the sustained operating determination.

- VENDORS

  Equipment vendors may visit the site as observers of the tests and provide guidance on the operation and maintenance of their equipment.

## PRIOR TO THE 90 DAY TEST

AIDEA will provide the following documents at least three (3) days before the test is scheduled to start:

1) Calibration sheets for instruments listed on Attachment A.
2) Samples of the hourly and daily printouts to be provided by the DCS. Data to be on these printouts are listed on Attachment B.
3) A sample printout set of all graphic displays available from the DCS.
4) A sample of a daily CEM printout.
5) AIDEA will provide a document presenting the following:
   - The pulverizers are properly adjusted.
   - The scrubber is adjusted and operating properly.
   - The exhausters have been repaired to like new condition.
   - The combustors are clean.
   - The DCS is operating properly.
   - Usibelli has been notified and will make best efforts to supply 90 days of performance test coal.
   - Sufficient limestone will be available for the test period.
   - The CEM is calibrated and in good operating condition.

## PRE-TEST MEETING FOR 90 DAY TEST

A pre-test meeting will be held at the site chaired by Harris Group. This meeting will be held immediately prior to the start of the test.

Attendees will be: Harris Group
AIDEA
GVEA

- Harris will review test protocol.
- AIDEA will present their operating plan and chain of responsibility.
- GVEA will present their chain of responsibility.
- Harris will review what procedures will be followed in abnormal events.
- Harris will review what information is to be logged.

## TEST INITIATION

AIDEA is to give preliminary notices seven (7) days notice prior to test start. AIDEA is to reaffirm at three (3) days prior to test start. Harris Group will notify AIDEA and GVEA that the test period is to begin. At the test start, on the hour, Harris will record the following data:

- Electric meter reading, gross, cumulative.
- Electric power meter reading, net, cumulative.
- MW load.

## DAILY INFORMATION

- Harris representative will read the same data as at test initiation at about the same time every day.

## DURING THE TEST

The test period shall be 90 days. The unit should be run at 50 MW as is reasonably possible.

The fuel mix and supply is AIDEA's responsibility. If there is an extended period (days) where the coal is run of nine, that is, at 7,815 BTU/#, Harris may declare a Force Majeure and delete that time from the test. Likewise, if there is an extended period where the coal is all waste, that is, below 6,105 BTU/#, and the combustors plug due to that fuel, Harris may declare a Force Majeure. However, the intent of the test is to demonstrate operation on a 6,950 BTU mix. Minimum average coal Btu during the test shall be 6,650 with a minimum of 6,105 BTU. This is the range of test fuel.

A Btu swing of more than 600 over 2 hours should be avoided.

AIDEA will continue to provide direction and control on the overall operation of the unit and GVEA will continue to provide operating personnel.

Reasonable adjustments to the operation of the unit by TRW/AIDEA will be allowed during the 90-day test period, but must be logged.

All trips or requested shutdowns during the test excluding out of range coal and operator error shall be included as part of the 90-day test. Only trips due to external problems shall be forgiven and the time to return to full load shall be considered as full load operation.

External trips of more than the 24 hours must be discussed at the time.

If more than three trips with more than 48 hours between events are attributed directly to the combustors, there will be a meeting between all parties to determine if the test shall be terminated and a restart at time zero shall be made.

The operator shall maintain the Control Room Log per existing GVEA procedures. In addition, if a significant process change is directed by AIDEA, it shall be logged. Also, if AIDEA makes any change to the control logic or to process control parameters, AIDEA shall write this up and provide copies daily to HGI.

In the case of an abnormal event such as a unit trip, boiler combustor trip, emissions violation, or the like, the Harris representative shall be paged immediately. The AIDEA person in charge will always decide on the course of action.

Items to be demonstrated during the 90 Day Test:

The plant shall generate 91,800 MWh during 90 days of operation corrected as follows:

- Add 50 MW/hr or the average output over the previous operating time equivalent to the outage time, whichever is less, for all hours of outage caused by items external to the facility or Force Majeure.
- KWh generated over 50 MW for extended periods shall not be counted. However, small variations on either side of 50 MW for short periods (2 hours or less) shall be counted.
- If a long outage is caused by external items, the time of the outage will not exist. However, consideration will be given to extending the January 1 date..

The unit must run at 50 MW for a substantial period.

The facility shall be required to complete the 90-day run even if required MWh have been generated.

## SUSTAINED OPERATIONS INFORMATION

- DAILY INFORMATION

  Harris Group will read the following information at the start of the test and at about the same time each day:

  - Gross MW cumulative
  - Net MW cumulative
  - Estimate of coal silo levels (from DCS)
  - Estimate of limestone silo level (from DCS)

- Oil supply reading
- The DCS hourly and daily printouts including alarm printouts will be provided to all four (4) parties
- Daily CEM printouts will be provided to all parties
- A daily print of all graphics will be made and distributed
- A daily log of all maintenance activities will be kept by AIDEA and provided daily to HGI
- A copy of the daily operators log will be made for all parties
- Daily coal and limestone samples will be taken
- Weekly bottom ash and fly ash samples will be taken

The Harris Group representative will print trends weekly of at least the following items: drum level, main steam temperature and pressure, $O_2$, combustor pressures, and circulating water inlet level, MW gross and MW net.

Items to be demonstrated for sustained operation information:

1) The combustor system does not slag causing pluggage during operation on any mix of test fuel.
2) The plant meets all environmental permits on the range of test fuel based on CEM data.
3) The boiler can maintain steam flow within the range of test fuel.
4) The boiler can maintain design $O_2$, steam pressure, temperature and drum level with the range of test fuel, within reasonable limits.
5) The boiler can operate from full load to 50% load or safe operating minimum point on two-combustor operation. Timing is at AIDEA's discretion, but three (3) day's notice must be given to HGI and GVEA.
6) Plant can ramp from full load to 50% or the safe operating minimum point over a two hour period. Timing is at AIDEA's discretion, but three (3) day's notice must be given.
7) The ash system continues to function in a reasonable fashion.
8) Pulverizers do not overload based on amps or significant slug flow within the range of test fuel.
9) The scrubber operates with reasonable operational attention and reasonable maintenance.
10) For 30 days the unit shall be dispatched similar to the operation of unit one. The timing of this shall be up to AIDEA.

## ITEMS TO BE REVIEWED AFTER THE TEST

- Boiler tube internals (spot checks)
- Exhauster condition
- Pulverizer condition
- Circ water pumps condition
- Condenser inlet box and tubes
- Scrubber spray nozzle
- Combustor internal condition

# ATTACHMENT A

## INSTRUMENTATION TO BE CALIBRATED

- Gross MW
- Net MW*
- Steam flow
- Steam pressure
- Turbine 1st stage pressure
- $O_2$
- Feedwater flow
- $SO_2$ readings*
- $NO_x$*
- Opacity*
- Turbine backpressure
- Attemperator flow
- Condensate flow
- Coal flow at belt scale (GVEA)
- FD fan air flow
- Limestone flow
- Coal feeder flows

*Items required for 90 Day Test. All others required for sustained operations information.

# Appendix H

## References


April 2000, Healy Clean Coal Project Demonstration Test Program Air Emission Compliance Testing Topical Report

Power Sales Agreement between AIDEA and GVEA, November 1991.

Construction Agreement between AIDEA and GVEA, March, 1995.

March 31, 2000 Healy Clean Coal Project Demonstration Test Program Boiler Performance Testing Topical Report

# Appendix I

## ACRONYMS & ABBREVIATIONS

| | |
|---|---|
| AIDEA | Alaska Industrial Development and Export Authority |
| B&W | Babcock & Wilcox |
| BTU | British Thermal Unit |
| CO | Carbon Monoxide |
| CCTDP | Clean Coal Technology Demonstration Program |
| CFS | Coal Feed System |
| DOE | U.S. Department of Energy |
| DTP | Demonstration Test Program |
| Foster Wheeler | Foster Wheeler Energy Corporation |
| GVEA | Golden Valley Electric Association |
| HCCP | Healy Clean Coal Project |
| HGI | Harris Group Inc. |
| MCR | Maximum Continuous Rating |
| MW | Megawatts |
| MWH | Megawatt-Hours |
| NPDES | National Pollution Discharge Elimination System |
| NPHR | Net Plant Heat Rate |
| NSPS | New Source Performance Standards |
| $NO_x$ | Oxides of Nitrogen |
| $O_2$ | Oxygen |
| O&M | Operations and Maintenance |
| PF | Power Factor |
| PM | Particulate Matter |
| PSA | Power Sales Agreement |
| ROM | Run-of-Mine |
| $SO_2$ | Sulfur Dioxide |
| Stone & Webster | Stone & Webster Engineering Corporation |
| SDA | Spray Dryer Absorber |
| $T_{250}$ | Ash Fusion Temperature |
| UCM | Usibelli Coal Mines |

# SECTION 10

## Harris Group Inc. Report

## Appendices to this Report available on request

# INDEPENDENT ENGINEER'S REVIEW

# OF

# HCCP 90 DAY TEST

# AND

# DETERMINATION OF

# SUSTAINED OPERATIONS

**HARRIS GROUP INC.**

DECEMBER 1999

# Independent Engineer's Report

## For

## HCCP 90 Day Test and Determination of Sustained Operations

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# SECTION 1

# INTRODUCTION

# INTRODUCTION

The Healy Clean Coal Project (HCCP) is a new 50 MW coal-fired power plant utilizing innovative combustion technology to achieve low $NO_X$ and $SO_2$ emissions, while burning a blend of waste coal and run of mine coal. The HCCP has been in operation for approximately two years, and in that time has undergone significant modifications to improve its performance. A 90 day test has been conducted from August 17$^{th}$ through November 15$^{th}$, 1999 to assess its long term commercial viability. An Independent Engineer (IE) has been retained to evaluate HCCP performance during the 90 day test period as well as its performance during the two years of operation both prior to and after the 90 day test.

The Independent Engineer is to report on the results of the 90 day test and is to render an opinion on the project's ability to operate for 25 years if operated and maintained under standard utility practices.

This report summarizes the major observations, findings and conclusions of the Independent Engineer.

This report is not intended to be a critique of the original design. It is an analysis of how the plant operates relative to the design criteria and is intended to answer the question of sustained operation as presented in the power sales agreement.

# SECTION 2

# EXECUTIVE SUMMARY

## 90 DAY TEST

There were only three requirements for the 90 day test: 1) that the plant generate 91,800 MWHrs (85% of 50 MW/hr for 90 days); 2) that the test run for 90 days and; 3) that the unit be run utilizing coal representative of that which will be supplied for the life of the plant as specified in the coal contract for the plant. It has been our understanding that the coal is to be a mix of 50% waste and 50% Run of Mine (ROM).

1) During the test, 102,373 MWHrs were credited as generated, therefore this requirement was successfully completed.

2) The test period of 90 days was achieved on November 15, 1999.

3) The blend of coal was actually 39% waste and 61% ROM and therefore did not meet the intent of the Power Sales Agreement. The result of burning 61% ROM was that approximately 23% less ash had to be processed during the 90 Day Test. Given this, it is our opinion that the test is significantly biased so that no definitive conclusion can be reached as to completion of the 90 Day Test.

In addition, the test was further biased because of the presence of a large on-hand maintenance crew, (17 AIDEA contractors plus AIDEA supervisors) which could and did respond quickly and in force to equipment problems during the 90 day test, thereby significantly reducing downtime. In addition, the on-line maintenance of critical equipment was beyond normal practice and the test was continued with equipment problems that normally would call for the unit to be shutdown for repair.

## SUSTAINED OPERATIONS

It is our opinion that the major systems of the project are performing in accordance with design specifications and tolerances.

It is our opinion that the plant, as configured and if operated and maintained in accordance with standard utility practice, could be considered as a commercial plant which is of comparable efficiency with similar plants if the coal delivered & burned remains above 7200 btu/lb. Note that maintenance of the coal delivery system will be much higher than that of other coal burning facilities.

If HCCP were operated on ROM coals having a heat content in the range of 7,200 to 7,800+ btu/lb, we find no reason that the project will not perform on a sustained operating basis if operated and maintained in accordance with standard utility practices. We do note however, that the maintenance on the coal transport system from the feeder outlet to the combustor inlet will be higher than industry standards, thereby reducing capacity factors.

It is our opinion that if coal of a btu content of less than 6,600 btu/lb is burned for an extended period, as is allowed in the coal contract with Usibelli, then the plant will not be able to run as a sustained operation.

Note that in any case, there are some parts of the original design that have not yet been demonstrated, some systems need additional work, there remains an extensive punch list to be addressed and decisions on several deferred equipment items must be made.

# SECTION 3

# HARRIS GROUP ASSIGNMENT

## HARRIS GROUP ASSIGNMENT

Harris Group Inc.'s (Harris Group) initial Scope of Work as Independent Engineer was as follows:

As the engineer under the provisions of Section 1 (1) of the Power Sales Agreement between AIDEA and GVEA, Harris is to determine whether HCCP has operated "at not less than 50 megawatts, net of station service, at a Capacity Factor of not less than 85 percent for a period of 90 consecutive days, using coal with characteristics equivalent to those of long-term Usibelli coal, as defined in the Coal Supply Agreement between (GVEA) and Usibelli Coal Mine, Inc. (Usibelli), dated January 1991."

Additionally, under the Section 1 (1) ii, Harris Group is to determine whether it can state "that, as a result of (its) independent observations of the test operations of the Project and tests and inspections required by (it), the major systems of the Project are performing in accordance with design specifications and tolerances and that (it) knows(s) of no reason why the Project will not perform on a sustained operating basis, as provided under this Agreement if the Project is operated maintained, and renewed according to standard utility practices."

Since Harris Groups' appointment is limited to whether the performance standards for the "Date of Commercial Operation" contained in Section 1 (1) of the Power Sales Agreement have been satisfied, any issue which involves other agreements between AIDEA and GVEA, including the Agreement for the Construction, Start-Up and Demonstration Testing of HCCP, is beyond the scope of our immediate engagement.

On December 6, 1999 Judge Mary E. Greene added to the Scope of Review by issuing the following order:

**ORDER ON SUMMARY JUDGMENT**

Plaintiff's Motion for Partial Summary Judgment on Contract Interpretation For "90 Day Test" Standards is granted. The independent engineer shall, in determining whether the "90 day test" conducted by AIDEA meets the parties' reasonable expectations as set forth in their contract, consider the parties' contract as a whole, specifically including the Construction Agreement and the Power Sales Agreement, and shall harmonize the provisions where possible and, in case of conflict, allow the PSA language to control.

Dated this 6th day of December, 1999.

____________________________________

The Honorable Mary E. Greene
JUDGE OF THE SUPERIOR COURT

**Harris Group will therefore include in its review, the issues of efficiency, economics and consideration of a retrofit.**

# SECTION 4

# POWER SALES AGREEMENT
# AND
# CONSTRUCTION AGREEMENT

# POWER SALES AGREEMENT

**AND**

**CONSTRUCTION AGREEMENT**

The relevant sections of the Power Sales Agreement and Construction Agreement follows:

## POWER SALES AGREEMENT

**Section 1 – Definitions**

**Page 6, Paragraph (l)**

(l) "Date of Commercial Operation: means the date, which shall not occur before the end of the Test Period, on which engineers retained for this purpose by the Authority and acceptable to the Purchaser have (i) determined the Project has operated at not less than 50 megawatts, net of station service, at a Capacity Factor of not less than 85 percent, for a period of 90 consecutive days, using coal with characteristics equivalent to those of long-term Usibelli coal, as defined in the Coal Supply Agreement between the Purchaser and Usibelli Coal Mine, Inc. dated January 1991, and (ii) stated that, as the result of their independent observations of the test operations of the project and tests and inspections required by the engineers, the major systems of the Project are performing in accordance with design specifications and tolerances and that the engineers know of no reason why the Project will not perform on a sustained operating basis as provided under this Agreement if the Project is operated, maintained, and renewed according to standard utility practices.

## CONSTRUCTION AGREEMENT

**Recitals**

**Page 2, Paragraph 3**

WHEREAS, the Project will provide GVEA the ability to meet its future electricity needs more efficiently;

**Section 1 – General Provisions**

**Page 3, Paragraph A**

*Underlined items relevant to Independent Engineer

This Agreement, together with the Power Sales Agreement dated December 6, 1991, the Professional Services Agreement dated December 2, 1992, the Ground Lease dated March 21, 1995, the Commercial O&M Agreement to be prepared, the Agreement Between Trustees for Alaska, GVEA, and AIDEA regarding The Healy Clean Coal Project dated June 1, 1994, the Memorandum of Agreement for the Healy Clean Coal Project by and among the United States Department of Energy, United States Department of the Interior, National Park Service, AIDEA and GVEA dated November 9, 1993, and the Agreement Between GVEA and AIDEA to Implement Memorandum of Agreement dated April 26, 1994, constitute the entire agreement between GVEA and AIDEA relative to the Project and supersede any other agreements. To the extent it is determined that there is any conflict between such documents, the terms of the Power Sales Agreement shall govern.

**Section 3 – Provisions Relating to Period Prior to Date of Commercial Operation**
**Page 25, Paragraph M-1**

M. FAILURE TO ACHIEVE COMMERCIAL OPERATION

1. Obligation to Retrofit

If the Project fails to become Commercially Operable, or by mutual agreement is deemed inefficient to operate, AIDEA shall obtain a recommendation from a mutually acceptable engineering firm to present alternatives to cure the reason(s) for the problem. GVEA shall participate in the review of the engineer'' work and provide comments and recommendations to AIDEA as to GVEA's preference for the retrofit. AIDEA shall consider GVEA's recommendations when deciding on a course of action for retrofit. Upon completion of the retrofit, the plant shall be tested to determine if it is Commercially Operable.

**Page 26, Paragraph N**

N. DEFERRED CAPITAL ITEMS

As a result of Project budget constraints certain capital items have been deferred. The Parties also contemplate that additional desired capital items will be identified during construction and prior to the end of the Test Period. AIDEA and GVEA shall jointly prepare a priority list of deferred and desired capital items not included in the plans and specifications for the Project. To the extent these deferred and desired capital items can be purchased with project funds, including all available retrofit funds if retrofit is not required, AIDEA will reasonably attempt to purchase and install the items that are prudent.

To the extent that the costs of mutually agreed upon deferred and desired capital items exceed available Project funds, the Parties will equally share the cost of such purchases.

# SECTION 5

## 90 DAY TEST

## OBJECTIVES

There were only three requirements for the 90 Day Test: 1) that the plant generate 91,800 MWHrs (85% of 50 MW/hr for 90 days); 2) that the test run for 90 days and; 3) that the unit be run utilizing coal representative of that which will be supplied for the life of the plant, as specified in the coal contract for the plant.

## METHODOLOGY AND QUALIFICATIONS

Harris Group provided on-site monitoring of the 90 Day Test. There was an engineer on-site every day for at least 10 hours and that person was on call for the remainder of each day.

The engineers were of a variety of power generation expertise: Dennis Swann, the Project Manager who has 13 years experience working in coal fired power plants and 26 years in design of power plants; Jimmy Keller, a chemical engineer with extensive experience in scrubber technology; Gary Julian, a mechanical engineer with coal fired power plant operating experience and many years of control systems design experience; Quinn Bailey, an engineer with several years of experience in boiler burner technology; Al Moore, a materials handling engineer; Tanya Mickel, an environmental engineer; Ed Wirth, a control systems engineer and programmer; Jason Hartman, a mechanical process engineer; Bob Scheck, an engineer with several years as a testing engineer and also with environmental design experience; and Dan Giovanni, an outside consultant with 25 years of specific experience in combustion technology. Prior to the test Harris Group had a structural engineer, an electrical engineer and an outside consultant with operating experience review the plant design and its' operations. Resumes are attached for all of these personnel (Appendix 1).

The on-site engineer walked down the entire unit 4 or 5 times per day noting operations, maintenance, sampling procedures and the condition of equipment and instrumentation. In addition, several hours were spent each day in the control room observing control room operations.

Data collected was as follows:

Hourly logs from the DCS specific for HGI consisting of 78 points of data.

Hourly logs designed by others consisting of 100 other points of data, mainly surrounding the combustors.

Daily strip charts produced by the DCS providing trends of 37 data items.

Daily environmental reports providing hourly data for emissions.

Daily GVEA dispatch logs providing hourly generation data.

Graphic displays showing a snapshot of over 100 data points.

Operator's daily logs.

Engineer's (AIDEA) logs.

The following test reports by others were reviewed by Harris Group:

Boiler tests by Foster Wheeler

SDA tests by B&W

Annual Relative Accuracy Tests by Haas, Morgan and Hudson - Technical Environmental Consulting

Turbine test by Fuji

Coal Sampler Bias test by CTE

Ongoing Combustor test reports by TRW

Other information was obtained by frequent discussions with the TRW representative, with the AIDEA shift supervisors and DCS engineer and with the GVEA operators and maintenance personnel. In addition, the Duke Energy Services personnel were kind enough to provide their daily summaries of operations and their observations.

Both GVEA and AIDEA provided data relating to the assignments of personnel assigned to HCCP.

Coal quantity data was collected from both the coal belt weightometer and from the coal feeders, all through the DCS. The coal samples were taken by the automatic coal sampler, which was tested by Commercial Testing Engineering (CTE) during the 90 Day Test for any bias, which could have lead to inaccuracies. The equipment was found to have no bias. The coal samples were sent to the Usibelli coal lab at the mine for analysis of btu content and proximate analysis; fixed carbon, volatile, moisture, sulfur and ash. This data was compared to samples sent from the same sample split for 30 days to CTE and there was no significant difference in btu content.

Limestone and ash samples were routinely taken and sent to an independent lab for analysis.

## CONCLUSIONS

There were only three requirements for the 90 Day Test: 1) that the plant generate 91,800 MWHrs (85% of 50 MW/hr for 90 days); 2) that the test run for 90 days and; 3) that the unit be run utilizing coal representative of that which will be supplied for the life of the plant as specified in the coal contract for the plant. It has been our understanding that the coal is to be a mix of 50% waste and 50% ROM.

4) During the test, 102,373 MWHrs were credited as generated, therefore this requirement was successfully completed. See HCCP 90 Day Test, Graph 1.

5) The test period of 90 days was achieved on November 15, 1999.

6) Given this, it is our opinion that the test is significantly biased so that no conclusion can be made. The blend of coal was actually 39% waste and 61% ROM and therefore did not meet the intent of the Power Sales Agreement. The result of burning 61% ROM was that approximately 23% less ash had to be processed during the 90 Day Test.

In addition, the test was further biased because of the presence of a large on-hand maintenance crew, (17 AIDEA contractors plus AIDEA supervisors) which could and did respond quickly and in force to equipment problems during the 90 Day Test, thereby significantly reducing downtime. In addition, the on-line maintenance of critical equipment was beyond normal practice and the test was continued with equipment problems that normally would call for the unit to be shutdown for repair.

Also, the 90 Day megawatt generation goal has been achieved with an O&M approach that is not typical of standard utility practices. AIDEA adopted a policy of not derating or taking critical pieces of equipment off-line for maintenance, if there was any way to implement a "temporary fix" on-line. Thus, there were several "partial-forced-outages" that did not materialize during the 90 Day Test that would have if the plant were operated in accordance with more typical utility practices than observed for the 90 Day Test. One area where this was observed involves the application of refractory and armor plates to areas of excessive wear and coal dust leaks. Another was the decision not to stop the unit to repair the dampers in the coal splitters until the conclusion of the 90 Day Test. There were several less significant items, which were also ignored during the 90 Day Test, such as leaking $NO_x$ ports, bottom ash hopper plugging, limestone feed rate problems and others.

## POWER GENERATED

The Power Sales Agreement required that 91,800 MWHrs net be generated during the 90 Day Test.

The rules set down by Harris Group were as follows:

- No power in excess of 50 MW net would be credited to the test period except to offset power under 50 MW net during a preceding or succeeding hour, thereby offsetting slight load swings over and below the 50 MW setpoint.
- NO power generated by burning oil solely for the purpose of generation will be credited.
- When testing at low loads for low load SDA tests, low load demonstration and the like, 50 MW will be credited to the test, if the unit is in a condition to operate at 50 MW or higher.
- Running at lower than 50 MWHr at dispatcher's request will allow 50 MW to be credited.

The plant was credited with 102,373 MWHr during the 90 Day Test, a capacity of 94.79%.

The plant actually generated 100,115 MWHr during the test period.

See Table 1 for details.

## QUALITY OF FUEL

Although the 1991 coal contract does not specifically state the coal will average 6,960 btu/lb, (note that it does state that quantities not taken under the take or pay concept will be invoiced as if they were shipped at 6,960 btu/lb) it is Harris Group's understanding that the project has long been based upon being able to demonstrate that it is capable of burning a blend of 50% ROM coal and 50% waste coal. This blend would result in an average fuel of 6,960 btu/lb.

Harris Group confirmed, before the test started, that a requirement of the test would be the need to burn coal approximating 6,960 btu/lb and there were no objections. In addition, AIDEA insisted that they be responsible for the delivery and blending of the fuel. At the pre-test meeting, it was again confirmed that the test must be run with coal approximating 6,960 btu/lb. During the first day of the test, AIDEA noted that the test was being initiated with ROM coal, 7,800 btu/lb, and Harris Group stated that this was acceptable, as long as AIDEA understood that the test had to be run with coal at an average of approximately 6,960 btu/lb. At the meeting held at the 23rd day of the test, it was noted that the coal was averaging above 7,200 btu/lb and the average btu content of the coal had to be reduced or the test would be deemed unacceptable. Again at the $57^{th}$ day point, it was noted that there had been no change in coal quality and that now a much lower quality of coal must be burned to bring down the average to approximately 6,960 btu/lb. The final 23 days utilized coal of about 7,000 btu/lb and it must be noted that operating problems began to appear during this time period. See Table 2, Test Coal BTU Data.

Note the letter from Usibelli, Appendix 2, which states that the coal received during the test to the date of the letter, Oct. 27, 1999, is representative of what will be sent to the site over the next 30 years.

Also note the presentation by Steve Denton, dated 4/11/1990, Appendix 3, which outlines qualities of coal that are potentially available for supply to HCCP. Available coal listed in the presentation, have the following btu content 6,699, 5,681, 6,784 and 6,363.

Another reference for coal quality is from Stone & Webster, dated 12/9/99, Appendix 4, which outlines the coal quality considered in the plant design.

During the test, the average btu content of the coal was 7,194 btu/lb. It is our opinion that the test was biased because of the higher quality coal and therefore lower ash content of the coal. Harris Group's calculations show that the total amount of ash that would have been processed at an average btu content of 6,960 btu/lb, rather than 7,194 btu/lb, would have been about 23% higher. During the first 66 days the ash processed may have been as high as 28% higher. See Table 3, 90 Day Test, BTU and Ash Data.

## SYSTEMS AFFECTED BY COAL QUALITY

There are 6 systems in the HCCP plant that are either new technology or that are affected by the new technology. These are: 1) The slagging combustors; 2) The coal system that feeds the combustors; 3) The boiler furnace; 4) The bottom ash handling system; 5) The slag ash handling system; and 6) The SDA/Baghouse system. Note that items 1 and 2 above are designed as 2 x 50 % systems and if they fail, only reduce load by 50%, the other 4 systems are 100% systems and shut down the unit should they fail.

A discussion of these systems and the impact increased quantities of ash may have on them is discussed below.

### Slagging Combustors

During the early part of the test, when the ash content was lower and the btu content was higher, the combustors operated well, with no evidence of internal plugging. During the later part of the test, when the ash and btu content was closer to the design point, there was some indication of plugging, demonstrated by the need to do an increased amount of rodding out of slag both from the scanners and the combustors, especially in combustor "B".

It is our opinion that there would have been ongoing plugging problems if the ash content had been higher during the entire test period. However, we cannot say that the unit would have failed the 90 day test due to this issue alone.

### Coal Feed System

For the purpose of this report, the coal feed system is defined as the equipment after the silos through to the combustors, but not including the combustors.

Parts of this system performed well during the 90 Day Test period. However, the exhausters showed significant wear caused by erosion during the 90 days. The exhauster blades were badly eroded. (Note that one of the exhauster wheels (B) was replaced during the 90 Day Test due to high vibration probably caused by the explosion.) In addition, the housings of both of the exhausters were very badly eroded at the areas of high coal velocity. During the 90 days it was necessary to put many patches on the steel shell of the exhausters. See the description of the exhauster inspection (Section 6, Page 27). Clearly, if the ash content had been much higher during the entire test period, there would have been worse erosion of the blades and of the exhauster housing. The ash is much more erosive than the coal itself. The wheels of the exhausters were in new condition at the beginning of the 90 Day Test and were in bad condition at the end. They may not have made it through the 90 Day Test with higher ash fuel. The housing of the exhausters had been exposed to operation equivalent to approximately 14 months at full load, however not much of that time was at lower btu coal operation. The average btu content for the two years of operation of HCCP is approximately 7,500 btu/lb. This equates to about an 82% ROM and 18% waste coal split.

### Boiler Furnace

The boiler furnace is the chamber wherein some ash builds up on the walls. At times it forms large pieces of slag which would fall off the wall and land either on the sloping wall tubes of the bottom ash hopper or in the slag ash tank. At times, the large slag falls had caused furnace pressure surges that had tripped the unit on high pressure. Since putting in the water lances low in the furnace, this has not been a problem and during the test period did not cause a trip nor was it noted as a problem.

Also, prior to the start of the 90 Day Test, large slag falls had broken a valve on the bottom of the dipper skirt and caused a shutdown. Internal inspection of the furnace and slag ash pit showed no apparent damage. Increased ash content most likely would not have had a serious impact in this area.

### Bottom Ash Handling System

The bottom ash handling system consists of 1) the pit that collects much of the ash that builds up on the furnace walls and then falls off the walls to the bottom of the furnace, as well as some of the heavier fly ash that doesn’t carry over into the back of the boiler and 2) the drag chain that removes the ash from the pit.

One half of the bottom ash pit was completely full of ash when the unit was shut down for inspection. This is a volume of about 4’ wide by 8’ high by 15’ long. It apparently had bridged over near the bottom of the pit because the drag chain continued to run until the end of the test.

The drag chain continued to operate during the test, however it had little or no ash to process during the latter stages of the test due to the bridging that occurred.

Foster Wheeler states that the boiler design is such that the structure can hold the ash build up even if both sides would bridge over and be filled with ash.

Most likely, if there had been much more ash to process, the ash hopper would have plugged much earlier in the test. (Note that the ash processed during the first 66 days was significantly less (about 28%) than if the design coal had been burned) It is our opinion that the buildup would have been much worse. It is certainly possible that the bottom ash pit cannot handle ash quantities as high as is generated with design fuel as it appears that the system was OK during the first 66 days and then plugged when higher ash fuel was burned. We cannot say that the test would have been interrupted and generation lost, however, there is a possibility that there would have been a shut down due to bottom ash buildup.

Slag Ash Handling System

The slag ash handling system consists of the pit that receives the slag that runs out of the two slagging combustors and some of the ash that builds up on the wall of the furnace and the drag chain that removes the slag ash from the slag ash pit.

The slag ash handling system performed well during the 90 Day Test. The inspection showed no visible damage and the drag chain worked well. It was noted that there was a significant increase in slag being handled by the drag chain during the final 30 days of the test, however the system continued to function well.

Would there have been a problem if much more ash were processed during the 90 Day Test? Certainly there would have been a heavier load on the drag chain and the need to break up large pieces of slag would have increased. We believe this would not have reduced load or caused an outage.

SDA/Baghouse System

The SDA is the system that removes the sulfur dioxide from the flue gases. It can be impacted by the amount of fly ash in the flue gases.

The SDA system functioned well during the test in spite of some plugging of the limestone slurry feed system both in the transport system and the atomizer. It must be noted that the system utilized significantly more (50 to 60% more) than the design amount of limestone for removal.

The amount of ash does not impact the slurry system so this would not have had an impact. The amount of ash in the flue gas does affect the removal of sulfur slightly, however we are of the opinion that this would not have impacted removal of $SO_2$ or operation of the system during the 90 Day Test.

## EXCESS STAFFING

During the 90 Day Test, AIDEA had on site around the clock several maintenance personnel in addition to the GVEA staff. The intended purpose of this crew was to perform punch list items. However, when the mill explosion occurred, this crew was on hand to immediately turn to the repair of the mill and the surrounding equipment. AIDEA contractors and 3 GVEA personnel worked a total of, at least, 1400 hours during the one week repair of the pulverizer and associated equipment. This equated to 20 people at 7 days for 10 hours per day. It is our opinion that this availability of personnel shortened the repair time by at least 50% of the time, which would normally have been required to repair the equipment. This longer time would have contributed to a further loss of generation of about 4,500 MWHrs. This would not have caused the unit to fail the 90 Day Test by itself.

It should be noted that this crew was also available for other emergency work during the test period such as clinker breaking, atomizer replacement, pyrites hopper cleaning, repairing the head pulley on the ash bucket conveyor and silo discharge chute battering to clear plugging.

Harris Group has attempted to determine the amount of time spent on maintenance for HCCP during the 90 Day Test. The data supplied by AIDEA shows that 14,838 man-hours were charged to HCCP by contractors and GVEA maintenance personnel during the 90 Day Test. Deducting the following items from that amount as applied to the test:

| | |
|---|---|
| • Test support | 1,054 |
| • P&ID review | 53 |
| • Fab (for punch list items) | 714 |
| • Platforms (Punch List) | 397 |
| • Punch List | 714 |
| • Seismic (punch list) | 484 |
| • Shutdown Prep | 99 |
| • Test support | 406 |
| • Tower mill beam (punch list) | 153 |
| • Misc (split 50/50 with test) | 1,053 |
| • Cleanup (split 50/50 with test) | 791 |
| • Incidental (split 50/50 with test) | 228 |
| Total | 6,146 |

This equates to 8700 hours attributable to HCCP operations. This equals 15 full time maintenance people on a 40-hour week basis.

See Table 4 and Graphs 2, Maintenance and 3, Regular and Overtime.

Note that Table 2 utilizes the data from the middle 12 full weeks for averages. The first and last weeks of the test were partial weeks and we have data for full weeks only.

# SECTION 6

# DETERMINATION OF SUSTAINED OPERATIONS

## CONCLUSIONS

As presently configured, and if operated in accordance with standard utility practices, the life of the plant will depend on the quality of coal delivered on a long-term basis from Usibelli to the HCCP under terms of the coal purchase agreement. The existing agreement allows Usibelli to deliver a wide range of coal quality, from waste coal having a heat content as low as 5,000 btu/lb to run-of-mine (ROM) coal having a heat content as high as 8,000 btu/lb. Moreover, a Usibelli representative has stated that ROM coal from the Two Bull Ridge seam, the primary source of coal for the HCCP in the future, will average approximately 6,500 btu/lb. Reference is made in engineering documents prepared by Stone & Webster Engineering Corporation, the plant design engineer, of "performance coal" having a 50/50 blend of waste and ROM coals with an average heat content of 6,960 btu/lb. However, the coal purchase agreement does not require Usibelli to deliver "performance coal" on average. Therefore, different conclusions may be drawn regarding the long-term viability of the HCCP depending upon the coal quality actually delivered:

- If HCCP were operated on ROM coals having a heat content in the range of 7,200 to 7,800 btu/lb, we find no reason that it will not perform acceptably for 30 years or more if operated and maintained in accordance with standard utility practices. Note, however, that maintenance on the Coal Transport System, feeders to combustors, will be higher than industry standards.
- If HCCP were operated on waste coals, or a blend of waste and ROM coals having a heat content significantly less than that of the hypothetical "performance coal," that is <6,960 btu/lb, it is our opinion that HCCP will not perform acceptably for 30 years, even if operated and maintained in accordance with standard utility practices, because of the very high erosion on the Coal Transport System.
- If HCCP were operated on a blend of waste and ROM coals having an average heat content equivalent to that of the hypothetical "performance coal", that is 6,960 btu/lb, and not varying by more than plus or minus 500 btu/lb for extended periods (e.g., >12 hours), HCCP in its present configuration will not perform acceptably for 30 years, even if operated and maintained in accordance with standard utility practices. The average coal quality for the 90 day test was 7194 btu/lb, and the average coal quality for the last 24 days of the 30 day test was 7,000 btu/lb. Indications of chronic operating and maintenance problems began to materialize in the final third of the test. Hence, sustained performance at lower coal qualities allowed under the coal purchase agreement was not demonstrated in the 90 day test. This is indicated by a significant increase in rodding out of scanners, see Table 5, scanner cleanings, courtesy of TRW. Modifications to HCCP to assure improved long-term performance with lower quality coals may include: 1) Elimination of the high pressure pulverizer exhauster subsystem; 2) Means for feeding higher quality coal to the precombustor and lower quality coals to the slagging combustor, instead of the current practice of feeding the same blend of coals to both the precombustor and slagging combustor; 3) Permanent reconfiguration of the secondary air injection ducts to the slagging combustor; 4) Improved coal pile blending and management practices; 5) Further refinement of the Distributed Control System for dynamic operation of the HCCP; 6) Further tuning of the TRW combustion system for lower $NO_x$; 7) or other changes.

## HCCP DEMONSTRATION TEST PROGRAM

The United States Department of Energy ("DOE") selected the HCCP as part of the Clean Coal Technology Demonstration Program. The purpose of the program is to meet power needs and demonstrate the effectiveness of new technologies to reduce emission levels below the requirements of EPA New Source Performance Standards ("NSPS"). The technology to be demonstrated as part of the HCCP Demonstration Test Program combines the TRW Entrained Combustion System and the B&W SDA System into a single, integrated, combustion/control process. These technologies were designed to reduce emissions of sulfur dioxide ("$SO_2$"), oxides of nitrogen ("$NO_x$"), and particulates, while meeting energy needs.

The HCCP Demonstration Test Program, initiated in early 1998, included several test activities including:

1. Coal Firing Trials,
2. Compliance Testing,
3. TRW Combustion System Characterization Testing,
4. B&W SDA Technology Characterization Testing,
5. Boiler Characterization Testing,
6. Coal Blend Testing,
7. Performance Guarantee Testing,
8. 90-Day Commercial Operating Test, and
9. Long Term Commercial Operation Demonstration.

**Coal Firing Trials**

Coal firing trials were initiated to complete the startup, check out, and tuning of the coal related equipment and assure its operating efficiency, reliability, and safety. The initial coal firing trial began in early 1998 and extended for a period of approximately four months. The trial procedures followed during the coal firing trail appear to be consistent to those outlined in the Final HCCP Demonstration Test Program. We have found no report specifically related to "Coal Firing Trials", however, this work continued throughout the 2 year demonstration period and is generally covered by TRW's interim report. The results indicate that much was learned about how the different coals affect the combustors and what modifications help to burn the range of coals tested.

**Compliance Testing**

As part of the Compliance Testing, an Environmental Monitoring Plan ("EMP") was generated to describe how water, waste, air and supplemental monitoring data was collected and reported. Quarterly reports were generated in compliance with the Demonstration Test Program and include:

- Monthly Discharge Monitoring Reports,
- Reported percentage of usable ash,
- Combined fly ash analysis results (once per year),
- Limestone analysis,

- Hazards in the work place,
- Facility operating reports as required by the Air Quality Permit to Operate,
- Performance testing reports, when available, and
- RATA tests, as required.

Except for a specific report on useable ash and one on hazards in the workplace, Harris Group has reviewed the reports, and finds all data and reports to be acceptable and complete.

**TRW Combustion System Characterization Testing**

The TRW Combustion System Characterization Test was comprised of three phases; 1) Initial Performance, 2) Operating Envelope, and 3) Steady-State Operation. The Initial Performance Characterization Test established baseline performance of the combustion system while burning performance coal (50% ROM/50% waste). The Operating Envelope Characterization Test characterized the performance of the combustor over a broad operating envelope and optimized the performance of the combustor for the integrated plant system. The Steady-State Operation Characterization Test evaluated the operating conditions of the optimized combustion system during longer term, steady-state operation.

The Characterization Tests were conducted during 1998 by TRW with continuing efforts in 1999 focusing on evaluating integrated system performance during longer duration steady-state tests. The tests were conducted in substantial compliance with procedures outlined in the Final HCCP Demonstration Test Program. Results from the test, as reported by TRW, indicated that while precombustor slagging behavior when burning ROM/waste coal blends needs improvement, the overall system has met or exceeded all goals for achieving low $NO_x$ and $SO_2$ emissions at the stack, low CO levels in the furnace, and high carbon burnout while burning both ROM and ROM/waste coal blends. It is our opinion that if one excludes consideration of the exhausters, TRW’s interim conclusions are appropriate. It should be noted that these tests were run only for purposes of technology support and not to demonstrate capacity or availability.

**B&W SDA Technology Characterization Testing**

The SDA Technology Characterization Test, conducted November 3, 1999 through November 15, 1999, evaluated the responsiveness of the SDA system to incremental changes in process conditions. The test was conducted at various plant loads, slurry temperature, limestone flow and SDA outlet temperature. Sixteen tests in total were run at various combinations of the above. Captured sulfur was characterized throughout the system including the combustors, SDA, and fabric filter.

Results of the SDA tests indicate that the SDA easily meets emissions limits with excessive amounts of limestone, however the intent to demonstrate a normal operation was not achieved..

**Boiler Characterization Test**

The Boiler Characterization Test consists of a series of tests used to characterize boiler operation. The tests included steady state evaluations conducted at a unit load of 100% of maximum continuous capacity and a series of load ramp tests to assess the unit’s capability during unsteady, load change operation.

Foster Wheeler Energy Corporation conducted a Boiler Performance Guarantee Test on March 29 and 30, 1999 (which included a unit load test at maximum continuous capacity).

While no series of load ramp tests have been run as part of the boiler characterization test, the dispatchability test the week of November 29, 1999 showed that major process parameters were held within normal tolerances during load swings down to 35 MW, from 35 MW to 50 MW and at 54 MW. The control system has not yet been tuned to optimize load swings nor control of process parameters. It is our opinion that the Boiler Characterization Tests were run in accordance with the requirements of the DOE Test Plan and that sufficient data has been gathered to assist the design team to proceed.

**Coal Blend Test**

The Coal Blend Test was conducted to demonstrate unit performance including environmental compliance with a range of ROM and waste coal mixtures. Again, no specific report has been issued relevant to this issue, but the 2 year test program continued to test coal blends and provided data required by the test program.

## Performance Guarantee Test

Performance Guarantee testing refers to those tests conducted on the SDA, boiler and turbine systems to demonstrate correct system set up and compliance with the contractual performance guarantees.

***SDA Tests***

An SDA Performance Guarantee test was conducted between June 8 and June 11, 1999 by Stone & Webster Engineers and Constructors ("SWEC") in substantial conformance with the Project requirements as outlined in the Final HCCP Demonstration Test Program. Based on the test results, SWEC reported that the SDA System at HCCP has met all performance guarantee requirements. SDA characterization tests were also run during the last days of the 90 Day Test. See SDA, Section 7.

***Boiler Tests***

Foster Wheeler Energy Corporation conducted the Boiler Characterization Test at maximum continuous capacity on March 29 and 30, 1999. Foster Wheeler concluded that the boiler contract performance guarantees were met. However, the test results were disputed by GVEA.

We have reviewed the correspondence relative to this test, the Foster Wheeler report, letters by GVEA, Zarling and the Strandberg report, Stone and Webster, and the original Boiler contract.

Clearly, from this correspondence, there is disagreement about what the contract states, how the test was run and the results.

In that none of these tests were run in a spirit of cooperation and the contractual requirements are subject to interpretation, we have looked at the boiler and boiler test in terms of 2 issues:

- Did it demonstrate conformance with the guarantees, listed below, based on the data.
- Do we know of anything that would prevent the boiler from operating in an acceptable manner if operated and maintained according to standard utility practice.

The following summarizes guarantees and test results:

| | Guarantee | Test |
|---|---|---|
| Steam Flow, LBS/H | 490,000 @ 1300 psig | 494,865 |
| Minimum load of 15 % on a solid fuel | 75,000 lb/h | Not tested |
| Steam Temperature Control Range | 955 +/- 10ºF | 957/953ºF |
| Maximum Steam side pressure losses, psid | 126 | 84.4 |
| Maximum Water side pressure losses, psid | 50 | 39.3 |
| Maximum Flue Gas Draft Loss, inwg | 19 | 15.9 |
| Maximum Pulverizer A shaft input power, kW | 330 | 213.6 |
| Maximum Pulverizer B shaft input power, kW | 330 | 204.4 |
| Maximum NOx emissions, lb/mmbtu | 0.35 | available, but not addressed |
| Maximum CO emissions, lb/mmbtu | 200 | available, but not addressed |

Accepting that the original test was run with7.025 btu/lb coal and the 90 day test was run with 7,187 btu/lb coal, the results of both tests were similar. Control parameters were within normally acceptable tolerances. The boiler test, using the heat loss method, showed a boiler efficiency of 76 to 77% while the 90 day test using the input output method showed 76 to 77%.

Taking the results of the performance guarantee demonstration test, and the results of the 90 day test, it is our opinion that the boiler demonstrated general conformance with the project design criteria and the important guaranteed parameters.

It is also our opinion that the boiler should run in an acceptable manner if operated and maintained according to standard utility practice.

***Tests***

The performance guarantee demonstration test for the turbine was conducted for a period of one week beginning December 13, 1999. Preliminary results from the test were reported by FUJI as follows:

Items reviewed:

- Preliminary Report of Turbine Performance Test for HCCP by FUJI Electric Co Ltd. dated 16 Dec 1999
- Performance Test Procedure by FUJI dated 23 Apr 1998
- Turbine Generator Design, Supply and Erection Contract between AIDEA and GVEA, unsigned and undated

NOTE: FUJI's test procedure, pg 5, specifies that heat rate is a guarantee, however, the primary agreement between AIDEA and GVEA, Div 3 Section 301.3.2.2, page 301-3-2 guarantees only turbine capacity.

- It appears that the test target conditions were 9.5% above the guarantee conditions and 4.3 % above the valves-wide-open case. The adjustments required to be applied to test data for comparison with guarantee, are less reliable the farther away the target conditions are from the guarantee conditions.
- It appears that one test was conducted for the purpose of meeting both demonstration of guaranteed capacity and maximum capacity. Maximum capacity is not guaranteed.
- The adjustments to test data reach into non-typical areas such as combustor cooling, auxiliary steam, etc. FUJI has shown no adjustment for steam flow, the most significant off-target adjustment. The test throttle pressure of only 1,21_.1 (illegible) is unbelievably low. The 90-Day test values fell within +/- 5 psi of the design 1,250 psig. This is -40 psi. And the 2.81% adjustment to power is not reasonable. Possibly steam flow is included in this adjustment. It is not apparent.
- The preliminary report indicates (after adjustments for comparison with guarantee) that the turbine generator has a margin of 9.6 % above guarantee. (64608.4/58.94 = 1.096).

A summary of the GVEA/AIDEA contract and the FUJI test results are given:

| | Guar | Test | Adjusted |
|---|---|---|---|
| Power at Generator Terminals, kW | 58,940 | 62,321 | 64,608 |
| Throttle flow, lb/h | 466,700 | 510,279 | ???? |
| Throttle pressure, psia | 1,265 | 1,21_ | 2.81% |
| Throttle temp, $^{o}$F | 950 | 943.9 | 0.23% |
| Throttle enthalpy, btu/lb | 1,468.1 | 1,465.8 | ---- |
| Backpressure, inHgA | 1.5 | 1.102 | -0.55% |
| Auxiliary steam flow, mmbtu/h | 7.0 | 21.2 | 1.26% |
| Comb cooling flow to DA, klb/h | 45.0 | 0.0 | 0.52% |

| | | | |
|---|---|---|---|
| Slag heat to condensate, mmbtu/h | 0.0 | 0.0 | 0.00% |
| Comb cooling heat, mmbtu/h | 0.0 | 3.753 | -0.20% |
| Spray water flow, klb/h | 0.0 | 7.244 | -0.08% |
| Power factor | 0.85 | 1.00 | -0.35% |
| | | | 3.67% |

Until the final report is issued by FUJI on how they treated adjustments to test data, the preliminary results are suspect.

Turbine efficiency results taken 2 years after initial operation are not representative of new unit and any guarantees will be questioned by the manufacturer.

It is our opinion that the turbine meets the output guarantee.

**90-Day Commercial Operating Test**

Completion of the 90-day Commercial Operating test is a requirement of the Power Sales Agreement between AIDEA and GVEA. Completion of the test within the performance criteria is a prerequisite for commercial acceptance of the HCCP by GVEA. Performance criteria include plant operation at not less than 50 MW, net of station service, at a capacity factor of not less than 85 percent for a period of 90 consecutive days.

The 90-day commercial operating test was run from August 17, 1999 to November 15, 1999 in general compliance with procedures outlined in the Final HCCP Demonstration Test Program. The test operated at an average net output of 46.3 MW and an average capacity factor of 92.6% (94.8%). See 90 Day Test Thermal Performance Table 3.

It is our opinion that the 90 Day Test was significantly biased by the quality of the coal burned and excess staffing, that no definitive conclusion can be reached as to completion of the 90 Day Test.

**Long Term Commercial Operation Demonstration**

The purpose of the Long Term Commercial Operation Demonstration is to generate stable typical operating data for the HCCP. The test requires operation of the Plant in a commercial dispatch mode that will provide data representative of a commercial unit as opposed to a test unit. This was to be a 6 month demonstration. The demonstration was conducted from November 29, 1999 through December 6, 1999, a period of time significantly less than what was outlined in the Final HCCP Demonstration Test Program. Over this short period , the test provided adequate results to indicate the unit is capable of operations, dispatched in the Alaska power system when the controls are finally tuned and the necessary operating data is obtained so that GVEA can properly place HCCP into dispatch mode.

## INDIVIDUAL SYSTEMS PERFORMANCE

The plant systems were evaluated for their process performance using Design Criteria, Rev 2 dated March 1993, provided by Stone & Webster (S&W) as the reference. Systems are defined the same as those in the turn over packages. Page references are from the S&W Design Criteria document.

**Individual System Performance**

Note that the coal handling system is not reported on here. The coal handling system was accepted by GVEA prior to the start of the 90 Day Test.

There are 2 coal handling issues still outstanding, however.

1. The Stamler has not been accepted by GVEA and is still an outstanding issue. The Stamler plugs on the average of once per week due to the introduction of large rocks. GVEA has requested that the stamler be replaced with a grizzley that can be run over with the bulldozer or front end loader. This is most likely a $750,000 item.

2. The two (2) hopper blending system was never accepted by either GVEA or AIDEA as an effective system. Coal pile management has replaced this system as the accepted method of coal blending the fuel. It is our opinion that GVEA's continued rotation of personnel through the coal handling positions limits the effectiveness of coal pile management.

Opinions are based on the fact that only 9 of 90 days were operated with performance coal or with lower quality coal than performance coal. Equipment and system operating margins are estimated on a basis that approximately 23% more ash would have been processed had the unit operated with performance coal for a majority of the test period.

This review evaluates equipment and system capacities and sizing. The systems as defined in the S&W design criteria document include:

| System ID | System Name | Pg |
|---|---|---|
| AF | Fly Ash Conveying | 3 |
| AB, AW | Bottom and Slag Ash | 4 |
| CS, MS | Plant Control | 7 |
| BA, FG, HG | Combustion Air and Flue Gas | 7 |
| CW, SW, VP | Circulating and Service Water and Vacuum Priming | 8 |
| BB, BC, BD, BI<br>BS, BV, BW, BX<br>FC, MW, NS | Coal Feed, Boiler and Associated Systems | 8 |
| CN | Condensate | 9 |

System ID System Name Pg

| | | |
|---|---|---|
| FW | Feedwater | 10 |
| JA, JB, JC, JF<br>JI, JR, JS, JT, JW | Flue Gas Desulfurization | 10 |
| LH | Limestone Handling | 11 |
| AR, AS, CA, CR<br>H, MS, SV, TE | Steam | 12 |
| AP, IA, SA | Plant Air | 12 |
| CD, DP, DS<br>DT, WD | Drains | 13 |
| EC, EX, GA, GM<br>LF, LO, PG, SC<br><br>SD, SY, TC, TG<br>TH, TI, TO, TS<br>TT, XG | Turbine/Generator | 13 |
| CF, DW, SS<br>WP, WT, WW | Plant Water and Waste Water Treatment | 14 |
| AD, DH, HT, HV<br>HW, LT, MD, ME<br>SL, SP, UC, VC<br>YD | Building and Balance of Plant | 14 |


**General Criteria**

1. After the demonstration phase is completed, the plant will operate as a base-loaded unit. (pg 1-2)

Harris Group Opinion

The unit will change load consistent with a base-loaded unit design.

2. The plant will have an economic life of 25 years with a capacity factor of approximately 85 %. The plant design life shall be 40 years. (pg 1-3)

Harris Group Opinion

Severe wear experienced on Exhauster B indicates that operation with performance coal would lead to excessive maintenance costs associated with the coal feed system. (Turn-over package system code - FC)

3. Btu/lb and an ultimate analysis of: (pg 2-12)

| | |
|---|---|
| Sulfur | 0.15 |
| Moisture | 25.11 |
| Carbon | 40.57 |
| Oxygen | 13.94 |
| Hydrogen | 3.07 |
| Ash | 16.60 |
| Nitrogen | 0.53 |
| Chlorine | 0.03 |
| Total | 100.00 |

Test Condition

The 90-day average as-received, higher heating value of the coal was 7,194 btu/lb. During the period used in calculating steady-state performance, the consecutive, full-load period of September 24th through October 27th the coal heating value was 7,202 btu/lb.

4. High temperature ash analysis constituent total ranges for waste and ROM coals are: (pgs 2-13,14)

| | |
|---|---|
| $SiO_2$ | 22 to 80 % |
| $Al_2O_3$ | 8 to 25 % |
| $TiO_2$ | 0.3 to 1.2 % |
| $Fe_2O_3$ | 2 to 12 % |
| CaO | 3 to 36% |
| MgO | 1 to 8 % |
| $K_2O$ | 0.9 to 2.5 % |
| $Na_2O$ | 0.05 to 2.5 % |
| $SO_3$ | 0.5 to 10 % |
| $P_2O_5$ | 0.2 to 3.5 % |
| SrO | 0.05 to 0.3 % |
| BaO | 0.1 to 2.8 % |
| MnO | 0.03 to 2.0 % |

Test Condition

Fly ash sample analyses indicate that calcium oxide (CaO) and sulfur trioxide ($SO_3$) contents were within the expected design range.

**Fly Ash Conveying**

Design criteria

1. Of the total coal ash, 20% is assumed to be removed by the fly ash handling system. (pg 2-11)

2. The drag chain conveyors and bucket elevator from the baghouse and SDA vessel shall be sized for a removal rate of 200 % of the expected accumulation rate of 11.25 tph based on waste coal with 25 % ash at a rate of 50 tph. (pg 2-11)

3. Fly ash from the boiler bank and air heater hoppers is expected to be 10 % of the total coal ash and flashed calcined material with a density of 50 lb/cuft. (pg 2-10)

4. The capacity of the boiler bank and air heater hopper vacuum pneumatic conveying system shall be approximately 9 tph. (pg 2-10)

Test Condition

The 90-day average coal ash content was 12.91 %. Coal ash and limestone waste averages were calculated on a daily basis using the sample analyses results. Limestone waste was calculated per the procedure in Harris Group December 22, 1998 report - "Audit Results for Quantity and Quality Measurements for Coal, Limestone, Fuel Oil and Ash". The averages are:

| | lb/d | tpd |
|---|---|---|
| Coal Ash, lb/d | 260,610 | 130 |
| Lime Waste, lb/d | 30,721 | 15 |
| Total Ash, lb/d | 291,331 | 145 |
| Fly Ash, lb/d (20% of total) | 58,266 | 29 |
| Slag/Bottom Ash, lb/d (difference) | 233,065 | 116 |

The drag chain and bucket conveyors from the SDA and Baghouse were operating at 29 tpd or only 5 % of their criteria capacity of 540 tpd (11.25 * 2 * 24)

Harris Group Opinion

The fly ash handling system capacity meets the design intent.

5. The fly ash storage silo shall be sized to store the ash and flash calcined material produced in 5 days when operating at full load while burning performance coal.

Test Conditions

From the limestone handling criteria, full load performance coal results in a 658 mmbtu/h heat input or a coal flow of 98,540 lb/h. With a 16.6 % ash content, the coal ash is 15,693 lb/h. From the limestone storage silo sizing criteria the expected limestone flow is 1,137 lb/h. Assuming that limestone waste is 15 % of coal ash and that fly ash is 20% of total coal ash, then total fly ash flow is 3,609 lb/h (15,693 * 1.15 * 0.2). A 5-day storage silo must hold 433,145 lbs (217 tons)

From the data above, the 90-day test average 5-day fly ash flow was 291,330 lbs (145 tons). (58,266 * 5)

Harris Group Opinion

The flyash silo is sufficiently sized to meet the design criteria and holds about 7.5 days of test flyash.

**Bottom and Slag Ash**

Design criteria

1. A base case burn rate of 50 tph of contract waste coal is assumed as the full operating load. (pg 2-7)

2. SLAG

 2.1 Of the total ash produced from the coal, 90 % is assumed to be in the form of slag ash discharging into the slag ash submerged drag conveyor. The maximum ash content of the coal is 25 % (based on firing waste coal). (pg 2-8)

 2.2 Normal slag size range is expected to be 0.25 to 6 inches. Abnormal slag size of 3 ft by 3 ft by 2 ft may be experienced. Emergency slag size may be as large as 7 ft by 7 ft by 3 ft. The largest slag piece capable of passing through the slag ash grizzly to the transfer conveyor shall be approximately 4.5 inches. (pg 2-8)

 2.3 The surface moisture content of discharged ash and material shall not exceed 30 % by weight. (pg 2-10)

Harris Group Opinion

The system meets the design intent, however, if performance coal is available for long-term firing then a clinker grinder should be installed to reduce operating labor in breaking up clinkers.

3. BOTTOM ASH

 3.1 Of the total ash produced from the coal at HCCP, 30 % is assumed to be in the form of bottom ash discharging into the bottom ash submerged drag conveyor. The maximum ash content of the coal is 25 % (based on firing waste coal). (pg 2-8) The bottom ash system shall also be capable of handling the intermittent discharge from Unit 1. The maximum burn rate for Unit 1 is assumed to be 25 tph. The maximum ash content of coal burned is assumed to be 10 %. Of the total ash produced from Unit 1, 20 % is assumed to be bottom ash. The design removal rate of Unit 1 bottom ash is assumed to be 15 tph for an intermittent operation of 8 minutes. (pg 2-9)

 3.2 Normal bottom ash size expected is similar to a conventional PC-fired boiler where sootblowing and fouling may occur. The largest bottom ash piece passing through the bottom ash grizzly shall be approximately 4.5 inches. The largest bottom ash piece of Unit 1 bottom ash is 0.75 inch. (pgs 2-8,9)

 3.3 The surface moisture content of discharged ash and material shall not exceed 30 % by weight. (pg 2-10)

3.4 The bottom/slag ash storage silo shall be sized for storage of 5 days, based on performance coal with 17 % ash content, which is approximately 980 tons including Unit 1 ash. (pg 2-10)

Test Conditions

From the fly ash calculations above, the 90-day average slag/bottom ash flow was calculated to be 116 tpd or 580 tons in 5 days.

Harris Group Opinion

This analysis is made without the benefit of demonstrating combined transport of HCCP and Unit 1 slag/bottom ash. From test observations, it appears that conveyor capacity is sufficient to add the Unit 1 load successfully.

Testing to date has been limited after the 90-Day Test and more work is necessary to tie-in Unit 1 bottom ash.

Without the requirement of Unit 1 bottom ash storage, the bottom ash silo appears to be sufficiently sized to meet the design intent and holds about 8.5 days of HCCP 90-Day test slag/bottom ash.

4. ASH WATER HEAT EXCHANGER

4.1 The maximum heat load to be removed by the ash water heat exchanger is assumed to be 38 mmbtu/h from the combustors due to radiant heat and slag heat (19 mmbtu/h from each combustor with a 9.4 mmbtu/h radiant heat component and a 9.6 mmbtu/h slag heat component) and 3 mmbtu/h from the boiler. This is based on firing 100 % waste coal. This shall be the criterion for designing the water recirculation system. The normal expected heat load per combustor based on performance coal is 13.4 mmbtu/h. (pg 2-8)

4.2 The bulk temperature of the water in the submerged drag conveyors shall not exceed 140 F. A differential temperature of 40 F (140 - 100) shall be considered for calculating the recirculating water flow. (pg 2-8)

Harris Group Opinion

No overheating problems were noted during the test period and it is our opinion that the system meets the design intent.

5. MILL PYRITES

5.1 Each pyrite hopper shall be sized for 15 cuft capacity. (pg 2-9)

5.2 The pyrite system shall be capable of removing coal after a main fuel trip at a rate of 30 cuft in 5 minutes or approximately 9 tph. (pg 2-9)

5.3 The largest size of pyrites discharges to the slag ash submerged drag conveyor is assumed to be 0.75 inch. (pg 2-9)

5.4 The slag ash submerged drag conveyor shall be capable of handling the intermittent discharge from the pyrites system in addition to the slag produced in the combustors under normal and abnormal conditions. (pg 2-9)

Harris Group Opinion

Other than normally expected pyrite system cleaning, no capacity problems were noted during the test and it is our opinion that the pyrite system meets the design intent.

**Plant Control**

No specific criteria was offered.

Test Conditions

Alarm and equipment status records were collected on a daily basis, put into text files and stored on CDs. 11 consecutive days from September 19th through the 30th were reviewed. Approximately 17,350 records were collected in 264 hours. This represents an average of one entry per minute. It is apparent why the operators do not want to print out alarms of this magnitude.

The purpose of an alarm system is to provide the operator with a quick, on-the-spot diagnosis tool to prevent unit outages and to determine events leading to outages. This tool requires a review of the past several minutes or hours of critical alarms, which could lead to an outage event.

Harris Group Opinion

1. The alarm system is not implemented to be useful to the operator or plant engineer to readily evaluate sequence of events and diagnose causes.

2. Significant tuning is required to operate on performance coal and lower quality coal. This should be remedied prior to turn-over.

3. A thorough review of the DCS Control scheme for the burner management system should be undertaken. The “B” Mill explosion and the “A” Mill puff necessitate this review.

**Combustion Air and Flue Gas**

Design criteria

1. The FD Fan shall be sized for expected steady state conditions and to account for expected system flow and pressure upsets as required by the boiler and combustor manufacturers. (pg 2-18)

2. The glycol heating system shall provide sufficient heat transfer capacity so that combustion air will be heated to the desired temperature at the maximum combustion air flow rate and at the minimum ambient air temperature. (pg 2-18)

3. The fluegas system shall be designed so that the ID Fan and ductwork are sized for the expected system flow and dust grain loading at normal steady state conditions and during pressure and temperature upsets. (pg 2-19)

Harris Group Opinion

Air temperatures and control damper positions during the test confirmed that the combustion air system equipment capacities meet the design intent.

**Circulating and Service Water and Vacuum Priming**

Design criteria

1. Component cooling water equipment shall be designed to provide cooling water with a maximum temperature of 95 F. A 10 % design margin shall be added to the water flow rate and heat load to accommodate increases in flow and heat loads due to changes in system configuration and increased plant equipment cooling requirements. (pg 2-24)

2. The design for circulating water for component cooling through the component cooling heat exchanger and bottom/slag ash heat exchanger shall allow sufficient flow with the sole driving force as the circulating water pumps during the normal operating mode. If this is marginal or not possible, a booster pump shall be installed to ensure flow. (pg 2-25)

Harris Group Opinion

Cooling water temperatures were not excessive during the test indicating that the equipment and system capacities meet the design criteria and it is our opinion that the system meets the design intent.

**Coal Feed, Boiler and Associated Systems**

Design criteria

1. The maximum continuous rating (MCR) of the boiler shall be 490,000 lb/h. The minimum steaming capacity of the boiler shall be 75,000 lb/h. Steam temperature control shall be 955 F (+/- 10 F) throughout the load range of 60 to 100 % of MCR. (pg 2-38)

Test Conditions

The unit produces 51 MW net at 463,000 lb/h steam flow. MCR was demonstrated on December 2 for 2 hrs at 490 lb/h steam flow, producing about 54 MW.

Harris Group Opinion

It is our opinion that the boiler capacity meets the design intent.

2. Boiler blowdown shall be designed to meet the boiler guaranteed steam quality and capacity while operating with a continuous blowdown rate equal to 1 % of the MCR flow rate. (pg 2-38)

Test Conditions

As indicated by steam-to-feedwater differential flow, the 90-day average boiler blowdown and sootblowing steam usage was 1.24 % of the steam flow.

Harris Group Opinion

This is within expectations for proper water treatment of the boiler makeup water.

3. Boiler envelope insulation and lagging surface temperature shall not exceed 140 F with an ambient air temperature of 80 F or less. (pgs 2-38,40)

Harris Group Opinion

Insulation appears to be adequate.

4. The coal feed system maximum rating shall be designed for 110,000 lb/h of as-received coal. (pg 2-39)

Test Condition

The 90-day average coal flow was 82,395 lb/h or 75 % of the design criteria requirement.

Harris Group Opinion

Except for wear on the exhausters and transport/classification equipment in the coal feed system, it is our opinion that the design intent for capacity of the system was met. If 50/50 blended coal is to be used, the system from the pulverizer outlet to combustor inlet must be replaced.

5. The pulverizers shall grind ¾ in by 0 in coal to a maximum of 70 % through 200 mesh and 2 % on a 50 mesh screen. (pg 2-39)

Harris Group Opinion

It is our opinion that the pulverizers met the design intent.

6. During normal operation each combustor is expected to have at least a 3:1 turndown ratio based on maximum firing rate. The combustors shall be designed to operate in a stable and reliable manner without burning fuel oil at all loads from 35 to 100% of MCR. The combustors shall be designed to burn 100 % ROM, 55 % waste / 45 % ROM, 50 % waste / 50 % ROM, and 100 % waste coal blends. (pg 2-40)

Harris Group Opinion

1. The unit will change load consistent with a base-loaded unit design.

2. With the current coal feed configuration, ratios of waste exceeding 50 % cannot be burned without significant erosion to the exhausters. Also ratios of waste exceeding 50 % caused operating problems. No long-term operation of performance coal or lower quality coal was demonstrated during the test.
3. The combustors were not demonstrated except for about 10% of the test period on performance coal. It appears that the combustors will operate satisfactorily on performance coal. Possibly they will operate satisfactorily on coal with two to three hundred btu/lb less heating value if the control system is properly tuned.

**Condensate**

Design criteria

1. The condenser size shall be optimized based on the turbine selected and the economics of the unit. (pg 2-20)

2. The condenser hotwell shall have a minimum of 5 minutes of condensate storage at the valves wide open condition. (pg 2-20)

3. The steam jet holding air ejectors shall be sized according to HEI standards for steam surface condensers. (pg 2-20)

4. The single hogging ejector shall be provided to evacuate the condenser and turbine shell volumes. It shall be capable of reducing condenser pressure from atmospheric to 10 inHgA within 30 minutes. (pg 2-21)

Harris Group Opinion

It is our opinion that the condensate system meets the design intent.

**Feedwater**

Design criteria

1. The general velocity guidelines for pipe sizing are:
   Boiler feedpump discharge – 15 to 25 fps
   Pump suction – 4 to 8 fps (pg 2-41)

Harris Group Opinion

There were no apparent operating problems with the feedwater system. The unit was run at 54 MW net and at a feedwater flow of 510,000 lb/hr with no apparent problems.

It is our opinion that the feedwater system meets the design intent.

**Flue Gas Desulfurization (Spray Dryer Absorber – SDA)**

The S&W Design Criteria does not address the spray dryer absorber capacity nor expected limestone usage. Opinions are offered with respect to the operation of the SDA and the limestone feed system criteria.

1. The SDA demonstrated that it could provide very efficient $SO_2$ reduction, however, AIDEA made no attempt to optimize limestone usage before or during the test in spite of continued requests by Harris Group, and therefore no conclusion can be made concerning the systems ability to track load swings and changes in sulfur content of the coal.

   The system was fed with up to twice the expected limestone during the entire test period.

2. We could find no turn-down criteria for limestone feed in the limestone handling system criteria. The over-sized range of the limestone feeder resulted in over feed of limestone. Another contribution to excessive limestone usage was the excessive fines in the delivered limestone. Sieve analyses results indicated that 95 % passed 200 mesh. S&W was expecting 70 % as indicated by their limestone handling system criteria. S&W was also expecting a 1.9 Ca/S ratio with a coal sulfur content of 0.2% to size the storage silo. The 90-day average sulfur content was 0.17% and the Ca/S ratio was 3.8 or double the expected usage for sizing the storage silo.

Design criteria

1. The airheater fluegas outlet temperature shall be maintained at a level sufficiently above the saturation temperature for all operating conditions to avoid condensation throughout the fluegas path. At full load conditions, the target airheater fluegas outlet temperature is 300 F with the SDA operating at 18 to 35 F above the adiabatic saturation temperature. (pg 2-19)

Harris Group Opinion

Based on test data it is our opinion that fluegas temperatures throughout the system were controllable within the design intent.

**Limestone Handling**

Design criteria

1. The system shall include storage capability for 9 days of operation on performance coal at 658 mmbtu/h and 0.2 % sulfur content at a stoichiometric ratio of 1.9 Ca/S. (pg 2-14)

Test Conditions

This criteria results in storage of 245,565 lbs (123 tons) of limestone with a calcium content of 39.5 % and a coal heating value of 6,960 btu/lb.

The 90-day average sulfur content was 0.17%, the Ca/S ratio was 3.8 and the heat input 596 mmbtu/h . Limestone was used during the test at an average rate of 1,589 lb/h or requiring 172 tons in 9 days.

Harris Group Opinion

1. By reducing limestone usage by 40 %, the storage silo meets its expected design criteria. This should be attainable with providing a better feed rate control and better material size distribution. If the usage of limestone is at the 3.8 Ca/S ratio as demonstrated during the test, then the storage silo is undersized.

2. The system shall be designed to handle limestone with a material size of 70 % passing 200 mesh, calcium carbonate purity of 90 % and moisture of 0.03 %.

Test Conditions

From averages from limestone analyses 95 % passed 200 mesh, calcium purity was 95 % and moisture was not analyzed.

Harris Group Opinion

It is our opinion that the system meets the design intent.

3. Baghouse air-to-cloth ratios shall not exceed 5:1 when used with an exhaust fan and the outlet loading shall meet or exceed 0.02 grain/dscf. (pg 2-15)

Harris Group Opinion

Since there were no apparent fugitive dust problems, it is our opinion that the filters meet the design intent.

4. Ductwork shall be designed for transport velocities in the range of 4,000 to 4,500 fpm. (pg 2-15)

Harris Group Opinion

The transport of limestone during the test was satisfactory, therefore it is our opinion that the system meets the design intent.

**Steam**

Design criteria

1. The main steam line shall be sized for the maximum expected steam flow at a design pressure of 1,326 psig and temperature of 965 F. (pg 2-16)

2. Each extraction steam line shall be designed with a maximum pressure loss of 3 % to the highest pressure heater and 5 % to the remaining feedwater heaters based on turbine extraction steam flange pressure. (pg 2-17)

3. The general guideline for steam piping velocities are:
   Low pressure extraction - 12,000 to 18,000 fpm
   Saturated steam at 15 psig and above - 1,000 fpm per inch pipe diameter
   Superheated steam to 1,400 psig - 4,000 fpm min and 15,000 fpm max (pg 2-42)

Harris Group Opinion

Steam pressures and temperature were within expected operating ranges and it is our opinion that pipe capacities meet the design intent.

**Plant Air**

Design Criteria

1. Three 50% capacity air compressors will be furnished to provide both service and instrument air. Cross-ties to Unit 1 service and instrument air systems shall be provided. (pg 2-37)

Harris Group Opinion

Plant air supply was within expected service during the test and it is our opinion that compressor and dryer capacities meet the design intent.

**Drains**

Design criteria

1. The plant process waste water drain system shall be designed to convey by gravity the maximum expected drainage from any floor or equipment drain. (pg 2-33)

Harris Group Opinion

It is our opinion that with occasional cleaning, the plant process waste water drain system is adequately sized.

**Turbine/Generator**

Design criteria

1. The steam flow passing ability at control valves wide open is calculated to be 5 % greater than required to make the guaranteed rating. This 5 % margin accounts for manufacturing tolerances and uncertainty in flow coefficients. The resulting generation is defined as the maximum capability of the machine. (pg 1-4) The turbine shall be designed with a 5 % flow margin above that required to produce the nameplate output at valves wide open operation. (pg 2-41)

Harris Group Opinion

The unit was run at 54 MW net for 2 hrs at 490,000 lb/h steam flow on December 2$^{nd}$. It is our opinion that the turbine/generator meets the design intent.

2. The unit will normally operate as a base-loaded unit. It shall be capable of operation under automatic load dispatch along with other units of an interconnected system. (pg 2-41)

Harris Group Opinion

Automatic load dispatch is not limited by turbine operation or control, but is limited by boiler operation. Load is dispatched to the unit manually from telephone conversation between the power plant operator and the load dispatcher. It is our opinion that the unit will change load consistent with a base-loaded unit design.

**Plant Water and Waste Water Treatment**

Design criteria

1. The number of raw water supply wells will be determined from the plant water balance calculation. If the plant water demand exceeds the capability of 1 drilled well, then the existing Unit 1 well will be used to supplement that source. The Unit 1 well capacity available to HCCP is assumed to be 25 gpm. A second well will be drilled only if these two sources are incapable of supplying the plant water demand. (pg 2-28)

Harris Group Opinion

There have been indications that the well capacity is marginal with full-load operation of both units. This condition may require further monitoring.

2. The filtered well water tank will be sized for a nominal volume of 20,000 gallons. (pg 2-29)

3. The boiler makeup water demineralizer system will be sized to produce mixed bed quality water at a rate equal to 4.0 % of the maximum steam flow rate for HCCP. (pg 2-30)

4. The demineralized water storage tank will be sized for a nominal volume of 20,000 gallons. (pg 2-30)

Harris Group Opinion

It is our opinion that the tank size meets the design intent.

**Building and Balance of Plant**

Design criteria

1. Air inlet velocities through net openings of exterior wall louvers and storm-proof fan air inlets shall be limited to 1,000 fpm to prevent storm water entrainment in the air streams. (pg 2-34)

2. Fan tip speeds shall not exceed 12,000 fpm. (pg 2-34)

3. HVAC equipment for areas ventilated and cooled by outside air shall be designed to maintain indoor temperatures at 15 to 25 F above the outside temperature. The maximum design indoor temperature is 105 F. These areas shall be heated to maintain a minimum indoor temperature of 50

F. A minimum of 10 % of the total air supply shall be fresh outside air. The minimum exhaust rate shall be 2 cfm/sqft. (pg 2-35)

4. The domestic water system shall be sized to meet the demand for both HCCP and Unit 1 during a major maintenance period. 50 personnel are assumed present during an HCCP peak maintenance period. The usage rate during peak maintenance periods is 20 gallons/day/person. (pg 2-36)

5. The sanitary wastewater system shall be sized for the maximum number of persons expected on site during normal operating and maintenance outage periods. 50 personnel are assumed present during an HCCP peak maintenance period. The usage rate during peak maintenance periods is 20 gallons/day/person. (pg 2-36)

Test Conditions

The HVAC system maintained comfortable inside temperatures during the test period.

Harris Group Opinion

It is our opinion that both the HVAC system and sanitary wastewater system meet the design intent.

## ENVIRONMENTAL

The Project appears to be in substantial compliance with the conditions of its permits and environmental laws and regulations, and should be capable of maintaining compliance with current requirements provided it continues to be properly operated and maintained. This section discusses the Project's compliance with the limits and conditions of its key permits and other regulatory requirements that affect its operation.

The Project operates under conditions of its Air Quality Control Permit to Operate ("Air Permit"), Permit No. 9431-AA001, issued by the Alaska Department of Environmental Conservation ("ADEC") on May 12, 1994. The Air Permit authorizes the construction and operation of the HCCP facility and sets forth maximum allowable emission limits as shown below.

Emission Limits

| | lb/Mmbtu | lb/hr | tons/yr |
|---|---|---|---|
| $NO_x$ [1] | 0.350 | --- | 1,010 |
| $SO_2$ [2] | 0.10 | 65.8 | 248 |
| CO [3] | 0.20 | 132 | 577 |
| PM [3] | 0.02 | 13.2 | 58 |

Notes:

1. $NO_x$ emission limit is based on a 30-day rolling average.
2. $SO_2$ emission limit is based on a 3-hour average. Annual average limit is 0.086 lb/Mmbtu.
3. CO and PM emission limit is based on an hourly average.
4. Annual limits in tons per year are based on full-load operation.
5. Opacity emission limit is 20 percent opacity for a three-minute average and one six-minute period per hour of 27 percent.

Monitoring of the criteria pollutants and fuels fired is required to determine both initial and continuous compliance with the Air Permit. A Continuous Emission Monitoring System, located on the HCCP exhaust duct, monitors $NO_x$, $SO_2$, CO, and opacity on a continuous basis to determine compliance.

During the 90-Day Test, HCCP exceeded its emission limit for $SO_2$ on five occasions and exceeded opacity limits twice. Two of the $SO_2$ exceedances, on August 19 and September 28, 1999, were attributed to switching the atomizer, two others on September 7 and September 11, 1999 were a result of startup activities, while the third exceedance, on November 11, 1999, was due to a plugged slurry pump. Both opacity exceedances, on September 7 and September 11, 1999, were a result of startup activities. There were no $NO_x$ emission exceedances during the 90-day test. See Graph 4, $NO_x$ data courtesy of TRW.

As reported by AIDEA and GVEA, the State offers leniency towards emission exceedances as a result of mechanical problems and during periods of startup, provided efforts are being set forth to eliminate reoccurrence and obtain compliance status in a timely manner. AIDEA has made efforts to reduce excess emissions and no Notices of Violation were issued during the 90-day test. Additionally, $SO_2$ exceedances occurred less than two percent of the time and would likely not concern permitting authorities. However, as excess quantities of limestone were used throughout the duration of the test, reduced levels of $SO_2$ emissions were experienced and AIDEA failed to demonstrate HCCP's abilities to follow load changes while remaining in compliance with emission limits as set forth in the Air Permit.

With respect to the Project's water discharges, HCCP discharges its water to the Nenana River under terms and conditions of its National Pollutant Discharge Elimination System ("NPDES") Permit (Permit No. AK-002294-2). The NPDES Permit was issued by the U.S. Environmental Protection Agency and expires January 24, 2000. There were no violations of permit conditions or exceedances during the 90-day test.

Ash from HCCP is disposed of under terms of the long-term coal supply agreement between Usibelli and GVEA. The agreement states that Usibelli will, at GVEA's request and direction, remove ash after the combustion process.

## UNDEMONSTRATED SYSTEMS

The purpose of the 90-day, as mentioned above, is to demonstrate performance of all major systems in accordance with design specifications and tolerances at a sustained operating basis. Several systems were not demonstrated to acceptable standards during the 90-day test including the circulating water inlet canal, the DCS alarm printing and priority scheme, connection of Unit 1 and Unit 2 wastewater treatment systems, and connection of Unit 1 fly ash system to Unit 2.

The circulating water inlet canal was not properly demonstrated as a continuous stream between Unit 1 and Unit 2. During startup of the Plant, a barrier was constructed between the unit intakes as a means of reducing the initial influx of soils into the system. Although this barrier has not been removed to date, it is Harris Group's opinion that the system should work and will require less manpower to operate once transformed back to a continuous stream. As a minimum, it should be demonstrated. The continuity of water flow past the intake structures is designed to reduce the quantity of fines in the system, thereby reducing dredging and system flush requirements.

The DCS alarm priority scheme has not been addressed or implemented.

Connection of Unit 1 and Unit 2 wastewater treatment systems was not demonstrated as part of the 90-day test. Unit 1 and Unit 2 fly ash systems were connected from December 6 through December 14, 1999 but not satisfactorily demonstrated due to the limited operational time and existing system flaws. To this end, Harris Group cannot comment on these systems ability to operate commercially in accordance with standard utility practices.

## OTHER TECHNICAL ISSUES

In addition to the major issues listed in this report, there are several other technical issues that in our opinion should be remedied prior to deeming the unit as commercial.

These are:

### Turbine Performance

The FUJI preliminary report is vague. There may be issues with the turbine that will be noted in their final report, such as power generation at MCR and turbine efficiency.

### Mill Controls

Final resolution of the mill "B" explosion by way of a final Foster Wheeler report on the incident. It has come to our attention that there was a small puff on mill "A" during the last shutdown, this is the same operating condition as with the "B" mill explosion. This must also be reviewed and explained. The logic should be verified and accepted by Foster Wheeler and TRW.

### Limestone Slurry Feed

Limestone slurry feed equipment should have some level of redundancy added so that losses of the SDA are reduced to a minimum for this cause.

### Slag Ash Clinkers

The slag ash system should have a clinker grinder installed if it remains the intent to burn performance coal. During Harris Group walkdowns, about 360, there were 125 noted incipents of clinker build-up or manual attention to clinkers.

### Boiler Natural Circulation Valves

We understand these valves fail in position of a loss of power. These should be "Fail Open" on a loss of power.

### Flame Scanners

The flame scanners should be much more reliable without such frequent attention (rodding).

The combustors have 4 flame scanners and they require an abnormal amount of operator intervention to keep clean. The general understanding is that the flame signal deteriorates due to slag build-up in the combustor, even when the flames are acceptable. The amount of rodding out is unacceptable.

**Motors**

There are several motors in the plant that have temporary air blowers in place. These are: Limestone Feeder, Drag Conveyor, Hydraulic Skid for Slag Ash Conveyor and the Hydraulic Pump for Boiler Feed Pumps. These must be addressed.

**$NO_x$ Port Piping**

The $NO_x$ Port Piping should be monitored to prove the repairs made recently are effective.

**Silt Build-up In Intake Channel**

The Sparger system in the intake channel designed to keep the silt in suspension is marginal. Some redesign is necessary to minimize build-up.

**Silt Build-up In The Firewater Suction Piping**

There is significant build-up of silt in the suction to the Firewater Pumps from the inlet channel. It is about 40% full of silt. The weekly test of the diesel fire pump may not be of high enough velocity to disturb the silt, but the demands of a fire may be. Testing of the system under full flow should be done to assess the impact on silt and on possible plugging of nozzles.

**Ash Build-up**

Fine particles of ash build-up in the Ash Water Storage Tanks. This could be minimized by the addition of a cyclonic separator in the ash piping. This should be addressed.

## PUNCH LISTS

All plants have punch list items to be completed at the point of commercial operation and this plant will be no exception.

The most recent GVEA punch list is dated May of 1999. AIDEA has performed several thousand hours on punch list items since then, therefore, an updated list is needed.

This list will be required when AIDEA wishes to turn over systems to GVEA.

In that there is little or no communication between the parties, we cannot comment on the magnitude of remaining punch list items.

## TURNOVER OF SYSTEMS

It is rare that a demonstration test is run prior to turnover of the plant to the Owner, or in this case, the operating entity.

Before the unit could be declared commercial, it is our opinion that all systems should be turned over to GVEA, including agreement on outstanding punch list item.

Because GVEA has unrealistic expectations for a coal fired power plant, this effort will be prolonged.

It is our opinion that most systems are in a condition that they could be turned over quickly, albeit with a comprehensive punch list.

## DISPATCHABILITY OF UNIT

Dispatch Testing

No dispatch testing was performed during the 90 day test. AIDEA stated that dispatch testing was not a requirement of the 90 day test and only agreed to allow running in a dispatch mode after the 90 day test was complete. The Stone & Webster Design Criteria document and the Construction Agreement state that HCCP is to be run as a base load unit. However the DOE Long Term Commercial Operation Demonstration test documents state that the unit be demonstrated as able to be operated in a commercial operation mode. Harris Group requested that the last 30 days of the 90 day test be run in dispatch mode under control of the GVEA dispatcher to no avail.

An artificial plan for dispatch demonstration was detailed by Harris Group and the unit was run for 7 days according to this plan. Note that during this test period, the coal still was not near a 50/50 blend of ROM and waste.

No attempt was made to gather the required data and documentation for GVEA so that they could set up an automatic remote dispatch system.

**RESULTS**

In general, the unit responded to the needs of the test plan. When at steady loads of 50, 40, 35, 25 and 54 MW, the unit was generally stable (held load at +/- 1 to 1.5MW of set point). The controlled process parameters of steam temperature and pressure, drum level, air and flue gas pressures, emissions, and $O_2$ content of the flue gas were held within reasonably expected tolerances. The unit remained in automatic control mode during the entire test period except during the 25 MW test when oil had to be fired to stabilize the fires.

The unit did not change load as quickly as would be expected of a swing unit but it should be noted that the unit has had no tuning to be operated in this mode. Also, the operators had limited experience in changing load prior to this test period. It can be seen that as the test progressed, the operators were able to change load more rapidly.

Load changes in the downward direction were always done quicker than load increases. This is due to the large mass of the boiler and the difficulty of adding heat to the mass versus the ability to quickly reduce fuel input and thereby reduce load. The limiting equipment on load swings is the boiler, the turbine/generator will change load quickly.

By the end of the tests load reductions of 10 MW required approximately 24 minutes whereas load increases of 10 MW required 35 minutes. The 5 MW noon time reductions were at about 9 minutes and the 5 MW increases were at about 15 to 20 minutes.

The load reduction from 40 MW to 25 MW took 36 minutes or 0.4 MW per minute and the load increase back to 40 MW took 52 minutes or 0.3 MW per minute. It is our opinion that these reductions should occur in about 1 MW per minute and the increases should occur in about 1.5 MW per minute. These rates should be readily achieved once controls are tuned and the operators have more experience with the unit and its controls.

See Graphs 5 and 6 for typical load changes.

**Dispatch Demonstration Plan For HCCP**

Sunday Nov 28 Run from noon to Monday at 7 AM at 35 MW

| | |
|---|---|
| Monday | At 7 AM, ramp to 50 MW by 8 AM, hold until noon<br>At noon, take a 5 MW load reduction, hold until 1 PM, return to 50 MW<br>1 PM to 11 PM hold at 50 MW<br>At 11 PM, drop to 40 MW by 11:30 PM, hold until 7 AM |
| Tuesday | At 7 AM, ramp to 50 MW by 8 AM, hold until noon<br>At noon, take a 5 MW load reduction, hold until 1 PM, return to 50 MW<br>1 PM to 11 PM hold at 50 MW<br>At 11 PM, drop to 40 MW by 11:30 PM, hold until 7 AM |
| Wednesday | At 7 AM, ramp to 50 MW by 8 AM, hold until noon<br>At noon, take a 5 MW load reduction, hold until 1 PM, return to 50 MW<br>1 PM to 11 PM hold at 50 MW<br>at 11 PM, drop to 40 MW by 11:30 PM, hold until 7 AM |
| Thursday | At 7 AM, ramp to 50 MW by 8 AM, hold until noon<br>At noon, take a 5 MW load reduction, hold until 1 PM, return to 50 MW<br>1 PM to 11 PM hold at 50 MW<br>at 11 PM, drop to 40 MW by 11:30 PM, hold until 7 AM |
| Friday | At 7 AM, ramp to 50 MW by 8 AM, hold until noon<br>At noon, take a 5 MW load reduction, hold until 1 PM, return to 50 MW<br>1 PM to 11 PM hold at 50 MW<br>at 11 PM, drop to 35 MW by 11:30 PM, hold until 7 AM |

At some time when the unit is at 50 MW, the dispatcher will call for immediate load ramp to maximum load, say 54 MW net, AIDEA to determine what this is and how fast they can get there. After achieving that load, remain there for two hours and return to 50 MW.

At some time when the unit is at 40 MW, the dispatcher will all for immediate load ramp to minimum load, say 25 MW net, AIDEA to determine what this is and how fast they can get there. After achieving that load, remain there for two hours and return to 40 MW.

This load pattern should mimic somewhat the normal operating conditions for a swing unit that is the largest on a system.

## PRESENT CONDITION OF UNIT

### Condition Of The Unit

After the 90 day test the unit was shut down for an inspection of the condition of the unit. This inspection was performed by Dennis Swann of Harris Group. He was accompanied during the boiler inspection by Alex Taybah of Foster Wheeler and Bernd Pankos of Duke Engineering Services.

Overall, with the exception of the exhausters and the DCS, the unit is in a condition that could be termed ready for commercial operation.

The boiler inspection revealed the following:

- Steam drum – There was evidence of a leak near the steam drum. Later it was discovered that there was a leak in the $10^{th}$ steam drum generating tube roll. This would have been a construction error and not a failure.
- Penthouse – There was a significant build-up of ash in the penthouse and it was not possible to inspect for any damage to the penthouse elements. The penthouse should be cleaned and an inspection performed. AIDEA plans on accomplishing this during the December outage. Future consideration should be given to preventing the build-up of so much fly ash.
- Generating tubes – There was no apparent wear or problems with the generating tubes.
- Superheater – There were some loose alignment tubes on the superheater pendent tubes. No other problems were noted in the superheater area.
- Economizer – There were no apparent problems noted in the economizer area.
- Furnace – The furnace looked clean and no apparent erosion was noted.
- Air heater – Both the top and bottom of the air heater was visually inspected and except for a small amount of flyash build-up on the top, no tube pluggage was noted and the tubes looked clear of any corrosion or build-up.
- Slagging combustors – Both combustors appeared to be in good condition. There was a bit more slag build-up in the “B” combustor but nothing of concern.
- Pre-combustors – The precombustors also looked clean, again with a bit more slag in the “B” precombustors but no concern was noted.
- Boiler nose – No apparent wear or erosion could be seen in this area.
- Bottom ash hopper – The north ½ of the bottom ash hopper was completely full of ash. This ash was packed and very hard. The drag chain had continued to run so it is postulated that the ash bridged

over the drag chain. AIDEA is planning on installing a water jet system to try to solve this problem. Only time will prove the concept.

- Slag ash hopper – The slag ash hopper was in very good condition. The drag chain also was in good condition. The drag chain has had routine maintenance and seems to be OK.
- Dipper skirt – The dipper skirt appeared to be in good shape. We were a bit surprised as early in the operation of the unit, before the installation of the water lances low in the furnace, there had been several instances of very large slag falls.
- Feeders – We only looked at the feeders through the observation ports but the internals looked to be in good condition.
- Pulverizers – Inspection of the pulverizers showed both to be in very good condition. Each pulverizer had one roller with small waves building up. The grinding table to roller gap was about ½ inch and Foster Wheeler has recommended a small adjustment. We understand that AIDEA intends to make these adjustments during the December/January outage. There were a few wear bars that showed high wear and AIDEA planned to replace these. Each pulverizer has processed about 160,000 tons of coal, probably about 14 months of wear. Note that the average btu content of all the coal burned is about 7,500 btu/#, or an average of about 18% waste coal.
- Exhausters – The exhauster wheels had been in a new condition at the start of the 90 day test. After the explosion in "B", the wheel had been replaced due to high vibration most likely caused by the explosion therefore the wear was not representative of wear during the 90 day test. The wheel in the "A" exhauster was in very bad condition. The blades were almost worn through in many places. The location where the coal enters the exhauster wheel was also very worn. A hole 3 to 4" in diameter was eroded into the 1" plate at that location. It is our opinion that if a 50/50 blend is burned, a wheel as presently designed and built will have to be inspected and replaced every three months.

  The exhauster housings were in very bad shape. At any point where high velocity flows occur there was extremely bad erosion patterns. The housings had been patched while on-line in many places during the last 90 days of operation. Replacement of large portions of the ceramic blocks was required in both exhausters as well as almost total replacement of the ¾" outside steel plating. It is our opinion that if a 50/50 blend of coal is burned, a major overhaul of the exhauster housings will be required if in fact they can be maintained without total replacement every two to three years.
- Coal splitters and associated ductwork and piping – In general this equipment was in good condition. There is an area below the splitter on line "B" that has a large patch. Apparently this was caused by a damaged damper that caused the coal flow to concentrate on this area. The damper has been repaired and no further wear was noted. It is our opinion that there are some flat spots in the piping and that more CO monitors would be prudent if this system is continued to be used.
- N0x port piping – This application was not appropriate, the elbows were weak and broken. AIDEA has replaced the piping and this installation should be monitored.

The inspection of the balance of equipment showed the following:

- Spray Dryer Absorber – The atomizer nozzles showed signs of plugging. Two nozzles were totally plugged and 4 others were partially plugged. It is not clear if this plugging occurred during the shutdown or during operation but the SDA was operating well prior to the shutdown so we have assumed this is a shutdown issue and so, not significant. It is our opinion that routine inspection of the atomizers should be scheduled every 5 to 6 months.

- The pug mill was very clean, having just been cleaned.
- No other SDA equipment was inspected internally.
- Condenser water boxes, inlet & outlet – There was a small amount of debris in the inlet box. There was no plugging noted on either the inlet or outlet. We expected some erosion on the inlets of the tubes but none was felt or visible.
- Circulating water pump "A" – the impeller was only slightly worn and had no damage. Again we were surprised because of the high silt content of the water.
- Circulating water inlet channel – There was about an inch of silt built up on the floor of the channel. However both of the outlet pipes for firewater and service water were almost ½ full of silt. The service water line is never used so this may not be a problem. It may be that the silt build-up in the firewater line has reached an equilibrium because the pipe appears to be oversized. This should be monitored. No other problems were noted.
- ID and FD fans – An external inspection of the fans showed some corrosion of the outside housing on the bottom of the ID fan. This does not appear to be a major problem but should be monitored and inspected internally when the fans are opened the next time. Otherwise no problems were noted.
- Limestone system – An external inspection of the limestone system showed no apparent problems. There is no obvious erosion of piping occurring and the limestone feeder seems to be working as designed. The sprocket on the limestone feeder is oversized and so the SDA receives too much feed at all times. Repeated requests to have this changed were ignored during the test.
- Water treating system – An inspection of the system and discussions with the GVEA operators indicated that the system functions well but a few small changes are still being requested by GVEA.
- Ash handling systems – The ash handling systems show that they have been in service for a while but other than normal wear they appear to be functioning in an acceptable manner. The Unit 1 tie was made, but not satisfactorily demonstrated, therefore no comment can be made regarding the operation of the equipment when fully installed as designed. It should be noted that the head pulley on the ash bucket elevator was replaced during the 90 day test, a normal expectation for this type of equipment.
- DCS System – The DCS alarm printing scheme is effectively useless. Significant work needs to be done with this system to make it useful. In addition, little work has been done to optimize operation of the unit during load transitions or at lower loads than 50 MW. The Combustion Control Logic and the Burner Management Logic should be reviewed and the logic verified as acceptable by both Foster Wheeler and TRW. Many changes have been made in the field by a variety of personnel. DCS system also has lots of code in memory that is not used. This is not a big issue for operations but makes it very difficult to trouble shoot the system. This system needs lots of attention.

**<u>Boiler Tube Metallurgical Analysis</u>**

During the post-test boiler inspection, four tube samples from the Nose area and side walls were taken and two tube samples from the combustors were taken and submitted to Foster Wheeler for metallurgical analysis. See Appendix 6 for the final report.

The report states that the water wall tubes were not affected by the early PH excursions and looked normal.

The report shows that the tubes from the combustor had radial cracks near at many of the shield fin-to-tube welds. The tubes sampled are the only tubes in the combustors that have fins welded to them. All other tubes and the major part of the sampled tubes have normal round studs attached for slag retention. The report notes that the cracks are the only distress issues found.

TRW has reviewed this issue and their preliminary plan is to replace the fins with normal studs prior to a return to service. A final decision will be made the first week of 2000.

It is our opinion that these tubes should be investigated within 8 to 10 thousand hours of operation to confirm that the TRW changes have been successful.

# SECTION 7

**DEMONSTRATION OF**

# NEW TECHNOLOGY

# TRW COMBUSTION SYSTEM

The HCCP includes two (2) 350 mmbtu/hr multi-stage combustor systems, designated "A" and "B", designed and supplied by TRW. Each combustor system consists of a precombustor (PC) and a slagging combustor (SC). The outflow of the PC is injected into the SC. The TRW combustors are positioned in a symmetrical arrangement (mirror image) on the boiler structure. Two independent coal trains (silo, feeder, pulverizer, exhauster fan, 2-way splitter, blowdown cyclones, 5-way splitter, and associated transport piping, dampers, and valves) feed each combustor system. The coal train is a unique and unconventional feature of the HCCP. In order to achieve the desired partitioning, the coal and primary combustion air passes at high pressure and velocity through the series splitters, cyclones, and portioning dampers. Even though reinforced with refractory and hardened materials, this subsystem is prone to accelerated wear and tear, particularly when firing higher quantities of waste coal. Redesign and/or reconfiguration of this subsystem would be required for a steady supply of Usibelli coals having a heating value less than 7,000 btu/lb, and it is our opinion such coal may be supplied to the HCCP by Usibelli under the existing coal purchase agreement.

Typically, forty percent (40%) and sixty percent (60%) of the pulverized coal is injected into the PC and SC respectively. The PC portion of the coal is fed directly to a conventional low-$NO_x$ pulverized coal burner located in the headend. Coal is combusted with air preheated to 500 to 700$^{o}$F in the PC under superstochiometric conditions. Coal is combusted in SC under substoichiometric conditions. The hot gases from the PC are fed to the SC, and the balance of combustion air is injected through $NO_x$ ports in the boiler where it mixes with the SC product gases.

In the year preceding the 90-day test, two very significant advancements occurred with the TRW Combustion System, both of which have proven critical to the viability of the technology. First, the secondary air originally injected into the PC mix annulus and $NO_x$ ports were transferred to the SC headed and boiler $NO_x$ ports, respectively. This produced a PC product gas whose temperature was typically greater than 3,400$^{o}$F, significantly above the $T_{250}$ temperatures for the ash in the blended waste and ROM coals. Thus, slag freezing in the PC was significantly reduced and SC operating temperatures were boosted to assure runny, not molten slag. Note, the equipment configuration to effect these modifications on a short-term basis is not considered to be suitable for long-term operation and a permanent design needs to be implemented for the long term. Second, the aerodynamic flame pattern of the low- $NO_x$ burner in the PC was adjusted to minimize contact of the flame and its ash particles with the PC enclosure. In the absence of these two advancements, the TRW Combustion System would not be considered to be a commercial technology because it would slag-up to a degree requiring shutdown at an unacceptable frequency (i.e., several times per year).

Even with these two advancements, it is possible to accumulate an unacceptably thick frozen ash layer in the PC, particularly when firing higher concentrations of waste coal. More importantly, however, it was demonstrated to be possible to reverse the accumulation of ash layer in the PC on line, without necessitating a shutdown, by changing the operating parameters in the PC. Specifically, through adjustments to the PC stoichiometry, coal firing rate, and unit load, or by firing ROM coal or oil, it is possible to "clean" the PC of the ash layer and restore it to acceptable conditions for continuous operation.

$NO_x$ emissions during the 90 Day Test were typically 0.27 lb/mmbtu, well below the permit limit of 0.35 lb/mmbtu but above the target value for the technology of 0.20 lb/mmbtu. There appears to be ample opportunity to further reduce the $NO_x$ emissions by: (1) reducing the combustion stoichiometry in the SC from 0.8 to 0.75; (2) reducing the overall excess air level in the boiler; and (3) relocating the $NO_x$ ports in the boiler. These measures were not explored due to concerns that they may exacerbate slagging in the SC and boiler in an unacceptable way and the fact that time was running out on starting the 90 Day Test. Even without pushing the operating conditions of TRW Combustion System to minimize $NO_x$ emissions, the performance is comparable or better than that for conventional low-$NO_x$ burners.

The HCCP coal preparation system includes all equipment common to a conventional pulverized coal system, plus several additional major components, including: (a) high pressure pulverizer exhauster fan; (b) vertical transportation duct from the exhauster fan to the coal spitter inlet; (c) centrifugal coal splitter; (d) slagging combustor cyclone; (e) precombustor cyclone; and (f) coal fine vent subsystem to the precombustor or $NO_x$ ports. The explosion that occurred on the "B" Coal Preparation Equipment rendered that side to be more sensitive to coal quality variations and operational settings. Subsequent to the explosion, and perhaps since a fire that occurred prior to the 90 Day Test, the coal splitter did not perform to specification, critical dampers were frozen and severely bent, and the exhauster did not operate to specification. Consequently, the B-side PC required much closer attention in order to control slag build-up; particularly when the coal quality dipped to lower btu values (e.g., < 7,000 btu/lb). As noted above, however, when slag build-up occurred on the B-side PC during the final 30 days of the 90 Day Test, it was possible to reverse the build-up without a shutdown.

The pulverizer startup and shutdown procedures recommended by FWEC will minimize, but not eliminate the potential for problems with this coal preparation and delivery system. Further considerations (bypasses, CO monitors, etc.) are recommended for study prior to commercial acceptance of HCCP.

We recommend elsewhere in this report that a review of the Combustion Control Logic and the Burner Management Logic be done, and that Foster Wheeler and TRW concur with the findings.

In addition, the final Foster Wheeler report on the "B" Mill explosion must be incorporated into this review.

Operations of the HCCP with lower btu value coal since approximately October 15, 1999 (i.e., the last month of the 90 Day Test) may be the most instructive period of the 90 Day Test. Coal quality had routinely averaged more than 7,270 btu/lb throughout the first two months of the 90 Day Test, and it dropped about 270 btu/lb in the October 15 to November 15, 1999 time period. During this latter period, generation has been maintained at or near target levels, but it has not been easy. The B-side, particularly the B precombustor, has shown a dislike for the lower quality coal and measures have had to be implemented to prevent shutdown of the system. The measures have included well documented techniques, such as: biasing of primary air, adjustments to B-Precombustor stoichiometry, biasing of coal feeder throughput to the A-side, and megawatt load shedding. The measures have also included less documented techniques, such as: Rodding and poking of slag formations through the precombustor scanner ports, firing of ROM coal, oil firing and adjustments to the air registers on the FWEC low-$NO_x$ burner.

While these above difficulties have been chronic on the B-side, whenever the coal quality has dropped below 7,000 btu/lb, the A-side has not exhibited similar problems of the same magnitude. The performance of the A-side throughout the 90 Day Test is the most significant factor in our recommendation to retain the combustors.

It is probable that continued operation with coal qualities significantly below 7,000 btu/lb will cause slagging problems in the precombustor on both the A and B sides.

In summary, the TRW Combustion System at the HCCP has proven that it can operate on a continuous basis for coals supplied by Usibelli down to 7,000 btu/lb and about 15% ash. For lower quality coals, design changes are most likely required for sustained operation.

## SPRAY DRYER ABSORBER

### Introduction & Summary

The Spray Dryer Absorber (SDA) system consists of a single spray dryer vessel, a multi-compartment fabric filter and an extensive slurry preparation system. Alkalinity for the reaction is obtained from limestone, which is injected into the furnace, where it is converted to lime. This lime, along with coal flyash, is collected dry then milled and mixed with water to form a slurry, which is injected into the spray dryer. Here the reaction to remove oxides of sulfur from the flue gas stream takes place by forming calcium sulfate solids.

The SDA was evaluated using the criteria as set forth in other sections[1]. Unfortunately, the test did not demonstrate 90 day reliability under reasonable guarantee conditions nor conditions typical of utility industry operation.

- The spray dryer absorber failed to operate within regulatory parameters due to SDA system malfunctions (e.g. slurry flow interruption by plugging of the feed line to the atomizer). Other episodes were due to boiler malfunctions and start-ups. These combined with miscellaneous operational upsets resulted in at least five (5) episodes totaling 33 hours of operation above regulatory limits (3-hr average). It is our professional opinion that these figures would have been substantially higher had a lower (and more normal) level of maintenance manpower been available to correct system problems.

- During the 90 Day Test, limestone feed rates averaged 50% greater than performance guarantees and nearly four (4) times that theoretically required. This high addition rate allows target $SO_2$ emission levels to be achieved more easily, but are very costly and inappropriate for long-term operation.

- The system of automatic controls for the SDA apparently failed to demonstrate that it is capable of maintaining required emission levels several days after boiler start-up.

[1] During the days 78 through 82 of the 90-day test, a separate SDA Parametric Test was run to more fully characterize the spray dryer operation and its operating envelope. The results of this parametric test is the subject of a separate report being issued by Stone & Webster and its evaluation is beyond the scope of this document. Because SDA operation was purposely set to extreme limits during this period, the performance data from during the SDA Parametric Tests is disregarded in this evaluation of overall SDA performance.

## Evaluation of SO2 Control Performance

Figure 7 presents a plot of the peak 3-hr average $SO_2$ emission over the 90 Day Test period. Also shown is the regulatory limit of 0.10 lb. $SO_2$ per million btu fired to the furnace. The figure shows this limit was exceeded five (5) times: of these two occurred well after boiler start-up. Although in general the regulatory community may be lenient with regard to excursions during start-up, shutdown and boiler malfunctions, three other episodes were due to problems with the SDA itself: plugging of nozzles or lines or operational control problems. See table below.

| Date | Test Day | Episode | Number of Hours $SO_2$ Over 3 hr average |
|---|---|---|---|
| Aug 19 | 2 | Boiler Start-up | 6 |
| Sept 7, 8 | 21, 22 | Boiler Re-start | 10 |
| Sept 11 | 25 | SDA Malfunction | 9 |
| Sept 28, 29 | 42, 43 | SDA Atomizer Change-out | 6 |
| Nov 11 | 86 | SDA Malfunction | 2 |
| Total | **5 Episodes** | | **33** |

A second indicator of control performance is the ability of the SDA system to meet the average annual limitation of 0.086 lb. $SO_2$/mmbtu. The peak values shown in Figure 7 average 0.074, less than this limitation. From this we can conclude that the SDA is capable of achieving annual average emission goals, provided that extraordinary levels of maintenance labor are available to rapidly correct malfunctions and excessively high levels of expensive limestone are consumed. (See below).

## Evaluation of Limestone Consumption

To evaluate limestone consumption, total daily coal flows as measured by the pulverizer feeders were used. Uncontrolled sulfur was obtained from daily composite analysis of samples taken the previous day when bunkers were filled. Lime quantities were calculated based on daily total weight from the feeder for limestone. Limestone analyses corresponding to 54% CaO (lime) was used.

Figure 8 demonstrates that the molar ratio averaged 3.67 and was in great excess of a performance guarantee value of 1.95. Also, during the test period, limestone flow averaged 1650 lb/hr or 50% more than allowed for in SDA performance guarantees. By providing more "driving force," the high ratio allowed the SDA to more easily achieve the required emission levels goals. For this reason, the 90 Day Test failed to demonstrate that the emission levels obtained during the test could be considered representative of what may be expected during normal operations.

Excess limestone is transformed to excess un-reacted lime, which reports with the flyash. In this regard, the following items also deserve consideration:

- The un-reacted lime content of the flyash raises the pH of the ash to be disposed-of; perhaps to levels unacceptable for uncontrolled disposal in the mine.
- The excess lime increases the weight and cost of flyash disposal.

- The pugmill, which mixes water with flyash to control dust during truck unloading, is acting as a lime slaking device to form calcium hydroxide, and in doing so, generates a substantial and significant amount of uncontrolled heat and steam. This could be deemed a personnel safety issue.
- The value of the excess limestone averaged approximately 9 tons/day, which at a cost of $100/ton, increases cost to generate power by $350,000/year or about 0.8 mills/kWh.

# SECTION 8

# NET PLANT HEAT RATE

## NET PLANT HEAT RATE

INTRODUCTION

Hourly data was collected from the DCS to evaluate Net Plant Heat Rate (NPHR) and Boiler Efficiency (Eb). The input/output method was used to report boiler efficiency.

SUMMARY

Net Plant Heat Rate

The 90-day average NPHR was 12,800 btu/Kwh at a 92.7% coal-fired availability. The heat into the boiler was calculated using the Usibelli coal heating values and the coal loading weigh scale measurement which are the basis for coal purchase. Refer to Table 6 and Graph 9. Graph 9 illustrates that the data scatter is +/- 8%. Data from September 6 and 7, 1999 was insufficient to include since the unit was down for part of these days. Average and total data for the test period is 88 days.

Consecutive hours of full load operation occurred during the period from September 24 through October 27. The average NPHR during this period was 12,585 btu/Kwh. This represents a 100 % availability period.

A letter dated March 12, 1998 from Stone & Webster (S&W) to AIDEA projects a net plant heat rate when burning 6,960 btu/lb coal is 12,215 btu/Kwh. S&W recognizes in this letter that the actual heat rate must be determined from field testing.

Boiler Efficiency

The 90 day average Eb is 76.9% based on an average as-received coal higher heating value of 7,187 btu/lb. Graph 10 illustrates that the average efficiency is about 2 to 4% lower than the expected efficiency as predicted by Stone and Webster in their Design, Supply and Erection Contract, Attachment 2, Division 3 Boiler Performance Data dated February 22, 1993

Consecutive hours of full load operation occurred during the period from September 24 through October 27. The average Eb during this period was 77.5 % when burning an average as-received coal higher heating value of 7,202 btu/lb. This represents a 100 % availability period.

DEFINITIONS

NPHR = (Wms * Hms - Wfw * Hfw) / Pnet, where

NPHR, btu/kWh

Wms - Main steam flow, lb/d

Hms - Main steam enthalpy, btu/lb

Wfw - Feedwater flow, lb/d

Hfw - Feedwater enthalpy, btu/lb

Pnet - Net Power Out, kW

Eb = (Qout / Qin) * 100, or Heat Out / Heat In where

Eb - Boiler efficiency, %

Qout = (Wms * Hms - Wfw * Hfw), mmbtu/d

Qin = Wcoal * Hcoal, mmbtu/d

Wcoal - Daily coal loaded belt scale, lbs

Hcoal - Higher heating value determined from samples taken from the automatic sampler on the coal feed-to-storage belt.

METHODOLOGY

Heat rates and efficiencies were calculated on a daily basis and presented both on a 90 day and consecutive full-load period basis.

Hourly values of net power were obtained from the GVEA dispatcher's log on a daily basis.

Power, steam flow and feedwater flow were totaled for the day.

Hourly values of main steam temperatures and pressures were averaged for the day.

Steam enthalpy was obtained from an inter-active computer program with temperature and pressure inputs. Feedwater enthalpy (400 btu/lb) was obtained from the same computer program with a temperature of 422$^{o}$F and a pressure of 1,385 psia as obtained from a review of the hourly data.

HEAT INTO THE BOILER

Coal heat into the boiler is the product of coal flow and its heating value.

For purposes of these calculations, the automatic coal sampler data was used with the coal feeder flow data.

The coal samples taken manually at the feeder were not used in this analysis for the following reasons:

1) The feeder sample probe was not collecting a representative sample. The larger size coal containing a higher heating value was not being collected probably for 3 reasons.

a The semi-circular 6 inch probe diameter is too small to sample a larger size coal stream discharging from the feeder belt,

b The probe port is located to catch material closer to the belt which is smaller in size, and

c Larger size coal was rejected during unloading the sample probe. This occurred by scraping off excess coal above the diameter of the semi-circle of the probe before sacking the sample.

2) Until about September, 25 1999, it appears that sample coal which would not fit through the vanes of the splitter during the daily sample splitting process were being thrown aside and not included in the final samples.

Early in the 90 Day Test, the Usibelli loaded coal analyses were suspect as being too high. The theory was that their sample grinder was not sufficiently powerful enough to grind hard rock such as granite and that granite in the sample was being rejected. Rejection of rock in the sample results in biasing the results to a higher value. Samples were sent to a commercial testing lab and the results confirmed that regardless of the possibility of rejection of rock at Usibelli, the effect was not significant. Also the fact that a small amount of rock is manually removed on occasion by operators seated at a pick station near the top of the conveyor upstream of the automatic sampler cannot be detected in any sample results.

## HCCP RELATIVE TO OTHER FACILITIES

### EFFICIENCY OF HCCP RELATIVE TO OTHER

### SOLID FUEL FACILITIES OF SIMILAR SIZE

To illustrate where the NPHR of HCCP fits into other similar small solid-fuel plants, a list is compiled for comparison. Only coal and coke-fired units are included. This data is taken from recent operating reports in Harris Group's library.

The comparison list includes:

| | NPHR BTU/kWh |
|---|---|
| Healy Unit 1 (1998) - A 20 MW net coal-fired plant burning 7,200 btu/lb coal in a PC boiler with low NOx burners | 13,786 |
| A 33 MW net waste coal-fired plant burning 8,350 btu/lb coal in a circulating fluidized bed boiler | 13,756 |
| A 50 MW net waste coal-fired plant burning 5,050 btu/lb coal in a circulating fluidized bed boiler | 13,496 |
| A 66 MW net coal and pellet-fired cogeneration plant burning | |

| | |
|---|---|
| 12,860 btu/lb coal and 7,845 btu/lb pellets in a PC boiler | 13,438 |
| A 17.5 MW net coal-fired plant burning 12,716 btu/lb coal in a bubbling fluidized bed boiler | 13,429 |
| | NPHR BTU/kWh |
| A 57 MW net fluidized petroleum coke-fired cogeneration plant burning 14,000 btu/lb coke and processing 488 btu/lb coker gas in two circulating fluidized bed boilers | 13,297 |
| A 51 MW net waste coal-fired plant burning 5,724 btu/lb coal in a circulating fluidized bed boiler | 12,918 |
| A 30 MW net waste coal-fired plant burning 5,701 btu/lb coal in a circulating fluidized bed boiler | 12,894 |
| Healy HCCP 50 MW net waste coal-fired plant burning 7, 187 btu/lb coal in a low NOx combustor PC boiler | 12,800 |
| A 53 MW net coal-fired cogeneration plant burning 11,700 btu/lb coal in a circulating fluidized bed boiler | 12,127 |

The NPHR for each non-cogeneration plant is calculated from recent operating data and is defined as:

$NPHR = Q_{in} / E_{net}$ where

NPHR - Net Plant Heat Rate, btu/kWh

$Q_{in}$ - Heat into the boiler, btu

$E_{net}$ - Net power out, kWh

For those units which cogenerate steam, a fuel-charged-to-power NPHR is defined as:

$NPHR = ( Q_{in} - Q_{equiv} ) / E_{net}$ where

$Q_{equiv}$ - Net heat In equivalent to generate export steam, BTU

$Q_{equiv} = W_{stm} * ( H_{stm} - H_{mu})$ where

$W_{stm}$ - Export steam flow, lb/h

$H_{stm}$ - Export steam enthalpy, btu/lb

$H_{mu}$ - Boiler makeup water enthalpy, btu/lb

This definition applies to plants which receive no condensate return from their host. Condensate return energy is considered in plants where condensate is returned.

# SECTION 9

# ECONOMICS

## PLANT HEAT RATE

The plant heat rate for HCCP over the 90 Day Test was 12,800 btu/nkwh, as noted in Section 7. It is our opinion that this is comparable with other solid fuel units of similar size.

There are some possibilities that this heat rate might be reduced if the project goes forward.

First, if the exhausters are retrofit there could be some small reduction in auxiliary power usage and therefore in heat rate.

Second, if FUJI's preliminary calculations are correct, the turbine may have lost 2% of its heat rate in the first two years of operation. It is possible that this could be recovered during a turbine overhaul, thereby reducing the overall heat rate by over 200 btu/nkwh.

## OPERATIONS

During the 90 Day Test, GVEA charged HCCP for full-time equivalent personnel of 27.6. That is; 14,178 hours over the full 12 week period. Note that we have deleted 40% of the coal handling time, as it should be charged to unit 1, per the project agreement.

During the 90 Day Test, AIDEA charged 14,838 hours. We have deducted those hours that were charged to punch list items, test support, and 50% of the time charged to miscellaneous, cleanup, and incidental. This results in equivalent full time personnel of 15.3.

This gives a total of 43 full-time equivalent personnel assigned to HCCP during the 90 Day Test.

We have considered the following items in our assessment of personnel.

- GVEA's estimate of additional personnel required for the added unit of 25.5 and a total operating staff at Healy (see F. Abegg testimony before the APUC, Appendix 5). It is our opinion that this estimate is reasonable for the first years of a demonstration project, but that over a period of time this number should be reduced by 10 to 15%.
- The fact that the control rooms for HCCP and Unit 1 were not combined so that a single operator could operate both units. Note that it is our opinion that because the technologies are so different and it takes the full attention of one operator to operate HCCP when there is a significant amount of waste coal being burned, the operations most likely cannot be combined and performed by one operator.
- We are aware of and have reviewed both the R.W. Beck and Sterling reports related to staffing. Based on our observations, our belief that two Control Room operators may be needed and also a review of the Union contract, we are of the opinion that these reports provided very aggressive opinions on staffing.

Based on the GVEA proposed 55.5 and adding 4.5 for a second control room operator, we arrive at 60 total personnel. Utilizing the 60/40 split generally agreed to by the parties for charges to the units, the expected compliment of personnel for HCCP should be about 36.

It is our opinion that the work force on-site during the test was excessive and not representative of what will be required for long term operation of the unit. However, AIDEA chose that work force and so the numbers are: 43 personnel worked on HCCP during the 90 Day Test, and 36 would be a normal expectation.

We are of the opinion that the ultimate operating and maintenance force could be less than 50.

It should be noted that the GVEA Control Operators have taken over operation of the unit during the 90 Day Test. As their confidence grew, the AIDEA personnel were able to back away from hands on control.

## LIMESTONE USAGE

The 90 Day Test did not demonstrate what long-term limestone usage may be because of the continued operation with excess limestone feed. This mode of operation certainly guaranteed that there would be no excess $SO_2$ emissions, however, it is standard utility practice to optimize the limestone feed such that emissions are not exceeded, but reagent usage is minimized.

We cannot conclude anything more about limestone usage than actual long-term usage should be less than utilized during the 90 Day Test.

# SECTION 10

# RETROFIT CONSIDERATIONS

## RETROFIT CONSIDERATIONS

It is our opinion that conversion of the combustion equipment from the existing TRW precombustor/slagging combustor system to conventional low-$NO_x$ burners will not improve the commercial viability of HCCP. In fact, if converted to conventional low $NO_x$ burners, limitations on coal quality may have to be more severe in order to prevent excessive fouling of the boiler. Also, the scrubber and baghouse will be affected by the additional flyash in the flue gas (up to three times as much) and particulate emissions may increase. Moreover, the TRW system can be expected to perform acceptably on a long-term basis when the slagging combustor is continuously operated on waste coals, as long as the coal quality fed to the precombustor is maintained at higher levels (e.g., >6,800 btu/lb).

The low $NO_x$ burners installed on Unit 1, did show that lower btu coal could be burned during a long operation period in 1998. GVEA has chosen not to burn any waste coal on Unit 1 for all of 1999 and beyond because, we have been told, there is too much maintenance on the pulverizers to make it economic to burn waste coal. Therefore, it seems that retrofitting low $NO_x$ burners on HCCP would be a step backward.