TOXECON™ Retrofit for Mercury and Multi-Pollutant Control on Three 90-MW Coal-Fired Boilers

Preliminary Public Design Report

Prepared By
Wisconsin Electric Power Company
333 West Everett Street
Milwaukee, WI 53203

May 15, 2006

DOE Cooperative Agreement No.: DE-FC26-04NT41766

Theodore J. McMahon, USDOE Project Officer

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Executive Summary

This document provides a summary of the design efforts involved in the project *"TOXECON™ Retrofit for Mercury and Multi-Pollutant Control on Three 90-MW Coal-Fired Boilers."* This project is being conducted under the Department of Energy's Clean Coal Power initiative. The project is taking place at the We Energies Presque Isle Power Plant located in Marquette, Michigan.

The project features the installation and commercial demonstration of the EPRI-patented TOXECON™ air pollution control process. This process is an integrated emission control system for removing mercury and particulate matter that will treat the flue gases from three 90-MW subbituminous coal-fired units. The process involves the injection of sorbent between an existing particulate collector (at Presque Isle, the existing collectors are hot-side electrostatic precipitators) and a fabric filter (baghouse) installed downstream. The sorbent collects mercury that is then removed from the flue gas using the baghouse. The project will also investigate the capabilities of the system to control SO_2 and NO_x emissions.

In addition to the primary air pollution control system, balance-of-plant design considerations are addressed. These include booster fans, compressed air system, ash handling system, ductwork, electrical, and instrumentation and controls. A task in the project is devoted to advancing a monitoring system that will reliably measure mercury in flue gas from coal-fired power plants. Design considerations of a mercury continuous emissions monitor are included in this report.

The costs of equipment and installation for the TOXECON™ and balance-of-plant systems are $34.4 million, including the engineering effort.

1.0 Introduction

1.1 Purpose of the Public Design Report

The purpose of this Public Design Report is to provide non-proprietary design information for the TOXECON™ air pollution control system being installed at the We Energies Presque Isle Power Plant located in Marquette, Michigan, under U.S. Department of Energy Cooperative Agreement No. DE-FC26-04NT41766.

1.2 Project Overview

1.2.1 The Clean Coal Power Initiative

The project described in this report is being conducted under the Department of Energy's (DOE) Clean Coal Power Initiative (CCPI). CCPI is an industry/government cost-shared partnership to implement clean coal technology under the National Energy Policy (NEP). The NEP investment in clean coal technology focuses on increasing the domestic energy supply, protecting the environment, ensuring a comprehensive energy delivery system, and enhancing national energy security. CCPI is an important platform for responding to these priorities.

CCPI was initiated in 2002 with a goal of accelerating commercial deployment of advanced technologies to ensure the United States has clean, reliable, and affordable electricity. CCPI builds upon the advancements made by previous and continuing clean coal research and ensures the ongoing development of advanced systems for commercial power production.

1.2.2 This Project

We Energies and the project team will design, install, evaluate, and operate an integrated emissions control system for mercury and particulate matter that will treat the flue gases of three 90-MW subbituminous coal-fired units. This will be the first commercial full-scale TOXECON™ demonstration with activated carbon injection (ACI) for mercury removal. TOXECON™ is an EPRI-patented process (U.S. Patent 5,505,766) for removing pollutants from combustion flue gas by injecting sorbent in between an existing particulate collector (at Presque Isle, the existing collectors are hot-side electrostatic precipitators) and a fabric filter (baghouse) installed downstream of the existing collector for control of toxic species. The TOXECON™ configuration, shown in Figure 1, allows for separate treatment or disposal of the ash collected in the hot-side ESP (99% or greater) and the ash/sorbent collected in the TOXECON™ baghouse.

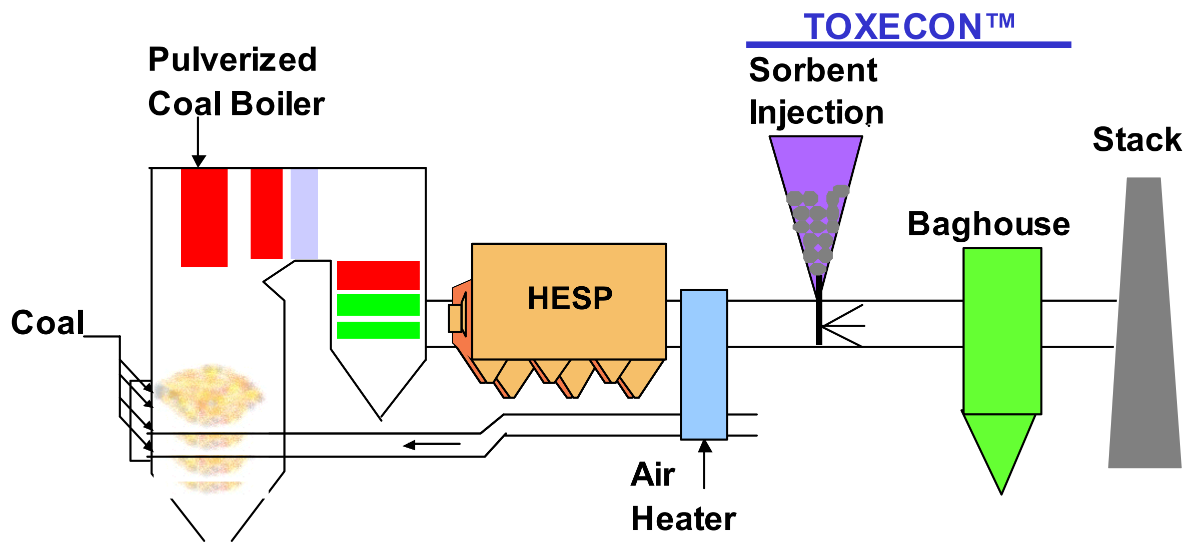

Figure 1. TOXECON™ Configuration.

The proposed project will advance the ancillary processes that are key to mercury control, such as mercury measurement technology and waste minimization. The proposed project will also investigate the capabilities of the system for SO_2 and NO_x control, although these evaluations are secondary priorities and will be dealt with after the mercury control issues have been addressed.

The project will take place at We Energies' Presque Isle Power Plant located in Marquette, Michigan. Presque Isle Power Plant has nine boilers. This project will be applied to Units 7, 8, and 9, each of which is a 90-MW unit with an individual hot-side electrostatic precipitator (HESP) as the primary particulate matter (PM) control device. The exhausts from the three HESPs are ducted into individual flues of a common stack. The project involves controlling the emissions from the three units using a single baghouse. Integrating the three units into one project and structure provides significant cost savings over treating the units separately, and optimizes the use of space.

The TOXECON™ process is ideal for the Presque Isle Power Plant because the existing HESP exhausts will benefit from the additional PM control, especially during start-up and shut-down. Also, the existing HESPs used for PM control do not have the ability to remove mercury from the flue gas, and injection of powdered activated carbon (PAC) into these HESPs is not feasible due to the high flue gas temperatures. The TOXECON™ process will also allow We Energies to continue to sell its fly ash from the HESPs because the carbon is injected downstream of these units.

The project team includes We Energies, ADA-ES, Inc., Cummins & Barnard, and the Electric Power Research Institute (EPRI). We Energies provides and operates the demonstration site, as well as providing project management, environmental permitting, and reporting. ADA-ES is the project management interface with DOE's National Energy Technology Laboratory (NETL), and is responsible for design of the mercury control system, design of the mercury monitoring system, demonstration testing of the entire process, and reporting. Wheelabrator is responsible for the design and construction of the baghouse, support of baghouse installation, and provides start-up support under a subcontract to We Energies. Cummins & Barnard (C&B) provides architect and engineering services, construction management, design and specification of equipment, equipment installation, and start-up training for plant operators. EPRI provides technical advice to We Energies.

1.2.3 Site Information

The Presque Isle Power Plant (PIPP) Units 7, 8, & 9 were placed in service in 1978, 1978, and 1979 respectively by Upper Peninsula Power Co. to meet the needs of Cleveland – Cliffs Iron Co. Wisconsin Electric purchased the plant in 1988.

The boilers are Riley Turbo units rated for a maximum continuous capacity of 615,000 lb/hr steam flow at 1625 psig superheater outlet pressure and 1005 ^{o}F. Reheater steam flow is 555,000 lb/hr at 390 psig and 1005 ^{o}F. Each unit is fired by two 10' X 13' Riley Ball Tube Mills and Directional Flame Burners.

The precipitators were designed and built by Joy-Western and are designed as hot side precipitators with an operating range of 565 – 745 ^{o}F. The units are two chambers wide and are a weighted wire unit consisting of six mechanical fields per chamber and twelve electrical frames, six per chamber powered by six full wave T/R's. The units were designed to collect fly ash from a pulverized coal boiler with a gross rating of 93 MW and a design ACFM of 530,000. The design collection efficiency was 99.20%.

The combustion process is controlled by an Emerson Distributed Control System with a Smart "Combustion Optimization" software package to optimize NO_x and LOI.

The Presque Isle Power Plant burns Powder River Basin (PRB) subbituminous coal in Units 7–9. Table 1 provides an analysis of this fuel. The arithmetic mean average of mercury in PRB coal is 0.13 μg/g (Stricker and Ellis, 1999). Analysis of the coal sampled at Presque Isle in 2001 showed a mercury concentration of 0.046 μg/g.

PRB coal is supplied by several mines in Wyoming and Montana (dependent on the price of the fuel) and shipped by rail to Superior, Wisconsin, where it is then loaded onto a lake boat for delivery to the PIPP.

Table 1. Compositional Analysis of Subbituminous Coal Used at the Presque Isle Power Plant.

Characteristic	Typical Value
Higher Heating Value, Btu/lb	9,052
Analysis, percent by weight	
Moisture	25.85
Carbon	52.49
Hydrogen	3.65
Nitrogen	0.75
Sulfur	0.28
Ash	4.64
Oxygen	12.33
Chlorine	0.01

Typical flow rates and gas components in the flue gas exiting the HESPs of Units 7–9 are shown in Table 2.

Table 2. Comparison of Flue Gas Composition Downstream of HESPs in Flues 7, 8, and 9 at the Presque Isle Power Plant.

Characteristic	Flue 7	Flue 8	Flue 9
Gas Volumetric Flow Rate, acfm	377,719	375,014	335,439
Average Gas Temperature, ºF	364.6	344.8	366.6
Flue Gas Moisture, % by volume	12.1	13.3	12.7
Average % CO_2 by volume, dry basis	12.8	13.0	13.0
Average % O_2 by volume, dry basis	6.2	6.0	6.0
Filterable PM, lb/hr	15.13	9.99	20.35
NO_x, lb/hr	407.8	410.5	406.8
SO_2, lb/hr	461.9	464.7	474.7
Mercury, ppm dry (Average Units 7–9)	0.062	0.062	0.062

2.0 Technology Overview

Injecting a sorbent such as PAC into the flue gas represents one of the simplest and most thoroughly studied approaches to controlling mercury emissions from coal-fired boilers (Government Accountability Office, 2005). The gas-phase mercury in the flue gas contacts the sorbent and attaches to its surface. The sorbent with attached mercury is then collected by the existing particle control device, either an electrostatic precipitator (ESP) or fabric filter. Over the past several years, the results from numerous full-scale evaluations of ACI for mercury removal indicate that activated carbon is a viable technology for mercury control on many coal-fired power plants (Durham, et al., 2003; Bustard, et al., 2001).

For some plants, one of the disadvantages of injecting activated carbon is its impact on the salability of ash for making concrete. Tests have shown that the activated carbon interferes with chemicals used in making concrete (Bustard, 2003). One straightforward, cost-effective approach to achieving high mercury removal without contaminating the fly ash is the use of the EPRI TOXECON™ process that is currently commercially offered. With the TOXECON™ configuration, the ash collected upstream of the carbon injection remains acceptable for sale. The downstream fabric filter provides an effective mechanism for the activated carbon to have intimate contact with vapor-phase mercury, resulting in high levels of mercury control at relatively low sorbent injection rates.

The advantages of the TOXECON™ configuration are:

- Sorbents are mixed with a small fraction of the ash (the nominal 1% that exits the primary PM device), which reduces the impact on ash reuse and waste disposal.
- Full-scale field tests have confirmed that fabric filters require significantly less sorbent than ESPs to achieve similar mercury removal efficiencies (Bustard, 2004).
- Outage time can be significantly reduced with TOXECON™ systems in comparison to major ESP rebuilds/upgrades that might be required to handle the increased loading and greater collection difficulty of the injected carbon. Since the TOXECON™ unit is added downstream of the ESP, experience shows that it can be built, installed, and checked while the ESP is still in full operation, thus keeping outage time to a minimum.
- Baghouse types include shaker-cleaned, reverse-air-cleaned, pulse-jet-cleaned, and sonic-cleaned. A pulse-jet-cleaned baghouse was chosen for this application. Pulse jet baghouses use fabric filtration media shaped like tubes called bags, which are usually 4-6 inches in diameter and 10 to 26 ft. long, to remove the particulate matter from the flue gas stream. The bags are mounted (hung) from a tube sheet and the gas stream flows from the outside of the bag through the bag, depositing particulate matter on the outside of the bag. The particulate matter is removed from the bag by a cleaning system that employs compressed air (systems are designed to use compressed air from 30 – 120 psig) to back flush the bags. (McKenna, J.D.).

The following information provides the reader with an introduction to common terminology related to fabric filters and the TOXECON™ technology.

- **Pressure Drop/Drag** – Pressure drop and drag are both used to monitor the permeability of the filter and filter cake. Pressure drop is a direct measurement of the pressure difference across the fabric filters. Drag is a calculated number that normalizes pressure drop to flow by dividing pressure drop by the A/C ratio. These values are a function of inlet grain loading, filtering characteristics of the particulate matter, flue gas flow rate, and time between cleaning. The particulate matter, or dust, adhering to the outside of the bags is usually referred to as "cake", which acts as a filtering medium and presents a resistance to flow. A greater inlet loading or longer bag cleaning cycle time will result in deposition of a thicker cake collected on the bag surface. A thicker cake on the surface results in a higher pressure drop Excessive pressure drop is undesirable because of the energy required to overcome it. Fans need to be sized to compensate for this expected pressure drop and higher pressure drops require larger horsepower and subsequently more power. Once a system is designed and in operation, excessive pressure drop is a problem if the pressure drop exceeds the fan capacity. In this case, a generating unit becomes load limited due to insufficient fan capacity to run at full load. In addition, the cleaning system needs to run more often, which consumes additional compressed air motor energy, and the bag life is shortened due to having to more cleaning cycles. Bags flex when they are cleaned because they are made of a fabric material, and this flexing eventually causes a failure of the material. (McKenna, J.D.).
- **Cleaning Frequency** – Pressure drop and drag are controlled in a baghouse by the cleaning frequency. Higher inlet loading causes increased pressure drop and subsequent increased cleaning frequency. Cleaning cycles are initiated by a set pressure drop value for the system. When the system pressure drop increases to this point a cleaning cycle is initiated (see "Cleaning Modes" below). It is expected that cleaning frequency will increase with the increased particulate loading from sorbent injection. Cleaning frequency will be monitored before, during, and after sorbent injection.
- **Opacity/Emissions** – Cleaning frequency and particulate matter characteristics can affect collection efficiency across the baghouse. Most emissions occur immediately following cleaning, so increasing the cleaning frequency can increase outlet emissions. The emissions could also increase if the particulate does not form a high-efficiency filter, but tends to work through the fabrics.
- **Air-to-Cloth (A/C) Ratio** – The ratio between flue gas flow (acfm) and total fabric surface area (ft^2), expressed in ft/min. A lower A/C ratio indicates a larger, more conservative design. Typically, pulse-jet fabric filters are designed with A/C ratios between 3 and 4 ft/min. COHPAC® and TOXECON™ applications target a higher, more economical design between 5 and 8 ft/min.
- **Cleaning Modes** – Pulse-jet fabric filters are generally cleaned with either "online" or "offline" cleaning. In either case, cleaning is usually initiated when a predetermined pressure drop or drag setpoint is reached. In the case of offline cleaning, when the setpoint is reached, inlet and/or outlet dampers close, isolating a

single compartment. This compartment is then systematically pulsed, row-by-row, until it has been entirely cleaned. The isolating dampers are then opened and flue gas reenters the compartment. In the case of online cleaning, when the setpoint is reached single rows are cleaned around the various compartments without any isolation. Because flue gas continues to flow through the bags being cleaned during online cleaning, the degree of cleaning is reduced. The benefits of online cleaning are that there is not a pressure spike (from isolating a compartment) and there is not a sudden very clean area in the fabric filter. When a compartment is cleaned offline, it creates a "hole" in the fabric filter, which can temporarily reduce particulate control and potentially mercury control.

2.1 Full-Scale TOXECON™ Testing at E.C. Gaston Unit 3

DOE/NETL began supporting full-scale evaluations of sorbent injection for mercury control in 2000. The first site tested in 2001 was Alabama Power's E.C. Gaston Station Unit 3 (Bustard, et al., 2001). In this short-term test, activated carbon was injected upstream of a COHPAC® fabric filter. COHPAC®, also an EPRI technology, is a fabric filter installed downstream of the existing particulate control device and is used to capture particles escaping from the primary particulate control device; however, with COHPAC® there is no sorbent injection for control of toxic species. Although this unit was designed as a COHPAC® fabric filter, when ACI was added, the test was actually evaluating the TOXECON™ configuration.

Figure 2 presents the results from parametric tests, which evaluated mercury removal at different PAC concentrations. The tests showed that 90% mercury removal could be achieved at relatively low injection concentrations (<3 lbs/MMacf); however, they also showed that baghouse cleaning frequency increased proportionally with injection rate (Figure 3).

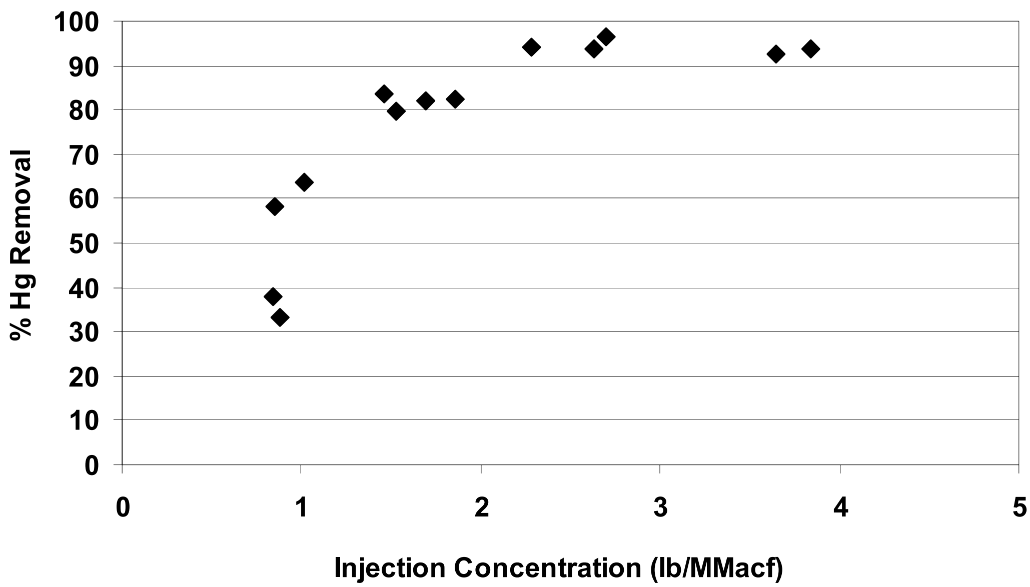

Figure 2. Mercury Removal with Activated Carbon Injected Upstream of COHPAC® at Alabama Power Plant Gaston, Spring 2001.

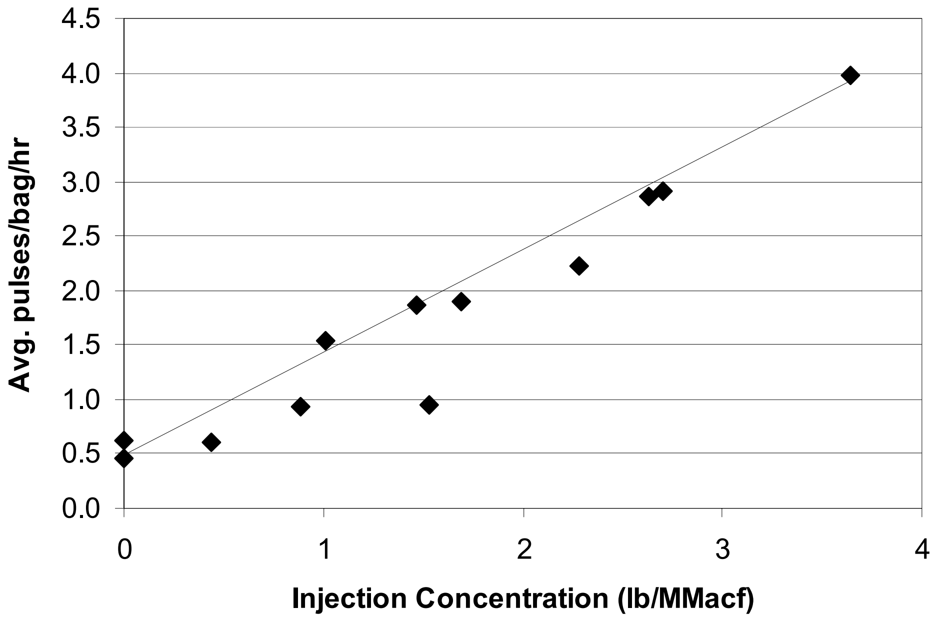

Figure 3. COHPAC® Cleaning Frequency in Pulses/Bag/Hour as a Function of ACI Concentration. Measurements Made During Parametric Tests, March 2001.

Based on these results, a two-week injection test was conducted at an injection concentration of 1.5 lbs/MMacf, which was the highest injection rate possible without significantly impacting cleaning frequency. Figure 4 presents inlet and outlet mercury concentrations, boiler load, and carbon injection rate for a portion of the two-week test. Also shown in this graph are the results from Ontario Hydro mercury measurements.

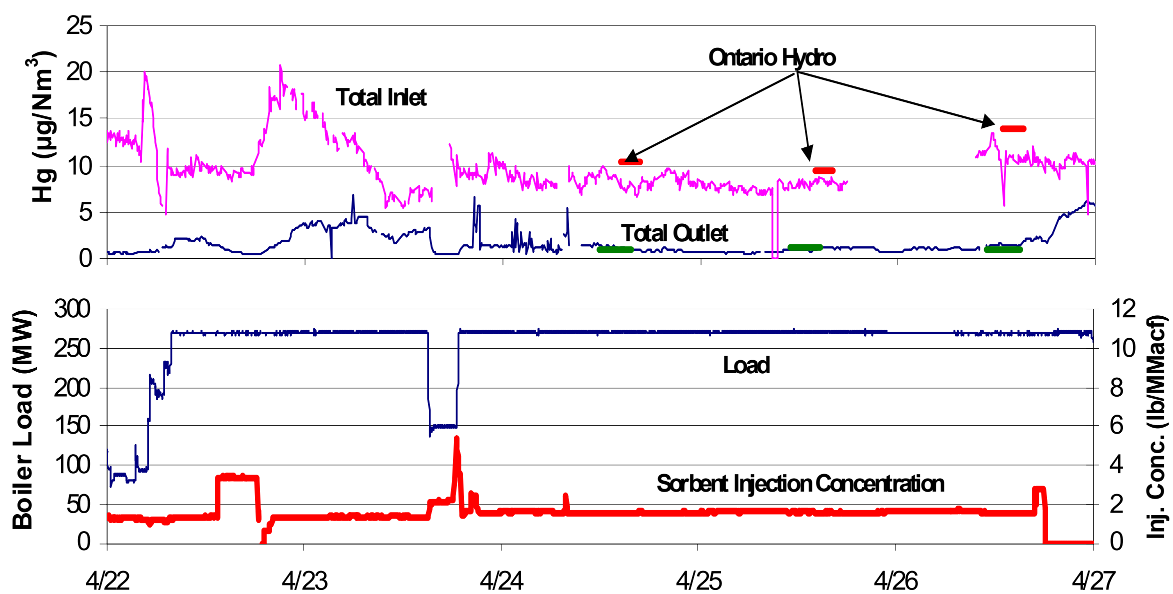

Figure 4. Inlet and Outlet COHPAC® Mercury Concentrations, Boiler Load, and ACI Rates; Plant Gaston, 2001.

The results from this 2001 field test program at Gaston provided a good indication of the capabilities (high mercury removal) and limitations (high cleaning frequency) of the TOXECON™ technology for controlling mercury. However, the tests were performed for a limited amount of time (<200 hours of continuous operation) and did not allow for a thorough operational analysis of the use of this technology for mercury control. The tests also suggested that designing the baghouse for a lower A/C ratio might allow carbon injection at a rate consistent with high removals without excessive pressure drop.

In the fall of 2002, NETL selected ADA-ES to conduct a long-term evaluation of ACI into the COHPAC® fabric filter at the Gaston Station (Berry, et al., 2004). The overall objectives of this yearlong mercury control program were to assess the operational impacts to COHPAC® and the ability to effectively control mercury over varying operational and seasonal conditions.

The test program was designed with three test periods plus a short-term test evaluating performance at a lower A/C ratio. The purpose of each test is described below:

1. Baseline: Testing in this period was dedicated to understanding fabric filter operation and mercury removal with no carbon injection.
2. Optimization: The tests in 2001 showed that carbon injection directly impacted fabric filter cleaning frequency (Bustard, et al., 2001). This period was included to find a carbon injection scheme that achieved the highest mercury removal within the operational limits of the system.
3. Long-Term Testing: Operate continuously at optimized injection conditions.
4. Low A/C Test: Obtain operating data at an A/C ratio deemed appropriate for a TOXECON™ fabric filter.

2.1.1 Baseline Tests

In the follow-on tests, COHPAC® cleaning frequency and native mercury removal (removal of vapor-phase mercury by the carbon in fly ash) were very different from what was seen during the 2001 tests. Figure 5 presents mercury concentrations, mercury removal, cleaning frequency, and inlet mass loading for a portion of the baseline test. Cleaning frequency was much higher than expected, and was above the target maximum cleaning frequency of 1.5 pulses/bag/hour (p/b/h), which was used during the two-week test in 2001. As can be seen, there were times when the fabric filter was cleaning continuously at 4.4 p/b/h.

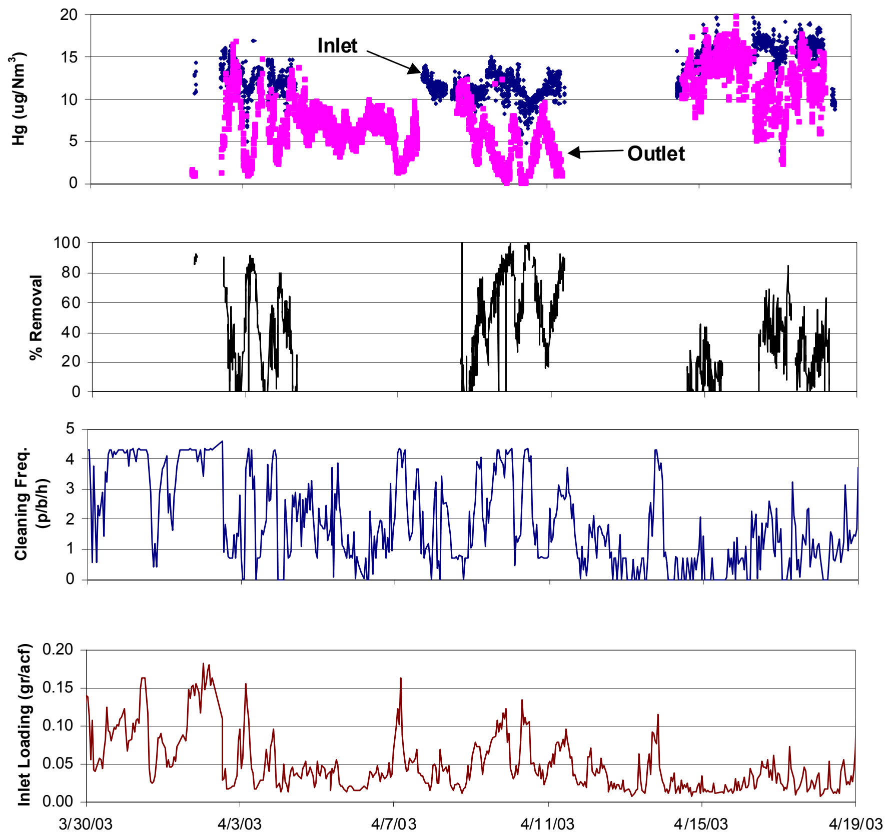

Figure 5. Mercury Concentrations, Inlet Mass Loading, and Cleaning Frequency for Unit 3B COHPAC® During Baseline Operation in Spring 2003.

In the earlier tests, there was virtually no mercury removal at baseline conditions. In this second round of tests, mercury removal varied between 0 and 90%, as shown in Figure 5, and was dependent on inlet mass loading.

The difference in performance was caused by substantially higher particulate mass loading exiting the HESP and entering the fabric filter. Hot-side ESP performance was evaluated and suggested that the HESP was operating within design conditions for the type of ash being collected and without any flue gas conditioning. So, although the HESP was performing within design specifications, there was a much higher amount of ash exiting the unit, creating an inlet loading greater than the design conditions for the COHPAC® fabric filter.

In order to understand the high inlet loading to the COHPAC® unit, Loss on Ignition (LOI) tests were performed on the ash. The LOI is an indication of the carbon content in the ash, which can affect the native mercury uptake. A high LOI can also adversely affect the performance of ESPs, allowing more particles to escape the unit. The LOI of the ash in the first baseline tests was 11%, while the second baseline tests showed an LOI of 17.4% (Bustard, et al., 2003). This increase in LOI could have been a factor in both the high inlet loading to the COHPAC® unit and the intermittent high native mercury removal. Figure 6 shows a visual comparison between the ash samples collected in the first baseline tests in 2001 and the samples collected in 2003.

Hamon Research-Cottrell was brought in to inspect the HESP in an effort to determine why there was a high particulate loading entering the COHPAC® unit. Power levels were found to be extremely low in all fields of the HESP, which may have been caused by the high carbon/low resistivity ash. Low power levels could also directly reduce capture efficiency. Also, two chambers fields were out of service, which could also negatively impact capture efficiency (Bustard, et al., 2003). Several other factors may have contributed to the creation of low resistivity ash such as coal type and/or boiler operations, but no definitive source was identified.

Figure 6. COHPAC® Hopper Ash Comparison.

2.1.2 Optimization Tests

Because of the highly variable baseline conditions and the already poor performance of the fabric filter, the ability to inject activated carbon was severely limited. To overcome this, an injection scheme was implemented that balanced the need to decrease carbon injection during times when inlet loading to the fabric filter was high and increase carbon injection when inlet loading and mercury removal were low. A signal from a particulate monitor measuring COHPAC® inlet mass loading was used to control ACI. The control settings can be seen in Table 3. When inlet loading was less than 0.07 gr/acf, injection rate was set to either 16 or 20 lbs/h (0.52 or 0.66 lbs/MMacf). When inlet loading was higher, between 0.07 and 0.14 gr/acf, the injection rate was lowered to 10 lbs/h (0.35 lbs/MMacf). When inlet loading was greater than 0.14 gr/acf, the baghouse was often in a state of continuous cleaning and carbon injection was turned off. Removal efficiency was not significantly impacted at the lower rates because the natural loading and mercury removal efficiency were higher.

Table 3. Optimized Activated Carbon Injection Settings.

Ash Inlet Loading (gr/scf)	Ash Inlet Loading (gr/acf)	Carbon Injection Concentration (lbs/MMacf)	Carbon Injection Rate (lbs/h)	Carbon Injection Rate (gr/acf)
<0.1	<0.07	0.52 or 0.66	16 or 20	0.0036–0.0046
0.1–0.2	0.07–0.14	0.35	10	0.0025
>0.2	>0.14	0	0	0

2.1.3 Long-Term Tests

Figure 7 presents a snapshot of data during the long-term test. Inlet and outlet total vapor-phase mercury, calculated mercury removal, carbon injection concentration, baghouse cleaning frequency, and inlet mass loading are presented. During this period, inlet mass loading varied from 0.03 gr/acf to 0.19 gr/acf and carbon injection concentration can be seen to adjust to these changes. The baghouse was in continuous clean, even when carbon injection was turned off. Mercury removal varied between 50 and 98%, with an overall average of 90%.

Average daily and weekly inlet and outlet mercury concentrations and mercury removal efficiencies for a four-month period are presented graphically in Figure 8. The average inlet mercury concentration was 14.3 $\mu g/Nm^3$, with daily average concentrations varying between nominally 5.1 to 25.6 $\mu g/Nm^3$. The average outlet mercury concentration for the same period was 2.1 $\mu g/Nm^3$, with daily average concentrations varying between 0.24 and 6.2 $\mu g/Nm^3$. Average mercury removal was 85.6%, with a minimum daily average of 63.5% and a maximum daily average of 98.1%. The maximum carbon injection concentration was 0.66 lbs/MMacf, and at times carbon injection was turned off. The average injection concentration was 0.55 lbs/MMacf, which was much lower than what was needed in the 2001 test to obtain similar removal efficiencies (Bustard, et al., 2001).

It is believed that the higher removal efficiencies obtained at lower carbon injection concentrations than predicted in the earlier tests occurred because there was significant carbon on the bags from the higher baseline mass loading entering the baghouse. The COHPAC® hopper ash had a relatively high carbon content with LOI between 15 and 30%.

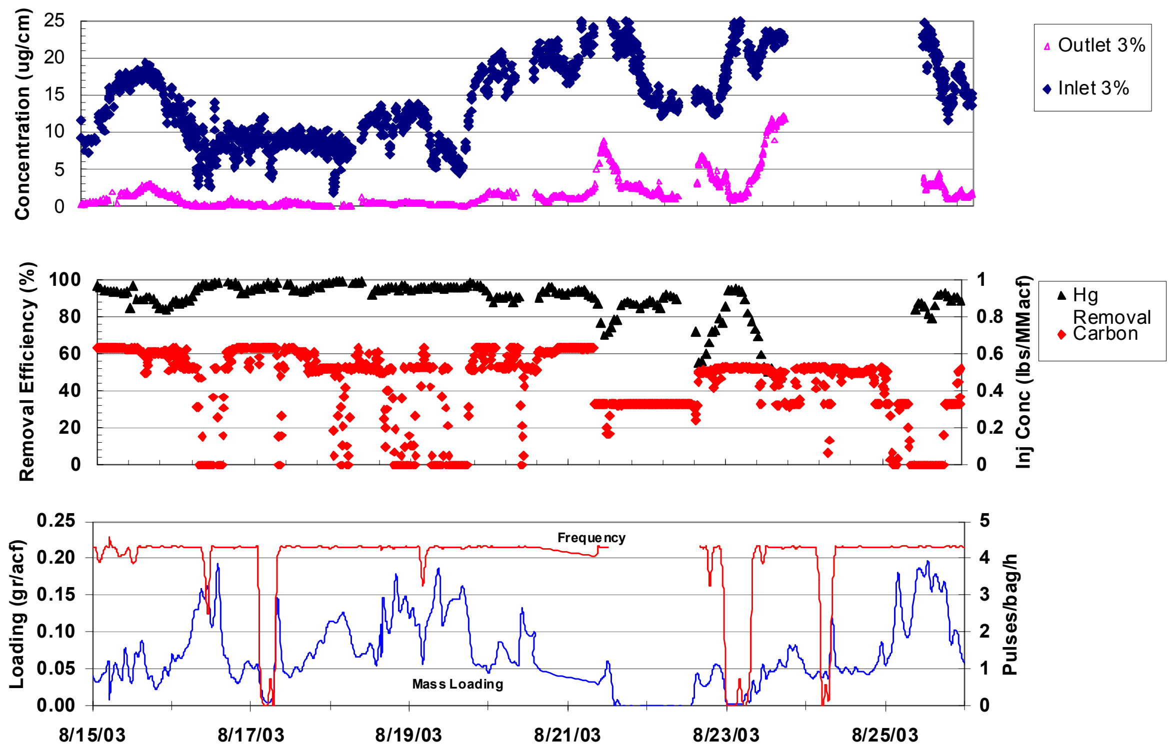

Figure 7. Mercury Concentrations (corrected to 3% O_2), Removal Efficiency, Injection Concentration, Inlet Mass Loading, and Cleaning Frequency for Unit 3B COHPAC® During Long-Term Testing, 2003.

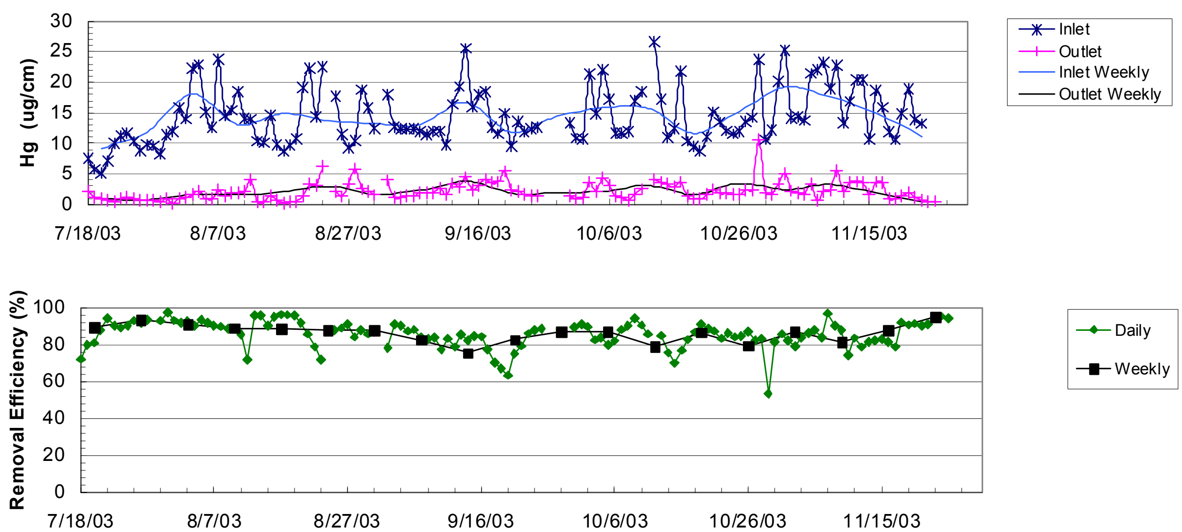

Figure 8. Daily and Weekly Averages of Inlet and Outlet Mercury Concentrations and Mercury Removal from July 19 through November 23, 2003.

2.1.4 Low-Load Tests

Throughout these tests, the higher than expected mass loading into COHPAC® limited the quantity of carbon that could be injected. Although the test plan and injection logic was altered to accommodate these real-life conditions, the question of how this information could be used in the design of new TOXECON™ systems was left virtually unanswered.

One thing that was clear from these tests was that the current A/C ratio was too high to inject sufficient carbon to achieve 90% mercury control. A new TOXECON™ baghouse would have to be designed at a lower A/C ratio. One way to overcome the operating limitations at this site was to operate at low load/lower flow for an extended period. While at these conditions, carbon injection could be increased and performance data could be tracked. The primary objectives of these short tests were to 1) determine the injection concentration necessary to achieve 90% removal, and 2) determine the impact of carbon injection on cleaning frequency at this lower A/C ratio. An educated estimate of the ideal A/C ratio was about 6.0 ft/min.

Alabama Power was able to schedule an extended period of low load operation for Gaston Unit 3. Full load at Gaston is nominally 270 MW. The flow rate is split into two baghouses so that at full load the flow into 3B baghouse is nominally 520,000 acfm. In November 2003, Unit 3 was operated at 195 MW for a 72-hour block of time. ADA-ES measured the flow rate into Unit 3B at 375,000 acfm using a mass flow meter. Table 4 summarizes the differences in key variables at these two load conditions.

Table 4. Comparison of Flue Gas Characteristics for High and Low Flow Conditions.

Unit 3 Boiler Load (MW)	**270**	**195**
Unit 3B Flow (afcm)	520,000	375,000
Unit 3B A/C ratio (ft/min)	~8.0	~6.0
Gas Temperature (ºF)	277	268
Oxygen Concentration (%)	7.84	8.35
Bag Surface Area (ft^2)	62,000	62,000
Ash Particulate Loading (gr/acf)	0.0761	0.0062

Three injection rates were evaluated during the 72-hour test. The first test was conducted at the highest injection rate possible under normal operating conditions, 20 lbs/h. At this rate and the lower flow, the injection concentration was 0.9 lbs/MMacf instead of 0.6 lbs/MMacf. The injection concentrations were then increased up to a maximum of nominally 3.3 lbs/MMacf.

The results from this test, including inlet and outlet mercury concentrations, mercury removal, and cleaning frequency are presented in Table 5. These data more closely matched the results shown in Figure 2 from the 2001 tests. At an injection concentration of 0.9 lbs/MMacf, mercury removal was between 80 and 90%. When injection concentration was increased above 2 lbs/MMacf, mercury removal was well above 90%, and there were no episodes when the removal dropped below this level. Cleaning frequency was acceptable at all injection rates during these short duration tests (baghouse pressure drops normally increase over long operational periods requiring increased cleaning frequency).

Table 5. Results Summary from Low Load Tests, November 2003

Injection Rate (lb/h)	Injection Concentration (lbs/MMacf)	Inlet Hg Concentration (µg/Nm^3)	Outlet Hg Concentration (µg/Nm^3)	Removal Efficienc y (%)	Cleaning Frequency (pulses/bag/hour)
20	0.9	20.6	3.2	84.2	0.6
45[a]	2.0	22.2	1.0	94.6	0.8
70	3.3	21.4	0.61	97.1	1.4

a. The last 18-hour time period of 45 lb/h test.

The results of the tests performed at Gaston showed that the TOXECON™ process can remove particulate and up to 90% of the mercury in the flue gas streams. Utilizing the existing COHPAC® unit allowed testing of the TOXECON™ concept at full scale, but was not flexible enough to provide the information needed to assess a full-scale, commercial installation. The Gaston tests were not sufficient to evaluate the commercial potential due to the size of the COHPAC® unit, which was designed to filter only the particulate loading from the HESP unit and not additional sorbent particles, which is the TOXECON™ contribution. However, Gaston testing provided valuable information in designing the full-scale TOXECON™ unit, such as a maximum A/C ratio of 6, desired carbon injection rate, etc.

2.2 Pilot-Scale TOXECON™ Testing

Over the years, EPRI has conducted numerous pilot- and bench-scale tests of TOXECON™ (Sjostrom, et al., 2002). Figure 9 summarizes results from these tests showing mercury removal trends on both bituminous and PRB coals. Since no full-scale COHPAC® or TOXECON™ fabric filters exist on units firing PRB coals, the best data available to predict performance at Presque Isle are shown in this figure. Both trends indicate that high mercury removal, 90%, can be achieved with an injection concentration less than 3 lbs/MMacf.

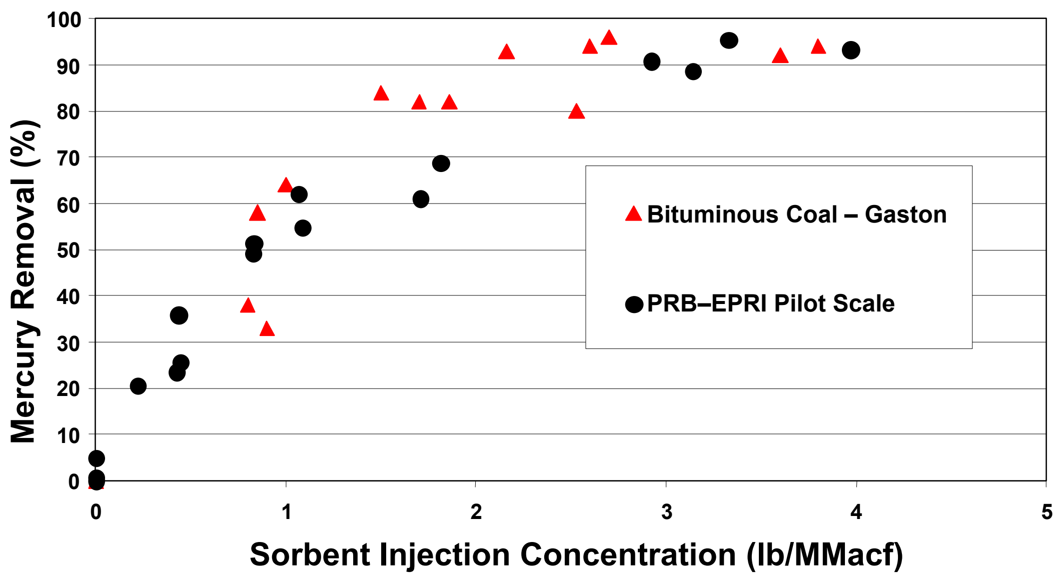

Figure 9. Mercury Removal in TOXECON™ Tests on Bituminous and PRB Coals.

2.3 Design Recommendations for Presque Isle TOXECON™

A full evaluation of the commercial potential of TOXECON™ requires long-term data on an installation that is specifically designed for both particulate control and sorbent injection. The installation should also have the flexibility to handle potential variability in particulate loading, as was seen at Gaston between the short-term and long-term testing periods.

Operational experience from the only two existing COHPAC® fabric filters in the U.S. (Gaston Units 2 and 3 and TXU's Big Brown Units 1 and 2) and test results from bench-, pilot-, and full-scale tests provided a good basis for design recommendations (Miller, et al., 1999; Bustard, et al., 2001). These recommendations included:

- **Air-To-Cloth Ratio** – The Gaston tests showed that TOXECON™ units designed at lower A/C ratios than COHPAC® are capable of high, 90%, mercury removal (short term). The recommendation for this TOXECON™ fabric filter, based on the low A/C ratio tests at Gaston, was for a maximum design gross A/C ratio of 6.0 ft/min.
- **Fabric** – The most accepted fabric for pulse-jet fabric filters installed on coal-fired power plants is made from a polyphenylene sulfide fiber, commonly referred to worldwide as PPS. PPS felted material is currently available under the trade names TORCON™ and PROCON™. The original equipment manufacturer (OEM) fabric for the four existing COHPAC® fabric filters was an 18 oz/yd^2, 2.7 denier, PPS felt. Denier is a unit used to measure the fineness of fabric, equal to the mass in grams of 9,000 meters of thread. For example, 9,000 meters of 15 denier nylon, used in nylon stockings, weighs 15 g/0.5 oz, and in this case the thickness of thread would be 0.00425 mm/0.0017 in.

  In recent years, advancements have been made with higher permeability fabrics that operate at lower pressure drop. A high permeability fabric, made with a 7.0 denier fiber, has replaced the OEM fabric at both Gaston and Big Brown. The 2.7 denier fabric was recommended for PIPP because:

  - TOXECON™ is designed at a lower A/C ratio than COHPAC® and should not require higher fabric permeability.
  - Field observations indicate that there may be higher particle penetration through 7.0 denier bags. Although this has not been quantified, it is desirable in this demonstration to use a more conservative design.

- **Sorbent** – NORIT Americas Inc. DARCO® Hg (formerly DARCO® FGD) activated carbon has been the benchmark sorbent used in test programs starting as early as 1991. This sorbent has a proven record on many different coals, excellent quality control, and adequate capacity to supply 20–30 units. DARCO® Hg is made from Texas lignite coal, has a mass mean diameter of nominally 17 microns and a bulk density of about 30 lbs/ft^3. Appendix A contains detailed information on DARCO® FGD carbon. DARCO® FGD carbon was used at the Gaston plant with excellent mercury removal efficiencies (Bustard, et al. 2004). The initial PAC injection concentration will be 3.0 lb/MMacf and is based on the Gaston and EPRI tests described above (Bustard et al., 2001; Sjostrom, et al., 2002).

- **Cleaning** – In order to obtain the highest utilization of the activated carbon, it is desirable to keep it on the bag as long as possible before cleaning. With this in mind, online cleaning is recommended.

3.0 System Design

The TOXECON™ system at Presque Isle consists of modifying the flue gas ductwork from each of the three units into a single duct that leads to the new baghouse. The single duct exits the baghouse and is then split into three individual branches with three new booster fans. The ducts exiting the booster fans are then recombined into a single duct back to the existing stack where the combined duct is again separated into three branches that supply the three existing individual unit stack flues. The combined three-unit flue gas system flow is 1,200,000 acfm @ 350 °F with approximately 14” w. c. of pressure drop.

Also included in the TOXECON™ system are the PAC storage silo and injection system and a new ash storage silo.

Refer to Appendix C general arrangement drawings 4937-CGA-M1000, 4937-CGA-M1001, 4937-CGA-M1002, 4937-CGA-M1003, and 4937-CGA-M1004 for a layout of the project. Drawing 4937-CBA-M0112 is a piping and instrumentation diagram of the flue gas system.

3.1 Baghouse Design

The mercury concentration in the ducts exiting the HESPs at Presque Isle was measured in 2005 using both the Thermo Electron Continuous Emissions Monitor (CEM) and the Sorbent Trap Method (STM) and was found to be around 6 $\mu g/dNm^3$ (Sjostrom, 2005). This is the mercury concentration that will be entering the baghouse along with the nominal 1% of the total ash.

3.1.1 Inlet Particulate Loading

The particulate loading is based on the collection rate of fly ash (200 lb/hr max) and the injection rate of PAC (450 lb/hr max), which includes not only the initial PAC collection, but any recycled material that might be collected in later tests. The total maximum baghouse loading for fly ash/PAC is 650 lb/hr (0.325 tons per hour).

Particulate tests were performed at the stack at Presque Isle in June 2005. Table 6 shows the particulate loading for Presque Isle and a comparison to the conditions during testing at Gaston.

Table 6. Typical Particulate Loading at Presque Isle.

Location	Particulate Loading (gr/acf)	Carbon Injection (gr/acf)
PIPP Flue #7	0.0047	-
PIPP Flue #8	0.0031	-
PIPP Flue #9	0.0071	-
PIPP Estimated Inlet (Total 7–9)	0.0050	0.021
Gaston – Low Load	0.0062	0.0063–0.014
Gaston – High Load, Mid-Range Values	0.07–0.14	0.0025

3.1.2 Type of Baghouse

A pulse jet style baghouse was selected for Presque Isle. This style reflects a typical industry standard and requires a small footprint area for the congested Presque Isle site. Based on a competitive bid process, a baghouse provided by Wheelabrator Air Pollution Control was selected. The baghouse is appropriate for the Presque Isle TOXECON™ project since baghouses of this type have been installed successfully in other power plant applications where the flue gas flow and particulate loading were much higher than the conditions at Presque Isle.

3.1.3 Air-to-Cloth Ratios

Low flow tests performed at Gaston show that a baghouse configuration utilizing an A/C ratio of less than 6 ft/min was recommended for new TOXECON™ units (Bustard, et al., 2004). These tests also showed that a mercury removal over 90% was achievable under these conditions (Table 5). This table also indicates that the outlet Hg concentrations varied from 3.2 to 0.61 $\mu g/Nm^3$ for an injection concentration of 0.9 – 3.3 lbs/MMacf respectively. For PIPP to have a 90% removal at an inlet concentration of 6 $\mu g/Nm^3$ or an outlet concentration of 0.6 $\mu g/Nm^3$ it is anticipated that the design injection rate of 216 lbs/Hr (3.0 lbs/MMacf) is adequate. Gaston is used as a guide here since no other test data was available. The differences in coal composition and gas temperatures are substantial. Knowing this, the installed excess injection capacity should allow for adequate removal considering that the system can inject up to 600 lbs/Hr (8.3 lb/MMacf). The excess capacity also allows testing of recycle of the PAC injection material.

Based on industry historical experience, test results from Gaston, bag supplier experience, the project stated goals, and compartment configuration; an A/C ratio of 5.5 ft/min was selected. The net (one compartment out of service) and net-net (two compartments out of service) A/C ratios are 6.1 and 6.8 ft/min, respectively. If one reviews Table 4 (A/C of 8.0 for Gaston) and Table 6 for loading (0.14 gr/acf for Gaston) and compares it to the PIPP design of 0.036 gr/acf at an A/C of 5.5, it certainly appears that there is enough capacity in this design.

The volumetric flow of 1,200,000 acfm of flue gas was calculated using heat balance software and compared to test data that were taken for air heater performance tests and stack emissions tests. The final selection of flow was chosen at 350 °F, which was determined to be an achievable flue gas temperature considering the historical operational flue gas temperatures.

3.1.4 Flue Gas Cooling

A technical concern of this project is the expected range of flue gas temperatures. The air preheater on each of the three units deviates significantly from its design such that the gas outlet temperature operating range is about 350 °F to 380 °F. This range is above the optimal condition for untreated sorbent performance and would likely preclude acceptable mercury control with the standard sorbent. Additionally, the high gas exit temperature could have a negative impact on unit heat rate and will be a risk to the filter bags. As such, efforts are being undertaken to reduce the gas outlet temperature using sootblowers on the air preheaters in each of the three units. This should improve the efficiency of the air preheaters and increase the cooling of the exit gas from the HESPs. The alternative is to use a spray system to cool the flue gas before treating it with sorbent. After completion of the parametric testing, the project team will determine whether the spray cooling system will be needed, or a brominated sorbent which is better suited to this temperature range.

3.1.5 Bag Material and Length

The fabric filter bag material chosen is a polyphenylene sulfide (PPS) material, based on the flue gas temperature, flue gas analysis (Table 2), and PAC properties (Appendix A).

The base design for the TOXECON™ fabric filter is to use PPS fabric bags with the following specifications:

- Felted, 2.7 denier PPS fabric
- Weight of nominally 18 ounces/yd^2
- Singed on both sides
- Scrim material made from 3 ounces/yd^2 of PPS
- Mullen burst minimum of 500 psi
- Maximum temperature for continuous use is 375 ºF
- Permeability at 0.5 inches H_2O of 25–40 cfm/ft^2

Three of the four baghouse proposals offered a 26-foot bag, while the fourth offered a 20-foot bag. The final selection was a 26-foot bag with a nominal 5-inch diameter.

3.1.6 Cleaning Method

Baghouses typically clean the filter bags in one of two methods: offline and online cleaning. Offline cleaning is accomplished by isolating an individual compartment in the baghouse from the flue gas flow prior to cleaning the bags. The bags are then cleaned in the stagnant compartment and the dust allowed to settle into the ash hopper before opening the compartment to the flue gas flow. Offline cleaning is an efficient method for cleaning the bag thoroughly; however, a disadvantage to this method is an increase in velocities (and pressure drop) in the other compartments in service when isolating a compartment for cleaning. The increased velocities create the additional pressure drop. Online cleaning is accomplished without isolating the compartment from the flue gas flow. As the bags are cleaned, the normal flue gas flow through the compartment would occur. Although the online cleaning method would cause some re-entrainment of the dust on the bags, an advantage of the online cleaning method is that it can be accomplished in a shorter duration because compartment isolation is not required.

Both cleaning methods clean the filter bags by using pressurized air to blow down the filter bags. The burst of compressed air that travels down the filter bag snaps the bag outward, causing the agglomerated ash and carbon on the bag to fall off the bag and into the collection hopper at the bottom of the compartment.

Online and offline cleaning capabilities were considered and online cleaning was chosen, with the objectives of maintaining a consistent pressure drop across the baghouse and dust cake on the bags. With offline cleaning, all of the bags in a compartment are cleaned at once, dislodging the fly ash/activated carbon dust cake and potentially creating an area with lower pressure drop and higher flow that does not have adequate sorbent to maintain a high mercury removal. Testing will be conducted to confirm or disprove this approach.

Initially, the baghouse will be configured to clean a couple of rows of filter bags in a compartment, then advancing to another compartment. Staggering the cleaning cycle through multiple compartments will evenly distribute the flow through the baghouse and prevent short circuit issues.

3.1.7 Compartments

The selection of ten compartments in the baghouse design is based upon the total footprint area available at Presque Isle, and the desire to isolate compartments in order to simulate higher A/C ratios. Each compartment has 18 rows and 18 columns, and contains 648 bags. In this configuration, isolating one or two compartments will allow testing at A/C ratios of 6.1 and 6.8 ft/min.

3.1.8 Tube Sheet Pressure Drop

The specified design pressure drop across the TOXECON™ baghouse tubesheet is expected to be between 4” w. c. and 6” w. c., which is typical for baghouses installed on coal-fired boilers. At this site, the particulate cake consists of PAC/ash, and adsorption on the cake is the primary mercury removal mechanism.

The PIPP baghouse was sized based on WAPC historic design parameters and the design guideline of the We Energies specifications. The plenums were sized based on traditional flow velocities and were within the guidelines set by the We Energies specifications. Inlet and outlet dampers were sized as large as physically possible for the plenums and compartments selected. The compartments were provided with vanes and perforated plates to achieve the flow and dust distribution required in the specifications and not specifically to reduce pressure loss. Inlet and outlet plenums were modeled with various vaning arrangements to reduce pressure loss without any significant improvements. The model study mechanical pressures losses exceeded the expectations of WAPC. WAPC stated the model study results were not representative of past WAPC baghouse designs.

ADA's calculation using a residual filter drag coefficient generally accepted in the industry is listed below. The formula for predicting pressure loss in a fabric filter is:

$\Delta P = \Delta P_R + K_2 V^2 Ct/7000$ Predictive equation for fabric filter pressure loss, where:

K_2	Specific resistance coefficient of freshly deposited dust, (inches of water gauge)/(fpm)/(lb/sq ft)
K_2	70 (" w.g.)/(fpm)/(lb/sq ft)
ΔP_R	Anticipated residual drag is 0.7" w.g./(fpm) at design air-to-cloth ratio
ΔP_R	5.48 fpm
V	Face velocity or A/C (fpm)
C	Dust loading (grains/acf)
t	Filtration time (minutes)

The residual filter drag coefficient of 0.7 for this calculation is conservative for this application. The calculated pressure loss based on the above factors is 8.0 w.c. with a cleaning time of about 100 minutes. The allotted pressure drop for the PIPP collector is 8.0" w.c. The calculated cleaning cycle time for the fabric filter was every 100 minutes. A minimum accepted cleaning cycle time was every 40 minutes.

3.1.9 Model Study Objectives and Results

NELS Consulting Services modeled the baghouse and surrounding ductwork at a 1/12 linear scale. The objectives of the flow model study were to determine the configuration of flow distribution devices and to achieve the following:

- Determine baghouse gas flow and dust distribution
- Confirm design velocities and flow distribution in compartments
- Evaluate temperature mixing at the baghouse inlet
- Determine pressure drop of system
- Confirm minimal dust deposits in the ductwork
- Configure PAC injection location flow distribution
- Determine velocity distribution and gas flow angle at proposed CEM duct location
- Confirm balanced flow in the three stacks

Flow modeling is used primarily to study gas flow distribution in the inlet and outlet ducts and in the baghouse primarily in the hopper region. These model studies can visually show gas distribution patterns. Model testing of filter bag/tubesheet loss is not accurate and is just used to simulate resistance in the system for the purpose of flow and dust distribution.

The purpose of the baghouse model study is primarily for flow and dust distribution.

The findings indicated that the design goals had been achieved. Additionally, the locations and configurations of the flow control vanes were determined by NELS during the testing.

Design velocities within each TOXECON™ baghouse compartment were chosen based upon ash-only baghouse designs with similar pressure drop and outlet emissions. Low vertical gas velocity at the bottom of the filter bags is desired since this enables online bag cleaning. Providing low vertical gas velocity was accomplished by including gas distribution baffles in the compartment inlet hopper area that direct a portion of the gas flow away from the bottom of the compartment toward the top of the filter bags. This distribution also had an additional benefit of providing a flow pattern that caused the particulate flow to impact the bags rather then dropping out when it entered the bag compartment. Deposition of particles on the bags is beneficial in this application because it provides gas-solid contact that enables mercury capture, as compared with conventional baghouse applications where particle drop out is desirable. The distribution baffles were included in the baghouse model study that confirmed their performance.

With regard to particle re-entrainment, the individual particles collected on filter bags agglomerate in conventional baghouse applications where fly ash is filtered. This system was designed assuming carbon particles will agglomerate with fly ash particles making them large and heavy enough to fall to the hopper, not subject to excessive re-entrainment. Wheelabrator Air Pollution Control (WAPC) experience is that a portion of the filter ash cake falls into the hopper after bags are pulsed and a portion of the ash returns to the filter bags. The pulse causes all of the ash cake to break and when a portion of the ash is re-deposited on the filter bag the structure of the ash cake is altered in a manner that further reduces resistance to gas flow.

3.2 Powdered Activated Carbon System Design

NORIT Americas and ADA-ES are teaming to provide the PAC injection system for Presque Isle. NORIT Americas supplies the PAC and hardware, while ADA-ES supplies the engineering design for the system, and the distribution and duct injection system. The system consists of two general components: the PAC storage and feeding system and the duct injection system.

The PAC storage and feeding system consists of a bulk storage silo with pneumatic truck unloading capability, multiple PAC feeder trains each consisting of a feed hopper and variable speed feeder, an eductor, and a transport air blower. This system is complete with the necessary control provisions to operate and monitor the system equipment.

The duct injection system consists of the transport piping from the feeding system and the necessary injection lances.

The PAC system was designed for an injection concentration of 3 lbs/MMacf. This projected injection rate was based on data obtained from full- and bench-scale testing (Section 2.1). Appendix B contains a simplified drawing for the PAC system to be installed at Presque Isle.

The design parameters for the TOXECON™ system using PAC alone at Presque Isle for Units 7, 8, and 9 are as follows:

- Design flue gas flow rate: 1,200,000 acfm at 350 ºF.
- PAC design injection concentration: 3.0 lb/MMacf
- PAC design injection rate: 216 lb/hr
- Number of PAC injection trains: 3
- Capacity of each train: 200 lb/hr
- Total injection capacity: 600 lb/hr
- Silo storage capacity: 4,490 cu ft
- Silo storage capacity at 35 lb/cu ft: 157,000 lbs or 78 tons
- Storage capacity of bulk storage silo at design injection rate: 30 days
- Method for determining PAC distribution to the baghouse compartments: physical flow modeling, 1:12 scale

As a part of the effort to optimize the design of the injection system and the performance of the PAC system for mercury removal, NELS performed physical modeling of PAC injection at two locations in the ductwork leading to the baghouse using the existing 1/12 scale model. This modeling looked at the distribution of the injected PAC in the baghouse inlet duct and inlet plenum and at the discharge of each of the compartments. The testing used two methods for making this determination: visible plume testing in the ducts, and carbon monoxide concentration distribution.

The first injection location consisted of a multi-lanced injection grid in the duct just prior to the inlet connection to the baghouse. Because of a widely varying flue gas flow distribution at this point the modeling indicated a very uneven PAC distribution to the baghouse compartments using this design.

The second injection location consisted of a single injection lance in the round duct at the ID fan outlet for each generating unit. The modeling indicated that injecting at these locations gave a significantly better PAC distribution to the baghouse compartments.

Based on these tests, the PAC injection system will use a single lance in the discharge duct of each ID fan. With three feeder trains, each generating unit will have a dedicated injection train, transport line, and injection nozzle. The injection rate will be controlled based on several variables, including boiler load/flue gas flow and mercury removal. Two CEMs, one measuring mercury concentration prior to ACI and the other in the common booster fan discharge duct, will be used.

The overall system design includes the capability to inject a recycled PAC/ash mix collected from the baghouse hoppers. Since this mix would include partially spent PAC along with ash, the volume of injected mix would increase substantially. Thus, the system capacity as stated above will accommodate the injection of the PAC/ash mix with the design PAC injection rate of sorbent (3.0 lb/MMacf) with a 50-50 mix with ash. Since the necessity of recycling the PAC/ash mixture is still unknown, the recycle testing will be performed in batch mode at Presque Isle and will not simulate the full process dynamic.

3.3 Balance-of-Plant Considerations

3.3.1 Booster Fans

3.3.1.1 Two Versus Three Fans

With the additional pressure drop associated with the installation of the TOXECON™ baghouse and associated ductwork, new ID booster fans were required. A study was prepared outlining the pluses and minuses of two versus three booster fans. The final decision to select three booster fans was influenced by the following issues:

- Three fans would allow designating a single fan for each of the three boiler units, thereby maintaining the established practice at the plant of individual components for the three units.
- The three-fan arrangement had a smaller impact on the plant's electrical systems.
- Turndown of the three-fan arrangement would be greater and would ensure compliance with National Fire Protection Association boiler purge flow requirements.

3.3.1.2 Margin (Test Block Performance)

The booster fans were sized for a single unit's full load flue gas flow and the calculated pressure drop of the new ductwork and baghouse. A margin was then applied to these values based on typical power industry practice of 15% margin on flow, 32% margin on head, and 25 ºF margin on temperature. The conditions of the fan with margin are referred to as "Test Block" conditions. The expected operating conditions are referred to as "Net" conditions. Test Block conditions are specified to account for system losses in the actual fan installation as compared to the ideal test setup installation that the fans have been shop-tested with to determine their capacity.

3.3.1.3 Purge Flow

The booster fans need to have sufficient turndown capability in order to purge the boiler during a unit startup. The initial purge flow requirements were calculated and it was determined that the fan manufacturer needed to install sealing strips on the fan control damper to limit leakage. This would achieve the turndown on the fan performance necessary to meet the purge flow requirements.

3.3.1.4 Inlet Damper Versus Variable Inlet Vanes

A variable inlet vane (VIV) control damper was selected for the booster fans. The VIV has a higher efficiency than inlet dampers. A 13–15% increase in power consumption was projected when an inlet damper configuration was evaluated. The VIV had a higher initial cost; however, the savings in electricity offset this cost.

3.3.1.5 Fan Description

Manufacturer:	Fläkt Woods
Quantity:	3
Test Block Rating:	460,000 acfm @ 375 ºF with 18.5” water static pressure
Net Rating:	400,000 acfm @ 350 ºF with 14” water static pressure
Total Efficiency	87.7% (test block), 87.6% (net)
Operating Speed:	893 rpm
Fan Configuration:	Double inlet
Fan Blade Style:	Airfoil
Fan Bearings:	RENK-ERZLQ 18–180mm - Pressure lubricated
Control Damper:	Radial Variable-Inlet-Vane (VIV)
Damper Actuator:	Jordan Controls SM-60000
Motor Size:	1,700 hp
Motor Voltage:	2,300 Volts
Vibration Transmitters:	Alaron Model VT-100
Lube Oil Console Manf.:	Howard Martin
Lube Oil Console Capacity:	3.5 gal/min

This minimum design of 400,000 acfm @14 inches is consistent with the flow modeling. The flow model report stated “The pressure drop measured in the model study ductwork and baghouse from the ID fan discharges to the stack was 10.72” w. c**., excluding the filter bags, ash cake on the bags, and buoyancy effects of the hot flue gas in the stack.”** The result of summing the expected pressure drop across the bags and cake (4-8 inches) and the buoyancy effect of the hot flue gas (negative 1.5 – 2 inches) is 12-16 “ w.c.. This result indicated that the design was close to the modeling results.

Each fan is sized for one unit’s flue gas flow. The booster fans control the draft on the discharge side of the ID fans by modulating VIV control dampers at the fan inlet. The booster fans were sized to offset the additional pressure drop of the baghouse and ductwork. The booster fan control scheme is to mimic the existing pressure conditions at the ID fans discharge prior to the TOXECON™ retrofit by measuring the pressure at the common flue gas ductwork and modulating the booster fan dampers. Each booster fan has an isolating guillotine gate on the inlet and outlet to allow online maintenance.

3.3.2 Compressed Air System

3.3.2.1 Compressed Air Users

The compressed air system provides instrument quality compressed air to the following systems and equipment:

- PAC System (10 SCFM)
- Ash Handling System (52 SCFM)
- Fabric Filter Baghouse (350 SCFM)
- Mercury CEMs Shelter (20 SCFM)

3.3.2.2 Capacity and Design

The compressed air system consists of the compressed air skid and the associated distribution piping network. Refer to Drawing 4937-CIA-M0113 for a P&ID of the compressed air skid. The compressed air skid is supplied by Sullair and includes:

- Pressure: 80–120 psig (normal operation at 100 psig)
- Dew point: -40 ºF at 100 psig
- Particulate: Less than 1 micron
- Oil Content: 0.008 ppm
- Maximum Flow: 475 SCFM

3.3.2.3 Equipment Description

The compressed air system consists of the compressed air skid and the associated distribution piping network. The piping distribution network consists of ASTM A53 carbon steel piping. The compressed air skid includes:

- Two (2) single stage, heavy duty, flood lubricated rotary screw type compressor units.
- Coalescing prefilters
- Two (2) fully automatic, regenerative desiccant dryers composed of a fully automatic pressure swing, twin tower using an activated alumina desiccant bed.
- Particle after-filters
- Storage tank
- Flow controller

3.3.3 Ash Handling System

3.3.3.1 System Type

The ash handling system selected is a dilute-phase pneumatic conveying system. This type of system has been used in conveying both fly ash and PAC. The supplier of the system is United Conveyor Corporation (UCC).

3.3.3.2 Capacity and Margin

The particulate generation rate is based on the collection rate of fly ash (200 lb/hr max) and the maximum injection rate of sorbent (450 lb/hr max). The total maximum baghouse loading for fly ash/PAC is 650 lb/hr (0.325 tons/hr).

The conveying rate of the ash handling system is based on four times the total particulate loading rate of 0.325 tons/hr. This converts to 1.3 tons/hr.

3.3.3.3 Ash System Hardware

Refer to drawings M-54025-020, and M-54025-021 for piping and instrumentation drawings of the ash handling system.

The ash system at Presque Isle is a vacuum dilute-phase transport system. The hardware consists of the ten hoppers in the baghouse, transport lines from the bottom of each hopper leading to a filter/separator located on the penthouse of the ash storage silo, the ash storage silo itself, and finally trucks to transport the ash for disposal. A mechanical exhauster downstream of the filter/separator creates the vacuum in the lines.

Each of the ten hoppers has a valve at the bottom to separate the ash from the lines. The ash is removed from the hoppers sequentially, starting at the furthest hopper on one side of the baghouse. When one side is emptied, the sequence is repeated on the other side. A purge cycle then clears the main line of any residual ash. As each hopper is emptied, the ash/air mixture is conveyed to the filter/separator. When the level probe in the filter/separator is activated, the transport of ash from the hoppers is discontinued. Then the exhauster relief and the system relief valves open to relieve conveyor line vacuum and enable the mechanical exhauster to pull in atmospheric air. After a predetermined time delay, the bottom gate opens so the ash can discharge by gravity into the storage silo. After another predetermined time delay, the bottom gate closes. The exhauster relief and the system relief valves then close, allowing the system to reestablish a vacuum. With sufficient vacuum available, ash transporting resumes to the filter/separator.

Fly ash/PAC is removed from the conical bottom storage silo by two different means. The fly ash/PAC can be conditioned with water and unloaded through a pin paddle mixer, or it can be unloaded dry through a telescopic spout.

3.3.3.4 Unloading System Selection

Disposal of the fly ash/PAC mixture will be by open bed trucks to a landfill. A wet unloading system was selected to condition the ash/PAC mixture leaving the storage silo with water thereby binding the dust to allow transportation by open bed trucks. A dry unloading system will also be installed on the ash silo to allow the ash/PAC mixture to be recovered dry for use in testing re-injection (recycling) of the mixture into the flue gas stream, or for testing methods of recovering the mercury from the used PAC.

3.3.4 Ductwork

3.3.4.1 Layout, Area Constraints, Existing Ductwork Tie In

The layout of the ductwork system to tie the existing units to the new baghouse is governed by the configuration of the existing power plant and its surrounding structures and equipment. Refer to general arrangement drawings 4937-CGA-M1000, 4937-CGA-M1001, and 4937-CGA-M1002 for a layout of the plant. A location north of the existing Unit 9 boiler building is the site for the new baghouse. The location of the new baghouse is constrained to the north by the existing plant access road and property line, to the south by the existing Unit 9 boiler building, to the west by an emergency coal discharge chute and administration building, and to the east by the plant access road.

The ductwork layout to tie Units 7–9 to the new baghouse is constrained by the back wall of the existing boiler building and the exhaust stack for Units 7–9. With the proximity of the new ductwork run to the existing plant, the existing boiler room structure is used to tie into the new ductwork support structure. Because of the space constraints between the plant west wall and the existing stack, the use of round ductwork is precluded and rectangular cross-section ductwork is utilized. The ID fans for the existing units are located inside the existing boiler building near the back wall of the plant. The discharge ducts of the ID fans penetrate the back wall of the building and are routed to the exhaust stack location, which is centrally located on the centerline of Unit 8. The distance between the back wall of the boiler building and the exhaust stack provides just enough room to tie a supply duct and return duct into the existing flue gas stream. The supply duct and return duct are routed parallel with each other along the back wall of the boiler building and the tie-in location for each unit is "stepped" into the ductwork flow stream by increasing the vertical height of the common duct as each unit ties in.

3.3.4.2 Velocity Design

The new ductwork is sized to provide a similar cross sectional area to the existing round duct, thereby matching the existing velocity. The combined unit ductwork size is larger to provide a lower pressure drop. Table 7 reflects the sizing of the ductwork and the design velocities.

Table 7. Ductwork Sizing Summary.

Duct Section	Size (ft x ft)	Flow Area (sq ft)	Flow (acfm)	Velocity (ft/s)
One unit flow – existing duct	9.5 dia	70.88	400,000	94.1
One unit flow – new duct	8.5 x 8.5	72.25	400,000	92.3
Two units' flow – new duct	8.5 x 20	170	800,000	78.4
Three units' flow – new duct	8.5 x 30	255	1,200,000	78.4

A two-stage static mixer is included in the inlet duct to the baghouse to provide a more uniform temperature profile from the three units and promote even carbon distribution across the duct cross section. The static mixer consists of opposed inclined plates and is supplied by KOMAX Systems.

3.3.4.3 Structural Design

The structural design aspects of the ductwork system and its supporting structure utilize industry standard practices for ductwork and structural steel design. The provisions of the American Institute of Steel Construction's (AISC) *Specification for Structural Steel Buildings – Allowable Stress Design and Plastic Design (ASD)* presented in the *AISC Manual of Steel Construction – Allowable Stress Design (AISC-ASD)* are used with allowances made for elevated temperatures in the ductwork system. The load criteria governing the design of the structural systems includes dead loads; live loads; environmental loads such as wind, seismic, and snow loads; and operating loads such as normal and transient pressures, unbalanced pressures, operating and excursion temperatures, and ash loading. The various load combinations are analyzed to determine the most critical case for each component of the system. Once the most critical load case is determined for a particular component, the structural aspects of that component are designed to withstand the loads being applied. This philosophy is carried through the entire structural system to determine member sizes, spacing, and ductwork support locations.

3.3.4.4 Diverter Damper Provisions

The ductwork from each unit between the ID fan and the stack is modified to install two diverter dampers in series forming a four-port arrangement. The first port is connected to each unit's ID fan discharge ductwork, the second port is connected to ductwork that combines the flue gas flows from all three units into a common header directed to the fabric filter baghouse, the third port connects to the common return ductwork from the baghouse, and the fourth port connects to each unit's stack. When flue gas is to be directed to the baghouse, the diverter dampers will be aligned to block the direct flow of flue gas to the stack. If required, the diverter dampers can close the supply and return ductwork to the baghouse and bypass the flue gas directly to the stack. Normally, the combined flows of all three units will be directed by the common ductwork to the fabric filter baghouse. Since this is a test project for the TOXECON™ system, the ability to align the flue gas to the baghouse or the stack is a design criterion. The need for diverter dampers in a commercial application would most likely not be required.

An engineering and economic evaluation prior to damper procurement compared the costs associated with installation of three diverter dampers in lieu of nine guillotine type dampers. Based on considerations including the purchase cost of the dampers, the required ductwork costs, and flue gas pressure drop through the dampers and associated ductwork, the total evaluated life cycle costs of utilizing the diverter dampers for this application provided an overall savings in cost when compared to the guillotine damper option.

3.3.5 Electrical

3.3.5.1 Electrical Constraints and Upgrades

Presque Isle Power Plant is a mature power plant that has been expanded and developed over the course of many years. When installed, the plant electrical systems were designed for nominal load growth. Emissions controls and other upgrades have stretched some of the plant electrical systems past their design parameters.

For startup, the plant relies on reserve system transformers to provide power to the individual unit switchgear, until the time that the unit is up to operating speed and capable of powering the unit electrical loads via the unit auxiliary transformer. During a unit trip, the unit electrical requirements are transferred from the unit auxiliary transformer to the reserve system to maintain boiler draft and safely shut down unit loads.

Units 7, 8, and 9 switchgear (2,400 VAC) were studied to determine if the existing gear could adequately power the running load, and were capable of starting the motors. The plant reserve system was also checked to see if it could provide enough power to satisfy the requirements of startup and multiple unit trips. The study verified the suitability of the switchgear to handle the new running loads, but pointed out deficiencies in the reserve system used during emergency situations.

As a result of the study, upgrades to the plant reserve electrical system were identified and implemented to ensure the success of the TOXECON™ project. Refer to drawings 4937-CMP-E1000 and 4937-CMP-E1001 for an overview of the one-line diagram.

3.3.5.2 Electrical System Configuration and Hardware

The electrical systems supporting the baghouse are related to the function and size of the baghouse equipment. To achieve the desired exhaust gas flow from boiler to stack, ID booster fans are added to the baghouse outlet to compensate for the pressure drop across the baghouse and ductwork to maintain suitable flow to the stack. These booster fan motors are each rated 1,700 hp, with one booster fan associated with each unit. These motors are controlled by dedicated medium voltage starters, which are fed from the unit 2,400-volt switchgear attached individually from each respective unit. The motor starters receive commands from the baghouse distributed control system (DCS) for start/stop, and supply information to the DCS to allow operators in the control room to monitor booster fan performance. Based on the limitations of the existing plant electrical system and the reserve bus design, the motors are designed for a soft start utilizing an autotransformer. This allows the individual motors to start at reduced voltage and current draw.

Remaining baghouse systems comprise the balance-of-plant electrical system. These loads are powered from motor control centers (MCCs) operating at 480 volts. This system provides the operating power for all core baghouse functions, as well as the PAC injection system, ash handling, booster fan lube oil system, air compressors, the DCS system, lighting, HVAC, and damper operation for flue gas control.

Essential 480-volt loads are fed from MCCs, which receive power from existing plant equipment to ensure the most reliable source and functionality possible.

3.3.6 Instrumentation and Controls

The existing plant DCS system is based on the Emerson Ovation® platform. The DCS system expansion required to support the Presque Isle Power Plant TOXECON™ project is based on this same platform.

An overview of the DCS expansion for the PIPP TOXECON™ project is shown on the Control System Overview drawings 4937-CCX-K6000 and 4937-CCX-K6001. This expansion will provide all functions required for controlling the plant equipment and monitoring of other plant systems installed as part of the TOXECON™ project.

The DCS expansion will include three new cabinet groups that will be interconnected as shown on the Control System Overview drawings. Each cabinet group will consist of the required redundant controllers, I/O modules, redundant power supplies, communication modules, and other components as required to implement the required control strategies.

One of the cabinet groups (Unit 8 Drop 4) will provide control and monitoring for the baghouse. Unit 8 Drop 4 consists of the following cabinets:

- 79CX-CPU-0004 (Processor I/O Cabinet)
- 79CX-EXP-0004A (Expansion I/O Cabinet)

A second cabinet group consisting of unitized remote I/O cabinets (Unit 7 Drop 1, Unit 8 Drop 1, Unit 9 Drop 1) is dedicated to providing controls interfaces with the existing plant control system for booster fan draft control, control of their respective unit booster fans, control of their respective unit baghouse supply and return diverter dampers, and control of their respective baghouse supply and return diverter damper seal air blowers and valves. The remote I/O (RIO) group consists of the following cabinets:

- 7CX-RIO-0001 (Unit 7 RIO)
- 8CX-RIO-0001 (Unit 8 RIO)
- 9CX-RIO-0001 (Unit 9 RIO)

The third cabinet group (Unit 8 Drop 5) is dedicated to control of the remaining TOXECON™ balance-of-plant (BOP) equipment including booster fan draft control, fly ash system, powdered ACI, compressed air system, and baghouse outlet mercury CEMs. Unit 8 Drop 5 consists of the following cabinets:

- 79CX-CPU-0005 (Processor I/O Cabinet)
- 79CX-EXP-0005A (Expansion I/O Cabinet)
- 79CX-EXP-0005B (Expansion I/O Cabinet)
- 79CX-EXP-0005C (Expansion I/O Cabinet)

3.4 Mercury Measurements

When this CCPI program was selected in 2003, stack compliance-grade continuous emissions monitor (CEM) mercury monitors were not available. Several research-grade mercury monitors were proven to be accurate and reliable; however, they required operation by a highly skilled engineer and continuous maintenance.

In the past year, ADA-ES has worked with Thermo Electron Corporation to develop a mercury CEM for use on this program to measure mercury concentrations at the inlet and outlet of the TOXECON™ fabric filter. ADA-ES's role has been to validate different components by operating them in parallel with ADA-ES's semi-CEM (EMC unit). The Thermo Electron instrument has four key components: sample extraction probe, sample converter, mercury analyzer, and calibration module. Figure 10 shows a schematic of these components.

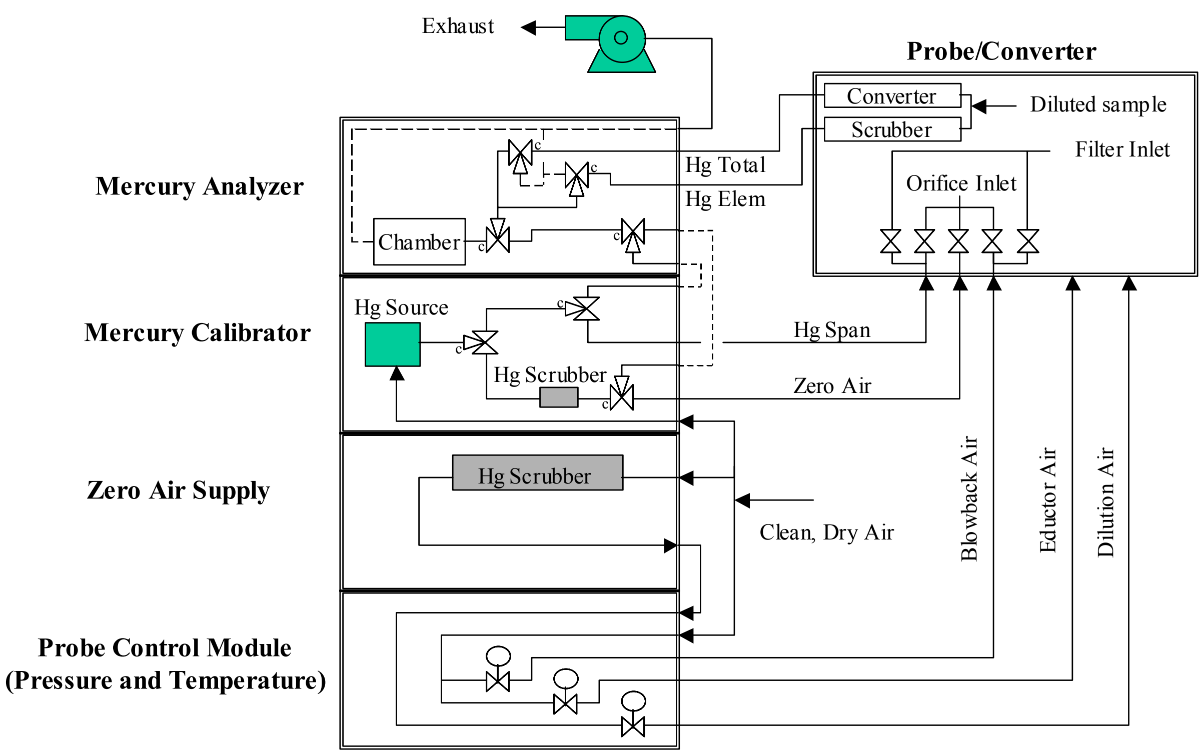

Figure 10. Schematic of Thermo Electron Prototype Mercury CEM.

The extraction probe uses an inertial filter to obtain a particulate-free vapor-phase sample without passing the gas through a fly ash filter cake. This minimizes the sample gas interactions with the fly ash, which can cause sampling artifacts. An eductor, driven with compressed, dry, mercury-free motive air, draws the ash-free sample from the inertial filter. The line between the inertial filter and the vacuum port on the eductor contains a critical-flow orifice. To maintain a constant sample flow rate to the analyzer, the eductor dilutes the sample with the motive air resulting in a dilution ratio between 25:1 to 100:1, depending on the size of the critical-flow orifice. The dilution ratio is determined based on flue gas conditions and operator preference. All of the extraction probe internal surfaces exposed to sample gas have a glass coating to prevent unwanted chemical reactions with the mercury.

Calibration gas from the calibration module can be introduced into the sample stream either upstream or downstream of the inertial filter.

The converter module converts the oxidized mercury in the diluted sample to elemental mercury for a total vapor-phase mercury measurement, or it scrubs oxidized mercury from the diluted sample to deliver only elemental mercury to the analyzer when a speciated measurement is desired. The proprietary design combines high temperature (>750 ºF) and a chemical reaction to achieve the conversions.

The analyzer measures mercury directly using Cold Vapor Atomic Fluorescence technology. Because the sample is diluted, it has low moisture, is relatively non-reactive, and therefore has minimal interference from other gases. Currently, the analyzer detection limit is 1 ng/m^3 (~0.1 ppt) and no cross interference from SO_2 has been observed.

The operation of the mercury analyzer system was tested following EPA PS12A protocol, including a Relative Accuracy Test Audit (RATA), 7-Day calibration error test, and a linearity check (Segall, et al., 2005). The CEM passed the Initial Certification Test Criteria (7-Day Calibration Error Test, Linearity Test, Cycle Time Test, Converter Efficiency Test, Measurement Error Test, and Zero and Upscale Drift Test). A RATA test was conducted and the Thermo Electron CEM was within the relative accuracy range for all 8 valid Ontario Hydro runs out of the 12 performed. EPA considers this a no-pass because 9 valid runs are necessary for a complete RATA test.

Figure 11 shows the results of field-testing in Holcomb, Kansas, using the Thermo Electron CEM along with the EMC unit. This figure shows that the two CEMs track well over time. Table 8 shows the comparison between the Thermo Electron CEM and the Ontario-Hydro Method. Both comparisons show that the Thermo Electron CEM is accurate in field conditions (Thermo Electron, 2005).

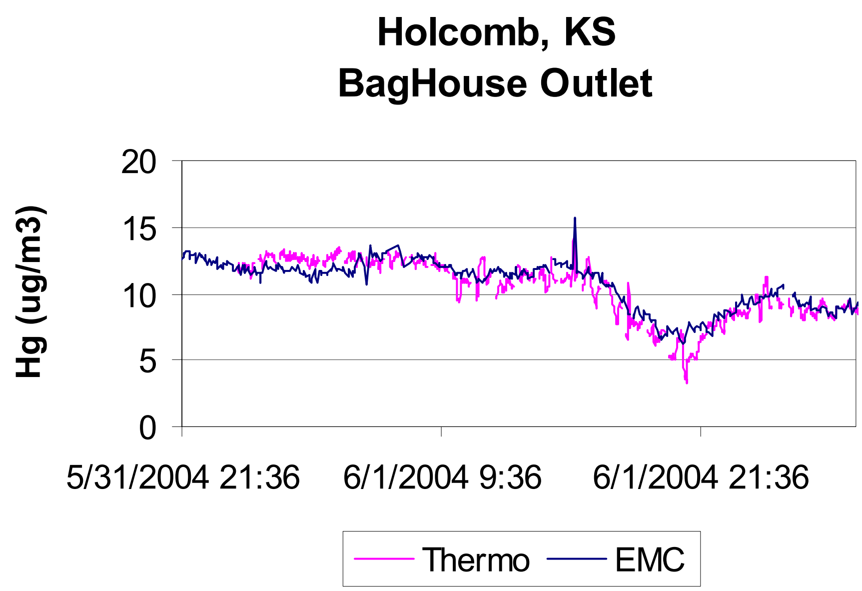

Figure 11. Mercury CEMS Field Testing.

Table 8. Ontario-Hydro Versus Thermo Electron Mercury CEM.

Run #	OH Train (µg/m^3)	CEM (µg/m^3)	% Variation
1	4.057	4.021	0.9
2	3.787	4.148	9.5
3	3.929	4.567	16.2

4.0 Costs

4.1 Project Costs

The project has a budget of $49,719,157 that is shared between the Department of Energy and We Energies. This budget covers the cost of performing 19 different project tasks over the period of the project (March 2004–March 2009). Project tasks are:

1. Design Review Meeting
2. Prepare Project Management Plan
3. Prepare NEPA Questionnaire
4. Balance-of-Plant Engineering
5. Major Equipment Procurement, Construction, Contractor Selection
6. Prepare Construction Plan
7. Procure CEM Package, Perform Engineering and Performance Assessment
8. Mobilize Contractors
9. Foundations
10. Erect Structural Steel, Baghouse, and Ductwork
11. Balance-of-Plant Mechanical
12. Balance-of-Plant Electrical
13. Equipment Pre-Operational Testing
14. Startup
15. Operate, Test, Data Analysis, and Optimize TOXECON™ for Mercury Control
16. Operate, Test, Data Analysis, and Optimize TOXECON™ for SO_2 and NO_x Control
17. Evaluate Options, Pilot Test, Procure Full-Scale System, and Evaluate Carbon-Ash Management System
18. Revise Design Specifications, Prepare O&M Manuals
19. Reporting, Management, Subcontract Management, Technology Transfer

4.2 Equipment Costs

The costs of equipment and installation for the TOXECON™ and balance-of-plant systems are given in Table 9.

Table 9. Summary of Equipment, Balance-Of-Plant, and Engineering Costs

TOXECON™ and Balance-of-Plant Equipment and Installation Costs Presque Isle Power Plant Units 7, 8, and 9	
Budget Item Description	**Cost**
Baghouse	
Baghouse Supply and Erection	$10,000,000
Equipment	
Electrical Equipment	$600,000
Controls (Including Enclosure)	$425,000
Air Compressor/Dryer	$140,000
ID Booster Fans	$1,200,000
Ash System	$650,000
PAC System	$700,000
Dampers	$650,000
Expansion Joints	$100,000
Ductwork and Structural Steel	$3,100,000
Erection	
Construction Supervision and Indirects	$2,400,000
Foundations	$1,550,000
Electrical Installation	$1,200,000
Mechanical and Structural Installation	$7,500,000
Other	
Engineering Costs (A/E and Utility)	$3,930,000
Mercury Continuous Emissions Monitors (2)	$300,000
TOTAL *(excludes testing program costs)*	**$34,445,000**

- **Baghouse:** Includes baghouse casing structure and support steel, hoppers, bags and cages, maintenance elevator, exterior siding and roof structure, inlet and outlet plenums, access stairways and platforms.

- **Electrical Equipment:** Includes medium voltage motor starters, motor control centers, and transformers.

- **Controls:** Includes a digital control system and a prefabricated enclosure for the digital control system equipment.

- **Air Compressor/Dryer:** Includes skid mounted air compressor with an air receiver tank and dryer.

- **ID Booster Fans:** Includes booster fans, motors, lube oil skid, and fan control instruments.

- **Ash System:** Includes ash storage silo, ash piping and ash hopper valves, vacuum exhausters, and ash system controls.

- **PAC System:** Includes powdered activated carbon storage silo, blower, piping, injection ports, and control instruments.

- **Dampers:** Includes damper assemblies and drives.

- **Expansion Joints:** Includes ductwork expansion joint material and hardware.

- **Ductwork and Structural Steel:** Includes, ductwork to and from the baghouse, internal turning vanes, static mixer, ductwork support steel, booster fan building support steel, access platforms, and stairways.

5.0 Commercialization

This demonstration project will be the first dedicated, full-scale use of the TOXECON™ process and will identify issues relating to the technology itself and balance-of-plant issues. Valuable experience will be gained by testing a full-scale TOXECON™ unit over the course of several years, allowing fine-tuning of the process. Removal of SO_2 and NO_x, and testing of new bag fabrics will also be investigated in conjunction with mercury removal. Marketplace acceptance will be higher by demonstrating long-term use of the TOXECON™ process and providing economic information so that other potential users can determine if TOXECON™ is cost-effective for their situation.

6.0 List of Abbreviations and Acronyms

A/C	Air-to-Cloth ratio
acfm	Actual Cubic Feet per Minute
ACI	Activated Carbon Injection
A/E	Architect/Engineer
BOP	Balance of Plant
CCPI	Clean Coal Power Initiative
CEM	Continuous Emissions Monitor
COHPAC®	Compact Hybrid Particulate Collector
DCS	Distributed control System
DOE	Department of Energy
EPRI	Electric Power Research Institute
ESP	Electrostatic Precipitator
gr/acf	Grains per Actual Cubic Foot
HESP	Hot-Side Electrostatic Precipitator
HP	Horsepower
HVAC	Heating Ventilation Air Conditioning
ID	Induced Draft
I/O	Input/Output
lb/hr	Pounds per Hour
LOI	Loss on Ignition
MCC	Motor Control Center
MMacf	Million Actual Cubic Feet
MW	Mega Watts
NEP	National Energy Policy
NEPA	National Environmental Policy Act
NETL	National Energy Technology Laboratory
NO_x	Oxides of Nitrogen
NFPA	National Fire Protection Association
O_2	Oxygen
O&M	Operation and Maintenance
OEM	Original Equipment Manufacturer
PAC	Powdered Activated Carbon
PIPP	Presque Isle Power Plant
PM	Particulate Matter
ppm	Parts-Per-Million
PPS	Polyphenylene Sulfide
ppt	Parts-Per-Trillion
PRB	Powder River Basin
psig	Pounds per Square Inch Gauge
RATA	Relative Accuracy Test Audit
RIO	Remote I/O
rpm	Revolutions per Minute
scfm	Standard Cubic Feet per Minute
SO_2	Sulfur Dioxide
VAC	Volts Alternating Current
VIV	Variable Inlet Vane
WAPC	Wheelabrator Air Pollution Control
w. c.	Water Column

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8.0 Appendix A – PAC Data Sheet

ISO 9002

FM 36335

NORIT Americas Inc.

Most Choices + Precise Fit = Best Performance.

DATASHEET

Product No. FGD
Revised 9-97

DARCO® FGD
POWDERED ACTIVATED CARBON

DARCO FGD is a lignite coal-based activated carbon manufactured specifically for the removal of heavy metals and other contaminants typically found in incinerator flue gas emission streams. It has been proven in numerous full scale operating facilities to be highly effective for the removal of gaseous mercury, dioxins (PCDD) and furans (PCDF). Its open pore structure and fine particle size permit rapid adsorption, which is critical for high performance in flue gas streams where contact times are short.

DARCO FGD is a free flowing powdered carbon with minimal caking tendencies which makes it ideal for automatic dosing systems with dry or wet injection. It is manufactured with a very high ignition temperature to permit safe operation at the elevated temperatures inherent in incinerator flue gas streams.

Product Specifications

Molasses decolorizing efficiency, %	80 min.
Moisture, % as packed	8 max.
Mesh size:	
Less than 325 mesh (45 µm), %	95 min.

Typical Properties*

Iodine number, mg/g	600
Bulk density, tamped, g/ml	0.53
lbs./ft^3	33

General Characteristics *

Surface area, m^2/g	600
Heat capacity	0.22
Total sulfur, %	1.8
Ignition temperature, °C	450

* For general information only, not to be used as purchase specifications.

Packaging

Standard package is 40 lb. bags, 50 bags per pallet for a net pallet weight of 2000 lbs. Alternate packages include bulk trailer, and woven polypropylene bulk bags, 900 lbs. net, with a glued plastic liner.

Safety

CAUTION: Wet activated carbon depletes oxygen from air and, therefore, dangerously low levels of oxygen may be encountered. Whenever workers enter a vessel containing activated carbon, the vessel's oxygen content should be determined and work procedures for potentially low oxygen areas should be followed. Appropriate protective equipment should be worn. Avoid inhalation of excessive carbon dust. No problems are known to be associated in handling this material. However, dust may contain greater than 1.0% silica (quartz). Longterm inhalation of high dust concentrations can lead to respiratory impairment. Use forced ventilation or a dust mask when necessary for protection against airborne dust exposure (see Code of Federal Regulations - Title 29, Subpart Z, par. 1910.1000, Table Z-3).

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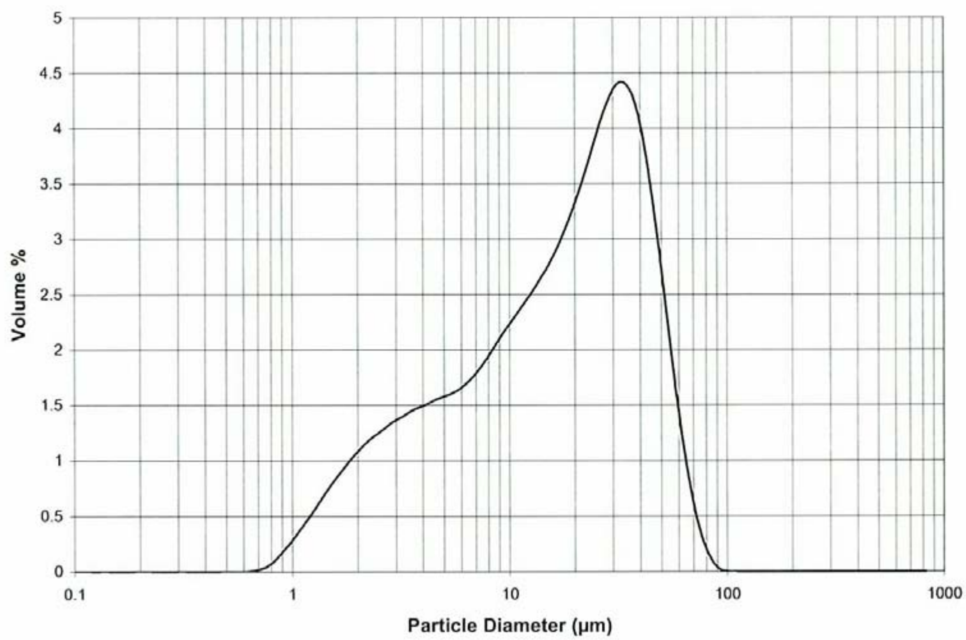
DARCO FGD
Typical Laser Particle Size Distribution

File name: fgd.$01
Sample ID: FGD Group ID: 1999
Comments: SAM#8051 / NO SONIC Operator: GWD



Calculations from 0.1 μm to 900 μm	
Volume:	100 %
Mean:	22.27 μm
Median:	18.6 μm
Mode:	35.52 μm
Specific Surf. Area:	7624 cm²/mL
95% Conf. Limits:	0 - 56.54 μm
S.D.:	17.48 μm
Variance:	305.7 μm²

Particle Dia. μm	Volume % <
5	18.76
10	32.45
44	87.17
74	99.31
149	100
220	100

	≤5%	≤10%	≤50%	≤95%	≤97%
Particle Size, μm:	1.964	2.887	18.6	55.49	60.85

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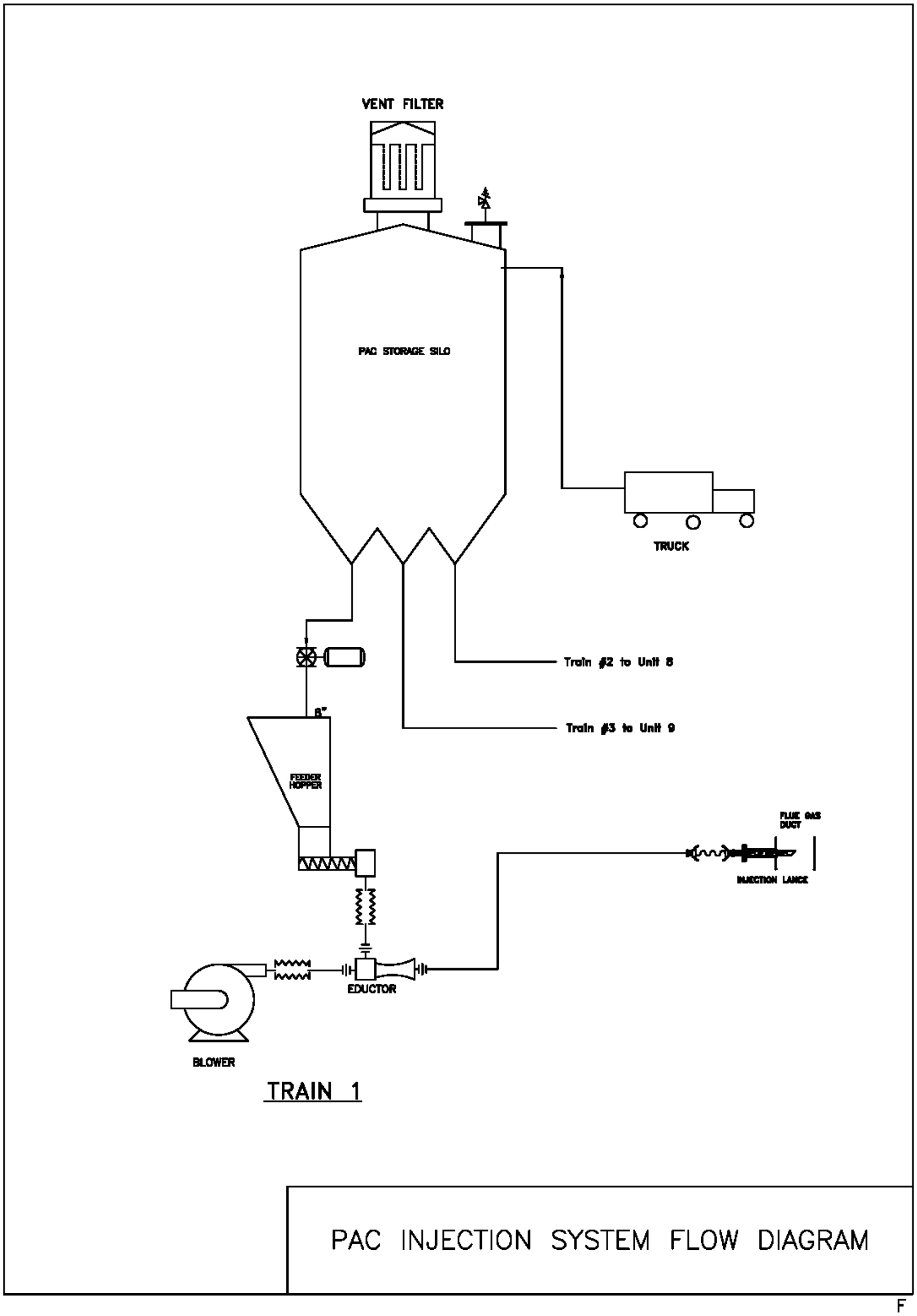
Rev. 1, APR 2001

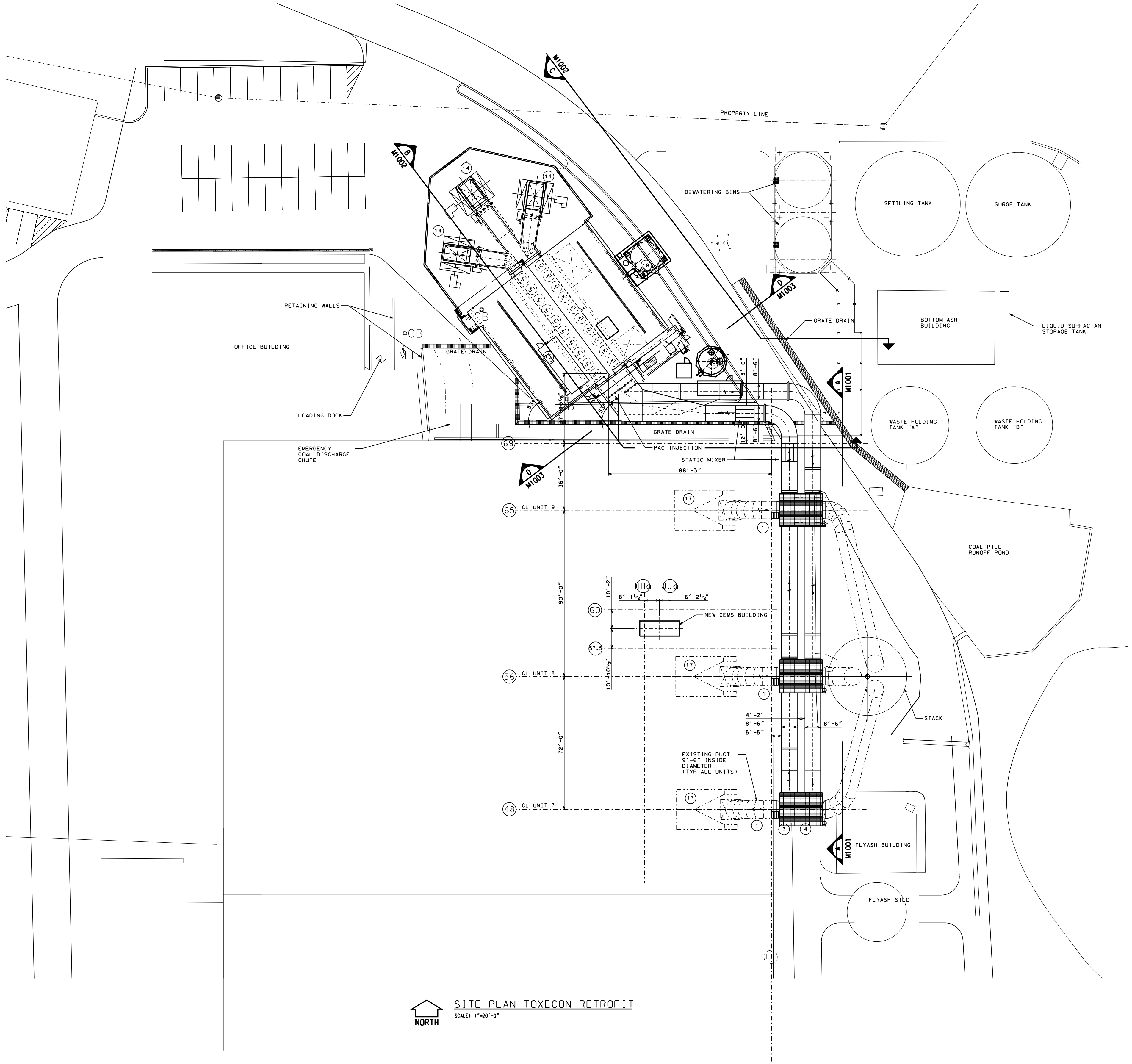
9.0 Appendix B – PAC Injection System Flow Diagram



10.0 Appendix C – Drawings

This Appendix contains the following drawings related to the project:

Drawing	Title
4937-CGA-M1000	Site Plan
4937-CGA-M1001	Flue Gas Ductwork West Elevation
4937-CGA-M1002	Baghouse and Fan Enclosure Elevation
4937-CGA-M1003	Fan Enclosure Plan and Sections
4937-CGA-M1004	Flue Gas Ductwork Sections and Details
4937-CBA-M0112	P&ID Flue Gas System
4937-CIA-M0113	P&ID Compressed Air Skid
M-54025-020	P&ID Fly Ash System
M-54025-021	P&ID Fly Ash System
4937-CMP-E1000	One-Line Diagram
4937-CMP-E1001	One-Line Diagram 7–9
4937-CCX-K6000	Control System Overview
4937-CCX-K6001	Control System Overview



SITE PLAN TOXECON RETROFIT
SCALE: 1"=20'-0"
NORTH

LEGEND

1. NOx, CO, CEMS, TEMPORARY SO2, Hg SAMPLING TEMPORARY PAC INJECTION
2. PRESSURE TRANSMITTER (NOT SHOWN)
3. BAGHOUSE SUPPLY DIVERTER DAMPER
4. BAGHOUSE RETURN DIVERTER DAMPER
5. FLUE GAS DUCTWORK
6. STATIC MIXER
7. PRESSURE SENSOR (NOT SHOWN)
8. Hg MONITOR (NOT SHOWN)
9. 6" EPA TEST PORTS (NOT SHOWN)
10. PARTICULATE MONITOR (NOT SHOWN)
11. NOx /SO2 MONITOR (NOT SHOWN)
12. FAN INLET DAMPER (NOT SHOWN)
13. FAN DISCHARGE DAMPER (NOT SHOWN)
14. BOOSTER FAN
15. DCS ENCLOSURE
16. EXPANSION JOINT (NOT SHOWN)
17. EXISTING ID FAN
18. ASH SILO
19. PAC SILO

NOT TO BE USED FOR CONSTRUCTION

REFERENCE DRAWINGS

REV NO.	DATE	REVISION DESCRIPTION	ACT	DRAWN	CHK'D	APPRV'D
D	12-15-04	BIDS		KFH		
C	10-22-04	REVISED		KFH		
B	8-13-04	REVISED		PVJ		
A	7-02-04	ISSUED FOR REVIEW		KFH		

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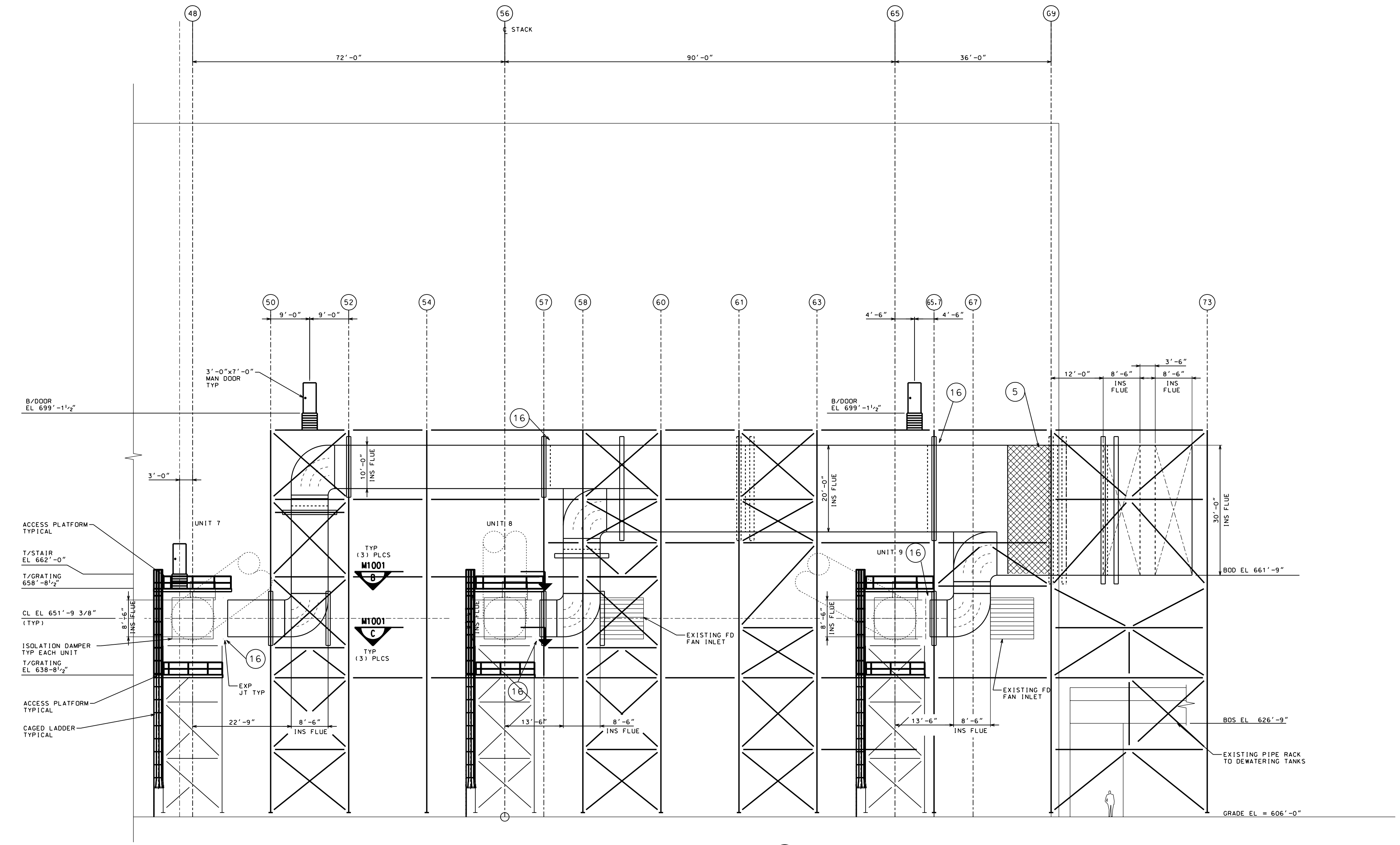
REVISION D
SHEET 4937-CGA-M1000

LEVEL USAGE
CGS REF FILES
MICROFILM NO. 354534
DRAWN KFH DATE 7-2-04
CHECKED DATE
APPROVED DATE
PROJECT NO. 493704
ACTIVITY NO. 5033
SCALE 1"=10'-0"
we energies
CGS NO. 115895

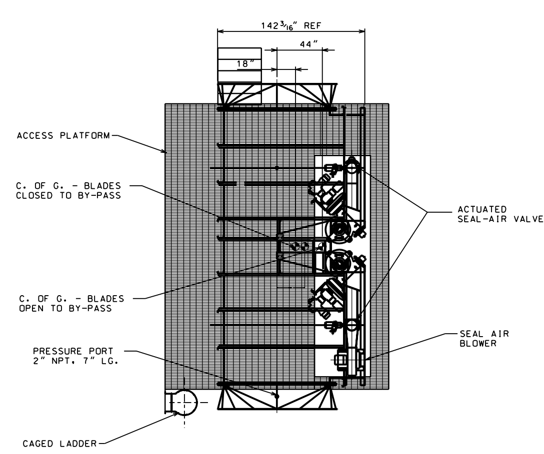
PRESQUE ISLE POWER PLANT
GENERAL ARRANGEMENT
TOXECON PROJECT
SITE PLAN

E PI 07 MEIL 403007

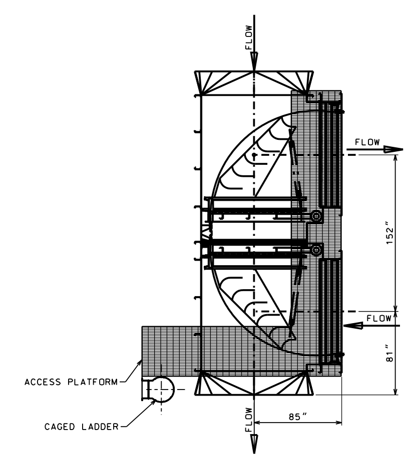
WAS:
$DATE$



WEST ELEVATION VIEW (A) M1000
SCALE: 1"=10'-0"



SECTION (B) M1001



SECTION (C) M1001

LEGEND

1. NOx, CO, CEMS, TEMPORARY SO2, Hg SAMPLING TEMPORARY PAC INJECTION
2. PRESSURE TRANSMITTER (NOT SHOWN)
3. BAGHOUSE SUPPLY DIVERTER DAMPER
4. BAGHOUSE RETURN DIVERTER DAMPER
5. FLUE GAS DUCTWORK
6. STATIC MIXER
7. PRESSURE SENSOR (NOT SHOWN)
8. Hg MONITOR (NOT SHOWN)
9. 6" EPA TEST PORTS (NOT SHOWN)
10. PARTICULATE MONITOR (NOT SHOWN)
11. NOx /SO2 MONITOR (NOT SHOWN)
12. FAN INLET DAMPER (NOT SHOWN)
13. FAN DISCHARGE DAMPER (NOT SHOWN)
14. BOOSTER FAN
16. DCS ENCLOSURE
16. EXPANSION JOINT (NOT SHOWN)
17. EXISTING ID FAN
18. ASH SILO
19. PAC SILO

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REFERENCE DRAWINGS

REV NO.	DATE	REVISION DESCRIPTION	ACT	DRAWN	CHK'D	APPRV'D
D	12-15-04	BIDS		KFH		
C	10-22-04	REVISED		KFH		
B	8-13-04	REVISED		PVJ		
A	7-2-04	ISSUED FOR REVIEW		PVJ		

LEVEL USAGE
1 2 3 4 5 6 7 8 9
10 11 12 13 14 15 16 17 18
19 20 21 22 23 24 25 26 27
28 29 30 31 32 33 34 35 36
37 38 39 40 41 42 43 44 45
46 47 48 49 50 51 52 53 54
55 56 57 58 59 60 61 62 63

CGS REF FILES

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REVISION D

SHEET 4937-CGA-M1001

MICROFILM NO. 354353

DRAWN PVJ DATE 7-2-04
CHECKED DATE
APPROVED DATE
PROJECT NO. 493704
ACTIVITY NO. 5033
SCALE 1"=10'-0"

we energies

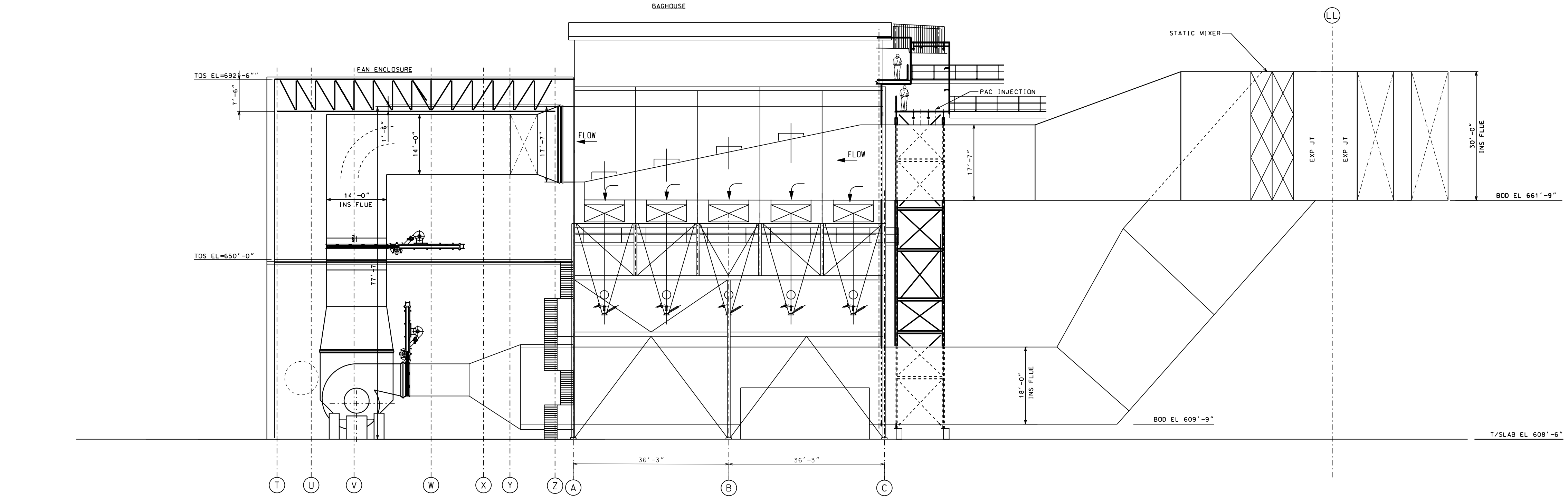
CGS NO. 115896

PRESQUE ISLE POWER PLANT
GENERAL ARRANGEMENT
FLUE GAS DUCTWORK
WEST ELEVATION

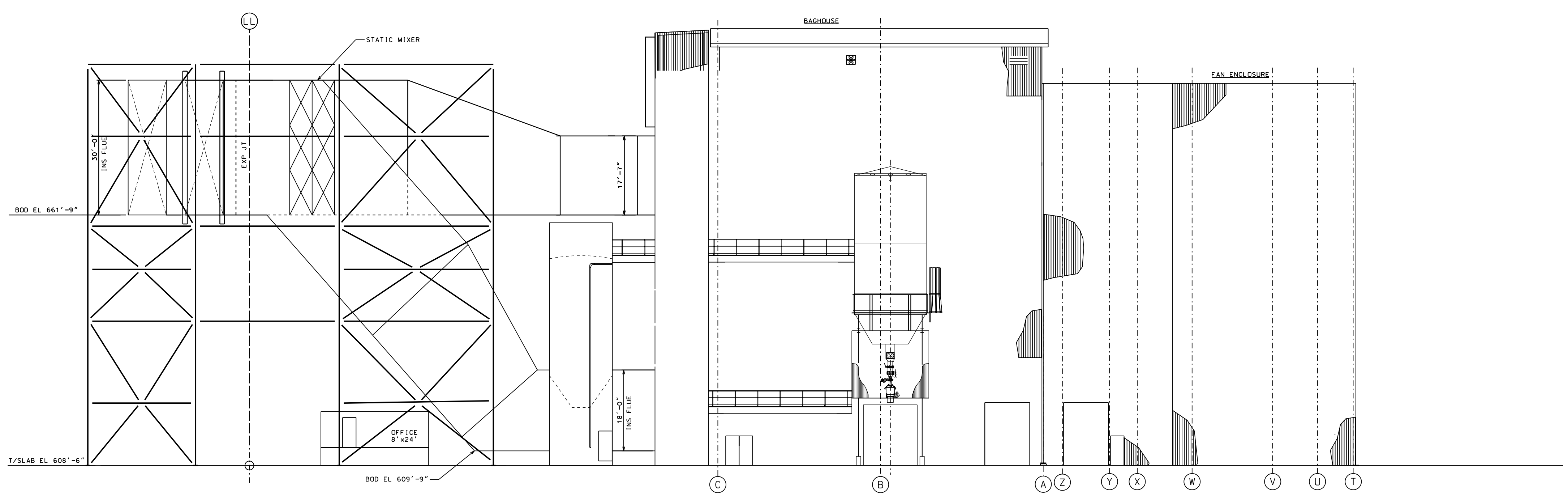
E PI 07 MEIL 403008

WAS:

$DATE$



SECTION TITLE B
SCALE: 1"=10'-0"
M1000



SECTION TITLE C
SCALE: 1"=10'-0"
M1000

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REV NO.	DATE	REVISION DESCRIPTION	ACT	DRAWN	CHK'D	APPRV'D
D	12-15-04	BIDS		KFH		
C	10-22-04	REVISED		KFH		
B	8-13-04	REVISED		KFH		
A	07-02-04	ISSUED FOR REVIEW		KFH		

REFERENCE DRAWINGS

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REVISION: D
SHEET: 4937-CGA-M1002

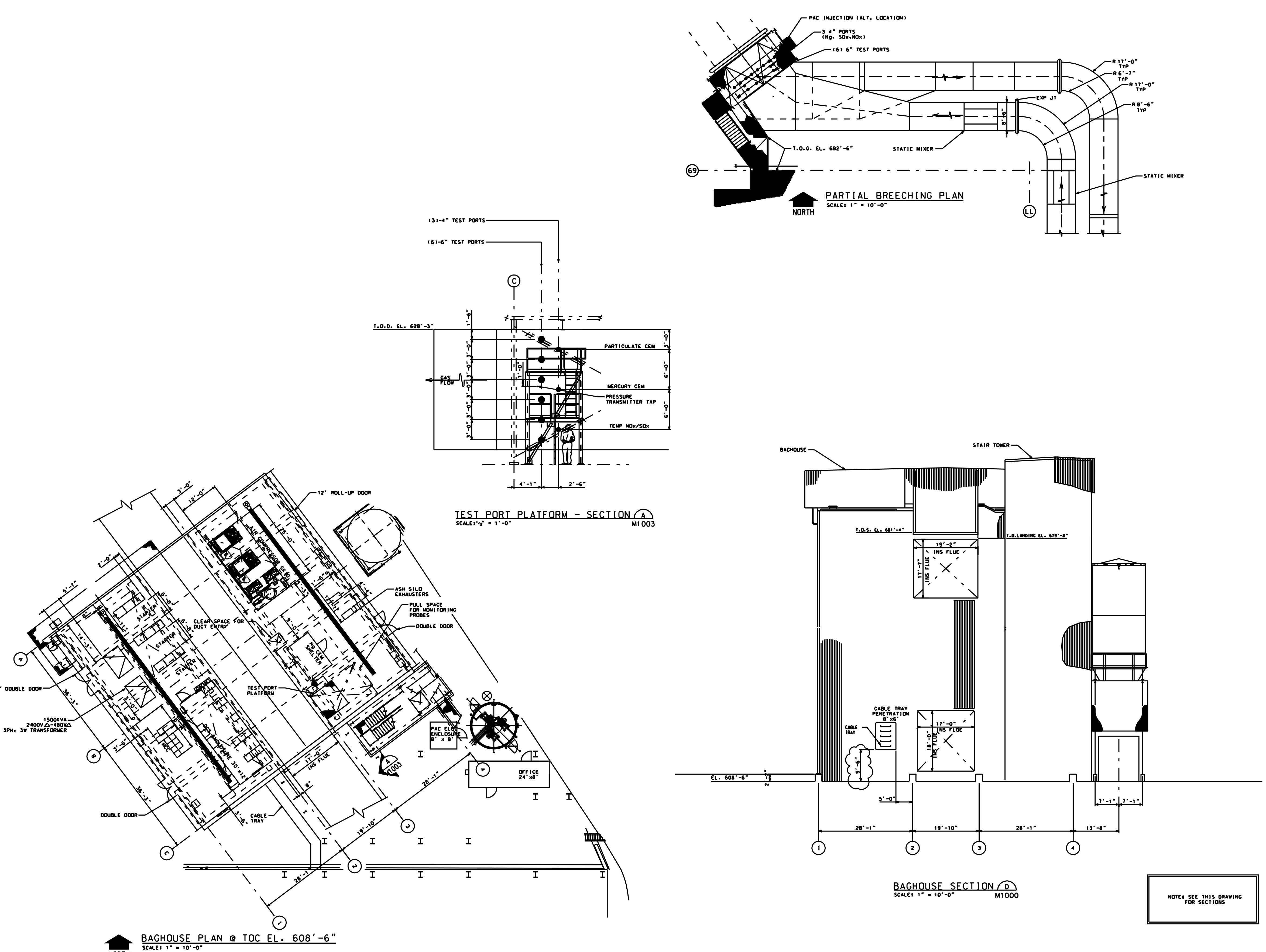
LEVEL USAGE
CGS REF FILES
MICROFILM NO. 354536
DRAWN KFH DATE 7-2-04
PROJECT NO. 493704
CHECKED DATE
ACTIVITY NO. 5033
APPROVED DATE
SCALE 1"=10'-0"
We energies
CGS NO. 115897

PRESQUE ISLE POWER PLANT
GENERAL ARRANGEMENT
BAGHOUSE & FAN ENCLOSURE
ELEVATION VIEW

E PI 07 MEIL 403009

WAS:

$DATE$



NOTE: SEE THIS DRAWING FOR SECTIONS

REFERENCE DRAWINGS
PI 07MEIL403007 - GA TOXECON PROJECT - SITE PLAN
PI 07MEIL403008 - GA FLUE GAS DUCTWORK - WEST ELEVEATION
PI 07MEIL403009 - GA BAGHOUSE & FAN ENCLOSURE ELEVATION VIEW
PI 07MEIL403011 - GA FAN ENCLOSURE PLAN & SECTIONS

REV NO.	DATE	REVISION DESCRIPTION	ACT	DRAWN	CHK'D	APPRV'D
0	03-18-05	ISSUED FOR CONSTRUCTION		KFH	JC	JC

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REVISION 0

SHEET 4937-CGA-M1003

MICROFILM NO. 354537

we energies

PRESQUE ISLE POWER PLANT
GA-FLUE GAS DUCTWORK
SECTIONS AND DETAILS

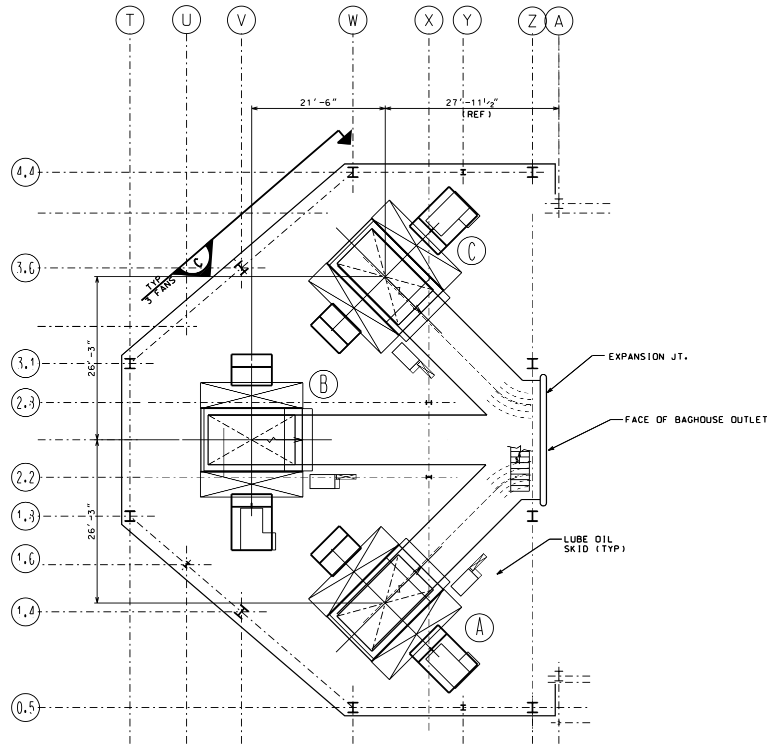
DRAWN	DATE	PROJECT NO.
PVJ	7-2-04	493704
CHECKED	DATE	ACTIVITY NO. 5033
APPROVED	DATE	SCALE 1"=10'-0"

CGS NO. 115898

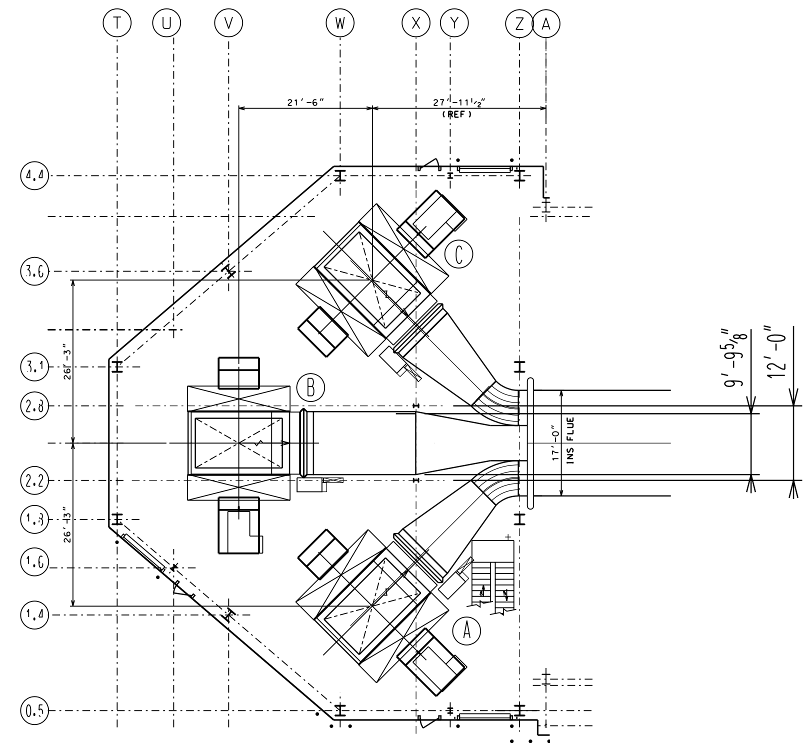
EPI 07 MEIL40301000

WAS:

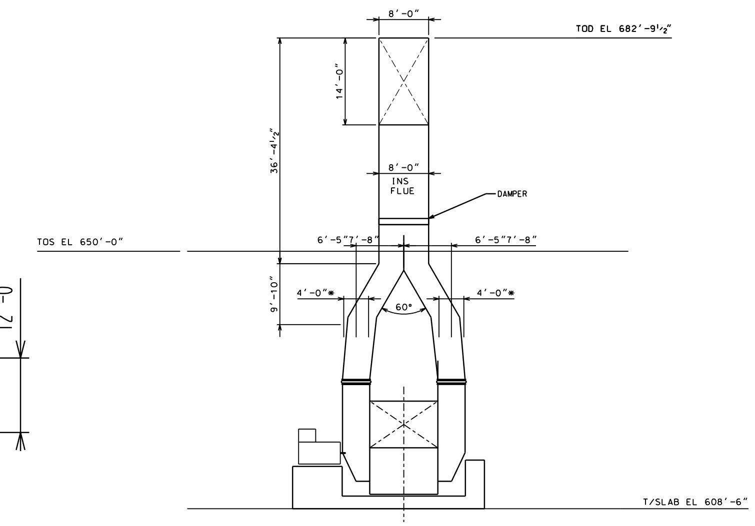
$DATE$



BOOSTER FAN INLET SECTION A
SCALE: 1"=10'-0" M1004

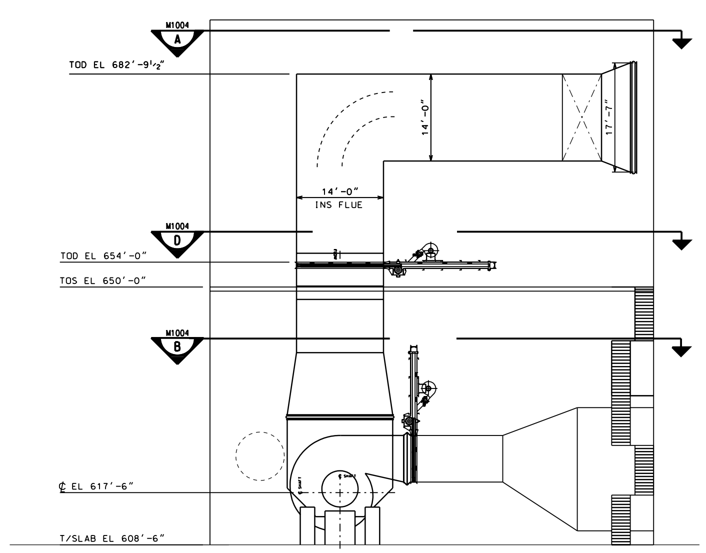


BOOSTER FAN OUTLET SECTION B
SCALE: 1"=10'-0" M1004

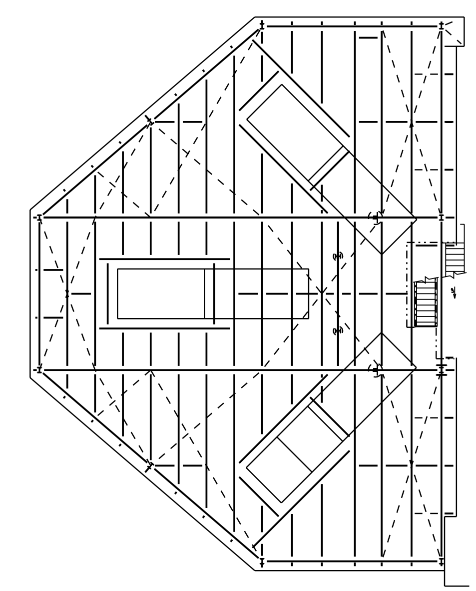


SECTION C
SCALE: 1"=10'-0" M1004

NOTE: DIMENSIONS WITH (*) TO BE VERIFIED AFTER FANS ARE PURCHASED.



TYPICAL BOOSTER FAN ELEVATION
SCALE: 1"=10'-0"



SECTION D
SCALE: ⅛"=1'-0" M1004

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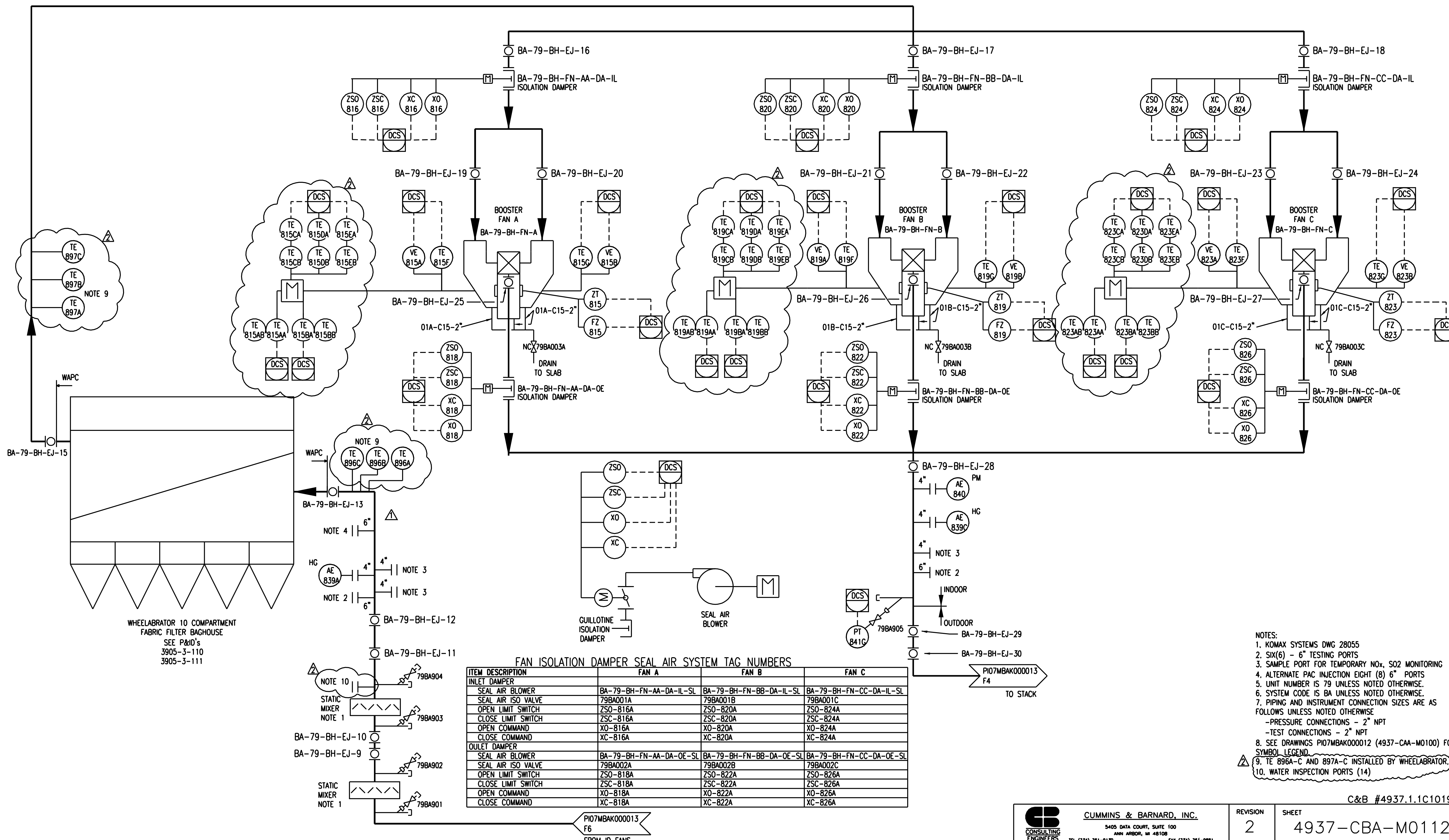
REV NO.	DATE	REVISION DESCRIPTION	ACT	DRAWN	CHK'D	APPRV'D
D	12-15-04	BIDS		KFH		
C	10-22-04	REVISED		KFH		
B	8-13-04	REVISED		KFH		
A	07-02-04	ISSUED FOR REVIEW		KFH		

REFERENCE DRAWINGS

REVISION: D
SHEET: 4937-CGA-M1004
MICROFILM NO. 354538
DRAWN KFH DATE 7-2-04
CHECKED DATE
APPROVED DATE
PROJECT NO. 493704
ACTIVITY NO. 5033
SCALE AS NOTED
CGS NO. 115899

PRESQUE ISLE POWER PLANT
GENERAL ARRANGEMENT
FAN ENCLOSURE
PLAN & SECTIONS

E PI 07 MEIL 403011



FAN ISOLATION DAMPER SEAL AIR SYSTEM TAG NUMBERS

ITEM DESCRIPTION	FAN A	FAN B	FAN C
INLET DAMPER			
SEAL AIR BLOWER	BA-79-BH-FN-AA-DA-IL-SL	BA-79-BH-FN-BB-DA-IL-SL	BA-79-BH-FN-CC-DA-IL-SL
SEAL AIR ISO VALVE	79BA001A	79BA001B	79BA001C
OPEN LIMIT SWITCH	ZSO-816A	ZSO-820A	ZSO-824A
CLOSE LIMIT SWITCH	ZSC-816A	ZSC-820A	ZSC-824A
OPEN COMMAND	XO-816A	XO-820A	XO-824A
CLOSE COMMAND	XC-816A	XC-820A	XC-824A
OULET DAMPER			
SEAL AIR BLOWER	BA-79-BH-FN-AA-DA-OE-SL	BA-79-BH-FN-BB-DA-OE-SL	BA-79-BH-FN-CC-DA-OE-SL
SEAL AIR ISO VALVE	79BA002A	79BA002B	79BA002C
OPEN LIMIT SWITCH	ZSO-818A	ZSO-822A	ZSO-826A
CLOSE LIMIT SWITCH	ZSC-818A	ZSC-822A	ZSC-826A
OPEN COMMAND	XO-818A	XO-822A	XO-826A
CLOSE COMMAND	XC-818A	XC-822A	XC-826A

NOTES:
1. KOMAX SYSTEMS DWG 28055
2. SIX(6) - 6" TESTING PORTS
3. SAMPLE PORT FOR TEMPORARY NOx, SO2 MONITORING
4. ALTERNATE PAC INJECTION EIGHT (8) 6" PORTS
5. UNIT NUMBER IS 79 UNLESS NOTED OTHERWISE.
6. SYSTEM CODE IS BA UNLESS NOTED OTHERWISE.
7. PIPING AND INSTRUMENT CONNECTION SIZES ARE AS FOLLOWS UNLESS NOTED OTHERWISE
 -PRESSURE CONNECTIONS - 2" NPT
 -TEST CONNECTIONS - 2" NPT
8. SEE DRAWINGS PI07MBAK000012 (4937-CAA-M0100) FOR SYMBOL LEGEND.
9. TE 896A-C AND 897A-C INSTALLED BY WHEELABRATOR.
10. WATER INSPECTION PORTS (14)

WAS:

C&B #4937.1.1C10198

REFERENCE DRAWINGS

REV NO.	DATE	ORDER NO.	REVISION DESCRIPTION	JOB	DRAWN	CHKD	APVD
2	02/11/05		ADDED INSTRUMENTATION				
1	01/10/05		REVISED PAC INJECTION LOCATION, TAG NUMBERS		JLC	JAC	JAC
0	10/11/04		FOR CONSTRUCTION		JLC	JAC	JAC

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REVISION 2

SHEET 4937-CBA-M0112

REF FILES

MICROFILM NO. 354533

DRAWN DATE | ORDER NO. 493704
CHECKED DATE | JOB NO.
APPROVED DATE | SCALE AS NOTED

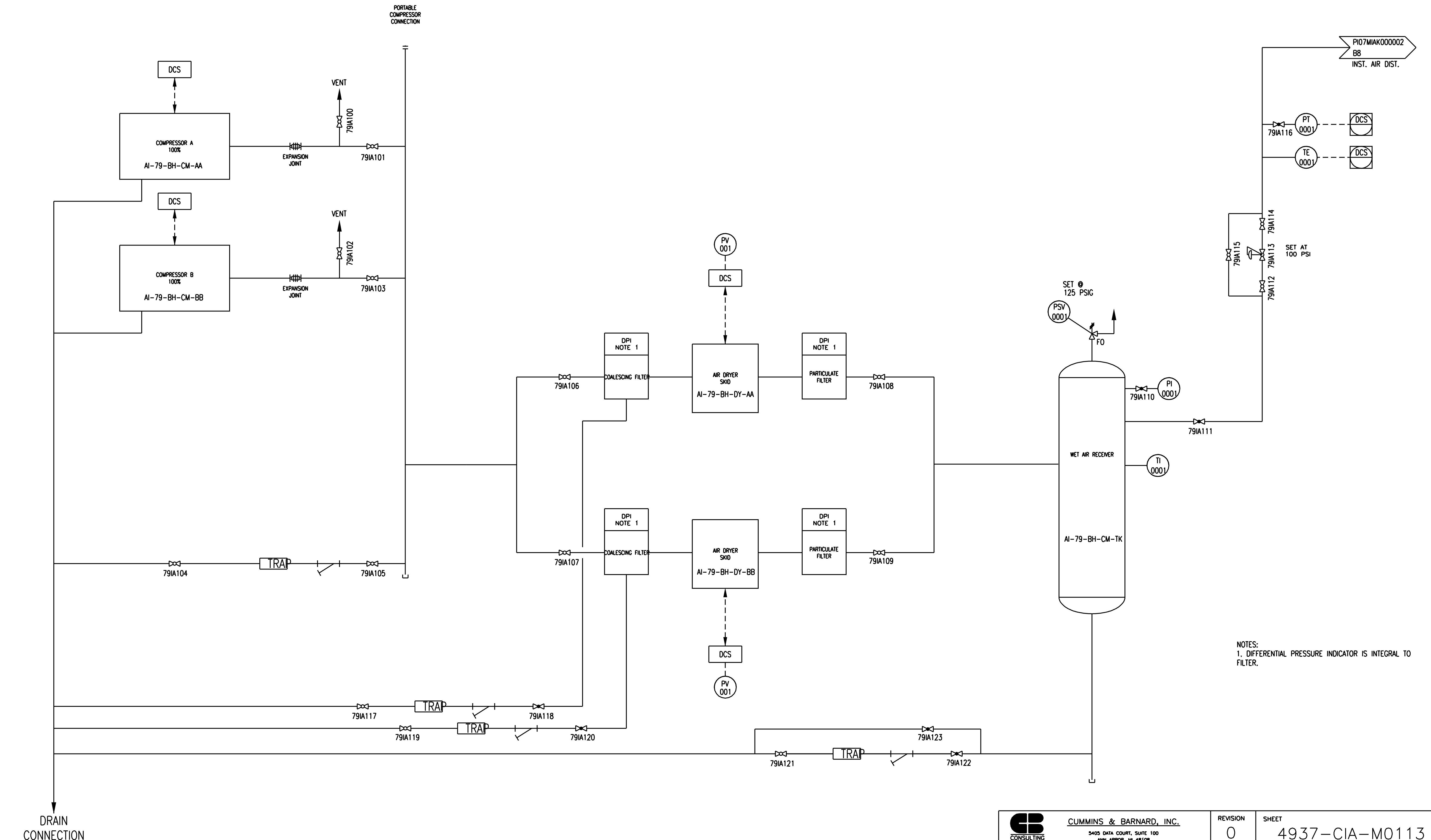
we energies

CGS NO. 115894

PRESQUE ISLE POWER PLANT
PIPING & INSTRUMENT DIAGRAM
FLUE GAS SYSTEM

D PI 07 MBAK 000 014 2

$DATE$



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REVISION: 0

SHEET: 4937-CIA-M0113

REFERENCE DRAWINGS
PI07MBAK000012 "P&ID LEGEND"

REV NO.	DATE	ORDER NO.	REVISION DESCRIPTION	JOB	DRAWN	CHKD	APVD
0	03/04/05		FOR CONSTRUCTION				

REF FILES
MICROFILM NO.

we energies

DRAWN ... DATE ..... ORDER NO. 493704
CHECKED ... DATE ..... JOB NO.
APPROVED ... DATE ..... SCALE AS NOTED
CGS NO.

PRESQUE ISLE POWER PLANT
PIPING & INSTRUMENT DIAGRAM
COMPRESSED AIR SKID SYSTEM

D PI 07 MSAK 000 003 0

$DATE$

NOTES:

1. FLY ASH SYSTEM VACUUM SETTINGS

   A. NO LOAD SETTING:
   FIELD SET FOR A VALUE APPROXIMATELY 1.5" HG ABOVE THE VACUUM OBTAINED WITH THE SYSTEM OPERATING AND PULLING GASES THROUGH AN EMPTY HOPPER. THIS IS BASED ON THE HIGHEST VALUE OBTAINED AFTER BALANCING AND CHECKING EACH BRANCH LINE.

   B. PLUGGED HOPPER SETTING:
   FIELD SET AT A VALUE 3.0" Hg TO 4.0" Hg ABOVE THE VACUUM OBTAINED WITH THE SYSTEM OPERATING AND ALL ASH INTAKES CLOSED. THIS SETTING WILL BE BETWEEN THE NO LOAD AND FULL LOAD SETTING.

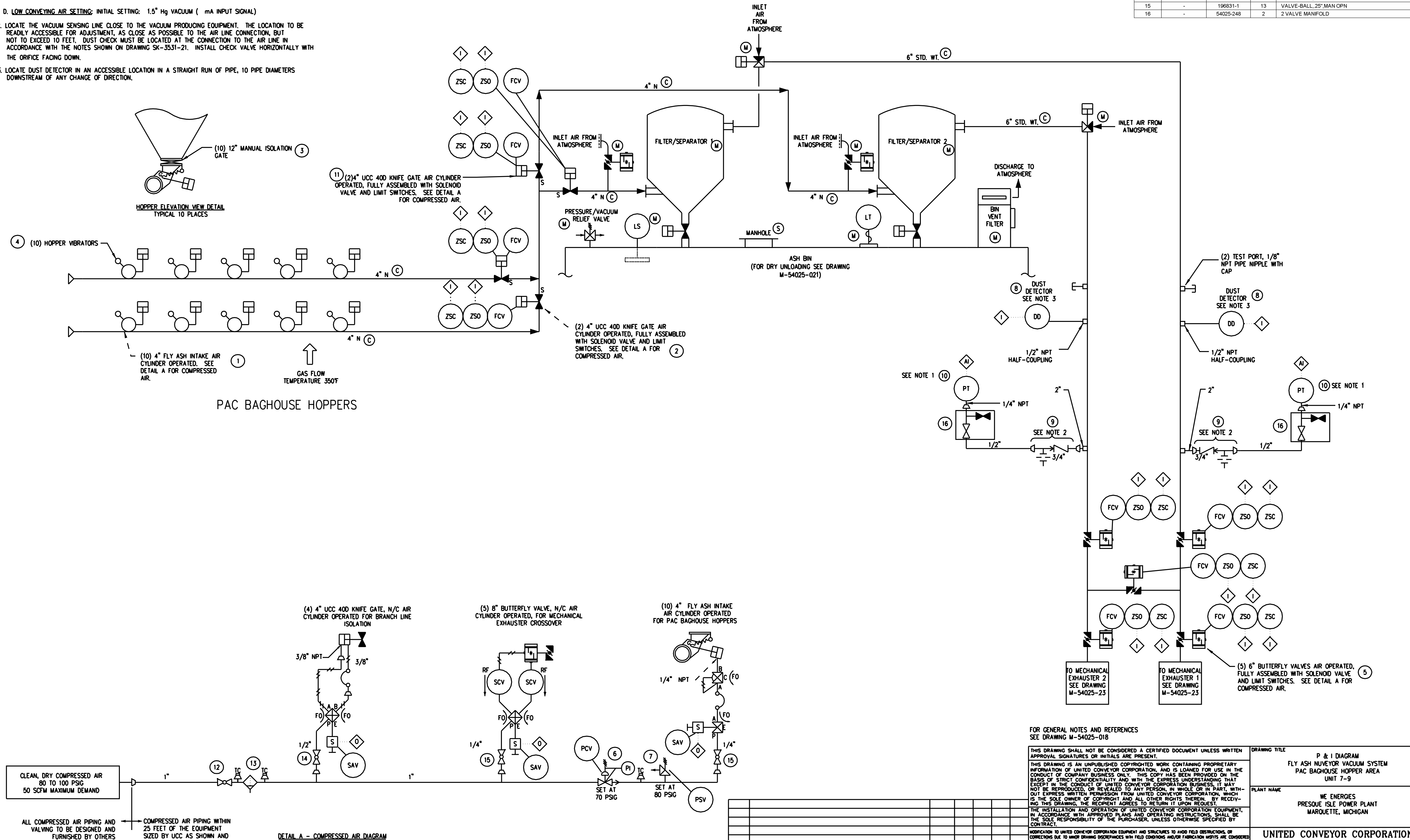
   C. FULL LOAD SETTING: SET AT 13.9" Hg VACUUM (mA INPUT SIGNAL).
   THIS IS THE MAXIMUM VACUUM AT WHICH THE SYSTEM IS DESIGNED TO OPERATE.

   D. LOW CONVEYING AIR SETTING: INITIAL SETTING: 1.5" Hg VACUUM (mA INPUT SIGNAL)

2. LOCATE THE VACUUM SENSING LINE CLOSE TO THE VACUUM PRODUCING EQUIPMENT. THE LOCATION TO BE READILY ACCESSIBLE FOR ADJUSTMENT, AS CLOSE AS POSSIBLE TO THE AIR LINE CONNECTION, BUT NOT TO EXCEED 10 FEET. DUST CHECK MUST BE LOCATED AT THE CONNECTION TO THE AIR LINE IN ACCORDANCE WITH THE NOTES SHOWN ON DRAWING SK-3531-21. INSTALL CHECK VALVE HORIZONTALLY WITH THE ORIFICE FACING DOWN.

3. LOCATE DUST DETECTOR IN AN ACCESSIBLE LOCATION IN A STRAIGHT RUN OF PIPE, 10 PIPE DIAMETERS DOWNSTREAM OF ANY CHANGE OF DIRECTION.

ITEM* A-B-N M - 020 -	DRAWING NUMBER	PART NUMBER	QTY	DESCRIPTION
1	5-1812-2	1812-2-03010703000	10	INTAKE FA,12" X 4",HT,SHRP,NUV,AC,SAV
2	5-1918-3	1918-3-043110100303A	2	GATE-KNIFE,4",40D,BRLN,AC,LS,SAV
3	-	197056-5-1	10	VALVE-KNFG,12",HANDWHEEL OPERATED
4	-	54025-237	10	VIBRATOR-HOPPER
5	-	197052-3-1-1	5	VALVE-8",BUTTERFLY,AC OPER,SAV,LS
6	SK-4411-29	44325-16	1	REGULATOR-AIR PRESSURE,1"
7	-	195750-15	1	VALVE-RLF,1,80 PSIF,BRZ,ASME
8	1-3505-807	3505-807-1	2	DETECTOR-DUST
9	SK-3531-21	3531-21	2	DUST CHECK-2"NPT
10	-	340486-2131-000-0201	2	TRANSMITTER-PRESS VAC, 0' TO 20"HG
11	5-1918-3	1918-3-043140100303A	2	GATE-KNIFE,4",40D,BRLN,AC,LS,SAV
12	-	196831-5	1	VALVE-BALL,1",MAN OPN
13	-	44324-10	1	FILTER-AIR,1"NPT
14	-	196831-3	4	VALVE-BALL,.5"MAN OPN
15	-	196831-1	13	VALVE-BALL,.25",MAN OPN
16	-	54025-248	2	2 VALVE MANIFOLD



FOR GENERAL NOTES AND REFERENCES SEE DRAWING M-54025-018

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REVISION	DESCRIPTION	DATE	DSGN	CHKD	APPD (ENGR)	APPD (PROJ)
A	INITIAL SUBMITTAL	11/22/04	GCL	MEM	GCL	GCL

DRAWING TITLE: P & I DIAGRAM FLY ASH NUVEYOR VACUUM SYSTEM PAC BAGHOUSE HOPPER AREA UNIT 7-9

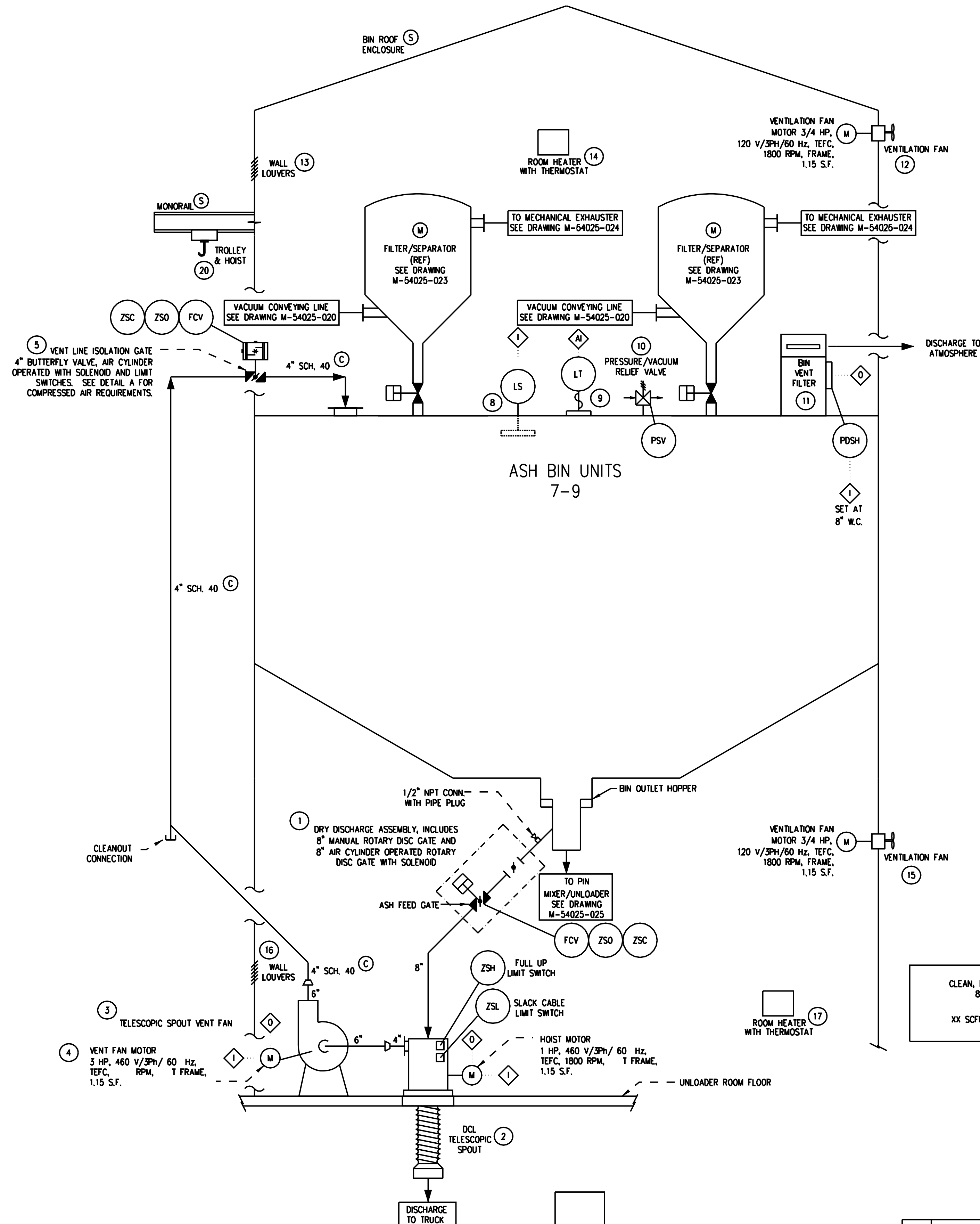
PLANT NAME: WE ENERGIES PRESQUE ISLE POWER PLANT MARQUETTE, MICHIGAN

UNITED CONVEYOR CORPORATION
2100 NORMAN DRIVE WEST
WAUKEGAN, ILLINOIS 60085

SCALE	CONTRACT NUMBER	SUBSYSTEM	DRAWING SIZE	DRAWING NUMBER	REVISION
NONE	54025-24	R	5	M-54025-020	A

N:\SYSTEMSENG\PROJECTS\54025\DWG\M-020.DWG

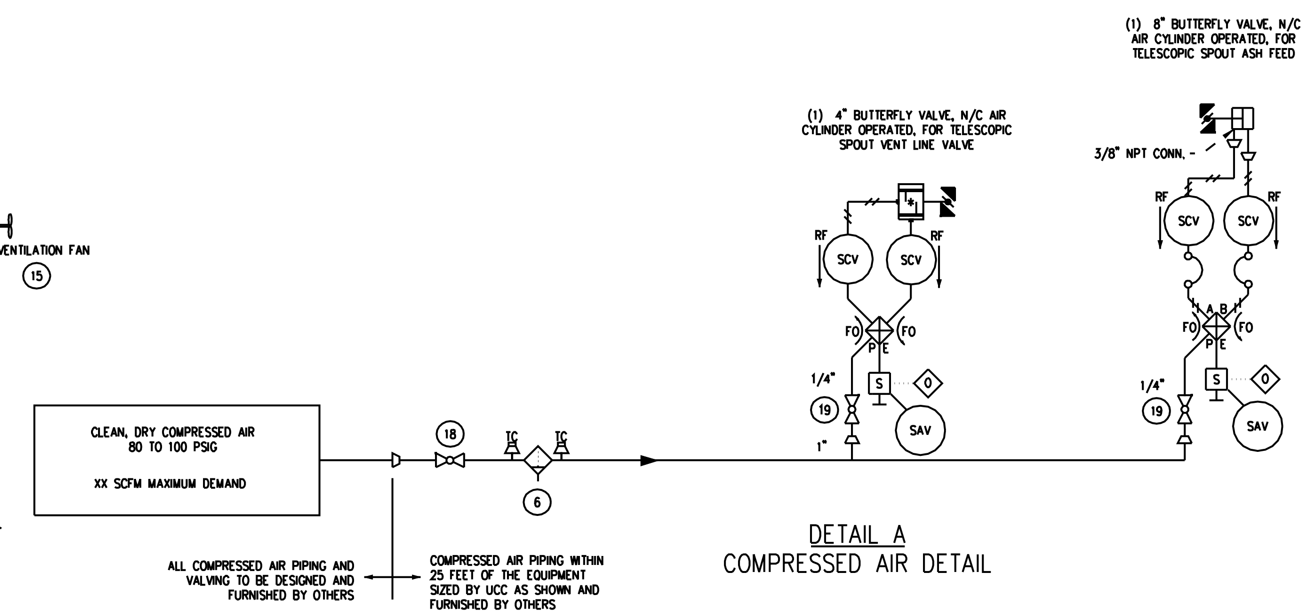
FORM 9820-09 10/99



ITEM* A-B-N M-021-	DRAWING NUMBER	PART NUMBER	QTY	DESCRIPTION
1	2-2326-31	2326-31-2-311	1	DISCHARGE-8" DRY UNLD
2	-	54025-231	1	SPOUT,TELESCOPIC
3	-	54025-234	1	FAN-VENT,6CI
4	-	54025-236	1	MOTOR- HP, RPM, 480V, 60 Hz, 3 Ph, TEFC
5	-	197052-1-1-2	1	VALVE-4",BTFLY,AC OP,SAV,LS
6	SK-4411-27	44324-10	1	FILTER-AIR,1" NPT
7	5-2417-8	2417-8	1	PANEL-CONTROL,TELE SPT & FAN
8	3-3403-88/98	3403-92	1	INDICATOR-LVL,120V,60 HZ,A=4'
9	-	34602-1-1-1-019-1	1	LEVEL-DETR-USONIC,19',200F MAX, 120VAC
10	3-1957-32	1957-32-4	1	VALVE-VAC/PRESS,RLF VENT
11	-	54025-238	1	BIN VENT FILTER
12	-	54025-240	2	BIN ROOF ENCLOSURE VENTILATION FAN
13	-	54025-241	2	BIN ROOF ENCLOSURE LOUVER
14	-	54025-242	2	BIN ROOF ENCLOSURE HEATER
15	-	54025-244	2	UNLOADING ROOM VENTILATION FAN
16	-	54025-245	2	UNLOADING ROOM LOUVERS
17	-	54025-246	2	UNLOADING ROOM HEATER
18	-	196831-5	1	VALVE-BALL,1",MAN OPN
19	-	196831-1	2	VALVE-BALL,.25",MAN OPN
20	-	54025-243	1	3 TON HOIST AND TROLLEY

NOTES:

1. TELESCOPIC SPOUT LOCAL CONTROL PANEL TO BE LOCATED NEAR GRADE LEVEL, IN A CONVENIENT LOCATION FOR OPERATOR ACCESS DURING THE UNLOADING PROCESS.



DETAIL A
COMPRESSED AIR DETAIL

FOR GENERAL NOTES AND REFERENCES SEE DRAWING M-54025-018

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DRAWING TITLE: P & I DIAGRAM BIN AREA AND DRY UNLOADING UNITS 7-9

PLANT NAME: WE ENERGIES PRESQUE ISLE POWER PLANT MARQUETTE, MICHIGAN

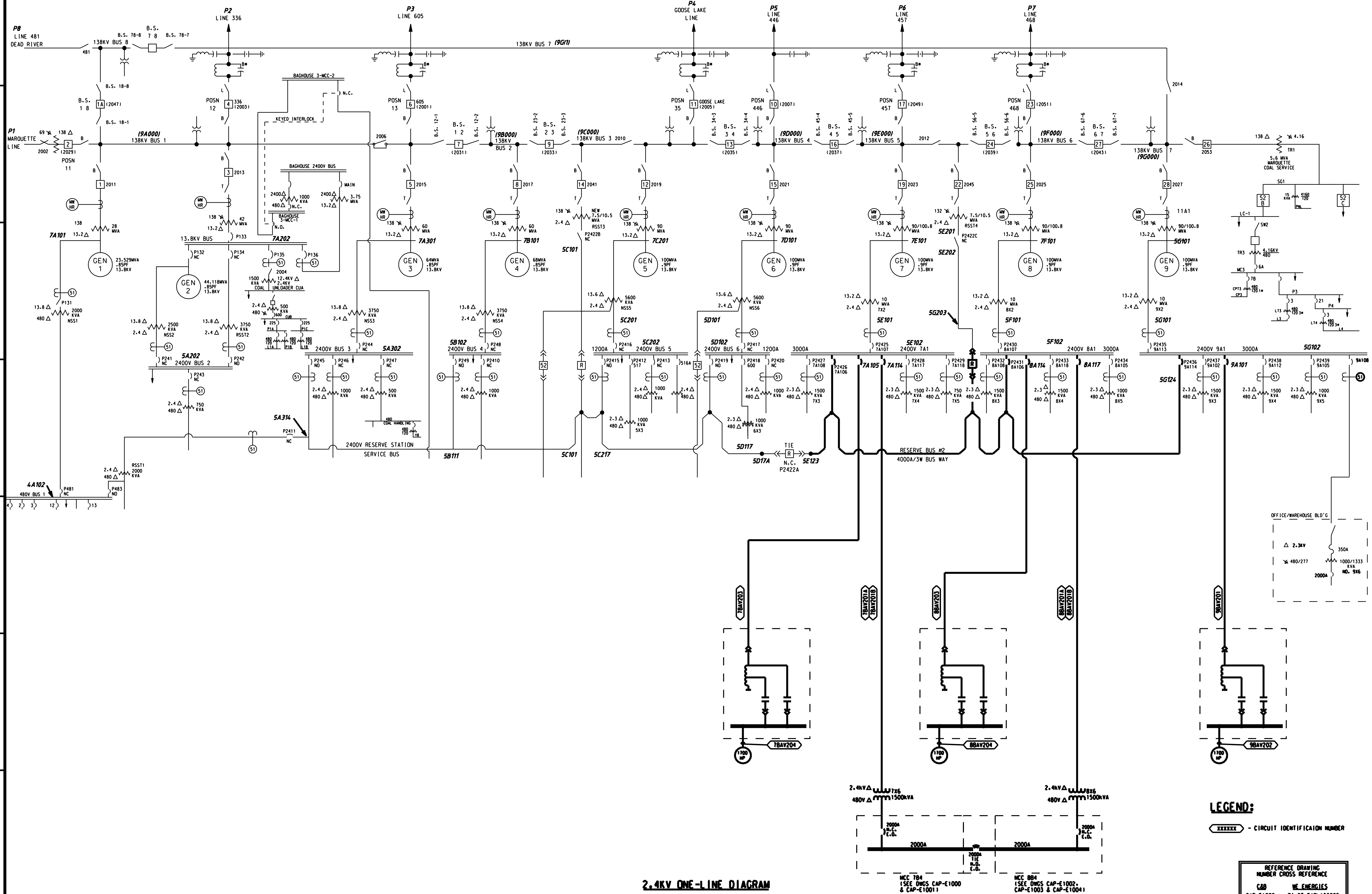
UNITED CONVEYOR CORPORATION
2100 NORMAN DRIVE WEST
WAUKEGAN, ILLINOIS 60085

REVISION	DESCRIPTION	DATE	DSGN	CHKD	APPD (ENGR)	APPD (PROJ)
A	INITIAL SUBMITTAL	11/22/04	GCL	MEM	GCL	GCL

SCALE	CONTRACT NUMBER	SUBSYSTEM	DRAWING SIZE	DRAWING NUMBER	REVISION
NONE	54025-24	V	5	M-54025-021	A

N:\SYSTEMSENG\PROJECTS\54025\DWG\M-021.DWG

FORM 9820-09 10/99



2.4KV ONE-LINE DIAGRAM

NOTE:

1. ID BOOSTER FAN STARTERS ARE AUTO-TRANSFORMER STARTS.

LEGEND:

XXXXXX - CIRCUIT IDENTIFICAION NUMBER

REFERENCE DRAWING NUMBER CROSS REFERENCE

C&B	WE ENERGIES
CAP-E1000	PI 07 EAPL166002
CAP-E1001	PI 07 EAPK166006
CAP-E1002	PI 08 EAPL166001
CAP-E1003	PI 08 EAPK166005
CAP-E1004	PI 08 EAPK166006

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REFERENCE DRAWINGS

0 4-21-05 ISSUED FOR CONSTRUCTION REB CMP JAC

CUMMINS & BARNARD, INC.
5405 DATA COURT, SUITE 100
ANN ARBOR, MI 48108
TEL (734) 761-9130 FAX (734) 761-9881

REVISION 0

SHEET 4937-CMP-E1000

MICROFILM NO. 364283

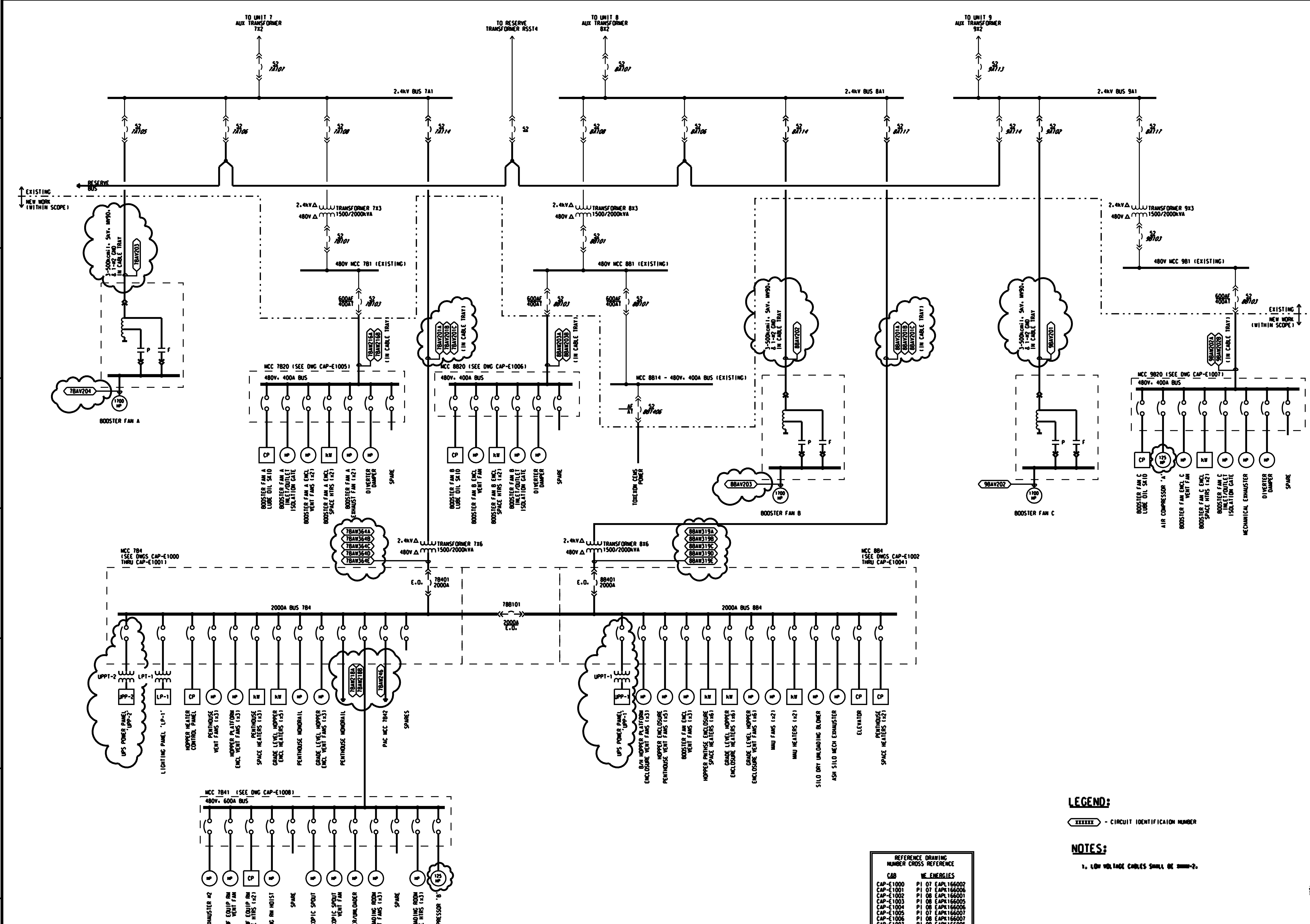
DRAWN REB DATE 11-15-04
CHECKED CMP DATE 4-15-05
APPROVED JAC DATE 4-15-05
PROJECT NO. 493704
ACTIVITY NO.
SCALE NONE

we energies

CGS NO. 120604

PLANT MEDIUM VOLTAGE ONE-LINE DIAGRAM

E PI 07 EMPK00000900



LEGEND:

XXXXXX - CIRCUIT IDENTIFICAION NUMBER

NOTES:

1. LOW VOLTAGE CABLES SHALL BE [illegible]-2.

REFERENCE DRAWING NUMBER CROSS REFERENCE

C&B	WE ENERGIES
CAP-E1000	PI 07 EAPL166002
CAP-E1001	PI 07 EAPK166006
CAP-E1002	PI 08 EAPL166001
CAP-E1003	PI 08 EAPK166005
CAP-E1004	PI 08 EAPK166006
CAP-E1005	PI 07 EAPK166007
CAP-E1006	PI 08 EAPK166007
CAP-E1007	PI 09 EAPK166005
CAP-E1008	PI 07 EAPK166008

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REFERENCE DRAWINGS

1	5-6-05	REVISED PER VENDOR DRAWINGS		REB	CRP	JAC
0	4-21-05	ISSUED FOR CONSTRUCTION		REB	CRP	JAC

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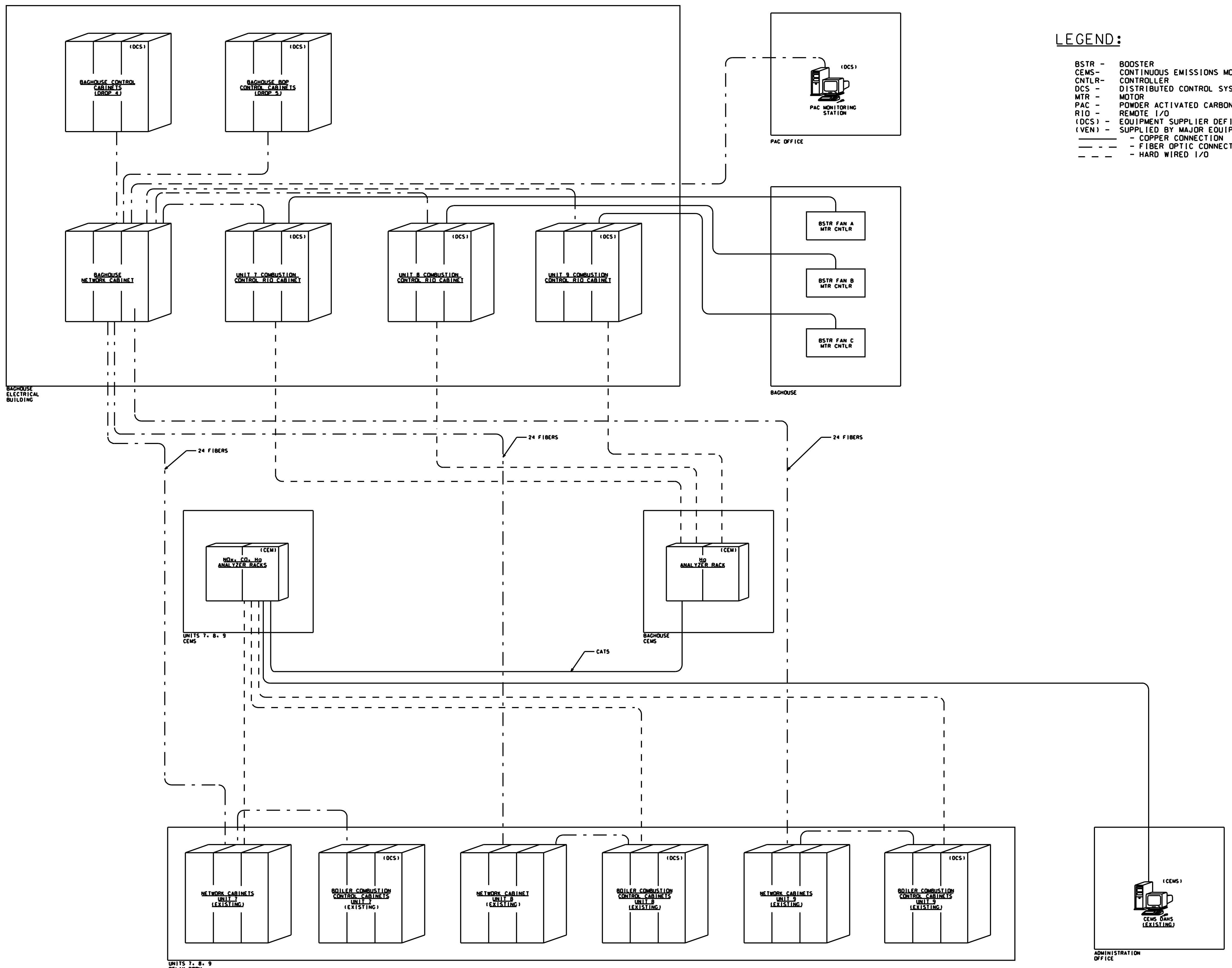
5405 DATA COURT, SUITE 100
ANN ARBOR, MI 48108

REVISION: 1
SHEET: 4937-CMP-E1001

MICROFILM NO. 364284
DRAWN REB 11-15-04 | PROJECT NO. 493704
CHECKED CRP 4-15-05 | ACTIVITY NO.
APPROVED JAC 4-15-05 | SCALE NONE
CGS NO. 120605

ONE-LINE DIAGRAM
UNITS 7, 8, & 9

E PI 07 EMPK00001001



NOTES:

1. ALL EQUIPMENT AND CIRCUITS ARE NEW UNLESS NOTED OTHERWISE.
2. DCS ARCHITECTURE INCLUDES DUAL REDUNDANT DATA HIGHWAY CONNECTIONS.

LEGEND:

BSTR - BOOSTER
CEMS- CONTINUOUS EMISSIONS MONITORING SYSTEM
CNTLR- CONTROLLER
DCS - DISTRIBUTED CONTROL SYSTEM
MTR - MOTOR
PAC - POWDER ACTIVATED CARBON
RIO - REMOTE I/O
(DCS) - EQUIPMENT SUPPLIER DEFINITION
(VEN) - SUPPLIED BY MAJOR EQUIPMENT VENDOR
——— - COPPER CONNECTION
— - — - FIBER OPTIC CONNECTION
— — — - HARD WIRED I/O

WAS:

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CONSULTING ENGINEERS SINCE 1937
5405 DATA COURT, SUITE 100
ANN ARBOR, MI 48108
TEL (734) 761-9130 FAX (734) 761-9881

REVISION 0
SHEET 4937-CCX-K6000

REFERENCE DRAWINGS

REV NO.	DATE	REVISION DESCRIPTION	ACT	DRAWN	CHK'D	APPRV'D
0	4-08-05	ISSUED FOR CONSTRUCTION		DAV	CAR	JAC

LEVEL USAGE
1 2 3 4 5 6 7 8 9
10 11 12 13 14 15 16 17 18
19 20 21 22 23 24 25 26 27
28 29 31 32 33 34 35 36
37 38 39 40 41 42 43 44 45
46 47 48 49 50 51 52 53 54
55 56 57 58 59 60 61 62 63

CGS REF FILES

MICROFILM NO. 356046

DRAWN	DATE	PROJECT NO.
KFH	6-16-04	
CHECKED	DATE	ACTIVITY NO.
CAR	4-08-05	
APPROVED	DATE	SCALE
JAC	4-08-05	NTS

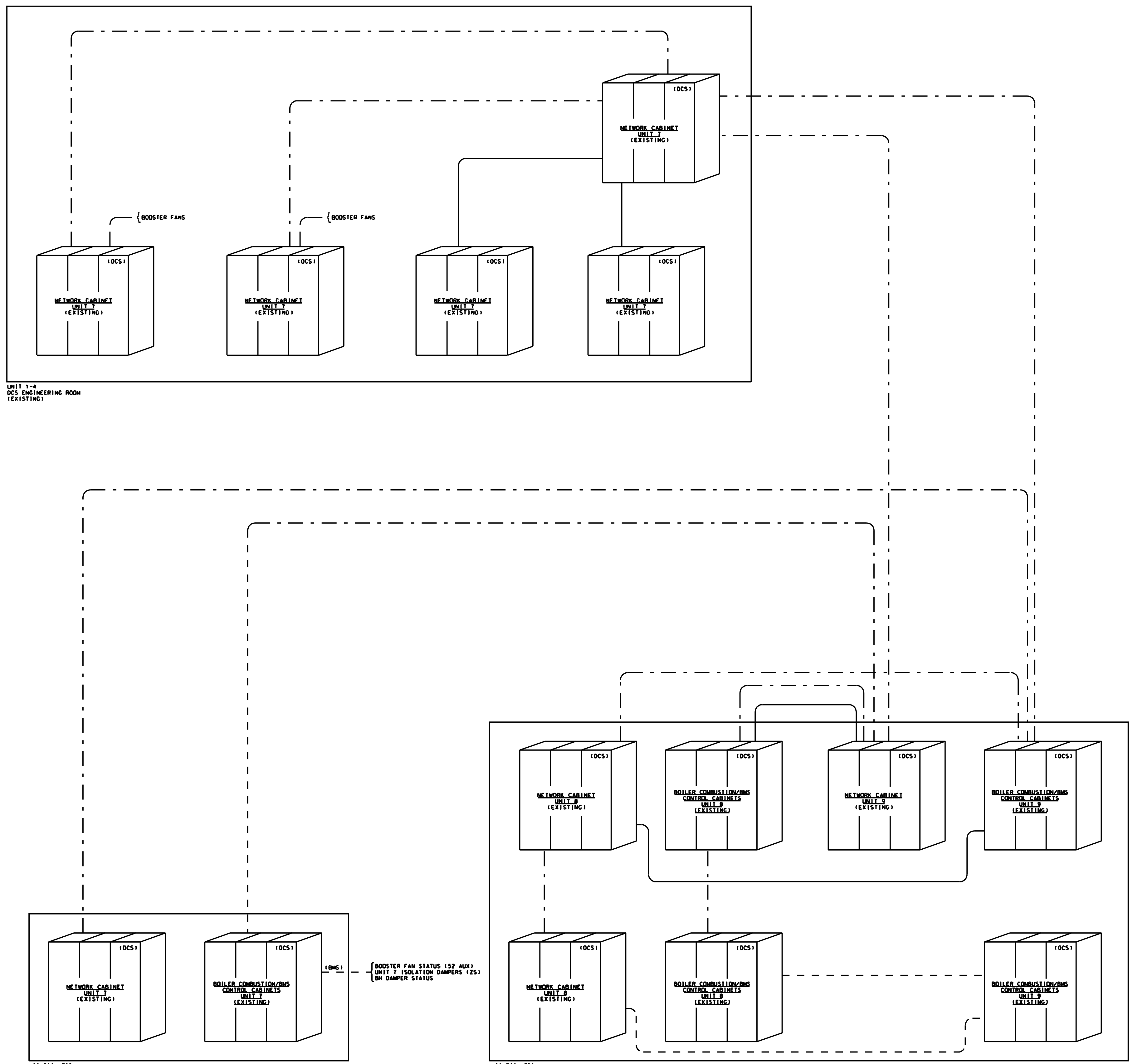
we energies

CGS NO. 116992

CONTROL SYSTEM OVERVIEW

E PI 07 ECXK 141 001 00

$DATE$



NOTES:

1. ALL EQUIPMENT AND CIRCUITS ARE NEW UNLESS NOTED OTHERWISE.
2. EACH DCS CONTROL & RIO CABINET WILL BE SUPPLIED WITH TWO (2) 120 VAC UPS POWER SUPPLIES.
3. DCS ARCHITECTURE INCLUDES DUAL REDUNDANT DATA HIGHWAY CONNECTIONS.
4. EACH UNIT RIO CABINET ON DROP 1 WILL BE RELOCATED TO ITS RESPECTIVE UNITS DROP 4 DCS CONTROL CABINET AFTER COMPLETION OF THE BAGHOUSE.

LEGEND:

BH - BAGHOUSE
DCS - DISTRIBUTED CONTROL SYSTEM
RIO - REMOTE I/O
(DCS) - EQUIPMENT SUPPLIER DEFINITION
(UCC) - SUPPLIED BY MAJOR EQUIPMENT VENDOR
——— - COPPER CONNECTION
— - — - FIBER OPTIC CONNECTION
——— - NETWORK CONNECTION
— — — - HARD WIRED I/O

NOT TO BE USED FOR CONSTRUCTION

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5405 DATA COURT, SUITE 100
ANN ARBOR, MI 48108
TEL (734) 761-9130 FAX (734) 761-9881
CONSULTING ENGINEERS SINCE 1932

REVISION: A
SHEET: 4937-CCX-K6001

CONTROL SYSTEM OVERVIEW

REFERENCE DRAWINGS

REV NO.	DATE	REVISION DESCRIPTION	ACT	DRAWN	CHK'D	APPRV'D
A	6/16/04	OWNER REVIEW		KFH	CAR	

LEVEL USAGE
CGS REF FILES
MICROFILM NO.
DRAWN KFH DATE 6/16/04
CHECKED DATE
APPROVED DATE
PROJECT NO.
ACTIVITY NO.
SCALE NTS
CGS NO.
EPI 07 ECXK141
$DATE$