Golder Associates

December 10, 2010

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BUREAU OF AIR REGULATION

103-87608

Ms. Trina Vielhauer, Chief, Bureau of Air Regulation
Florida Department of Environmental Protection
Division of Air Resource Management
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

RE: JACKSONVILLE ELECTRIC AUTHORITY
PERMIT NO. 0310045-022-AC/PSD-FL-265E
ENGINEERING STUDY TO INCREASE RELIABILITY AND AVAILABILITY OF THE SDA SYSTEM
NGS UNIT NOS. 1 AND 2

Dear Ms. Vielhauer:

Please find attached the study entitled *Engineering Study – Opportunities to Increase SDA Availability for JEA Northside Generating Station Units 1 and 2.*. The study was developed by JEA and Golder Associates in order to comply with Specific Condition III.49 of air construction permit No. 0310045-022-AC/ PSD-FL-265E. This condition requires that JEA provide an engineering study by December 31, 2010, detailing opportunities to increase the reliability and availability of the spray dryer absorber (SDA) systems on Northside Generating Station (NGS) Units 1 and 2. The attached report fulfills this requirement.

Per the permit condition, the report is also being provided to the Jacksonville Environmental Quality Division (EQD). We request that the Department send an email to me at dbuff@golder.com, acknowledging receipt of the report. If you have any questions, please do not hesitate to call me at (352) 336-5600.

Sincerely,

GOLDER ASSOCIATES INC.

David A. Buff

David A. Buff, P.E., Q.E.P.
Principal Engineer

cc: B. Gianazza, JEA

Attachment

DB/tz

Golder Associates Inc.
6026 NW 1st Place
Gainesville, FL 32607 USA
Tel: (352) 336-5600 Fax: (352) 336-6603 www.golder.com

REPORT

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BUREAU OF AIR REGULATION

ENGINEERING STUDY

Opportunities to Increase SDA Availability for JEA Northside Generating Station Units 1 and 2

Submitted To: Jacksonville Electric Authority
21 West Church Street
Jacksonville, FL 32202

Submitted By: Golder Associates Inc.
6026 NW 1st Place
Gainesville, FL 32607 USA

Distribution: **4 Copies – FDEP**
2 Copies – JEA
2 Copies – Golder Associates, Inc.

December 2010 **103-87608**

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Golder Associates

Table of Contents

List of Tables

List of Figures

Professional Engineer Certification

1.	Professional Engineer Name: **David A. Buff** Registration Number: **19011**
2.	Professional Engineer Mailing Address... Organization/Firm: **Golder Associates Inc.**** Street Address: **6026 NW 1st Place** City: **Gainesville** State: **FL** Zip Code: **32607-6018**
3.	Professional Engineer Telephone Numbers... Telephone: **(352) 336-5600** ext. **21145** Fax: **(352) 336-6603**
4.	Professional Engineer E-mail Address: **dbuff@golder.com**
5.	Professional Engineer Statement: *I, the undersigned, hereby certify, except as particularly noted herein*, that:* *1) The engineering features of this report have been review by myself;* *2) Based on information and belief formed after reasonable inquiry, that the statements made in this engineering report are true, accurate, and complete, and that, to the best of my knowledge, any estimates of emissions reported in this report are based upon reasonable techniques for calculating emissions.* David A. Buff 12/10/10 Signature Date (seal)

* Attach any exception to certification statement.

**Board of Professional Engineers Certificate of Authorization #00001670.

1.0 INTRODUCTION

Jacksonville Electric Authority (JEA) operates the Northside Generation Station (NGS), located in Duval County, Florida. NGS consists of two circulating fluidized bed (CFB) boilers, one oil/gas-fired boiler, four oil-fired combustion turbine units, and associated ancillary equipment to produce electric power. The CFB units (Units 1 and 2) are rated at 310 megawatts (MW) each, while the oil/gas unit (Unit 3) is rated at 564 MW. The combustion turbines are rated at 52.5 MW each. NGS currently operates under Title V Operating Permit No. 0310045-020-AV, issued January 1, 2009.

The CFB boiler units each have a spray dryer absorber (SDA) polishing scrubber to aid the units in meeting permitted emission limits for sulfur dioxide (SO_2) and acid gas emissions to the atmosphere. At times, the SDAs must be taken offline for normal repair/maintenance activities or due to malfunctions. During these times, all emission limits continue to be met, including the SO_2 emission limits, which are achievable primarily by increasing the limestone feed rate to the CFB boilers.

JEA submitted an air construction permit application in August, 2008, to request clarification from the Florida Department of Environmental Protection (FDEP) regarding JEA's ability to operate Units 1 and 2 with the SDA off-line during periods of malfunctions, maintenance, and repair. JEA requested the ability to operate Units 1 and 2 with the SDA off-line for an average of 12 hours per month per unit. FDEP subsequently issued Air Construction Permit No. 0310045-022-AC, allowing Units 1 and 2 to operate with the SDA off-line for a maximum of 12 hours per month per unit based on a 12-month rolling average.

As part of the approval to operate Units 1 and 2 with the SDA off-line, FDEP included a requirement for JEA to submit an engineering study detailing the opportunities to increase the reliability and availability of the SDA system. (2) The study must address potential improvements in (1) preventive and predictive maintenance, and potential equipment and system modifications (including opportunities for redundancy) which will result in minimizing the amount of time the SDA is off-line during CFB operation. The engineering study is also to include the (3) cost estimates associated with potential system/equipment modifications (including opportunities for redundancy) and the (4) cost effectiveness of the associated emissions reductions. The engineering study is required by Specific Condition No. 49 in Section III of the permit, and must be submitted (5) to FDEP and to the Jacksonville Environmental Quality Division (JEQD) no later than December 31, 2010.

In order to satisfy the permit requirements, this report addresses the potential improvements in preventative and predictive maintenance, and the potential equipment and system modifications which will result in minimizing the amount of time the SDA is off-line during operation of Units 1 and 2. This report includes equipment and system modifications which have been made since the original commissioning of the units. This report also includes cost estimates associated with equipment modifications (planned and completed) and the cost effectiveness of the associated emission reductions.

2.0 NORTHSIDE CFB UNITS OPERATION

NGS Units 1 and 2 are CFB boilers that fire coal and petroleum coke (petcoke). The units are rated at 310 MW each, with a maximum heat input rate of 2,764 million British thermal units per hour (MMBtu/hr). The units include solid fuel delivery and storage facilities, limestone preparation and storage facilities (including three limestone dryers), a lime silo, aqueous ammonia storage, polishing scrubbers (the SDAs), fabric filters (baghouses), and ash removal and storage facilities.

The NGS CFB boilers operate on the principal of combustion of fuel in a fluidized bed of material. Coal/petcoke is crushed to the appropriate particle size prior to being introduced into the CFB boiler. The coal and petcoke is burned in suspension within a bed of hot incombustible particles (limestone/fly ash). The particles are suspended by the upward flow of the fluidizing gas (combustion air/products of combustion) within the combustor. Due to high velocities in the CFB boiler, a portion of the limestone/fly ash is continually carried over from the bed (approximately 20-percent). Most of this material is collected in the cyclone separators and is then re-circulated back to the CFB boiler.

In addition to the petcoke and coal being injected as fuel, pulverized limestone is continuously added to the fluidized bed. The high temperature breaks down (calcines) the limestone into calcium oxide. This calcium oxide in turn reacts with the fuel sulfur in the combustion zone to form calcium sulfate. A portion of this sulfate material is continually removed from the bottom of the combustor using ash strippers, while the fresh limestone is continually added to maintain the calcium oxide inventory in the combustion bed. This reaction of the fuel sulfur with the calcium oxide and subsequent removal of the sulfate removes the bulk (75-90 percent) of the sulfur before it can become SO_2.

The use of limestone as the bed material in the CFB boiler also acts to inherently control acid gas emissions such as hydrogen chloride (HCl) and hydrogen fluoride (HF).

The NGS CFB boilers are also equipped with a selective non-catalytic reduction (SNCR) system to reduce nitrogen oxide (NO_x) emissions. The SNCR system sprays aqueous ammonia solution into the hot flue gas exiting the combustor before it reaches the cyclone separator. The injected ammonia reacts with the nitric oxide to form nitrogen and water vapor.

Additional removal of flue gas pollutants occurs in the SDA. Flue gas enters the top of the 150-foot (ft) tall spray dryer vessel. An aqueous slurry of atomized calcium-oxide-containing fly ash is sprayed into the flue gas stream. The calcium oxide chemically combines with the SO_2 remaining in the flue gas and forms heavy calcium sulfate and calcium sulfite particles. Other acid gases (HCL and HF) are captured in a similar manner.

At the same time, the atomized oxide-and-sulfate slurry is dried by the hot flue gas. By the time the particles reach the bottom of the spray dryer vessel, the oxide-and-sulfate particles are dried to a very fine, flour-like consistency. Most of this material joins the exiting flue gas stream, to be collected downstream in the fabric filter, while part of the material collects in the SDA bottom hopper. Much of this fine ash is removed through a two-valve air lock in the bottom of the SDA hopper.

A baghouse is installed downstream from the SDA vessel. Since the flue gas is at a relatively high velocity, considerable fine ash material remains entrained in this flue gas prior to the baghouse. This ash is removed by the filtering action of the baghouse system. As the flue gas is filtered by the thousands of glass-fiber bags, a cake of fine ash builds up on the upstream side of the bags. The still-active calcium oxide in this ash cake further reacts with and removes acid gases. A further benefit of this ash cake is the removal of some particulate mercury.

2
6

The baghouse also reduces particulate matter (PM) and particulate matter less than 10 microns (PM_{10}) emissions, while maximizing combustion efficiency to limit carbon monoxide (CO) and volatile organic compound (VOC) emissions, and minimizing NO_x formation.

A flow diagram of the air quality control system downstream of each unit is shown in Figure 2-1.

The combination of CFB boiler and SDA allows JEA to vary the limestone injection rate into the CFB and recycled ash slurry injection into the SDA in order to control SO_2 emissions to meet permit limits. At times when limestone injection into the CFB must be limited, the slurry feed to the SDA can be increased to achieve equivalent acid gas reduction. At times when the SDA must be taken off-line for repair or maintenance, the limestone feed to the boiler can be increased to achieve the necessary acid gas reduction. Limestone and slurry feed rates are also related to the sulfur content of the fuels being burned (coal ~~and/or pet~~coke). The NGS units currently burn about 90-percent petcoke and 10-percent coal on a by-weight basis.

The design of the CFB boiler allows operation over a large load range even though the units are base loaded. The CFB boiler vendor (Foster Wheeler USA) has guaranteed emission rates down to 50-percent load, and based upon initial demonstrations, operation at loads as low as 25-percent is achievable while still meeting performance and emission requirements.

SO_2, NO_x, and CO (and more recently, mercury) emissions are measured continuously by continuous emissions monitoring systems (CEMS). Opacity is also measured continuously by a continuous opacity monitoring system (COMS). Annual compliance ~~testing is required~~ for PM/PM_{10} emissions. Initial stack testing was conducted for VOC, lead (Pb), sulfuric acid mist (H_2SO_4), HF, and mercury (Hg).

Was the SDA put in to control SAM (Syed)?

If you could get T_{NO_3}, maybe you could get a better idea of "carbon" (when bypassing) when SDA was shut down

3.0 SDA SCRUBBER AND SLURRY SYSTEM OPERATION

The SDA is referred to as a "polishing scrubber" because the primary removal of acid gases from the units is in the CFB itself (see above description). At the top of the SDA vessel, the hot flue gases, which contain limestone/fly ash carryover from the CFB, enter the vessel. A slurry consisting of captured limestone/ash from the baghouse and water is introduced at the top of the vessel by atomizing spray nozzles. As the flue gas flows through the absorber, it mixes with the slurry, which is injected by the spray nozzles located at the top of the SDA vessel. The slurry reacts with the SO_2 and other acid gases in the flue gas stream. Most of the water in the spray particles evaporates, cooling the flue gas substantially, and creating tiny solid particles. Most of these remaining solid particles remain suspended in the gas flow, and exit the SDA along with the flue gases, to be captured in the downstream baghouse.

The OEM designed the SDA to operate with a minimum of 8 spray nozzles in service. JEA typically operates the SDA with 8 to 16 ~~spray nozzles~~ in service depending on unit load. Operations controls reagent slurry spray ~~flow~~ and the number of nozzles ~~in service~~ in order to maintain the SDA outlet temperature between 165 degrees Fahrenheit (°F) and 185 °F. What is T w/o SDA?

The SDA vessel includes a hopper located on the bottom of the SDA vessel. The gas and solids flow to the bottom of the SDA, turn 90 degrees and exit out the side of the unit. The hopper collects particles that fall out of the flue gas flow stream prior to the gases exiting the SDA vessel. The SDA is designed for an outlet flue gas temperature of 165 to 185 °F, in order to ensure proper chemical reaction of the slurry and the acid gasses. Evaporation of the moisture in the slurry quenches the flue gas to a temperature suitable for the downstream baghouse. Automatic controls reduce the slurry feed rate as necessary to maintain the SDA outlet temperature.

Material collected in the bottom of the SDA hopper is transferred to the SDA Ash Conveyor. The material is then passed through the SDA Ash Delumper and into the Recycle Slurry Mix Tank. Material collected in the baghouse is also transferred into the Recycle Slurry Mix Tank. Water is added to the Recycle Slurry Mix Tank from the heated recycle water header as necessary to maintain the desired slurry density. Recycle Slurry Transfer Pumps A and B move the slurry into the Recycle Slurry Separator and into the Recycle Slurry Storage Tank. The recycle slurry transfer pumps run continuously in order to ensure that the ash slurry remains suspended. The slurry is then pumped out of the Recycle Slurry Storage Tank by either Feed Slurry Transfer Pumps A or B and up to the SDA Penthouse. The slurry is then pumped through either of two final filters by Feed Slurry Pumps A or B and into the SDA nozzles to complete the cycle. Each of the pumps serving the SDA slurry system is redundant (A and B). There is no redundancy for piping, mix tanks, nozzles, or ring header.

A process flow diagram of the SDA system is presented in Figure 3-1.

4.0 SDA HISTORICAL MALFUNCTIONS

A summary of the majority of historical maintenance and repair activities conducted on the CFB boilers is presented in Table 4-1. The list includes events in which an SDA was removed from service while the CFB unit remained on-line. Each event is presented with the typical duration of the repair and the expected annual frequency of the events for each of the CFB units. The sections below describe each of these various SDA systems malfunctions in more detail. Also see Section 5.0, Equipment Modifications and Operational Changes, for a description of changes which have already been implemented, or are planned to be implemented, to reduce SDA downtime.

4.1 Vessel, Ring Header or Slurry Final Filter Pluggage

SDA vessel pluggage can occur when any one of the 16 nozzles on a given SDA unit is experiencing a spray pattern quality issue, and the slurry discharged from the nozzle is not being properly atomized. As a result, the slurry does not dry as designed along the flow path, resulting in wet slurry being deposited on the SDA vessel walls and in the form of agglomeration – large lumps of semi-dry ash. The only operational indication as to the location of the faulty nozzle is a differential temperature between adjacent flow zones in the SDA vessel. This difference in temperature allows an operator to determine which SDA spray zone is likely to have a spray quality issue. When this temperature differential occurs, the operators will take each nozzle in that zone out of service until the offending nozzle is located – as indicated by observing the differential zone temperatures. The corrective action is to replace the spray nozzle(s) with a spare unit. SDA downtime due to vessel pluggage can last between 4 and 8 hours.

Another indirect method to determine the spray quality is to temporarily divert the SDA hopper ash flow away from the recycle slurry mix tank to the emergency discharge pit. The operators can then visually inspect the ash as it collects in the ash pit. If the ash appears to be lumpy, there are spray issues to be investigated. If the ash has a fine flour-like consistency, the spray quality is acceptable.

Pluggage can occur throughout the slurry feed system piping, in the SDA spray nozzle ring header which supplies slurry to all of the nozzles in the SDA, and in the spray nozzles themselves. Solids can drop out of suspension and plug the ring header piping. When this occurs, operations and maintenance personnel work to determine the location of the pluggage. Maintenance personnel then disassemble the header as necessary to remove the pluggage. SDA downtime due to ring header pluggage can last between 4 and 12 hours.

The final filters (located after the Feed Slurry Pumps and before the SDA nozzles) have been historically subject to pluggage. Normally, only one final filter is in service with the other one serving as a standby. When both final filters become plugged, no slurry will flow to the spray nozzles, which then requires shutdown of the SDA. Corrective action is to isolate the filter(s), disassemble, repair, and reassemble the screen and scraper as necessary, and then reassemble the filter unit. SDA downtime due to simultaneous final filter pluggage can last between 4 and 10 hours.

At times, the recycle slurry forms tiny platelets of solid material that remain suspended in the high velocity slurry flow. When this slurry passes through the final filter screen, the platelets remain in the strainer and begin to plug the strainer. The platelets also cause the strainer's pneumatic scraper to jam up and not scrape the solids off of the strainer screen. After a period of time the scraper is wedged tightly in the strainer and cannot reciprocate to keep the strainer clean. At this time, the strainer quickly plugs up and the final filter screen can no longer pass slurry. The final filter is valved out and requires disassembly for cleaning. As stated above, SDA downtime due to simultaneous final filter pluggage can last between 4 and 10 hours.

Other vessel components that have historically been subject to pluggage events include the feed slurry pumps and line, mix tank, slurry vent valves, and ring header drain lines. When this occurs, operations and maintenance personnel work to determine the location of the pluggage. Maintenance personnel then disassemble the system components as necessary to remove the pluggage. Typical downtime due to these pluggage events is approximately 2 to 4 hours to allow for plant personnel to locate and resolve the problem.

4.2 Piping Leaks/Rupture

Piping serving the SDA system has experienced leaks and/or rupture episodes. Piping leaks are typically the result of pipe erosion and/or corrosion. SDA components that have historically been subject to leaks or failure include piping tees and elbows, feed slurry transfer pump discharge lines, recycle slurry pump suction line, and feed slurry return line. Originally, the corrective action had been to cut out the worn piece, fit and solvent weld in a new piece of pipe, and then thermally cure the new weld locations before returning the piping to service. Typical downtime due to piping leaks or ruptures last approximately 8 to 16 hours to allow for plant personnel to locate and repair (see Section 5.3 for current repair practices).

4.3 Re-Use Water Supply System Failure

The reuse water system is used to supply water to multiple components in the SDA slurry system, including: the atomizing spray nozzles, the recycle slurry storage tank, and the recycle slurry mix tank. Re-use water is also used throughout the system to flush components in order to minimize the opportunity for ash pluggage. The plant service water system could potentially be cross-tied into the re-use water system to provide redundancy. However, the plant service water system has insufficient pressure to properly supply the pump seals and flush the apparatus at the top of the SDA. Therefore, the SDA system must be brought offline. Loss of reuse water downtime events last approximately 12 to 36 hours per occurrence.

4.4 Atomizing Air Compressor Failure

When the slurry solution is sprayed into the SDA it must be properly atomized. Slurry is atomized using compressed air that is delivered by the atomizing air compressors. The atomizing air is transported from the air compressor house through the air header to the SDA penthouse. The compressed air is passed through a series of filters and then flows through a common ring to the individual spray nozzle stations. At each of the sixteen spray nozzle stations, the air flows through the air flow regulators and then into each of the nozzles located in the SDA vessel.

The existing cooling system for the three water-cooled atomizing air compressors was not originally adequate under certain operating conditions. The design air compressor coolant temperature could not be maintained with two compressors on-line, and a third could not be started during hot weather because the heat load on the system exceeded the cooling system design capacity. During such times, a compressor might trip out of service. The original corrective action was to remove spray nozzles from service to attempt to stay within the capability of two compressors until the proper number of compressors could be operated. The associated SDA downtime could last between 4 to 8 hours (see Section 5.2 for corrective action practices).

4.5 Preventative and Predictive Maintenance.

JEA utilizes various processes for sustaining and improving the reliability of the electrical power generation plants at the Northside Generating Station. The plan incorporates Reliability Centered Maintenance and Root Cause Failure Analysis. Through these processes, improvements in the predictive and preventative maintenance procedures are continuously implemented on the SDAs and the CFB units.

4.5.1 Reliability-Centered Maintenance

Reliability-centered maintenance (RCM) is a methodology driven by safety and economics. The logic of this analysis process is followed to identify the most applicable and cost effective maintenance practices that can be used to find and mitigate or avoid failures in machinery functions. RCM and most of its derivatives involve Failure Modes and Effects Analysis. RCM derivative processes include the Streamlined RCM Process, the Facilitated RCM Process and the Blitz RCM Process.

A system selection process is undertaken, based on study of data, to identify the systems incurring the most serious failures in terms of equipment availability, cost of repair, or capacity factor reduction. The top ten percent of these systems will be subjected to a Streamlined RCM process. The Streamlined RCM Process is defined as one that uses pre-existing templates that identify typical functions, dominant functional failure modes, failure causes and mitigation activities and strategies for critical components common to utility plants (e.g., pumps, motors, valves). Typical mitigation activities include condition monitoring and associated condition directed tasks, time directed tasks, and failure finding tasks.

The Facilitated RCM process will be used for the next ten percent of systems incurring the most serious failures in terms of equipment availability, cost of repair, and capacity factor reduction. The Facilitated RCM Process is defined as one where a facilitator, a person skilled in RCM methodology, collects information in a progressive manner from subject matter experts during a series of one-on-one meetings. The facilitator conducts boundary definition, a Failure Modes and Effects Analysis, and task selection. Short meetings are held to give an opportunity for parties involved to discuss and agree on the analysis.

Systems that are not addressed by the Streamlined or Facilitated RCM processes (i.e., the remaining 80 percent) are subjected to a Blitz RCM approach. The Blitz RCM approach is a derivative that uses a two person facilitator team to conduct meetings of subject matter experts for the purpose of analysis. In a typical Blitz RCM approach, the facilitators specialize in specific manufacturing processes and travel from plant to plant. At each plant, an RCM analysis is conducted with local subject matter experts. The team accumulates knowledge of failure modes, effects and mitigation strategies for the systems in which they specialize.

4.5.2 Root Cause Failure Analysis

Root Cause Failure Analysis (RCFA) involves the use of a variety of methodologies for finding the true cause of a failure. Root causes of failure fall into two fundamental categories: technical and programmatic. Technical causes involve equipment and systems design and interactions between components when they are operated. Programmatic causes involve adequacy of procedures and other documentation used in support of operations and maintenance, training effectiveness, attitude of the workers and supervisors, and quality control measures in place to help avoid mistakes leading to failures. Failure Process Mapping is a tool used in many approaches to technical RCFA. The central logic of the leading programmatic root cause failure analysis approach is presented in process map format. Process maps enable the analyst to keep track of many factors that contribute to almost any failure. This results ultimately in a better understanding of the chain of events leading from root cause to ultimate failure.

4.5.3 Predictive Maintenance Technology

Predictive maintenance technologies implemented by JEA are designed to evaluate the condition of equipment by performing periodic conditioning monitoring. The ultimate goal of the predictive maintenance technologies is to perform maintenance at a scheduled point in time when maintenance is the most cost-effective, and prior to equipment failure. Predictive maintenance technologies utilized by JEA include non-destructive testing such as vibration analysis and oil analysis.

Oil analysis is used to determine the suspended contaminants, wear debris and lubricant properties of lubricating oils used in equipment. Routinely performed oil analysis provides information on lubricant and component condition. The oil analysis sample results are tracked over the lifetime of the component in order to establish trends that can be monitored to prevent failure.

Vibration analysis is used on rotating machinery components which enables the early detection of faults before breakdown. The evaluation of the changes in vibration response, critical speeds, and stability of equipment is an important part of the predictive maintenance. Vibration analysis enables the diagnoses of faults, enabling plant personnel to perform repairs during scheduled outages and thus preventing unscheduled SDA downtime.

4.5.4 Preventative Maintenance

JEA has implemented routine preventative maintenance of SDA components in order to prevent unscheduled down time events. Preventative maintenance has been performed and modified over the course of the SDA service term as new maintenance issues arise. Preventative maintenance is continuously modified based on operational malfunctions and operator feedback. As operational issues arise, preventative maintenance is evaluated and adjusted in order to promote full functionality of air quality control equipment. Preventative maintenance is also adjusted or revised based on safety and environmental concerns in order to ensure equipment is properly maintained and no injuries to plant personnel or environmental impacts are experienced.

As described in Section 4.1, nozzle pluggage contributes significantly to SDA system down time. Preventative maintenance implemented to reduce downtime and ensure reliability of the SDA system due to nozzle pluggage includes daily cleaning of all nozzles as well as flushing the ring header twice per shift. Cleaning of nozzle heads and ring header flush is performed to minimize the potential for solid buildup which can lead to pluggage and associated SDA downtime.

Additional preventative maintenance practices routinely performed on both SDA systems serving NGS Units 1 and 2 include:

- SDA regular conveyor – Lubricate bearings, chain; take-up rods and rails (every 6 months)
- SDA emergency conveyor - Lubricate chain; take-up rods and rails (every 6 months)
- Goulds A and B Sump pumps – Grease bearings and capacity check (monthly). Changed to more reliable Galigher pumps in 2003.
- A, B, and C Fluidizing air blowers –
  - Change filters (monthly)
  - Lubricate drive bearings (monthly)
  - Change oil and check belt (monthly)
- 1A and 1B Induced draft fans – Grease inlet vanes and linkages (monthly). Sample and test bearing oil periodically.
- A, B, and C Atomizing air compressors – Replace primary inlet air filters (monthly)
  - Previously, motor filters were cleaned monthly and replaced annually. Cleaning filters monthly was determined to be not sufficient, so filters are now replaced monthly. Compressor oil sampled monthly.

- SDA – Grease equipment (monthly) including:
  - Feed Slurry Pumps A and B;
  - Feed Slurry Transfer Pumps A and B;
  - Recycle Slurry Pumps A and B;
  - Common Sump Pumps A and B;
- SDA Emergency Discharge Conveyor - Lubricate chain; take-up rods and rails (every 6 months)
- SDA Manual Isolation Valves – Lubricate (monthly)
- Induced Draft Fans 1A, 1B, 2A, and 2B – Grease inlet vanes and linkages (monthly)
- SDA Ash Delumper – Grease bearings monthly

5.0 EQUIPMENT MODIFICATIONS AND OPERATIONAL CHANGES

Numerous capital improvements were evaluated for potential implementation during recent outages. All modifications described below have been implemented or are planned to be implemented to address SDA component failure that can lead to system downtime. These system modifications have been determined as essential to improving SDA availability and are important to the functionality of the SDA components. Each of the SDA system modifications evaluated are described below, including the estimated project cost.

An analysis was also performed in order to determine the cost effectiveness of the potential emissions reductions associated with each modification. The cost effectiveness of each system modification is presented in Section 7.0.

5.1 Nozzle Air Flow Regulators Upgrade and Nozzle Flush System Installation

This project was ~~of high~~ priority due to the high incidence of nozzle failure and resulting SDA vessel pluggage. Vessel pluggage was the most frequent cause of SDA down time. When the slurry solution is sprayed into the SDA it must be properly atomized. This is performed with atomizing air that is delivered by an atomizing air compressor system. The atomizing air is transmitted from the air header through two coalescing air filters, through individual air flow regulators, and then into each of the 16 nozzles. The original flow regulators were unreliable and had high maintenance costs due to their sensitivity to moisture and water/rust particles from the air header.

One part of this project involved installation of new air flow regulators that were designed to reduce sensitivity to moisture and rust particles. The new air flow regulators have now been in service for five years and have been also shown to improve nozzle spray quality, which has the potential to improve the efficiency of the SDA system.

Another part of this project involved the installation of a new system that would ~~automatically flush~~ the nozzles periodically with re-use water. The new system prevents slurry from remaining in the nozzle when the SDA system is shutdown, which leads to plugging and requires additional maintenance.

The estimated capital cost for the nozzle air flow regulator upgrade and new flush system was $228,000. Typical SDA down time due to nozzle pluggage was difficult to estimate since the problem occurred on both units on a regular (nearly continuous) basis. The best estimate of SDA downtime would be four occurrences per year per unit and 48 hours per occurrence. It is estimated that this project has the potential to reduce SDA downtime by approximately 8 hours per unit per year.

5.2 SDA Slurry Atomizing Air Header and Air Filter Upgrade

This project replaced part of the original atomizing air header system. The atomizing air header supplies air from the coalescing filter to the spray nozzle air flow regulator system. The original system was constructed from carbon steel without a low point drain and had become internally corroded due to water condensation in the piping. In order to mitigate further corrosion, a low point drain was installed. However, the existing corrosion particles negatively affected nozzle performance and caused vessel pluggage and ultimately SDA downtime. The original atomizing air system utilized two sets of filters in series. There was a main filter which could not be maintained without taking the SDA offline. The second set of filters was located at each nozzle which added additional pressure drop and exacerbated air compressor loading.

The new atomizing air header was constructed from stainless steel. This project was designed to eliminate the corrosion issues and avoid introducing more rust afterwards. With the reduction of corrosion in the system, the second set of filters located in the nozzles could be removed with a corresponding reduction in air compressor loading. A second (parallel) filter was also installed which eliminated the need to take the SDA offline in order to perform maintenance on the main filter. A new automated low point drain was added to the system and was re-routed to allow for better drainage.

The estimated cost for the atomizing air header upgrade project was $311,000. This project has reduced the occurrences of SDA downtime due to air filter pluggage. SDA downtime due to air header final filter pluggage was approximately 2 to 6 hours per occurrence. SDA downtime events due to atomizing air header filter pluggage occurred approximately twice per year. This has been reduced to essentially zero.

The atomizing air compressor system was limited by the cooling water supply system limitations, especially during the extremely hot months. An additional set of plate heat exchangers for the compressors' glycol cooling system were installed to augment the original glycol-to-air heat exchanger system. Two cooling towers were installed to dissipate the additional heat load from the new plate heat exchangers. This has allowed continuous use of three compressors during the summer months, eliminating the need to take nozzles out of service. The estimated cost for this upgrade was $1,096,000.

5.3 Feed Slurry Transfer Pump Valves, Piping and Final Filter Upgrade

The SDA slurry transfer system utilizes two Feed Slurry Transfer Pumps that transfer slurry from the Recycle Slurry Storage Tank at ground elevation to the Feed Slurry Pumps in the SDA penthouse. This is accomplished using a long vertical common pipe which then separates into two pipes at the suction side of the Feed Slurry Pumps. The pressurized slurry then passes through two final slurry filters. The filtered slurry then enters the spray nozzles located inside the top of the SDA vessel.

The existing feed slurry pump isolation valves and final filter isolation valves were unreliable and required high levels of maintenance. The SDA system required a shutdown in order to rotate the pumps, final filters, and clean the system.

In 2004, an SDA project was implemented which was designed to improve final filter and feed slurry pump reliability and operability as well as to reduce maintenance and SDA down time events. The project involved removing the existing knife gate slurry valves and an existing head tank that was no longer utilized. New pinch valves were installed to increase isolation reliability. The final filters were hard-piped with one dedicated pump for each filter housing. The header was re-designed to improve flushing effectiveness and nozzle access. Having one dedicated pump for each final slurry filter allowed for pump and filter rotation without the necessity of shutting down the SDA system. Integration of filters and pumps into independent circuits facilitated pump flushes, pump rotation, and cleaning without shutting down the SDA. This project was given high priority and reduced unscheduled SDA downtime.

The estimated cost for the final filter and feed slurry transfer pump valve and piping upgrade project was $269,000. This project helped to reduce the occurrences of SDA downtime during piping, valve, and final slurry filter failure incidents. SDA downtime due to final slurry filter pluggage is approximately 4 to 10 hours per occurrence. SDA downtime events due to final slurry filter pluggage occur approximately three of four times per year. Total cost of this project was approximately $626,600.

The new final filter installation helped stop the nozzle plugging downstream in the spray heads, but the lime platelets in the slurry continued to cause the new-final filters to jam and plug up prematurely. Two projects were funded to eliminate this filter issue: (1) An upgraded rotary screener was installed in the recycle slurry transfer line to trap platelets before they got into the slurry storage tank and (2) a chemical injection system was added to add a polymer solution to prevent precipitation of the lime into platelets. Total cost of these upgrades was approximately $645,000.

After the 2005 SDA outage, the operation was improved considerably but maintenance issues continued. Due to isolation valve leak-through it remained difficult to isolate pumps, piping, and filters for maintenance. The original lined fiberglass piping continued to suffer wear-though failures in areas where the piping changed direction, especially in tees and elbows. Since these fittings and piping were solvent-welded, it required long outage times to fabricate the custom-fitted elbows and tees, solvent-weld them into place, and finally allow for curing time for the new welds.

During the fall of 2009 major outages, the feed slurry system on both units was completely re-designed and re-installed. The new system had additional isolation valves installed on each pump to allow better isolation of the system to optimize taking components out of service without forcing shutdown of the remainder of the slurry system. These valves were an upgrade from the previous valve type. These valves were tested in our process for two years prior to the whole-sale change-out of slurry system valves accomplished during this outage. All slurry supply lines to each feed slurry pump, to the final filters, and the slurry recirculation (down comer) lines were replaced with a much higher grade of abrasion-resistant epoxy-lined pipe.

At this time, most elbow and tee fittings take-out dimensions were standardized with bolted-flange connections to allow one to remove and replace the worn/leaking parts with standardized, pre-fabricated repair parts. This has minimized the time needed to fabricate, install, and thermally cure solvent-welded pipe fittings. Total estimated cost was approximately $255,000.

As a final operational modification, JEA now operates two recycle slurry transfer pumps on each unit to increase slurry flow to keep piping and flow meters clean.

5.4 Recycle Slurry Transfer Pumps, Piping, Mix Tank and Storage Tank Linings

The SDA Recycle Slurry Mix Tank accepts SDA ash from the Ash Delumper. The ash is mixed in the tank with water from the heated recycle water header. The Recycle Slurry Mix Tank feeds the Recycle Slurry Transfer Pumps, which in turn feed into the Recycle Slurry Storage Tank.

In 2005, major piping and valve upgrades were made to the recycle slurry system. Slurry density meters and slurry flow meters were installed to help optimize the control of the reagent slurry mixing process. Many issues were overcome at this time but valve failures and piping wear-through continued to be an issue. Total cost of project approximately $622,400.

During the 2009 fall outages, the rubber-lined mix tank and storage tank pump suction piping was replaced with a stainless steel pipe, which has improved SDA reliability. This project helped reduce occurrences of SDA downtime due to slurry pump suction pipe failure. Typical feed slurry line rupture repair time is approximately 6 to 8 hours. SDA downtime events due to slurry suction line failure occurred approximately once per year.

The entire recycle slurry system on both units was completely re-designed and rebuilt using a piping system that has a harder inner liner. The new system had additional isolation valves installed on each pump to allow better isolation of the system to optimize taking components out of service without forcing shutdown of the remainder of the slurry system. These valves were an upgrade from the previous valve type. These valves were selected and had been tested in our process for two years prior to the whole-sale change-out of slurry system valves accomplished during this outage.

Most elbow and tee fittings take-out dimensions were standardized to allow one to remove and replace the worn/leaking parts with standardized, pre-fabricated repair parts. This has minimized the time needed to fabricate, install, and thermally cure solvent-welded pipe fittings. Total project cost estimated at $255,000.

At the present time, JEA operates two recycle slurry transfer pumps to increase flow to keep piping and flow meters clean. Since the installation of the new piping system (approximately one year), there have been no piping, elbow, or tee failures in the upgraded system.

5.5 Re-Use Water System Modification (Installation of Fire System Inter-Tie)

All components in the recycle slurry system are regularly flushed out using high pressure re-use system water. The water is typically supplied by the re-use water header system. Whenever the reuse water system service must be interrupted, both SDA systems must be shutdown. The service water system cannot be used as an alternative because the system does not have enough pressure to supply water to the top of the 150-foot-tall SDA vessels. When the reuse water system is shutdown, mechanical pump seals in the pumps – especially at the top of the vessels - are damaged or destroyed. In addition, valve, filter, and piping flushing operations which must be performed at regular intervals cannot be performed and system pluggage occurs. This project installed a fire protection water system inter-tie connection to provide sufficient water pressure to allow for the SDA to properly operate whenever the re-use water system must be taken out of service.

The cost for the fire protection water system inter-tie connection installation project was $40,000. SDA downtime due to loss of reuse water typically lasts between 12 and 36 hours. Loss of reuse water events occur approximately twice per year.

5.6 Alternate Nozzle Evaluation

When any one of the 16 nozzles on a given SDA unit has a spray pattern quality issue, the slurry discharged from the nozzle in question is not properly atomized, and therefore does not dry as designed along the flow path, resulting in wet slurry being deposited on the SDA vessel and hopper cone walls. Other symptoms, such as the formation of large concrete-like formations, occur that compromise the operation of the ash conveyor at the SDA fly ash hopper exit. These hard formations lead to SDA vessel, ductwork, and conveyor pluggage. Due to the pluggage issues and associated SDA downtime events, each of the 16 nozzles in the SDA must be manually cleaned daily.

JEA has conducted evaluations of alternate slurry spray nozzle designs. The OEM nozzle technology continues to be the ~~preferred~~ design. This alternate nozzle evaluation project cost to date is estimated to be $111,300.

5.7 Modification and Change Cost Summary

In summary, JEA has engineered and installed significant design, operating, and maintainability changes since the two units were originally commissioned. The capital cost of the SDA system modifications implemented between 2004 and 2010 total nearly 4.2 million dollars.

6.0 COMPONENT REDUNDANCY

Components with a high occurrence of failure that result in frequent SDA downtime events were examined for potential redundancy, including the possibility of installing a completely redundant SDA system for each unit. Each component analyzed is discussed below with the associated costs.

6.1 Split Ring Header

The SDA ring header supplies slurry to each of the 16 nozzles located in the SDA. When the piping of the ring header becomes plugged, or when a leak occurs in the ring header, slurry can no longer be delivered to the nozzles, requiring the SDA system to be shutdown. SDA system downtime due to piping pluggage and failure could be reduced if a split ring header system were to be installed. A split ring header would allow slurry to be supplied to half of the spray nozzles by an operational header ring while one header ring is repaired, in the event that the other header becomes plugged or begins to leak.

A split ring header is estimated to cost approximately $500,000 per unit. The installation of a split ring header could result in a reduction of annual SDA downtime by approximately 4 to 8 hours. A split ring header system could be installed based on available space, and the slurry system could be designed to be compatible with the existing system.

6.2 Redundant SDA System

A completely redundant SDA system installed on each unit would eliminate or significantly reduce SDA downtime. In the event that a malfunction occurred requiring an SDA system to be taken offline, the redundant system could be brought online.

A redundant SDA system could potentially reduce SDA downtime by 144 hr/yr per unit. The cost for a completely redundant SDA system is estimated to be approximately $100 million per unit. A completely redundant SDA system is not possible due to the limited space available in the existing facility. The existing SDA system footprint is approximately 5,625 square feet (ft^2). Due to the proximity of the existing baghouse and CFB boiler units, a redundant SDA system would not fit into the available space.

7.0 COST EFFECTIVENESS

Specific Condition 49 in Section III of Air Construction Permit No. 0310045-022-AC requires JEA to include in this engineering study a cost analysis of the associated emissions reductions from the identified redundancies and equipment modifications which could potentially reduce SDA downtime. Emissions estimates were developed for operating the CFB boiler during repairs and for shutting down the boiler during repairs in order to compare the cost effectiveness of system modifications and redundancies for each possible scenario.

An analysis was performed in order to determine the cost effectiveness of the potential emissions reductions associated with each modification. The cost effectiveness of each system modification is presented in Table 7-1. Equipment modification cost effectiveness was examined for maintenance scenarios where the CFB boilers are shutdown to perform SDA repairs and for the CFB boilers operating with the SDA offline for repairs.

7.1 Air Emissions

In order to determine the cost effectiveness, emissions estimates for the following CFB boiler operating scenarios were developed:

- CFB boiler operating normally with the SDA online
- CFB boiler operating with the SDA offline while performing repairs
- CFB boiler shutting down to make allow repairs to be made

This is "total" on 35 lbs? Would certainly tend to mask large increases in a given pollutant typically emitted in small quantities by others (SO2) emitted in large quantities

These emissions data were presented in the air construction permit application for SDA maintenance downtime (Golder Associates Inc., 2008). Emissions were estimated for SO_2, PM, NO_x, CO, VOC, SAM, HF, Pb, and Hg for each scenario.

Under normal boiler operating conditions with the SDA online, the total pollutant emission rate was estimated to be 32,273 pounds (lbs) per unit over a 52-hour period. Total hourly emissions for operating the CFB boiler with the SDA out of service for 6 hours during this same period were estimated to be 32,782 lbs per unit. Therefore, the estimated increase in total emissions for operating a CFB boiler with the SDA offline while repairs are being performed is 509 lbs per maintenance event.

When the CFB boilers are required to be shutdown while repairs to the SDA are made, the total hourly equivalent emissions for the 52 hour shutdown/startup period are estimated to be 168,302 lbs per unit per maintenance event. Therefore, when a CFB boiler is shutdown for SDA maintenance, as opposed to the boiler operating normally with the SDA in service during the same time period, the increase in emissions is 136,029 lbs per unit per event.

7.2 Cost Effectiveness Calculations

The cost effectiveness of each project described in Section 6.0 and 7.0 was determined for the scenarios in which a particular CFB boiler would remain operating during repairs with the SDA offline, and for shutting down a boiler for repairs. In order to determine the cost effectiveness of each project, an estimate of cost per ton ($/ton) of emissions reductions was developed.

An annualized cost for each equipment modification or redundancy was determined based on the capital recovery cost. The capital recovery cost was calculated by multiplying the total capital investment by a capital recovery factor. The capital recovery factor used for this analysis was 0.0944 based on a discount rate of 7-percent annualized for 20 years.

operational costs / savings from less maintenance?

The annualized cost of a particular project is the sum of the direct operating cost, the indirect operating cost, and the capital recovery cost. However, it is assumed that since these are modifications to existing equipment, there will be no increase in operating costs associated with the changes.

To determine the cost effectiveness of each system modification and redundancies, the annualized cost was divided by the equivalent emissions reductions to determine a cost per ton of emissions reduction estimate.

7.3 Cost Effectiveness Results

The cost effectiveness results are presented in Table 7-1. As shown, the equipment (systems) modification cost effectiveness values range from $14/ton to $761/ton of pollutant reduction, assuming a boiler shutdown is eliminated for each event. JEA either has implemented, or is planning on implementing, all of these projects in the future to help eliminate SDA downtime.

As shown, the redundancy projects cost effectiveness values range from $173/ton to $8,674/ton of pollutant reduction, assuming a boiler shutdown is eliminated for each event. Due to the high cost, the economics of a redundant ring header are not favorable.

The reduction in SDA downtime and the associated emissions reductions due to the various proposed system modifications above are significant. The additional emissions reduction that would be added by the redundant systems modifications are insignificant compared to the proposed system modifications, except for the totally redundant SDA system. A redundant SDA system could potentially reduce SDA downtime by 144 hr/yr per unit. Such a project is considered to be extremely cost prohibitive ($100,000,000 capital cost). Additionally, a completely redundant SDA system is not feasible due to the limited space available in the existing facility. Due to the proximity of the existing baghouse and CFB boiler units, a redundant SDA system would not fit into the available space.

Therefore, JEA is not proposing to implement any of the redundant systems modifications.

7.4 Summary

Since 2004, JEA has spent approximately 4.2 million dollars to greatly reduce SDA downtime. The improvement processes described in this report continue to be utilized to further enhance SDA reliability.

TABLES

Table 4-1: SDA Maintenance Activities, JEA Northside CFB Units 1 and 2

Description of Equipment Failure	Duration of Repair (hours)	Frequency of Repair Per Unit (occurrences per year)
Vessel Pluggage	4 - 8	6
Plugged Ring Header	4 -12	2
Both Slurry Final Filters Plugged (No Slurry flow to the nozzles)	4 - 10	3 - 4
Feed Slurry Line Leak/Rupture	8 - 16	3
Loss of Reuse Water (due to leak or rupture)	12 - 36	2
Atomizing Air Compressor fail/trip	4 - 8	1

Table 7-1: Cost Effectiveness of SDA System Modifications and Redundancies

Project	Total Capital Investment (2 Units) ($)	Capital Recovery Cost [a] ($)	Reduction in SDA Maintenance Events [b] (events/yr/unit)	Equivalent Emissions Reduction w/ Boiler shutdown [c] (tons)	Equivalent Emissions Reduction w/o Boiler shutdown [d] (tons)	Cost Effectiveness w/ Boiler S/D [e] ($/ton)	Cost Effectiveness w/o Boiler S/D [e] ($/ton)
System Modifications							
Nozzle Air Flow Regulators Upgrade and Flush System	228,000	21,523	4	544	2.0	40	10,574
Atomizing Air Header Upgrade	311,000	29,358	2	272	1.0	108	28,847
Atomizing Air Compressor Cooling Upgrade	1,096,000	103,462	1	136	0.5	761	203,322
Final Filter and Feed Slurry Transfer Pump Valve and Piping Upgrade	1,526,600	144,111	4	544	2.0	265	70,801
Recycle Slurry Mix Tank, Pumps and Piping	877,400	82,827	3	408	1.5	203	54,256
Re-Use Water System Modification	40,000	3,776	2	272	1.0	14	3,710
Redundant Systems							
Redundant Ring Header (SDA Nozzles)	500,000	47,200	2	272	1.0	173	46,378
Totally Redundant SDA System	200,000,000	18,880,000	16	2,176	8.1	8,675	2,318,914

[a] Based on CRF of 0.0944 times TCI (20 yrs @ 7%).

[b] Reduction in SDA maintenance is a estimate based on frequency of downtime events for each Unit.

[c] Equivalent emissions reduction of 136,029 lbs/event/unit based on total emissions from SDA maintenance with unit shutdown minus the total emissions from normal operation multiplied by the reduction in SDA maintenance events.

[d] Equivalent emissions reduction of 509 lbs/event/unit based on total emissions from SDA Maintenance with unit operating and SDA off-line minus the total emissions from normal operation multiplied by the reduction in SDA maintenance events.

[e] Cost effectiveness based on project capital recovery cost divided by the equivalent emissions reduction for both units.

FIGURES

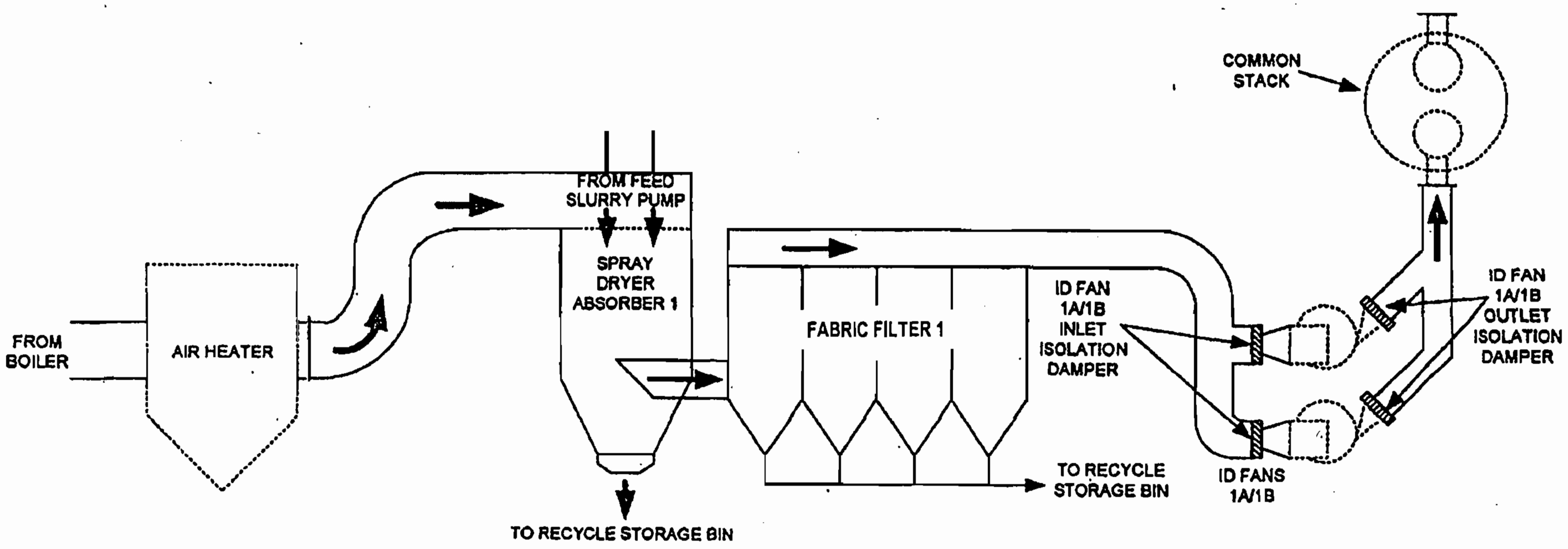
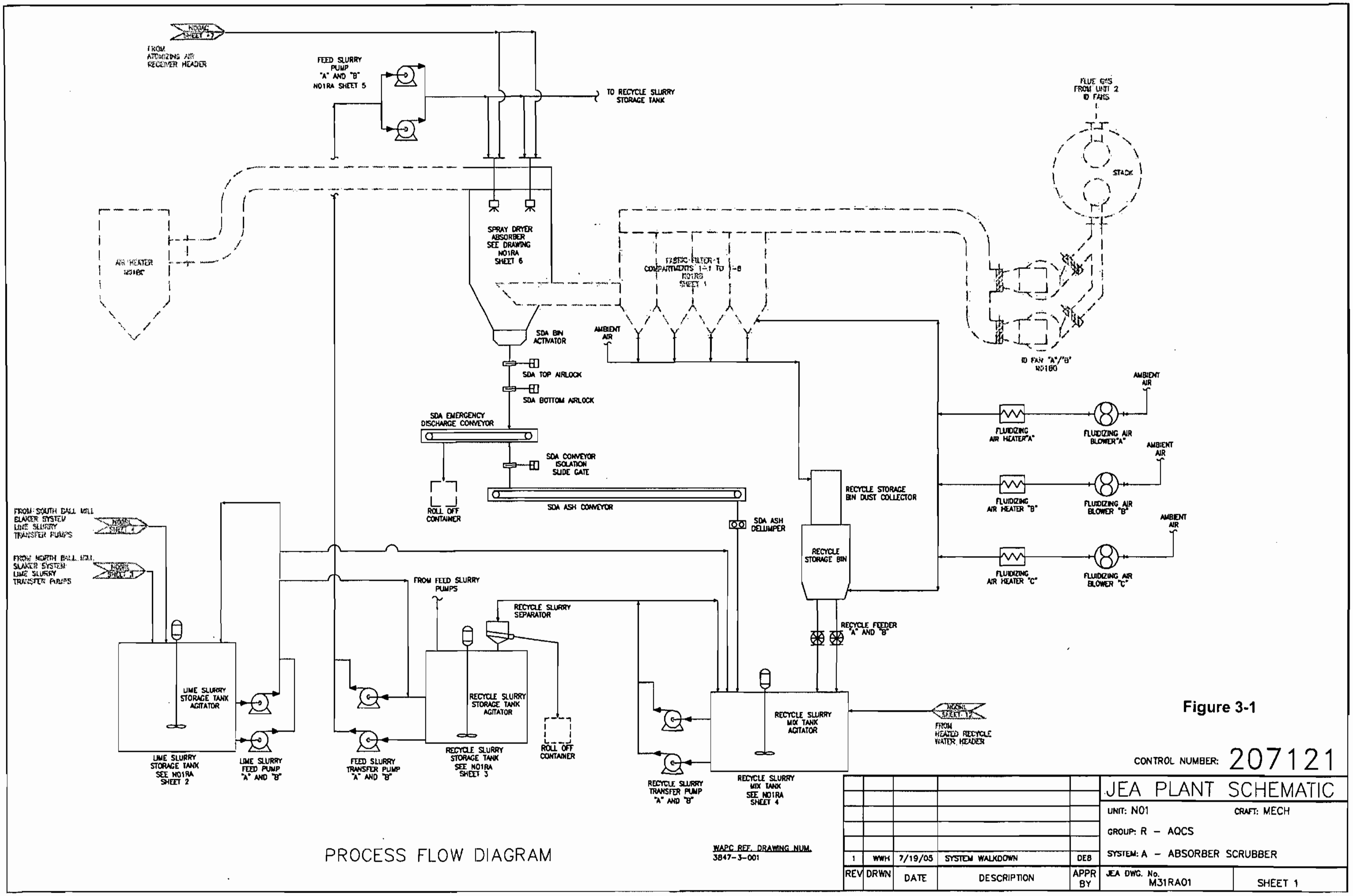


Figure 2-1
Air Quality Control System Flow Diagram
Northside Generating Station Unit 1 or 2

Source: Golder, 2010.

Y:\Projects\2010\103-87608 JEA Buckman TV\Report\Rev Final\Figure 2-1 AQCS Overview.docx

Golder Associates



FROM ATOMIZING AIR RECEIVER HEADER
FEED SLURRY PUMP "A" AND "B" N01RA SHEET 5
TO RECYCLE SLURRY STORAGE TANK
FLUE GAS FROM UNIT 2 ID FANS
STACK
AIR HEATER
SPRAY DRYER ABSORBER SEE DRAWING N01RA SHEET 6
FABRIC FILTER 1 COMPARTMENTS 1-1 TO 1-8 N01RB SHEET 1
SDA BIN ACTIVATOR
AMBIENT AIR
ID FAN "A"/"B"
SDA TOP AIRLOCK
SDA BOTTOM AIRLOCK
SDA EMERGENCY DISCHARGE CONVEYOR
SDA CONVEYOR ISOLATION SLIDE GATE
ROLL OFF CONTAINER
SDA ASH CONVEYOR
SDA ASH DELUMPER
RECYCLE STORAGE BIN DUST COLLECTOR
RECYCLE STORAGE BIN
FLUIDIZING AIR HEATER "A"
FLUIDIZING AIR BLOWER "A"
FLUIDIZING AIR HEATER "B"
FLUIDIZING AIR BLOWER "B"
FLUIDIZING AIR HEATER "C"
FLUIDIZING AIR BLOWER "C"
FROM SOUTH BALL MILL SLAKER SYSTEM LIME SLURRY TRANSFER PUMPS
FROM NORTH BALL MILL SLAKER SYSTEM LIME SLURRY TRANSFER PUMPS
FROM FEED SLURRY PUMPS
RECYCLE SLURRY SEPARATOR
RECYCLE FEEDER "A" AND "B"
LIME SLURRY STORAGE TANK AGITATOR
RECYCLE SLURRY STORAGE TANK AGITATOR
RECYCLE SLURRY MIX TANK AGITATOR
FROM HEATED RECYCLE WATER HEADER
LIME SLURRY STORAGE TANK SEE N01RA SHEET 2
LIME SLURRY FEED PUMP "A" AND "B"
FEED SLURRY TRANSFER PUMP "A" AND "B"
RECYCLE SLURRY STORAGE TANK SEE N01RA SHEET 3
ROLL OFF CONTAINER
RECYCLE SLURRY TRANSFER PUMP "A" AND "B"
RECYCLE SLURRY MIX TANK SEE N01RA SHEET 4
PROCESS FLOW DIAGRAM
WAPC REF. DRAWING NUM. 3847-3-001
CONTROL NUMBER: 207121
JEA PLANT SCHEMATIC
UNIT: N01
CRAFT: MECH
GROUP: R – AQCS
SYSTEM: A – ABSORBER SCRUBBER
1 WWH 7/19/05 SYSTEM WALKDOWN DEB
REV DRWN DATE DESCRIPTION APPR BY
JEA DWG. No. M31RA01
SHEET 1

Figure 3-1

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

Africa	+ 27 11 254 4800
Asia	+ 852 2562 3658
Australasia	+ 61 3 8862 3500
Europe	+ 356 21 42 30 20
North America	+ 1 800 275 3281
South America	+ 55 21 3095 9500

solutions@golder.com
www.golder.com

Golder Associates Inc.
6026 NW 1st Place
Gainesville, FL 32607 USA
(352) 336-5600 - Phone
(352) 336-6603 - Fax

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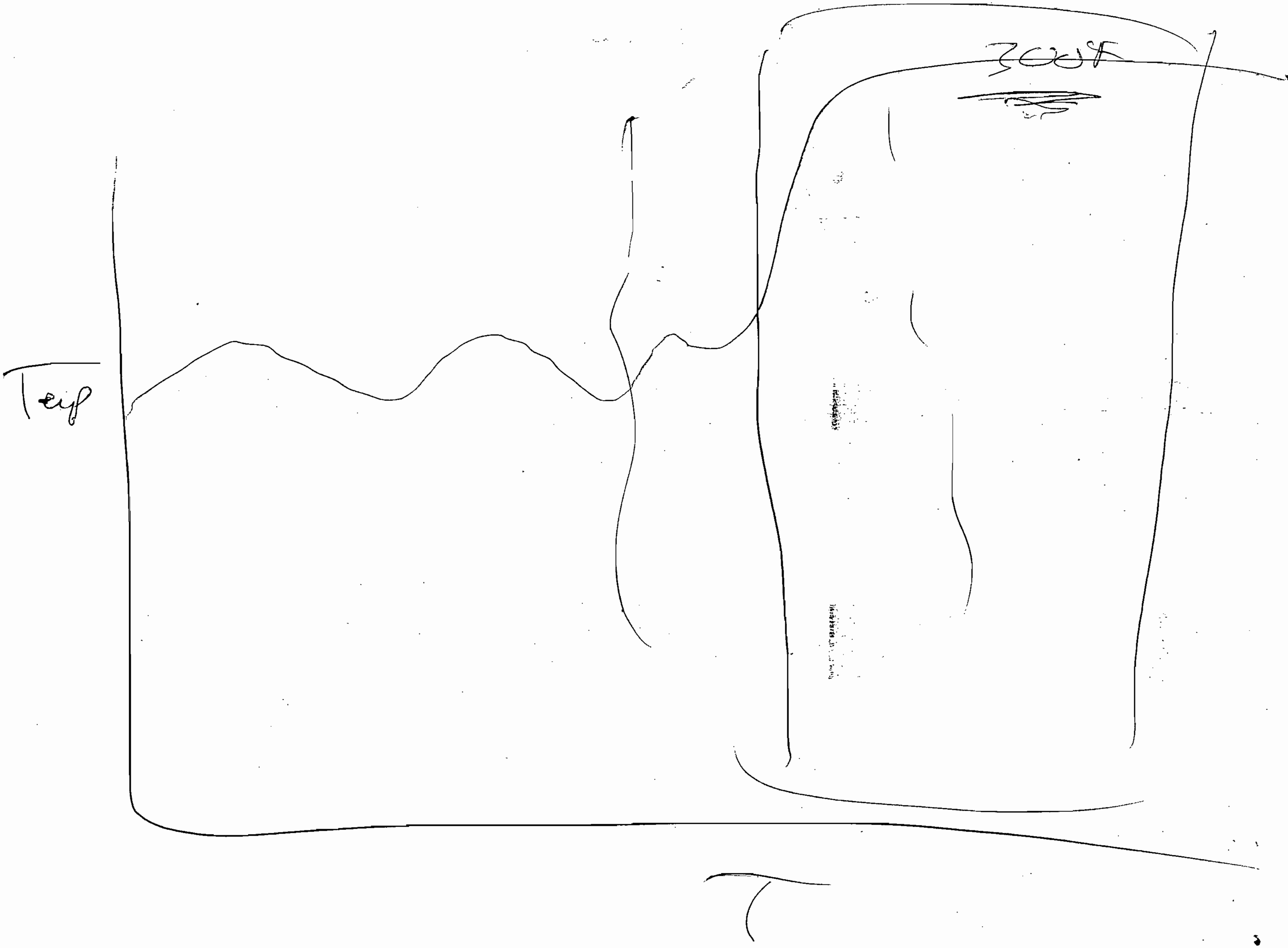

Temp
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