Automation of Formally Decommissioned Coal Preparation Facility

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ABSTRACT

GCI (Systems Integration Company) was invited to participate in the rebirth of the New Saint Nick, decommissioned coal preparation facility owned by Reading Anthracite. Discussion focuses on the collaborated effort to provide a cost effective control solution and the challenges associated with providing a simplified operation.

Although no prior hands on experience with coal preparation, Reading provided ample process flow and P&ID diagrams. With a strong background in process control and material handling systems, GCI introduced Reading to ISA S88.1[i] terminology, modeled the entire operation, and developed a detailed set of functional and design descriptions. Together with invaluable assistance from the electrical contractor we were able to resurrect the facility to efficient operating capacity. Today, the fine coal plant processes 200 tph (150 tph of run of mine anthracite and 50 tph of reclaimed silt from a local impoundment area). The product is cleaned to metallurgical coal specifications.

1 INTRODUCTION

Reading Anthracite planned to bring a decommissioned coal preparation plant back into operation after being idle for more than 10 years. In its original state, this was a plant that was controlled manually, with system feedback displayed on hard wired meters and gauges placed about a control room. Some of the indicators were located locally at the vessels or sumps and it was often necessary for an operator to climb multiple flights of stairs to keep track of what was going on. One of the design goals was to institute a centralized operator interface so that the entire process could be effectively controlled from a single location. From our perspective as a systems integration company, the proposed re-commissioning could benefit from some updated process automation.

When we (GCI) were introduced to the Reading Anthracite production team, we had no prior hands on experience or knowledge of coal preparation, so our first challenge was an initial technical language barrier. Since the two parties involved were not familiar with each other's particular terminology i.e., Reading Anthracite with the Instrument Society of America (ISA) and GCI with the process of coal preparation, we needed to get everyone on the same page so to speak. Our background in process control and the materials handling industry allowed us to introduce Reading Anthracite to ISA S88.1 terminology and we were able to get the design process under way with an equipment model and detailed functional specifications.

2 MODELING AND SPECIFICATION DOCUMENTS

Understanding the process of separating the coal from waste and classifying the sizes of coal began with P&ID drawings and a description of the process from Reading's General Manager

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[i] American National Standard, 1995 *ANSI/ISA–88.01–1995 Batch Control Part 1: Models and Terminology*, Research Triangle Park, NC, pg 13

with valuable input from the Plant Superintendant. While taking the time to understand the system we introduced the Reading team to S88.1 terminology. From Readings detailed descriptions, we were able to identify the collections of equipment that were related to the same major process functions and generated an equipment hierarchy around a ***Unit*** definition, explaining the model of equipment groups as Units that operate together for portions of the process. We introduced the concept of process action hierarchy and explained the differences between ***Phases*** at the lowest level, through ***Operations*** to ***Procedures*** at the highest level. For instance, the feed system would be a Unit that consists of the Hopper, Vibratory Feeder, In-feed Belts and Weigh Scale. The Feed System would be a Unit Procedure that would contain one Operation. The Operation would consist of a Vibration Phase controlling a drive to deliver a constant feed rate relying on the feedback from the weigh scale, and one or more Belt Run phases to control the conveyor motors. This would be the first Operation in a series representing a Procedure that would process the raw coal and slurry into the finished products while separating out the waste.

After the initial meeting we went to work taking the drawings that Reading Anthracite provided along with the description of the process and created a first draft of process models and specification documents. While we were in the design phase, Reading personnel were actively engaged in the mechanical rebuild of the facility. The plant design and mechanical design details were provided by the Reading GM. All mechanical construction was overseen by the Plant Superintendant. All new fabrication was done in-house by Bear Ridge. Electrical installation was done in-house by Albarell Electric Co. Further meetings were held to discuss their ongoing progress and any changes that arose during the physical rebuild of the system regarding motor sizing, current monitoring for pumps, sump level indication and torque detection on the clarifier rake.

On a side note, there is now a committee working on the standard that will be used for the continuous process industry called SP106. Much of the basis of this new standard will come from the S88 Batch Processing standard that has been in existence for more than 10 years and has been applied by our company and others to this type of industry.

3 CONTROL HARDWARE PLATFORM SELECTION METHODOLOGY

When selecting the control hardware platform for this facility we evaluated our choices based on cost, availability, and suitability for the environment. With the effort and expenditure expected for the rehabilitation of the facility, cost was the major factor. There is a large market for used Allen Bradley equipment, which would supply what was needed and provide for replacement parts well into the future.

For Reading Anthracite, we recommended the Allen Bradley SLC-500 Ethernet based platform to fit the requirements. The platform had all of the necessary digital and analog inputs and outputs necessary to complete the installation. The Ethernet capabilities of the processor would allow for future expansion, give Reading Anthracite the ability to access the system remotely for monitoring, and give GCI the ability to remotely diagnose problems and support the system in a timely manner. The footprint of the SLC-500 platform also lent itself well to the size constraints of the area in the motor control center where it was to be installed.

A second smaller PLC, capable of communication over a significant distance was necessary to control the make-up water pump. For this we chose an Allen Bradley MicroLogix 1400 with it's built in Ethernet port. After a site survey with Reading Anthracite it was decided that we would use a wireless Ethernet radio solution in a point to point configuration between the two processors to reduce the wiring costs.

Reading approved our electrical design and we were able to quickly procure the necessary hardware and fabricate the control sub-system. After a series of review meetings and discussions we invited Reading Anthracite and Albarell Electric to our facility for a demonstration of the operator interface and to see the electrical panel ready for installation. Changes were made to streamline the interface to make it more efficient for the operator and more details of the start-up were displayed on screen.

MOTOR LIST		
Drive / Mtr Designation	**Drive / Motor Description**	**Motor H.P.**
Raw Coal Feed AC Motor Section		
M001	Raw Coal Feeder	20
M056	Raw Coal Impact Crusher	250
M057	Raw Coal Take Away	30
M003	Secondary Crusher	200
M004	Raw Coal Vibratory Feeder	5
M005	Raw Coal Primary Belt Conv.	25
M039	Raw Coal Secondary Conv.	25
M007	Deslime Vibrator Deck 1	30
M008	Deslime Vibrator Deck 2	20
Heavy Media Circuit AC Motor Section		
M009	HM Cyclone Sump Pump	75
M010	Floor Sump Pump	15
M015	Refuse Dewatering Screen	15
M016	Refuse Magnetic Separator	7.5
M018	Clean Coal Dewatering Screen	15
M019	Clean Coal Mag. Separator	7.5
Clean Coal Separation AC Motor Section		
M021	Clean Coal Screen Deck 1	10
MS021A	Clean Coal Screen Deck 2	10
M022	Product Stock Conveyor	7.5
M023	Product Stock Conveyor	7.5
M024	Product Stock Conveyor	7.5
M025	Fine Coal Sump Pump	25
M026	Refuse Transfer Conveyor	15
M038	Mag Tails Sump Pump	50
M040	Mag Screw Feeder	5
Fine Coal Feed AC Motor Section		
M048	Silt Feed Transfer Conveyor	15
M049	Silt Feeder	15
M050	Silt Feed Hopper	25
M053	#5&6 Transfer sbm Conv.	5
M054	Refuse Conveyor	25
Fine Coal Processing AC Motor Section		
M031	Classifying Cyclone Sump	100
M035	Fine Refuse Dewatering Vib	15
M036	Fine Coal Dewateing Vib	15
M036A	Fine Coal Transfer Conveyor	15
M037	Ground Storage Conveyor	5
Water System AC Motor Section		
M027	Recycled Water Booster Pump	100
M028	Beachwood Mine Pump	25
M029	Thickener Agitator	10
M060	Thickener Rake Lift	10
M030	Refuse Black Water Pump	150
M033	City Water Booster Pump	10
M055	Gland Water Pump	10

4 OPERATOR INTERFACE

The user interface was developed with efficiency foremost in mind. A cost effective touch screen operator terminal was chosen that would allow a single operator to oversee the facility and react quickly to most situations. The design also allowed the flexibility to upgrade in the future to a system that was scalable, provide greater data collection or run from a mobile platform that would allow the operator to control the operation of the plant from anywhere inside the facility using a Wi-Fi connection.

Functionality was grouped into screens that would allow for easy operation. First, an overall picture for the startup of the system that shows the status of all major components on one screen with a direct link to the Screen Menu which will allow the operator to go directly to a Unit or the Loop Control screen. (Figures 1 and 2).

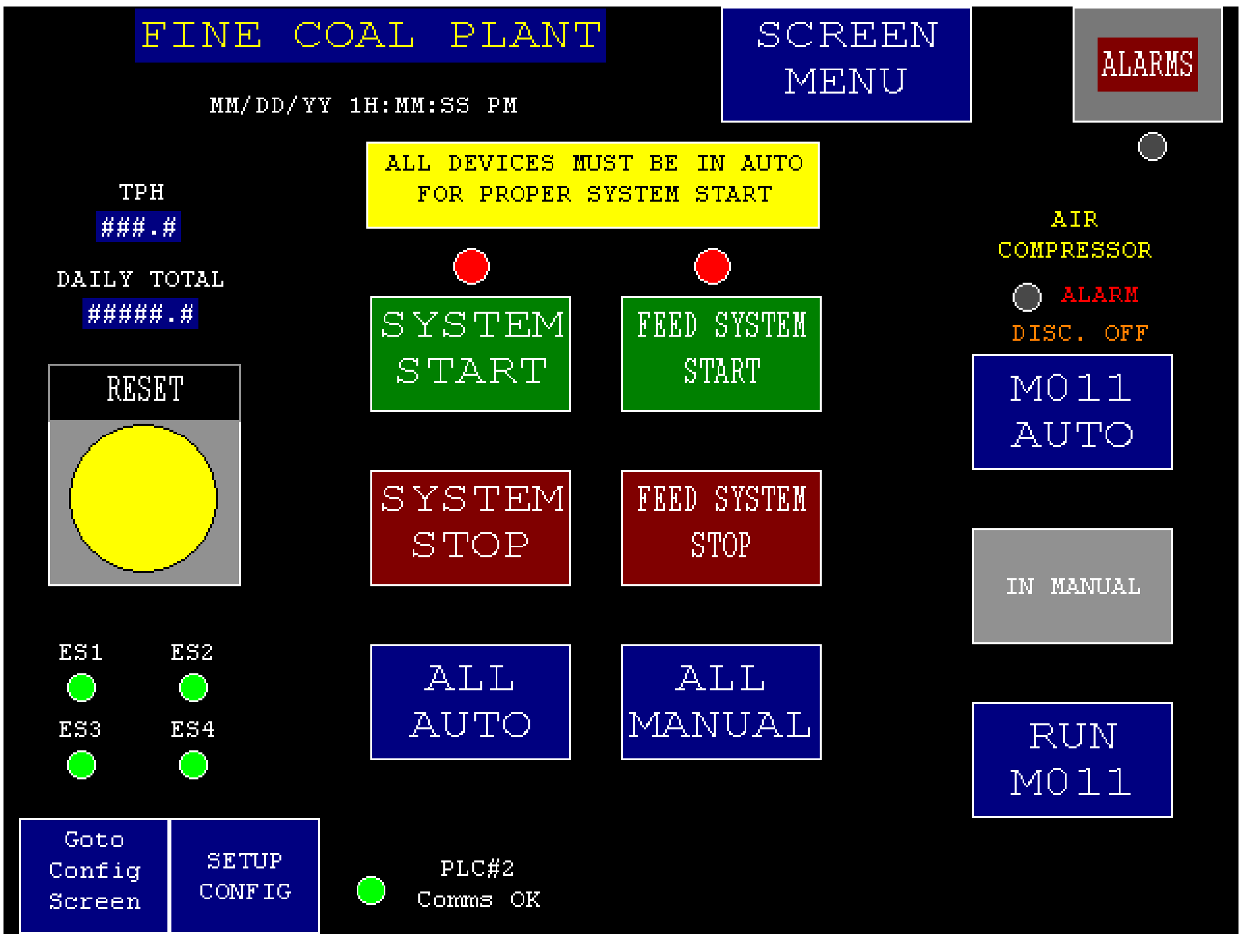

Figure 1
Start Control Screen

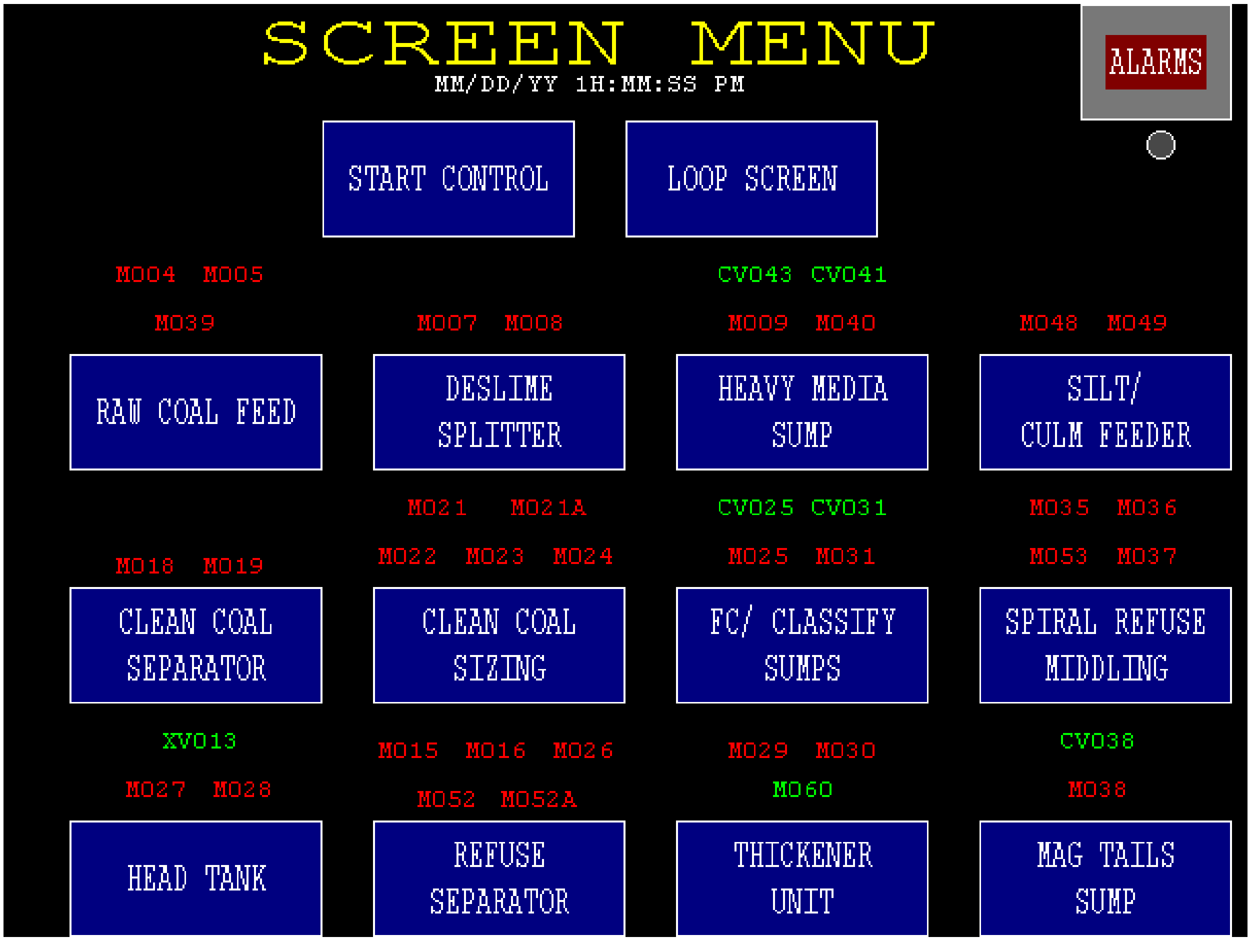

Figure 2
Screen Menu

The Screen Menu also shows the status of the individual Equipment Modules in the Unit. Secondly, a screen that allows control of the set-points for the smooth running of the facility (Figure 3) with sub screens (Figure 4) giving the operator quick access to mode of operation and set points, and finally, screens with grouped components that rely on each other for operation which would allow for one or more units to be placed in manual control to override a situation or for testing after routine maintenance. Buttons were also placed on all screens allowing the operator to quickly return to the most used screens to get an overview of the whole system.

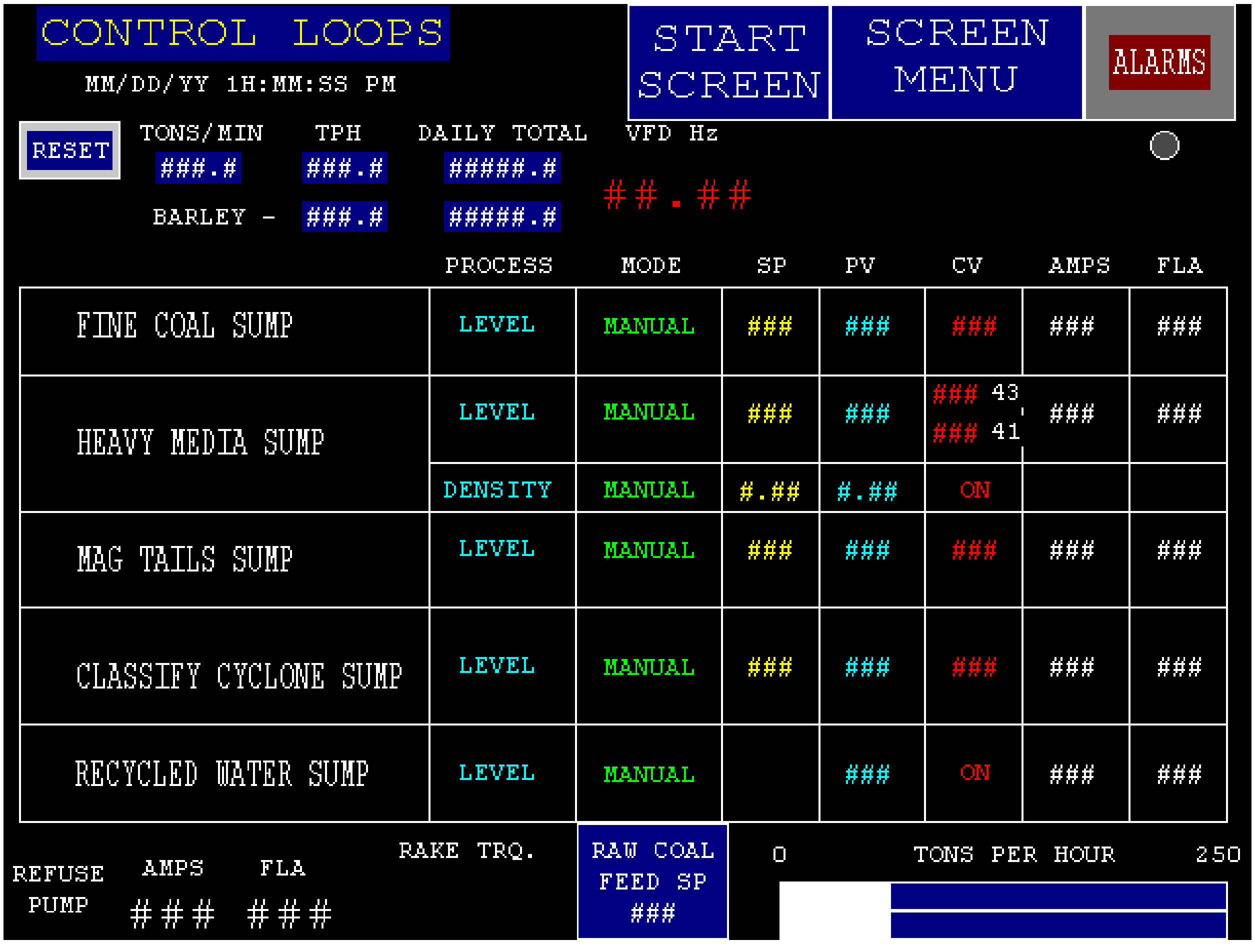

Figure 3
Loop Control Screen

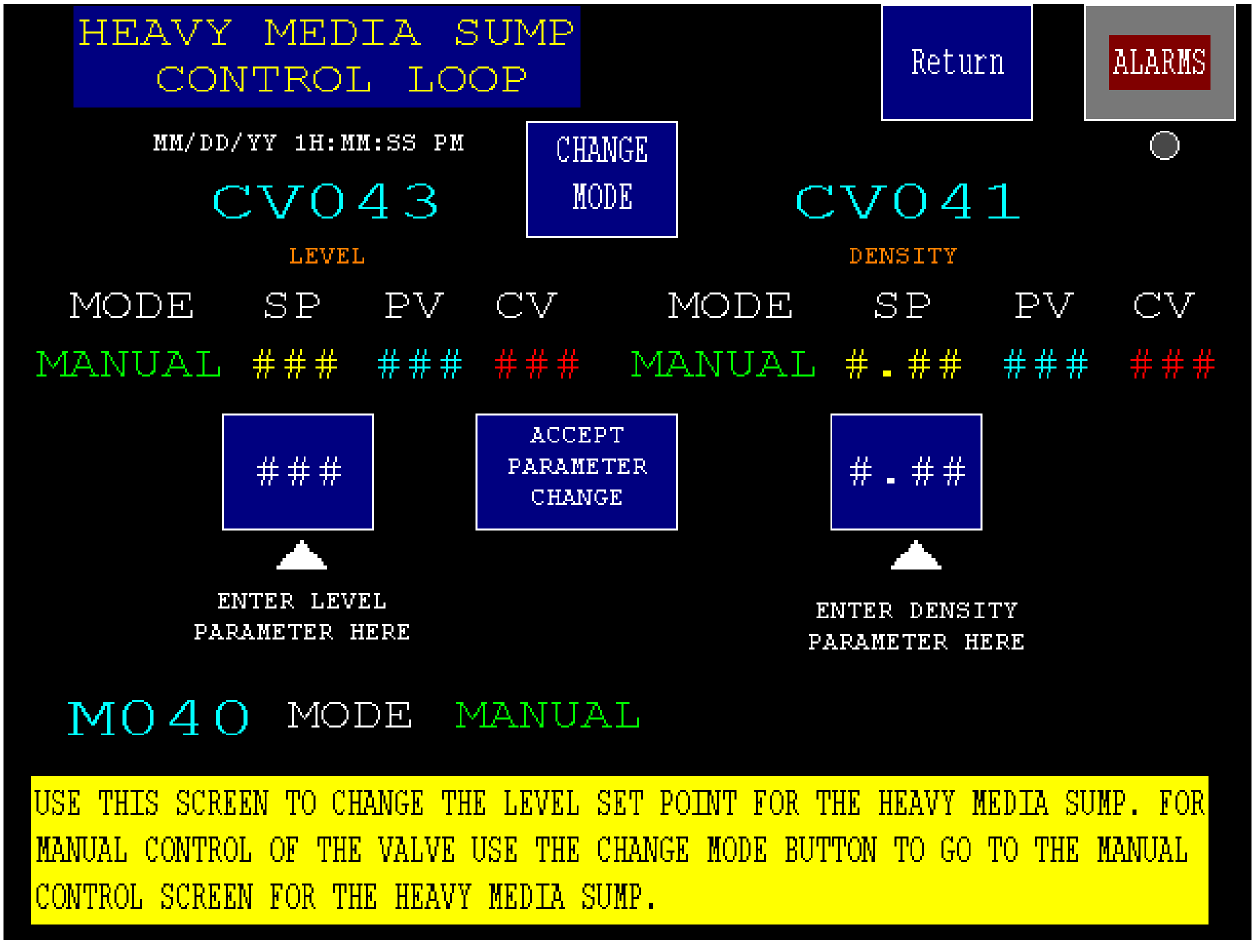

Figure 4
Example of an Individual Loop Control Screen

Each Unit screen provides the operator the ability to set the AUTO or MANUAL mode and allow jogging if in MANUAL only, and shows the statuses of the equipment RUNNING or STOPPED, and if there is an individual alarm and in this example if the disconnect switch is ON or OFF.

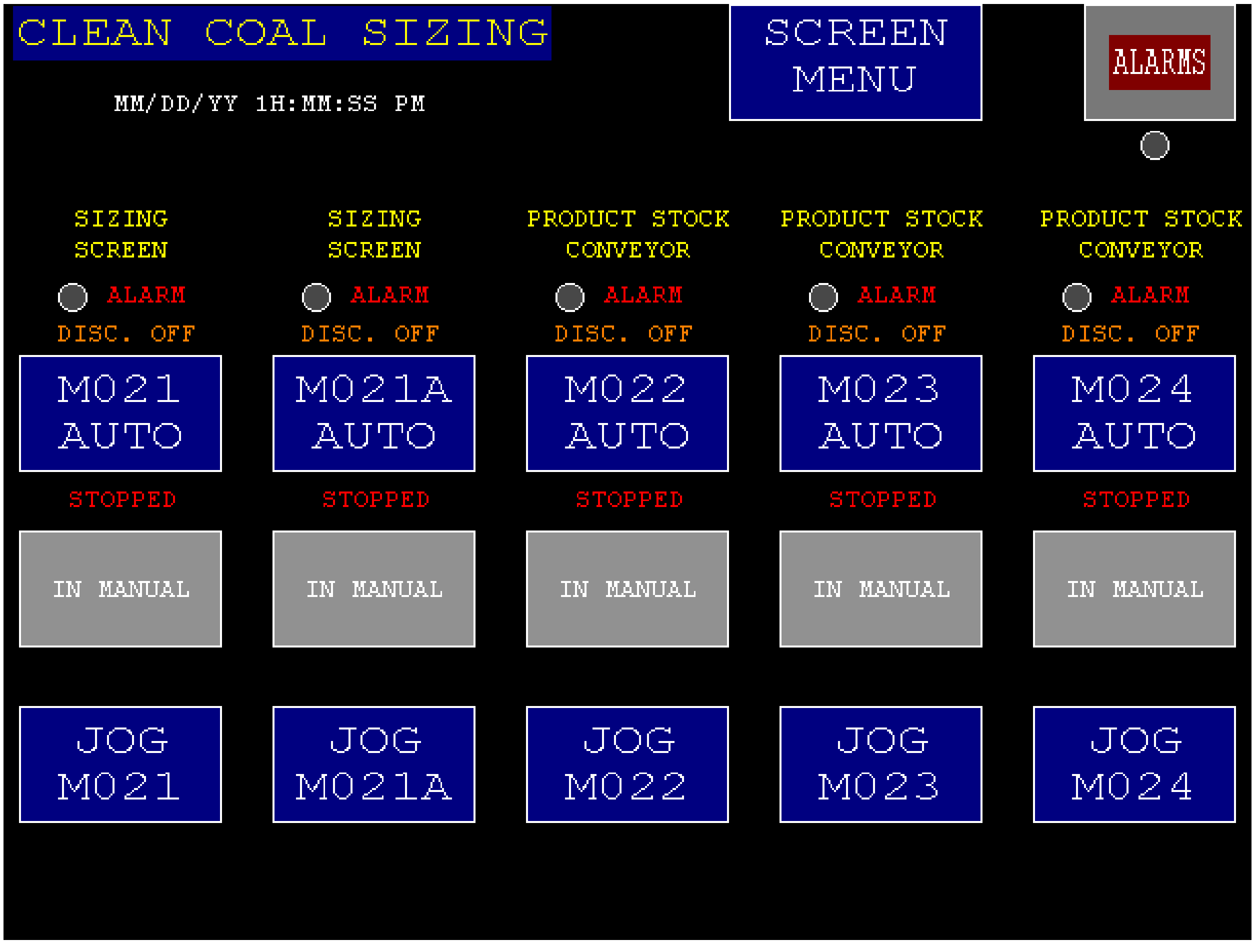

Figure 5
Clean Coal Sizing

The following example of a processing Unit displays some additional information to the operator and allows the process to be controlled manually in case of a feedback failure or other situation when manual control would be preferred. It gives the operator simple up and down control to change the output percentage of a valve or an immediate close request to control an overrun. The addition of the CLOSE button was an evolution of the screen during the commissioning process. Most pump motors have a display of the current amp draw and the Full Load Amps so that the system may be monitored for problems and maintenance issues.

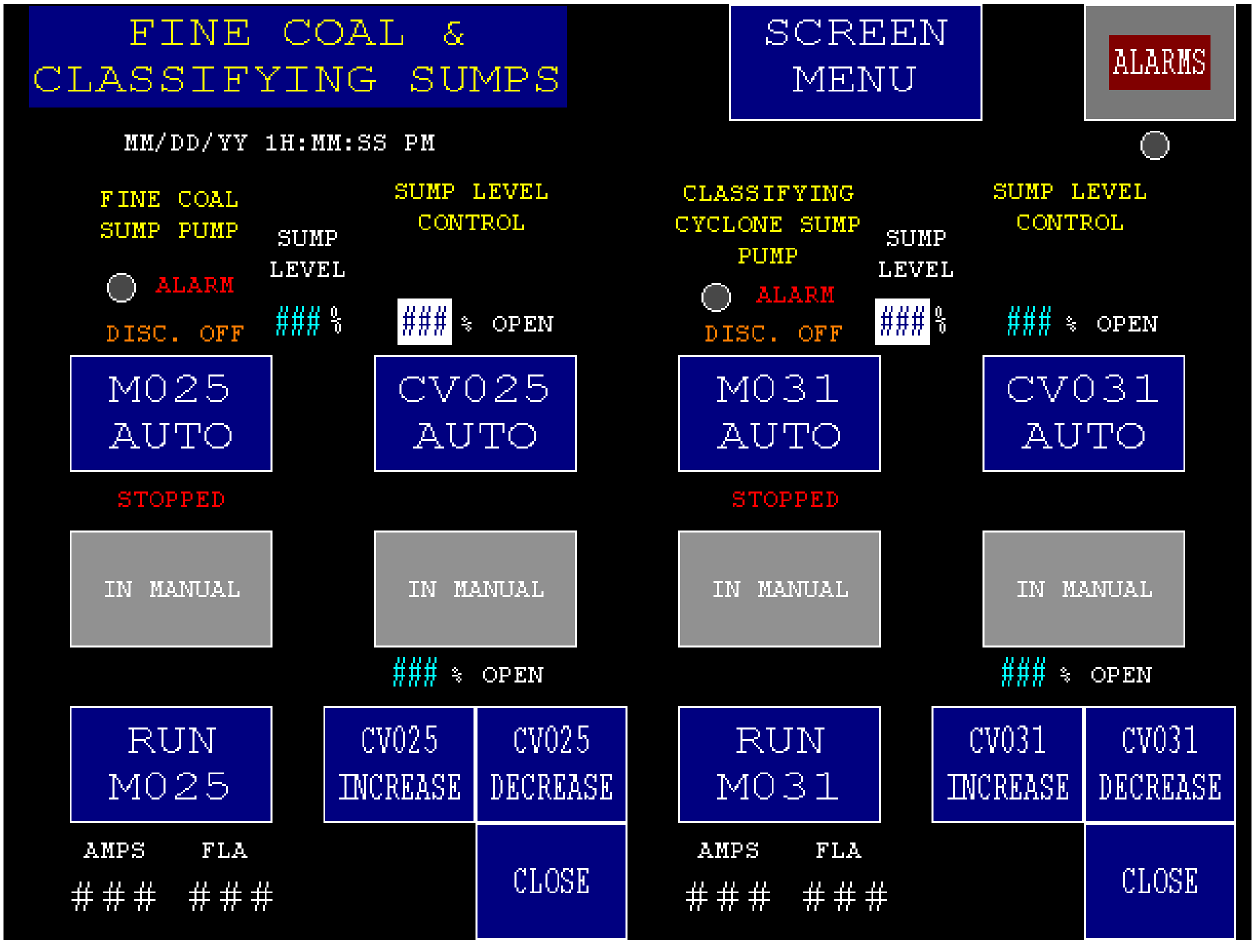

Figure 6
Manual Process Control for Fine Coal and Classifying Sumps

Not all equipment screens belong to Units. The S88.01 specification describes Equipment Resources, which are not directly part of adding value to the final product, but are generally used by one or more Units in the Procedure[ii]. The following screen example is the water resource for the system. Of note is the Beechwood Mine Pump which is controlled by a remote PLC connected via the wireless Ethernet Bridge. A metric in the lower right hand corner shows errors in the communications so that the system may be more closely monitored in case of interference in the radio transmission. The remote pump controls were designed such that they were as failsafe as possible. If there is a loss of communications for an extended period of time and the pump is in an auto run mode, the pump will be disabled to prevent a possible overflow. There is also a display of the status of a selector switch that is local to the pump. The same pump will provide manual truck fill water and will not run in AUTO mode for the breaker if the switch is in the HAND mode.

[ii] American National Standard, 1995 *ANSI/ISA–88.01–1995 Batch Control Part 1: Models and Terminology*, Research Triangle Park, NC, pg 14, 23

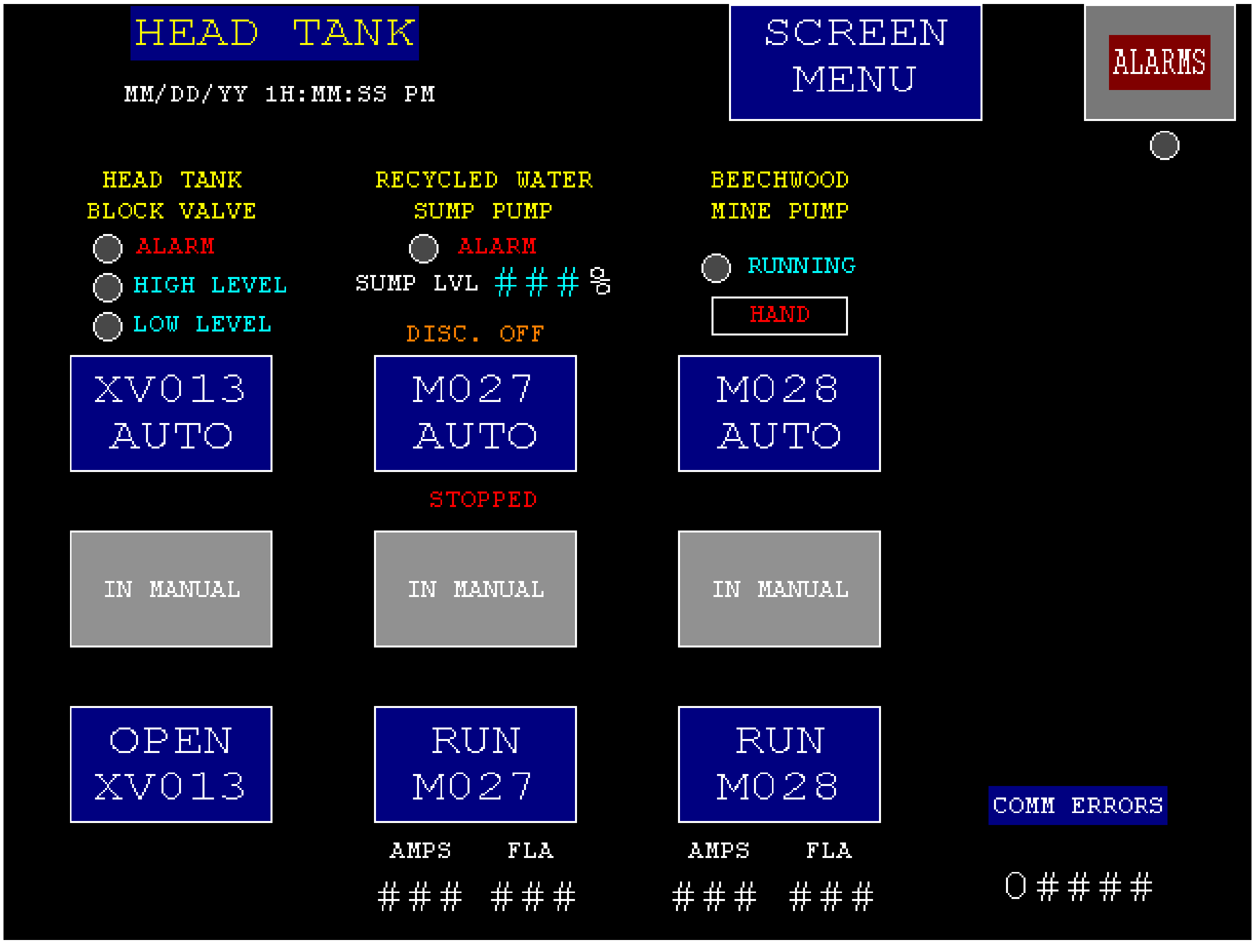

Figure 7
Resource Example – Head Tank

Close attention was paid to warning and alarm messages on the system to assist in maximizing up-time. Down time, when you should be in production, means lost dollars. Warning and alarm messages were designed as pop-ups so the operator would not miss an important problem, or understand when an operation was requested why a particular component was not operating. Statuses of motor disconnect switches and high currents for running motors allow for quick solving of problems with down equipment. Multiple alarms or warnings can happen simultaneously and the particular Allen Bradley PanelView 1000 that was chosen for this project could not display more than one pop-up at a time. As a solution, a Historical Alarm Screen was added which also gives the operator the ability to acknowledge and reset alarm interlocks in the programmable logic controller. Emergency Stop pull cord operators located along the conveyors provided safety so that a conveyor would not start without warning. The process of acknowledging and resetting alarms made it safe to re-start the other equipment as well. To adhere to MSHA regulations the operator had to remedy any problems before resetting the system.

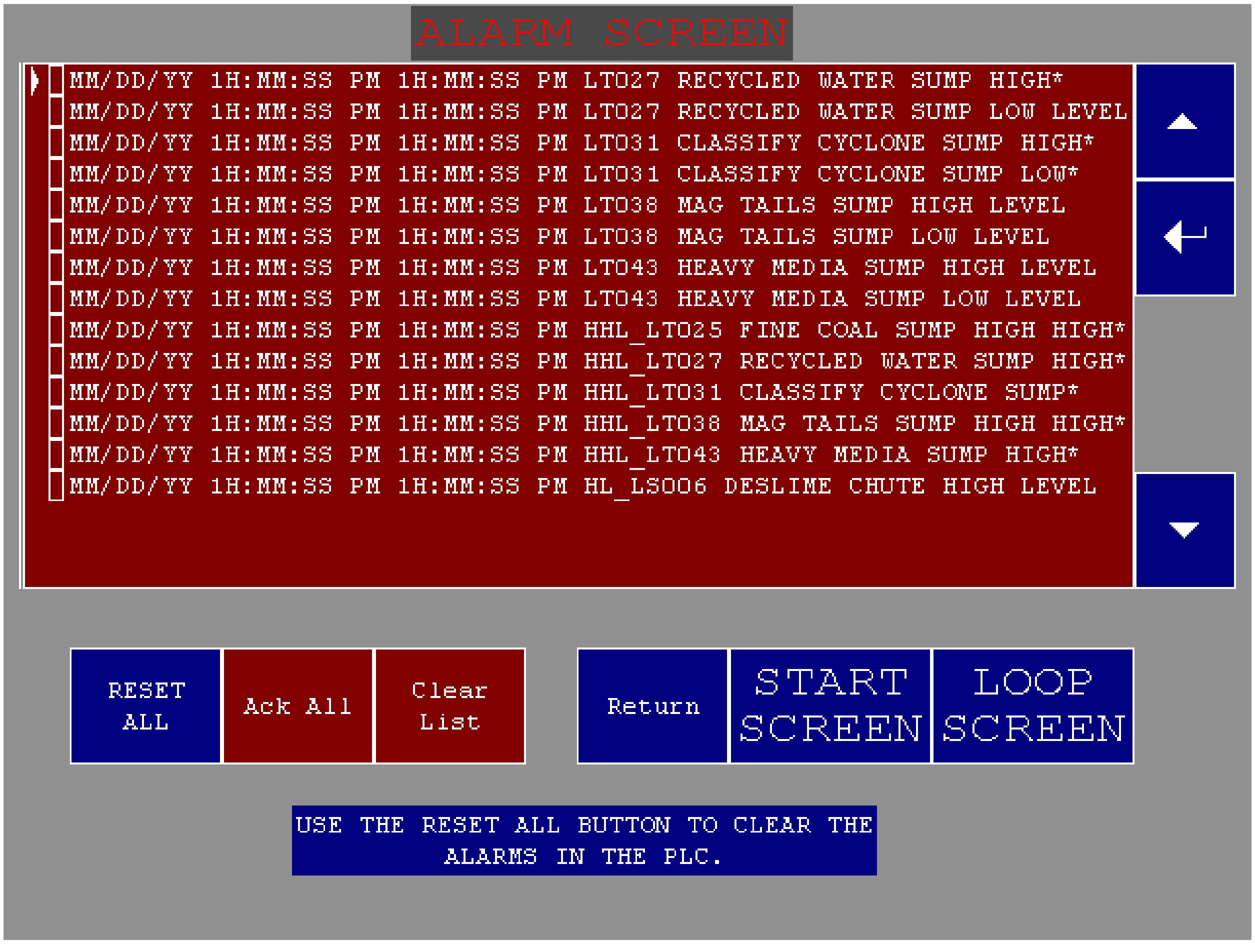

Figure 8
Alarm Screen

During one of the design review meetings Reading Anthracite asked for the ability to change the displayed full load amps of the pump motors without re-programming the PLC system. We provided a screen for them so that they could download new FLA values to the PLC if they changed out a pump motor and the amp rating was different. During the commissioning process, we implemented additional downloadable parameters that provided benefits for operator control or maintenance accessibility.

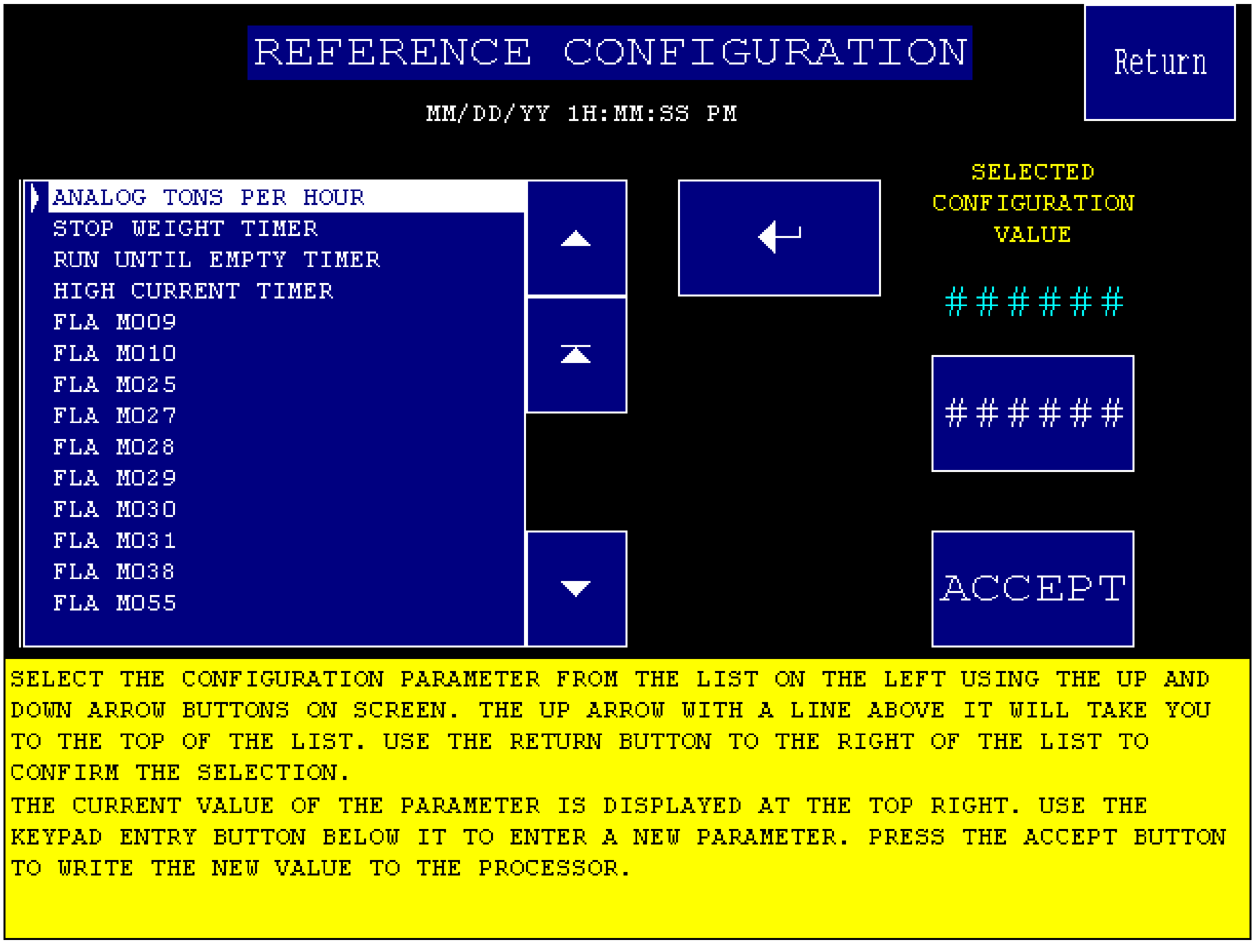

Figure 9
Parameter Configuration Screen

Detailed descriptions of the facility start-up and shut down procedures allowed us to design the automatic controls so that the operator could pay more attention to auxiliary equipment that is generally controlled manually. This saves time and allows the operator to dedicate his concentration on single tasks rather than keeping up with a manual start up or shut down sequence. Sensors were utilized to monitor tank levels and remote equipment was controlled over wireless Ethernet to keep costs down and reliability high when having to run pumps or other equipment in remote areas.

If a certain level needs to be met before a pump can run or another part of the process can start, the operator does not have to stay to monitor the level, the system will handle it automatically while the operator can visually inspect belts and other maintenance items.

5 START-UP CHALLENGES

As with any system start-up, getting the prep plant up and running to capacity was an exercise in perseverance. Our on-site process began during mid to late fall in a Northern climate. These sessions were to get a clearer picture of what the site looked like physically and to get a feel for the power distribution and motor control center. It was also a chance to see the instrumentation that was installed for current feedback on the pumps, torque feedback on the rake, sump levels and the nuclear density gauge with which we had no previous experience. These visits were also a great opportunity to experience the winter conditions in the plant, which gave us a new level of respect for the coal industry.

During the re-construction, there was an on-going welding effort, to repair and re-route pipes, holding tanks, man-ways and other odds and ends. After the installation of the control panel, we were able to proceed with the electrical checkout. Due to various reasons the entire system was not ready at one time and we started to work in phases as portions of the system were thought to be ready. Working with the Reading personnel and the electrical contractor, we were able to systematically check the wiring and power up each circuit. We encountered several electrical problems ranging from wiring issues (trying to figure out what was done more than 10 years ago), aging equipment, contactors in buckets whose coils had failed, failing overload protection, etc. Despite these obstacles, we were able to debug every circuit and finally test the PLC programming logic.

Getting a steady flow of raw coal from the hopper was a big challenge. Sizing the motor to run the vibrator and setting the gate width were both issues that took more than a few attempts. Some of the equipment was built on site by the welders and engineering changes were made based on the experience of the crew and management at the breaker. Having the Weightometer properly calibrated and dampened was another challenge to getting the raw coal to flow smoothly at the tons per hour set point.Reading Anthracite had a calibration company in to calibrate the level sensors a couple of times because of the difficulty of getting fluid levels in sumps to remain constant or to be able to change a level in the sump to check the span of the device.

After the system was mechanically and electrically sound, we had our turn in the barrel as we began to run into programming and interface bugs. Even though we spent as much effort on the design as we did, we still found issues on start-up where items that should be interlocked with one another were not and visa versa. Tank and sump levels had to correct before spraying could start. Proper timing of motors for starting sizing screeners had to be set. There were even some disagreements over how a particular set of valves worked to control level and density from water being returned from the cyclone and other equipment to the magnetic separators. The final authority came from the operator who was going to be working with it on a daily basis. We were able to set it up so that as little magnetite was wasted as possible. Tuning the loop to deliver the appropriate amount was also time-consuming. The effort to tune the whole system at once was a challenge because just about any one problem in the system caused us to have to start the process over again. Hiccups with the feed system caused sump levels to vary widely and make them difficult to dial in. Learning how to control level and density for the separating cyclones was made easier with the help of the experienced operator.

6 NSN OPERATION TODAY

Despite the start-up challenges, today the New Saint Nick facility operates at peak efficiency. The fine coal plant processes 200 tph (150 tph of run of mine anthracite and 50 tph of reclaimed silt from a local impoundment area). The product is cleaned to metallurgical coal specifications. The entire facility is run by a single operator via an interactive OIT. The PLC control system manages close to 200 discrete and analog devices including 40 pump/conveyor motors and the separation control loops. The operations of the control and safety systems have been approved by MSHA. With the exception of one minor pump speed adjustment and one undersized motor, the intended mass balance design expectations were met.

Acknowledgements

Prior to this implementation, GCI had no hands on experience in the coal preparation industry. We are thankful for our partners, Reading Anthracite and Albarell Electric, faith in our controls expertise to successfully bring this particular project to completion. Without the support and input of both parties, it would not have turned out to be the success that it has.

REFERENCES

American National Standard, 1995 *ANSI/ISA–88.01–1995 Batch Control Part 1: Models and Terminology,* Research Triangle Park, NC, pg 13, 14, 23