INTEGRATED PLANT CONTROL SYSTEM RETROFIT FOR A BASE LOAD COAL-FIRED POWER PLANT

PRESENTED BY

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For years now, existing power plants have been retrofitted with Distributed Control Systems (DCS). Since 1990, Utility Engineering (UE) and Xcel Energy have teamed up to successfully retrofit 16 power plant units of the southern Xcel Energy fleet. All 16 units have been upgraded to a Foxboro I/A DCS. The latest of these retrofits was Tolk Station near Muleshoe, Texas. Tolk Station consists of two 550MW tangentially-fired, pulverized-coal units. Lessons Learned during previous retrofits helped the team conform to strict outage schedules. Through proper planning, we developed a Quality Control system that ensures consistency not only within the plant, but across the company's fleet as well.

By standardizing to one DCS vendor, we can train several employees on one DCS system instead of expending the same resources to cross-train one employee on several different systems. Similarly-trained personnel can shift between plants as necessary. With a standardized operating interface, operators can transfer between plants with minimal retraining. Since retraining focuses only on the differences between plants, and not on the differences between plant interfaces, a new operator can be up to speed in 4-6 weeks, rather than after 2-3 months of cross-system retraining. Standardization also maximizes the effectiveness of Xcel's central engineering and support group. When a new software scheme is developed in a newer retrofit or by the DCS vendor, the support group can more efficiently implement it for the rest of the fleet.

Support group efficiency is also increased by creating subroutine and display templates, and by developing upfront philosophies to maintain a more consistent retrofit package. UE and Xcel developed subroutine templates for several types of motor control switches. Each template creates the lockout, trip, sustained and momentary start commands and other signals, even if those signals are not used. If a signal is needed during the troubleshooting and commissioning phases, the logic is already built-in and valuable checkout time is saved.

When the logic diagrams are designed the templates are simply referenced as a block, which makes the start and stop permissives more straight-forward. Before retrofits, and prior to the development of these templates, the operator may have known the permissives for starting a particular motor, but each permissive's status may not have been displayed. With the templates, each permissive's status is now displayed to the operator in a consistent, visible manner. The control displays are also configured with templates. By utilizing both types of templates, the displays can be configured more easily and consistently.

Integrating the subsystems with the boiler and turbine controls reduces the total Input/Output (I/O) point count, reduces spare parts, and provides for more uniform upgrades. Standardization of the DCS and control system ideologies at the plant level allows all processes to be monitored and controlled from any station in the plant, thus operators in remote stations are not obligated to remain in specific areas. The burner management system (BMS), sootblowing and ash-handling subsystems were originally Programmable Logic Controller (PLC)-driven systems that have been converted to DCS. The water treatment laboratory, motor starters and station power (MSS) subsystems were originally hardwired relay or local systems that have also been converted to DCS. I/O is reduced because the communication highway provides many of the previously hardwired permissives between the BMS and the boiler control system (BCS), the BMS and the MSS, the MSS and the BCS, and other subsystems. Some switches that were used for permissives or trips were eliminated from the hardwired circuit. When a transmitter, thermocouple or transducer measured the same conditions as a switch, the hardwired switch was replaced with a software switch. Removing switches provides the convenience of changing the switch setpoint in the DCS, and eliminates maintenance and calibration of the switches. In some cases the process measurement was already wired to the data acquisition system (DAS), and a switch was wired to the MSS as a permissive. The switch was abandoned and the permissive was utilized via the highway at no additional cost.

Incorporating the subsystems into the DCS eliminates the need for PLC spare parts and programming software. These subsystems can now be upgraded more quickly, and for lower cost.

In subsystems that had PLC logic, such as the baghouse and BMS, the wiring control scheme was not consistent with plant philosophy. The plant uses the control power to energize the starting and stopping relays, and to interrogate the on/off status of the motor. The subsystems originally used a separate power supply to interrogate the motor's status. When the subsystems were converted to DCS, the plant philosophy was incorporated even if it meant rewiring or adding circuits. The resulting consistency provides information about the circuit (such as loss of control power and trip alarms) that simplifies troubleshooting during checkout, and also simplifies routine maintenance.

The most important part of a controls retrofit is implementing and incorporating the I/O into the DCS. There are two ways to design the layout of the I/O cabinets. One is to leave the existing cabinets and field wiring in place, replace the existing I/O cards, and then internally wire to the existing field wiring. This method requires twice as many wire terminations, and mandates mounting the I/O cards during the outage. This option is undesirable in light of time constraints, but sometimes unavoidable due to physical constraints. The second method is to replace the existing cabinets, which requires that the field wires be cut. The new cabinets have the I/O cards already mounted and internally wired to terminal blocks. The new cabinet wiring and I/O are checked out prior to installation. This option requires only one termination for each wire of the color documented on the wiring diagram. Troubleshooting of wiring errors is simplified because of the wire color code. An estimated one man-week per cabinet is saved during the outage by replacing the cabinets. Replacing the cabinets as soon as possible allows for the time necessary to wire, troubleshoot and commission the I/O.

During the first stages of an outage, certain equipment must be operable even if the unit itself is off-line. For example, it may be necessary for the turbine turning gear and data acquisition associated with the turbine, ID fans and baghouse to continue to operate early in the outage. Careful planning is required, when performing the lockout/tagout procedures, to protect vital equipment and to maintain a safe working environment. All systems cannot be commissioned simultaneously, therefore a detailed outage schedule provides for a smooth transition. The first priority is to provide power and establish communication to the I/O cabinets. The next priority is to complete the sequence of events (SOE), so that all points associated with a piece of equipment can be completely checked out when that equipment is cutover. Most systems can be totally disconnected and replaced in whole, like the burner management, boiler control and data acquisition systems. However, the station power system requires a breaker-by-breaker cutover since the plant lighting, protective relaying and other equipment relies on the operation of the breakers. One engineer and one electrician are dedicated to the station power cutover for the entire outage. Eventually every I/O point is checked out.

Even when a point is wired and configured correctly, it still may not operate satisfactorily. Hart protocol I/O cards are used for transmitters, valve positioners and fluid-coupling drive actuators. Using the digital protocol to receive the feedback signal on the positioners and actuators saves on wire pulls, I/O points and field hardware. Hart is also used on the transmitters. Some problems with the Hart input cards have occurred on some retrofits. In these cases the signal would not update, but still showed as a good signal in the DCS. The problem occurred with both Yokogawa and Rosemount transmitters. The configuration of the input was eventually changed to a 4-20mA current signal in the DCS. The signal started updating properly using the 4-20mA option. It was not necessary to change the I/O module, but the benefits of the digital protocol were lost. Since the acceptable fix was in the software, the setback did not affect the schedule of the outage.

It is necessary to allow extra time for trip checks after a complete controls retrofit. Since the burner management I/O and processors are redundant, the trip checks must be doubled to check both sets of I/O and processors. Both processors must also be disabled to check the fail-safe position of the outputs. The hardwired pushbutton trip required by NFPA must also be checked. This requires a separate display that disables the DCS outputs by forcing them to manual, to verify that the hardwired relay is the only mechanism that trips the unit. After all trip checks are successfully completed, the unit must be started, tuned and completely commissioned.

Consistency and planning are key components of a successful control retrofit. Even when unexpected events occur, consistency among design philosophies reduces the time and expense associated with troubleshooting and commissioning.