The Technicians' Assistant
Integrating Today's Technology into CEMS Maintenance

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By Michael McMenus – Kansas City Power & Light, Inc.
and
Russell Berry – RMB Consulting & Research, Inc.

INTRODUCTION

The challenges of maintaining a continuous emissions monitoring system (CEMS) just got a little easier. In today's utility plant environment, with more limited resources and continually increasing emissions monitoring burden, CEMS technicians now have an additional "tool" to facilitate CEMS operation and maintenance (O&M) efforts. At previous EPRI CEM User Group Conferences, a few presentations have discussed the concept of automating CEMS to reduce manual recordkeeping efforts and improve diagnostic capabilities. This new "tool" pushes the concept of automation one step further. As part of a CEMS replacement project on Unit 5A at Kansas City Power & Light's (KCP&L's) Hawthorn Generating Station, hardware and software were developed that allows the CEMS technicians to more efficiently operate and maintain the CEMS. This work was performed in cooperation with CEM Solutions, Inc., M&C TechGroup, Environmental Systems Corporation (ESC) and RMB Consulting & Research, Inc.

The Hawthorn Station is located northeast of downtown Kansas City, Missouri. Unit 5A is designed to combust either natural gas or pulverized coal and is a natural circulation, balanced draft, sub-critical boiler. Unit 5A is a 590 gross megawatt boiler that is primarily fired with Powder River Basin (PRB) coal. It is equipped with Babcock & Wilcox DRBZ Low NO_x burners with over fire air. Exhaust gas from the unit is split into two ducts (Ducts A and B), and each duct is equipped with a selective catalytic reduction (SCR) system for nitrogen oxides (NO_x) control, a spray dryer absorber (SDA) system for sulfur dioxide (SO_2) control and a pulse-jet baghouse for particulate control.

There were a total of four CEMS and one shelter being replaced as part of this project. The CEMS being replaced included a:

1. NO_x/CO_2 CEMS at the Duct A SCR inlet,
2. NO_x/CO_2 CEMS at the Duct B SCR inlet,
3. $NO_x/SO_2/CO_2$ CEMS at the Duct A SDA inlet (aka, the SCR outlet), and
4. $NO_x/SO_2/CO_2$ CEMS at the Duct B SDA inlet (aka, the SCR outlet).

All four of the new CEMS are 100:1 dilution extractive CEMS using M&C probes and probe controllers. One ESC Model 8832 datalogger serves both CEMS on Duct A, and a second ESC

Model 8832 datalogger serves both CEMS on Duct B. There are also in-situ oxygen (O_2) analyzers, being used for control purposes, installed at the two SDA inlets. These two O_2 analyzers are incorporated into the dataloggers, as well, for operating and data recording purposes. Tying all of this equipment together (i.e., the probes and probe controllers, each individual analyzer and the dataloggers) is an Allen-Bradley programmable logic controller (PLC).

PROJECT OBJECTIVES

When evaluating the resources and time consumed to properly operate and maintain a CEMS and to comply with all of the recordkeeping and reporting requirements, several tasks seem to always dominate a CEMS technician's efforts. Once the decision was made to replace these four CEMS, KCP&L began considering ways to use today's technologies to improve their CEMS program efficiency and, in particular, facilitate the technician's CEMS related responsibilities. KCP&L's primary objectives regarding this aspect of the program were to:

1. Automate the daily recordkeeping efforts typically performed manually by a CEMS technician,
2. Collect and store critical CEMS operational data and analyzer diagnostic data to assist technicians when establishing preventative maintenance cycles and/or identifying and resolving CEMS problems, and
3. Create a system that would permit technicians to perform typical checks and initiate CEMS functions from the probe locations (and other locations if desired).

Automating the daily checks and recordkeeping efforts reduce the manpower requirements currently expended on such tasks. As a result, technicians are able to spend more of their time actually maintaining the CEMS. Basically, all of the data points recorded by the technicians can be recorded by a PLC or computer, and with a little effort to assign reasonable limits and trending alarms to these data points, the entire process can be more automated and also provide valuable diagnostic information to the technicians. Any PLC or computer system used to collect analyzer and CEMS operational parameters (e.g., reaction chamber temperature, sample pressure, lamp intensity, calibration gas pressures, dilution air pressure and dilution air flow rate) can also be used by a technician to trend this information to enhance preventative maintenance activities. Once the parameter data is collected by the PLC, screens can be developed to facilitate a quick, visual assessment of the CEMS operating status. This is especially beneficial to technicians responsible for maintaining several CEMS located throughout a facility. Specific tolerances can be set for each parameter such that an alarm is generated whenever these tolerances are exceeded. These tolerances can be set to generate both warning and failure alarms. The warning alarm can prompt a technician that a potential failure is eminent, but still provide an adequate timeline for performing corrective maintenance. This approach offers the dual benefit of providing a technician with the flexibility to address maintenance activities while, at the same time, reducing the potential for out-of control periods.

In addition to these passive, informative functions, KCP&L wanted the CEMS technicians to be able to use the PLC to initiate active CEMS functions (e.g., place monitors in and out of service and initiate calibrations) from each of the probe locations. Achieving this objective would permit a technician to perform maintenance or repairs at a probe location, review all of the CEMS operating parameters, inject calibrations gases to evaluate the repair and initiate the appropriate follow up quality assurance checks before leaving the probe locations – no more trips back and forth between the shelter and probe locations. Note that while KCP&L does not allow external access to its operational systems (including the CEMS software), this system could be used to access and operate the CEMS from any location with internet service.

HARDWARE AND SOFTWARE FEATURES

In these times of high-speed communications, the immediate availability of unlimited information and the commonality of powerful, ruggedized, touch-screen tablets, KCP&L wanted a system that offered no less. KCP&L's system uses a PLC as its "hub." The PLC gathers and process all desired data. It communicates with the CEMS datalogger to initiate specific O&M commands, it communicates with the probe controllers, and it allows access to all of the data using either a human machine interface (HMI) in the shelter or using a tablet computer which can be used at any of the four probe locations. A schematic of the PLC communication design is shown in Figure 1. The "overview" display, used on both the HMI and tablet, and a picture of the tablet is included as Figure 2. Both the HMI and tablet have similar functionality but some of the screens are slightly different. The tablet is a resistive touch only mode, i7 computer with 4 GB of RAM and a 320 GB hard drive. Both the HMI and the tablet have a security screen to protect the CEMS data acquisition and handling system (DAHS) records and CEMS O&M functions. As view of the tablet security screen is included as Figure 3.

As shown in Figure 4, the tablet has an overview page that provides a summary of important data for all four locations. This overview displays pressures, temperatures, the actual dilution ratio, the operating status and emission concentrations for each of the CEMS. For the probe and heated sample line (HSL) temperature displays, a temperature setup window will open up when the value is pressed. An example of the temperature setup screen in included as Figure 5. Furthermore, a red box around the perimeter of the value will be displayed when a temperature alarm exists. For NO_x, CO_2 and SO_2, pressing the screen value will open the corresponding analyzer window, and a red box around the perimeter of the value will be displayed when an analyzer alarm exists. Figure 6 provides a view of the tablet's main menu page. Pressing the "buttons" on this menu page opens additional tablet screens that are discussed and illustrated below.

The calibration gas summary screen for the tablet is shown in Figure 7 and the calibration gas setup page is presented in Figure 8. When the calibration gas is pressed, the corresponding calibration gas setup window will open. On the summary page, a capacity display box shows the approximate amount of gas remaining in each cylinder. Capacity resets are located on calibration gas setup pages. Both the unregulated and regulated gas pressure for each bottle are also provided with user configurable feedback alarms.

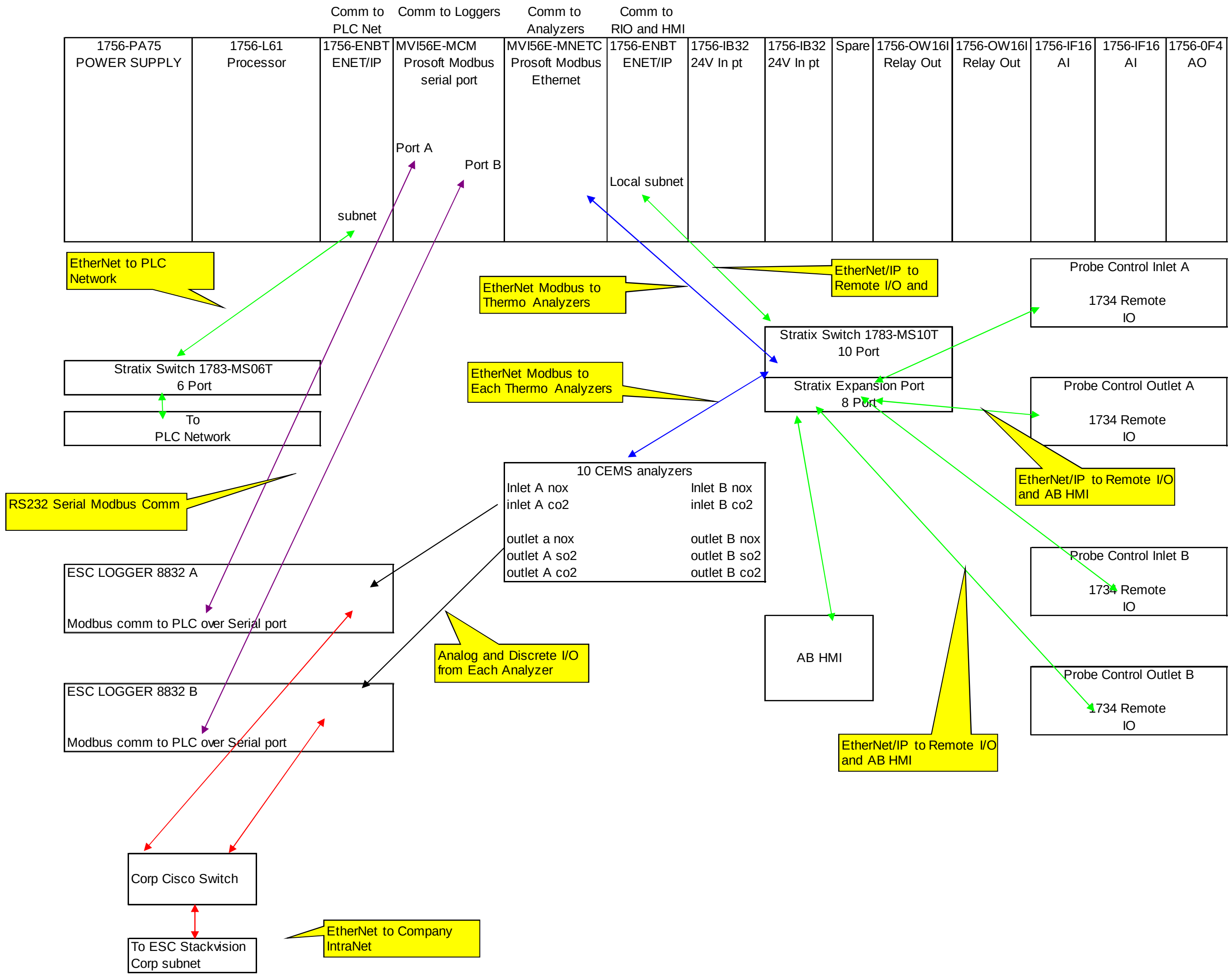

Figure 1: PLC Communitcation Schematic

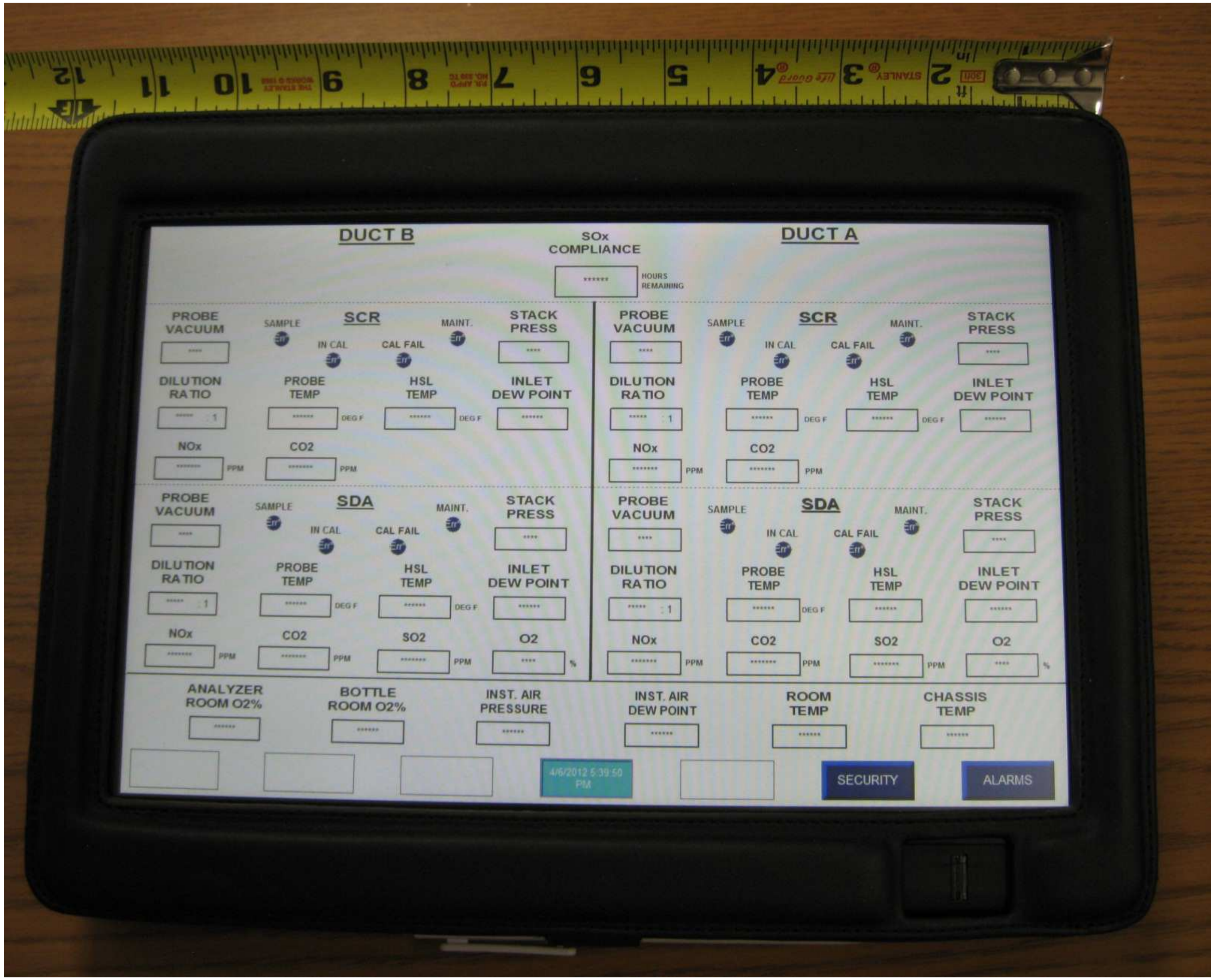

Figure 2: Tablet Computer

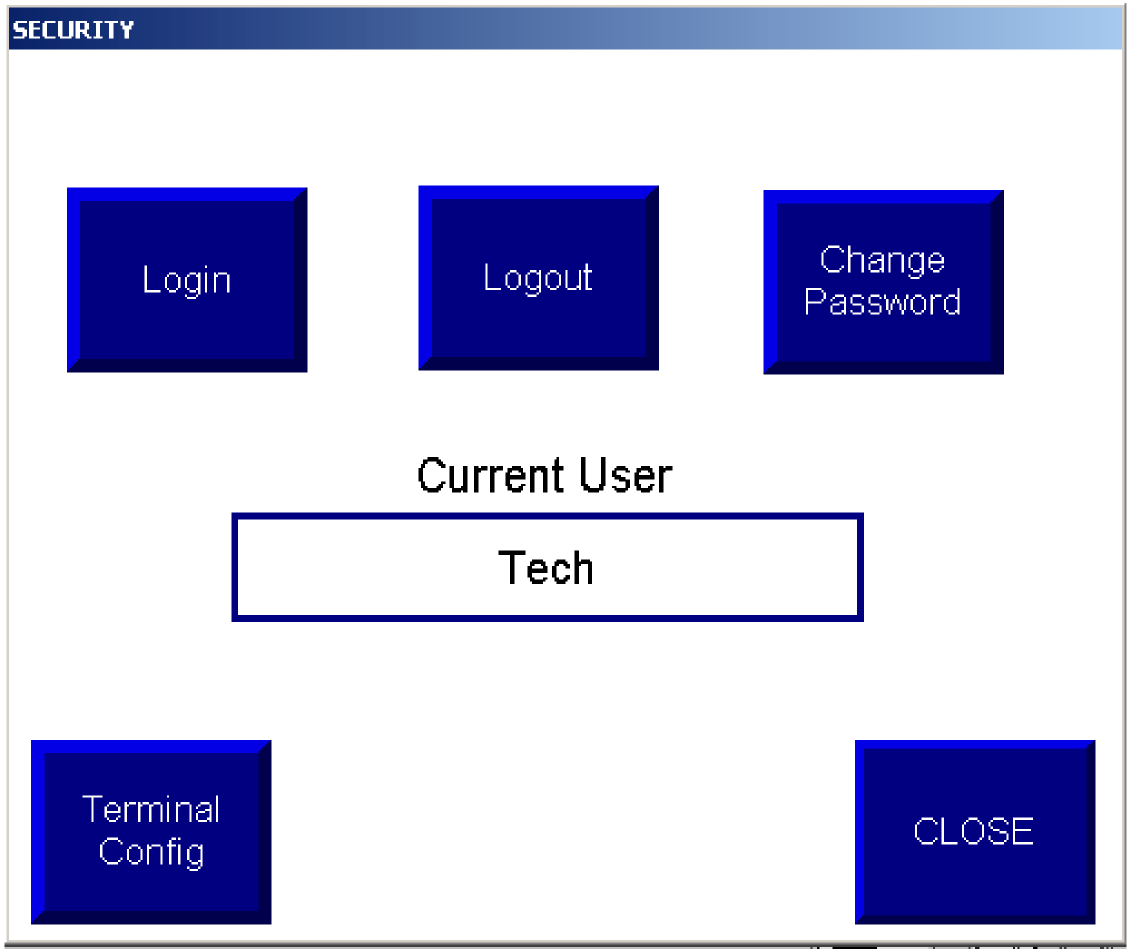

Figure 3: Security Screen

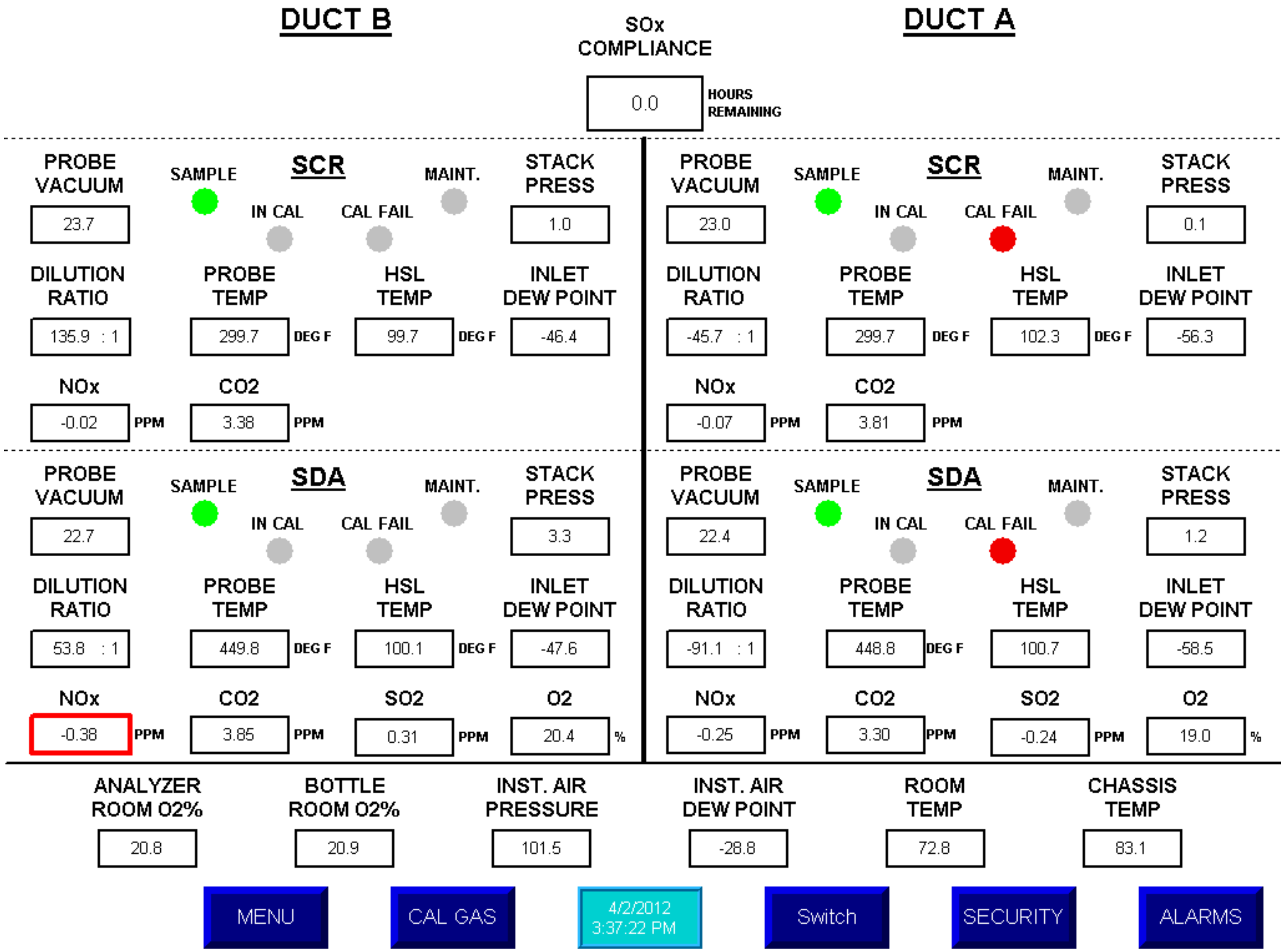

Figure 4: CEMS Overview Page for the Tablet

TEMPERATURE SETUP

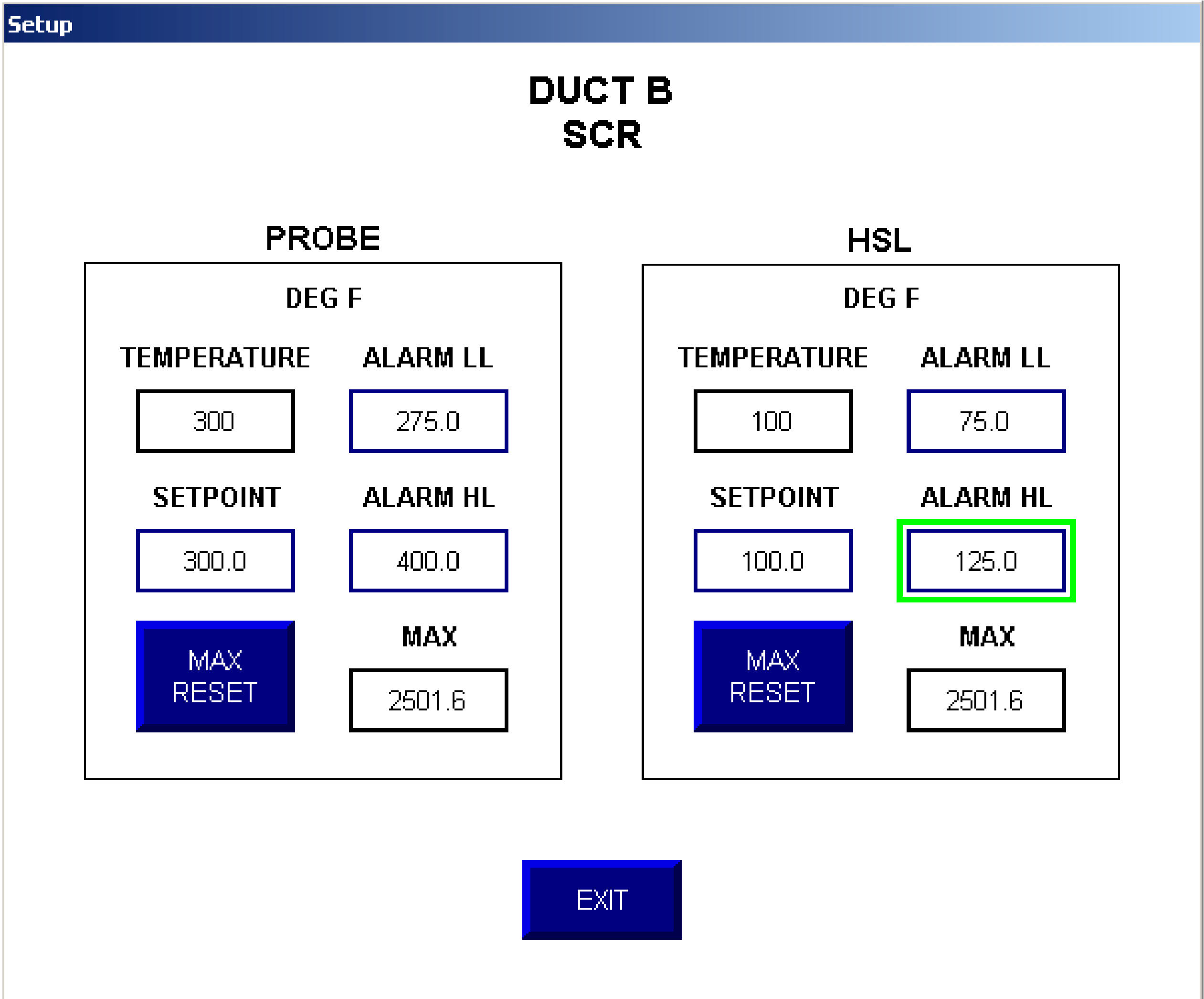

Figure 5: Temperature Setup Screen

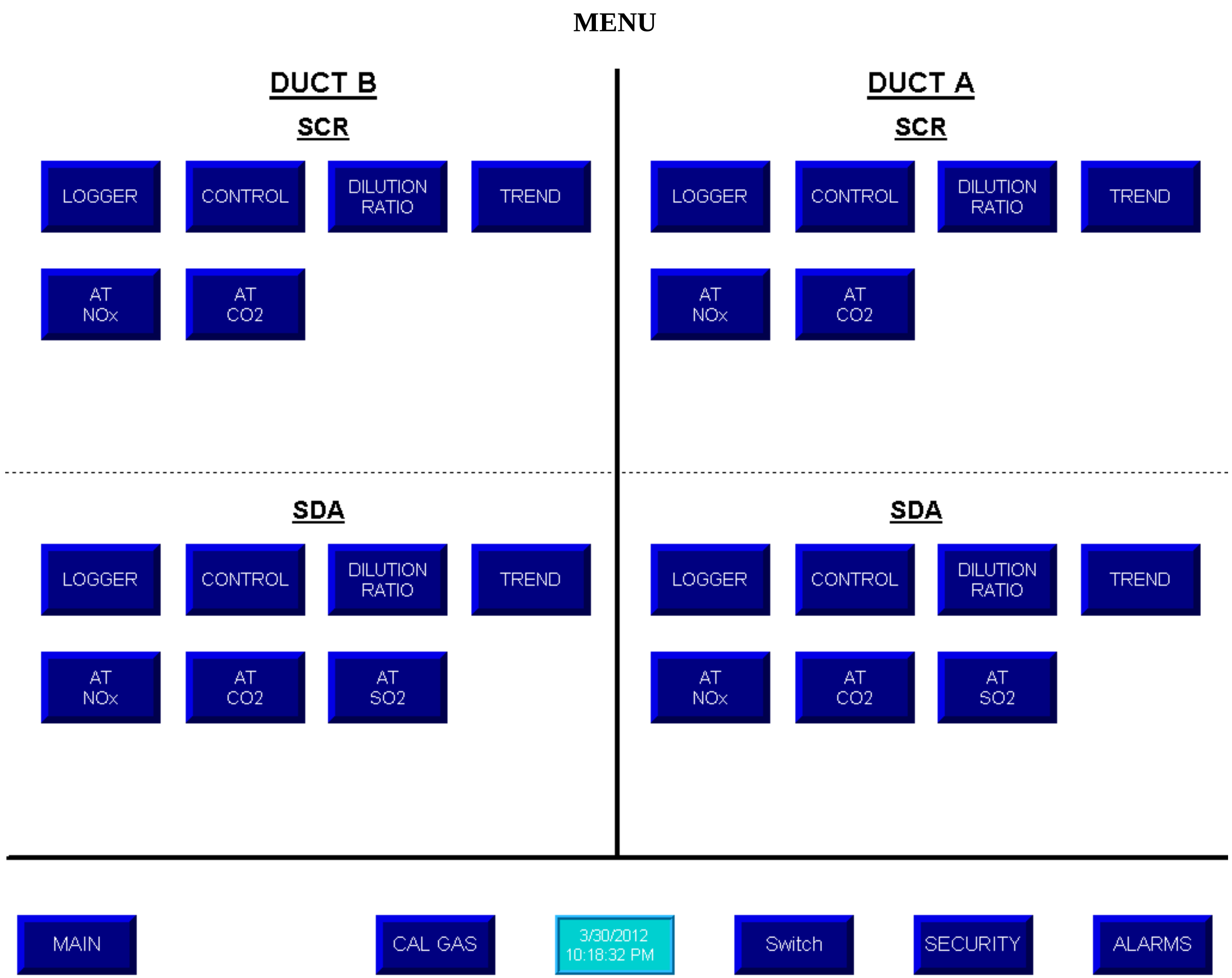

Figure 6: Menu Page for the Tablet

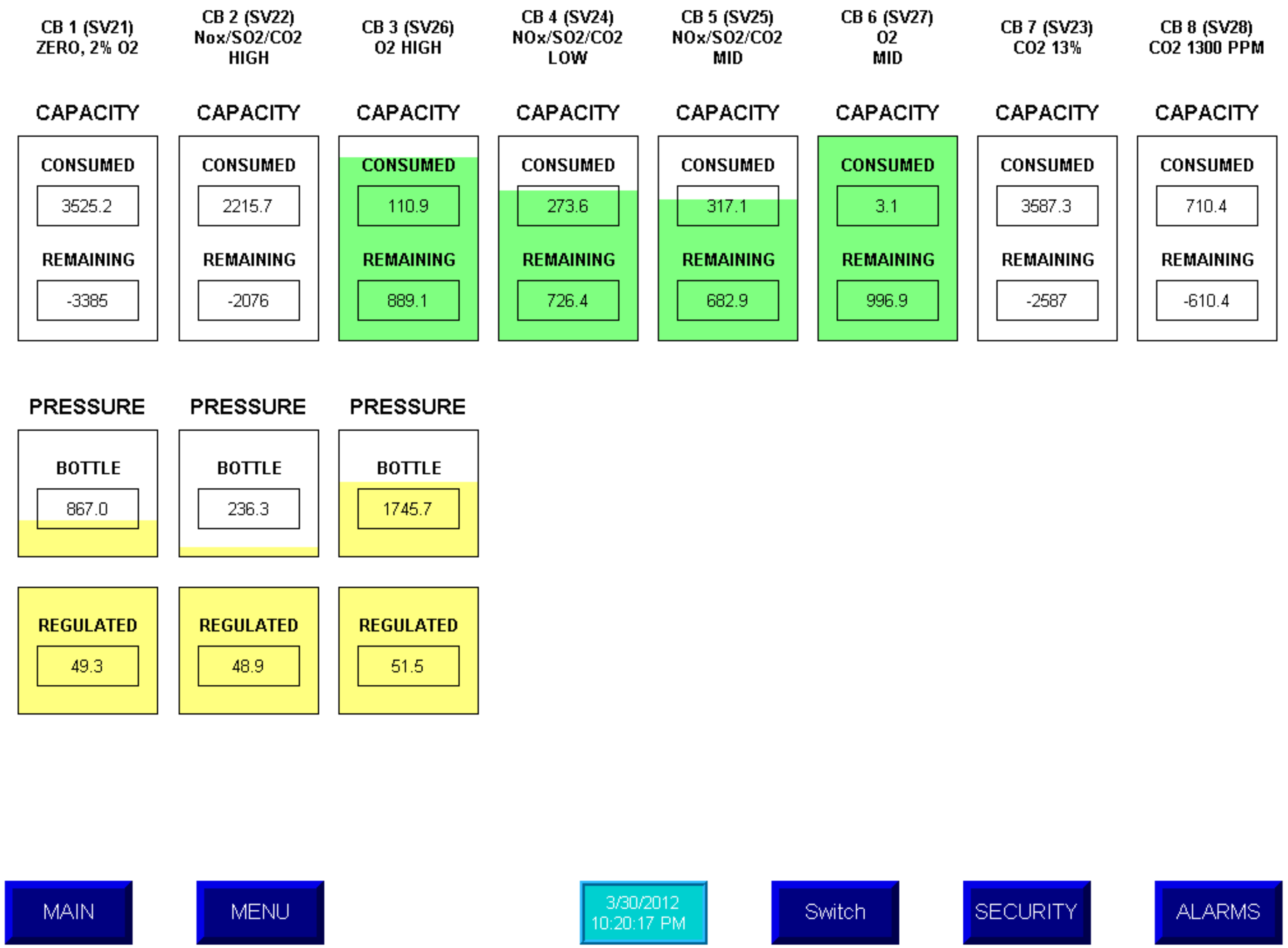

Figure 7: Calibration Gas Summary

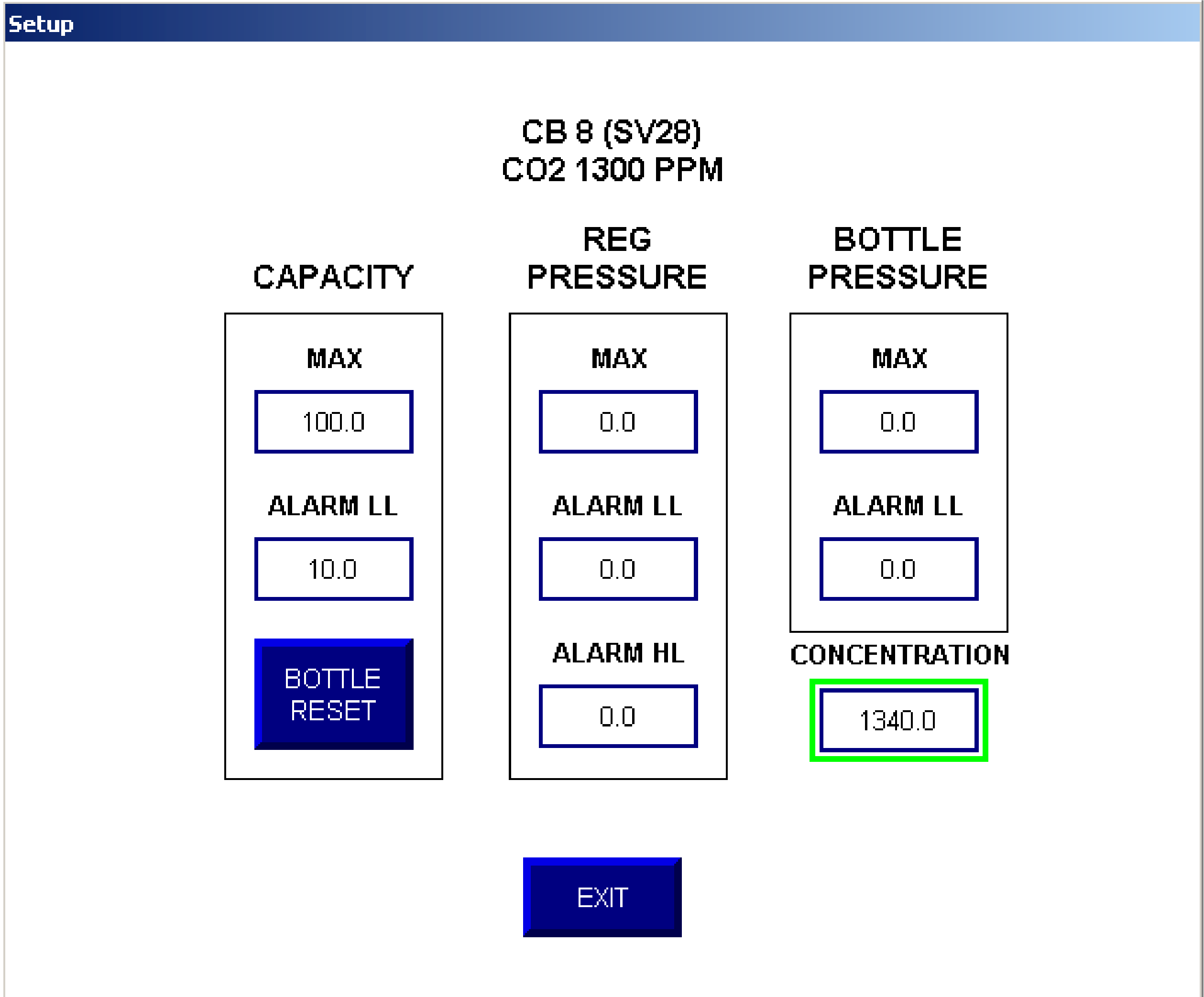

Figure 8: Calibration Gas Setup

As shown in Figure 9, the tablet also has an interactive datalogger screen. This screen allows the CEMS technician to determine the current operating status of each CEMS. The technician can place one or more analyzers in maintenance and can also initiate calibrations and linearities from any of the probe locations. Figure 10 shows the device control page which also allows the CEMS technicians to inject individual gases or purge the CEMS while in maintenance mode, track important probe values and monitor the analyzer responses all from this single screen.

As part of KCP&L's effort to improve the CEMS equipment in these new systems, a dilution ratio algorithm, initially developed as part of an effort by EPRI and some individual utilities to improve the accuracy of CEMS measurements, was also installed at all four locations. Shortly after the Part 75 monitoring requirement became affective CEMS operators began raising concerns about the sulfur dioxide (SO_2) and carbon dioxide (CO_2) measurements being made under the Acid Rain Program (40 CFR Part 75). Part 75 CEMS operators also raised concerns about CEMS measurements as they relate to the determination of heat input into the boilers and the subsequent impact on unit heat rate determinations and mass emissions of SO_2 (i.e., SO_2 allowances). Based on observations made by utilities nationwide, heat input and SO_2 mass emissions were being over reported by 5-25% from many electric utility boilers.

Originally, the problem was thought to be almost solely a function of the flue gas flow measurements. To evaluate CEMS flue gas measurement issues, the Electric Power Research Institute (EPRI) funded an investigation of potential flow-related sources of the heat rate discrepancy (Evaluation of Heat Rate Discrepancy from Continuous Emission Monitoring Systems – Final Report TR-108110, July, 1997). During the EPRI heat rate investigation, data from several sites indicated that CO_2 measurements were also playing a role in the observed discrepancies and that SO_2 measurements may be involved, as well. In addition, EPRI noted that utilities were experiencing considerable difficulty with SO_2, NO_x and CO_2 analyzer linearity tests. For many of the data sets that were evaluated during the heat rate project, a significant CO_2 high bias between 7 and 12% was observed. Field tests conducted during the heat rate project indicated CO_2 analyzer bias in the range of 3 to 3.5%. A smaller, but potentially significant SO_2 high bias was also suggested in some cases.

In order to resolve the biases and linearity test difficulties observed during the heat rate project, EPRI funded two additional projects -- the "CEMS Analyzer Bias and Linearity Effects (CABLE) Study" and an "Advanced QA/QC for CEMS" project. Based on information (presented by RMB at the 1998 EPRI CEMS User Group meeting) obtained while performing these two projects and additional experience acquired by helping resolve numerous CEMS issues for utility companies, guidelines were developed for the proper implementation of a dilution ratio algorithm. KCP&L has implemented this dilution algorithm on all four CEMS and the implementation of this algorithm is also controllable from the PLC tablet. Figure 11 shows the tablet's dilution ratio setup screen.

Figures 12 – 14 show the tablet's individual analyzer parameter screens for the NO_x, SO_2 and CO_2 monitors, respectively. These screens show the operating modes, alarms and values for key diagnostic parameters for each analyzer. Note that these data as well as all of the other data collected by the PLC are saved on the plants PI system. These data can also be retrieved and trended by the tablet. Figure 15 presents an example trending screen available on the tablet.

Figure 16 shows the alarm screen used to record any alarms identified by the PLC based on the technicians alarm set points.

BENEFITS

By automating the data collection and reporting process, KCP&L's CEMS technicians will be able to switch their efforts from data collection to maintenance activities. This will afford the technicians more time to address the causes of component failures or abnormalities in the data prior to them reaching an alarm status. By addressing potential problems proactively, KCP&L will be able to schedule component outages during periods when they will have minimal impact on the CEMS, improving CEMS accuracy, reducing component downtime and potentially reducing overtime/callout situations. At a minimum, since the PLC will automatically record and evaluate a large portion of the data that will facilitate diagnostic efforts when problems arise. By adding the interactive features of this system, KCP&L also expects to make the technicians work easier when they are trying to diagnose probe-related problems or perform probe maintenance.

By utilizing the PLC screens to provide user feedback on the status of the CEMS components, additional personnel, such as unit operators and shift supervisors can assist with evaluating the equipment condition in the absence of technical personnel. This should result in faster diagnosis of CEMS problems, minimizing downtime.

KCP&L hopes to track and improve preventive maintenance strategies. The O&M information collected by this system could provide useful information when technicians are evaluating the cost effectiveness of specific preventive maintenance activities.

The O&M automation enhancements presented in this paper describe a beneficial "second step" in developing technologically advanced CEMS features that will assist the CEMS technicians in their efforts to efficiently operate and maintain KCP&L's CEMS.

LOGGER

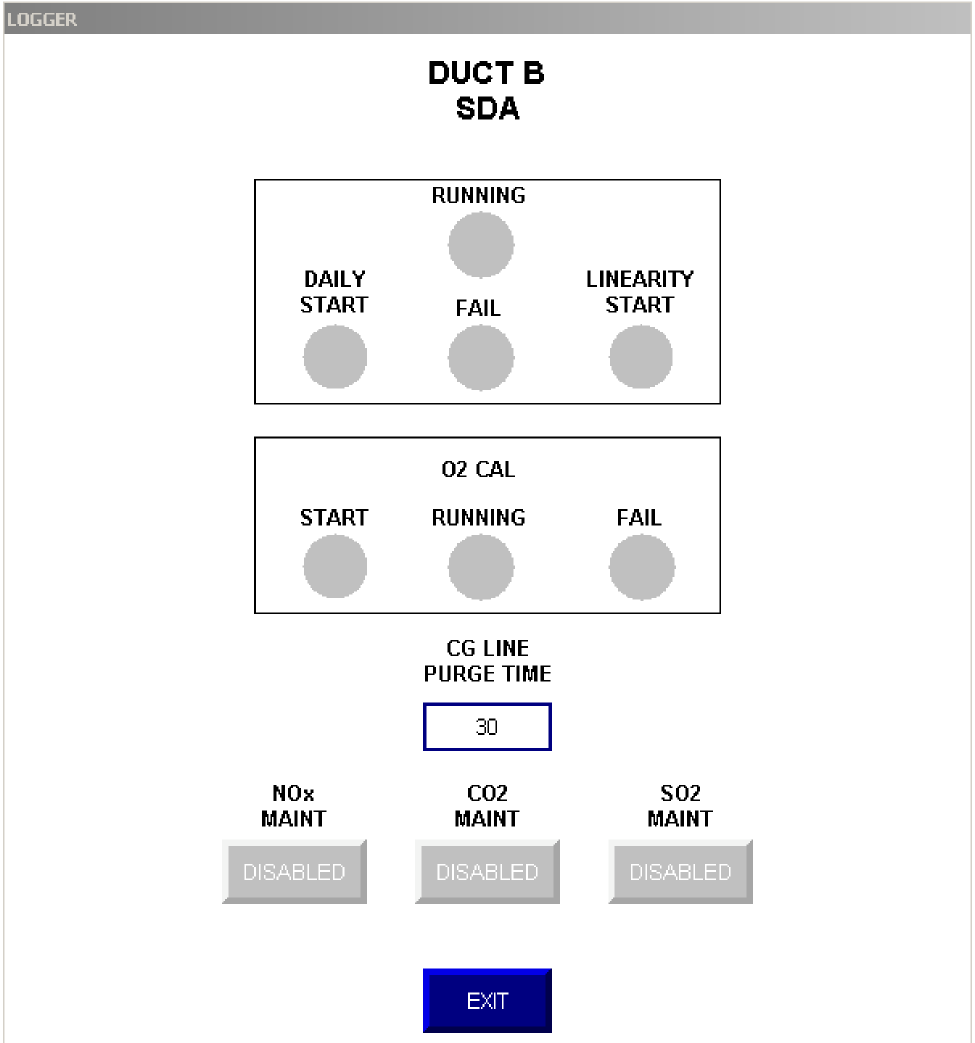

Figure 9: Interactive Logger Screen

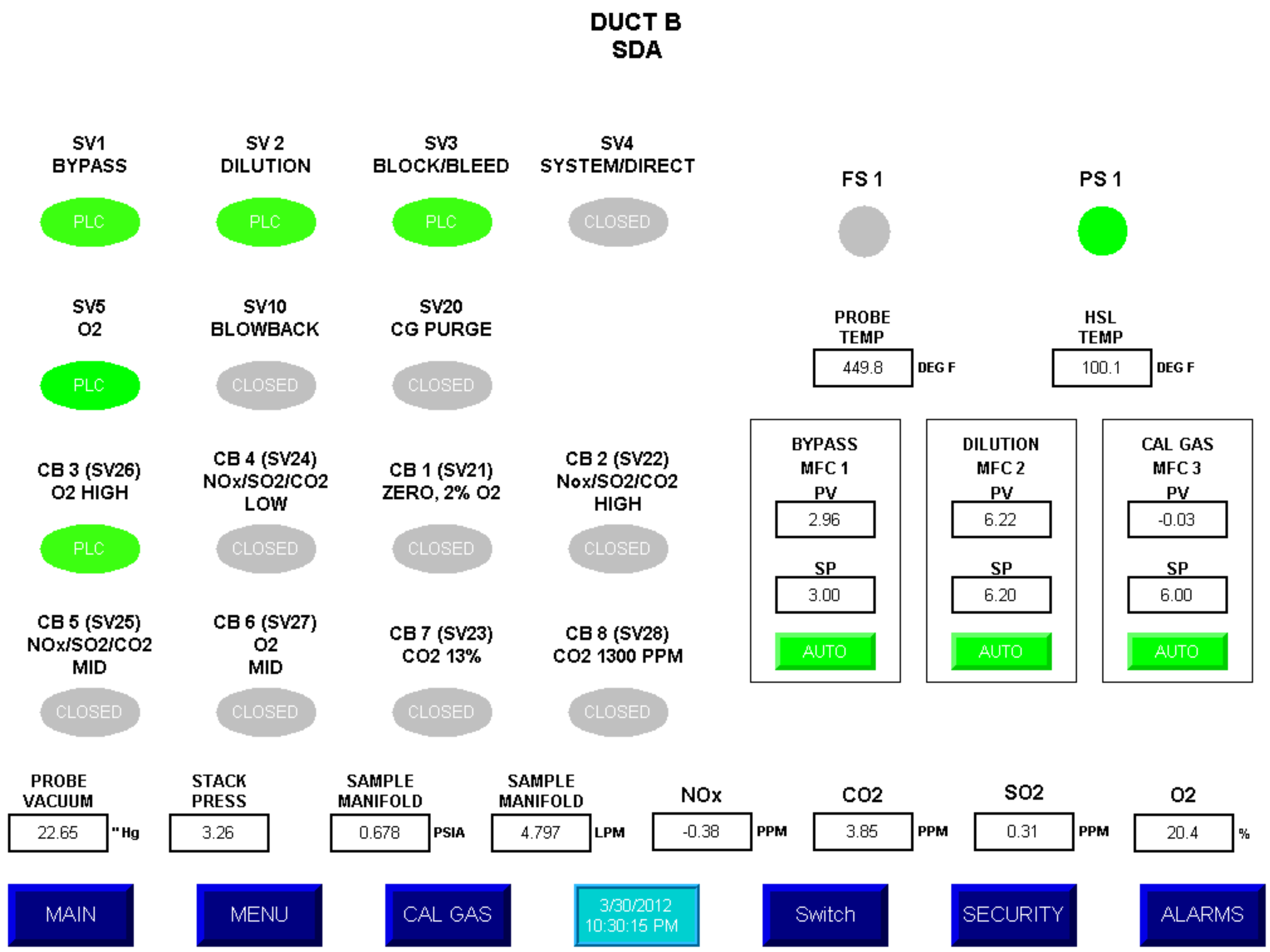

Figure 10: Device Control Screen

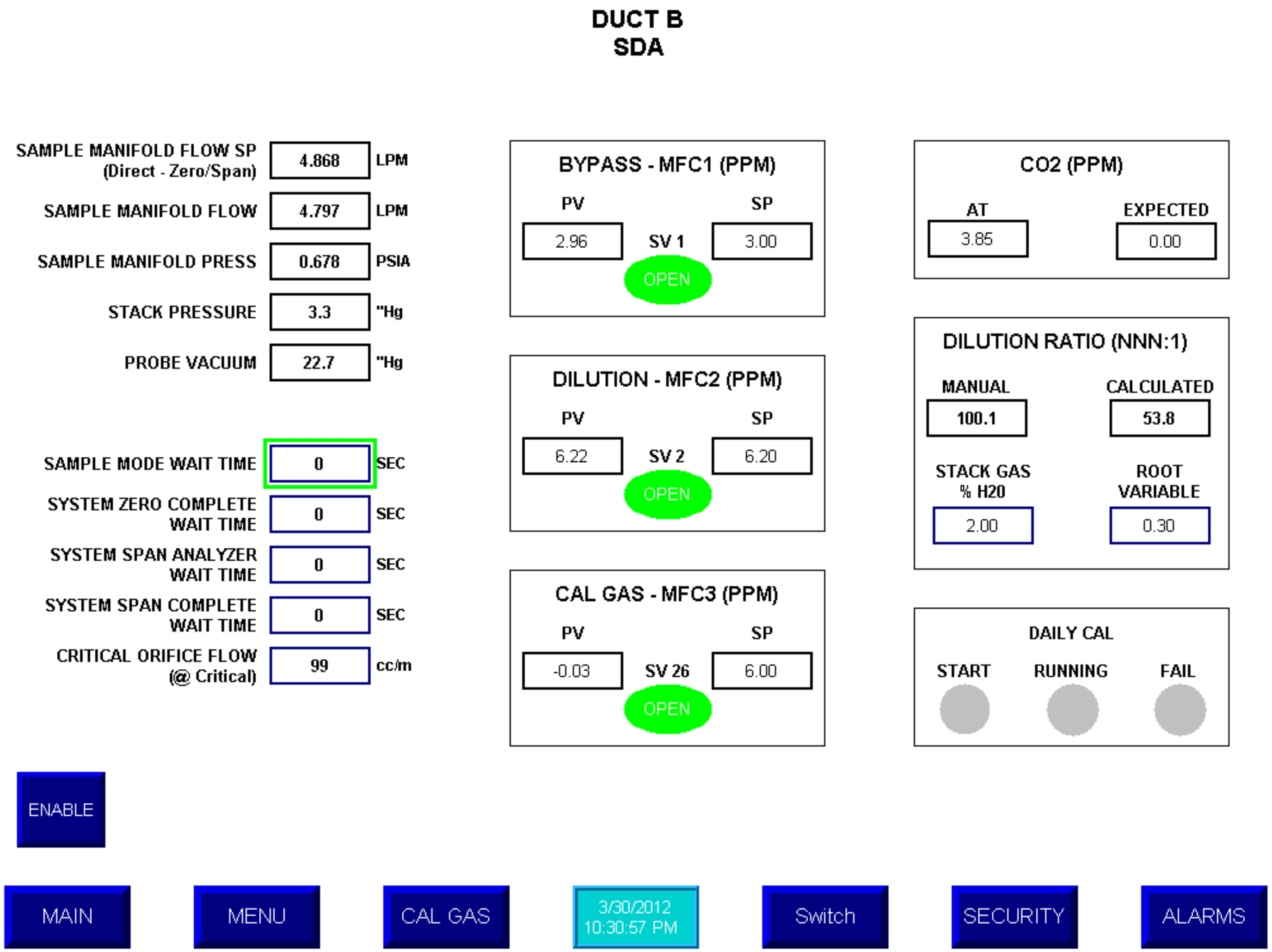

Figure 11: Dilution Ratio Setup Screen

NO_x ANALYZER

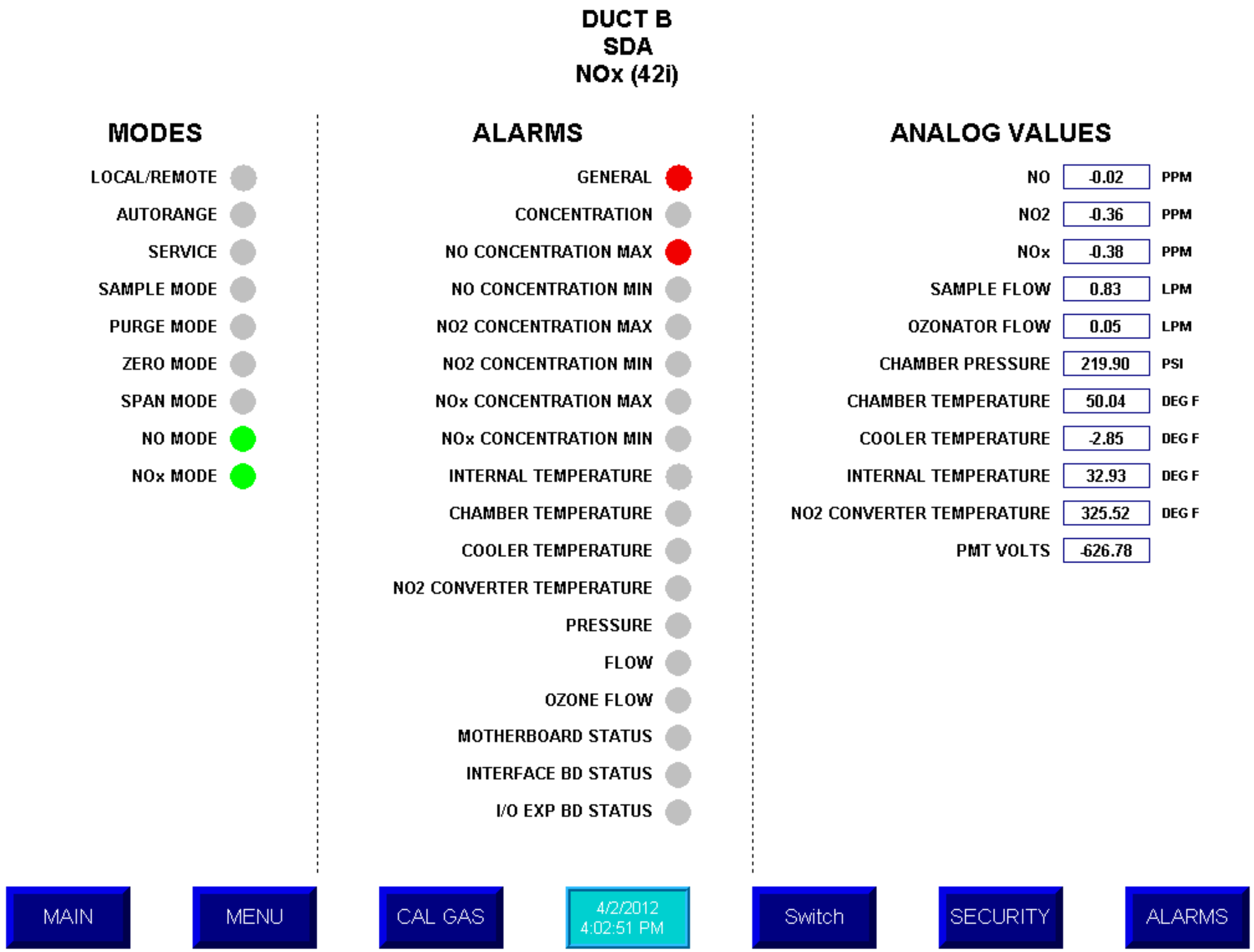

Figure 12: NO_x Analyzer Parameters

SO_2 ANALYZER

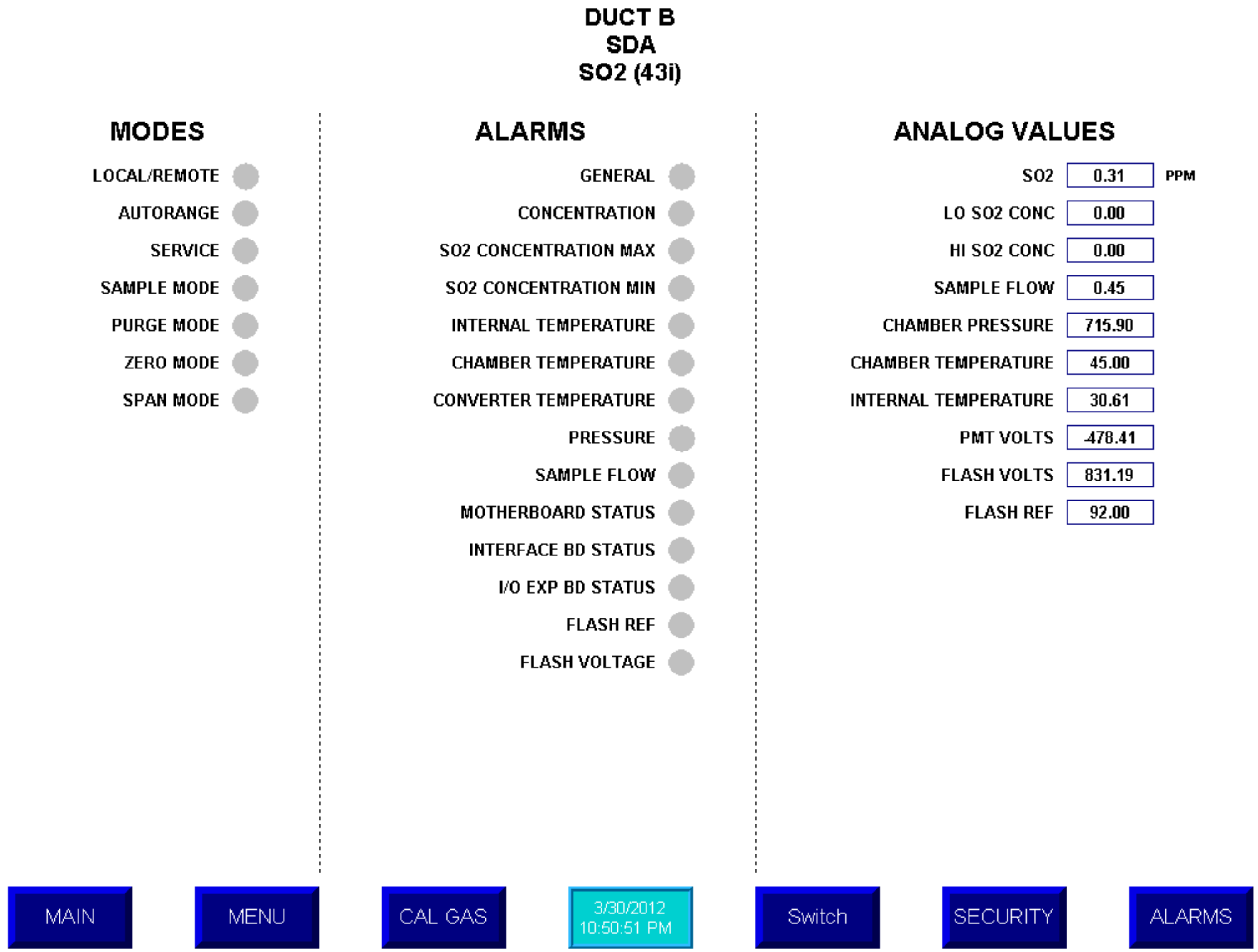

Figure 13: SO_2 Analyzer Parameters

CO_2 ANALYZER

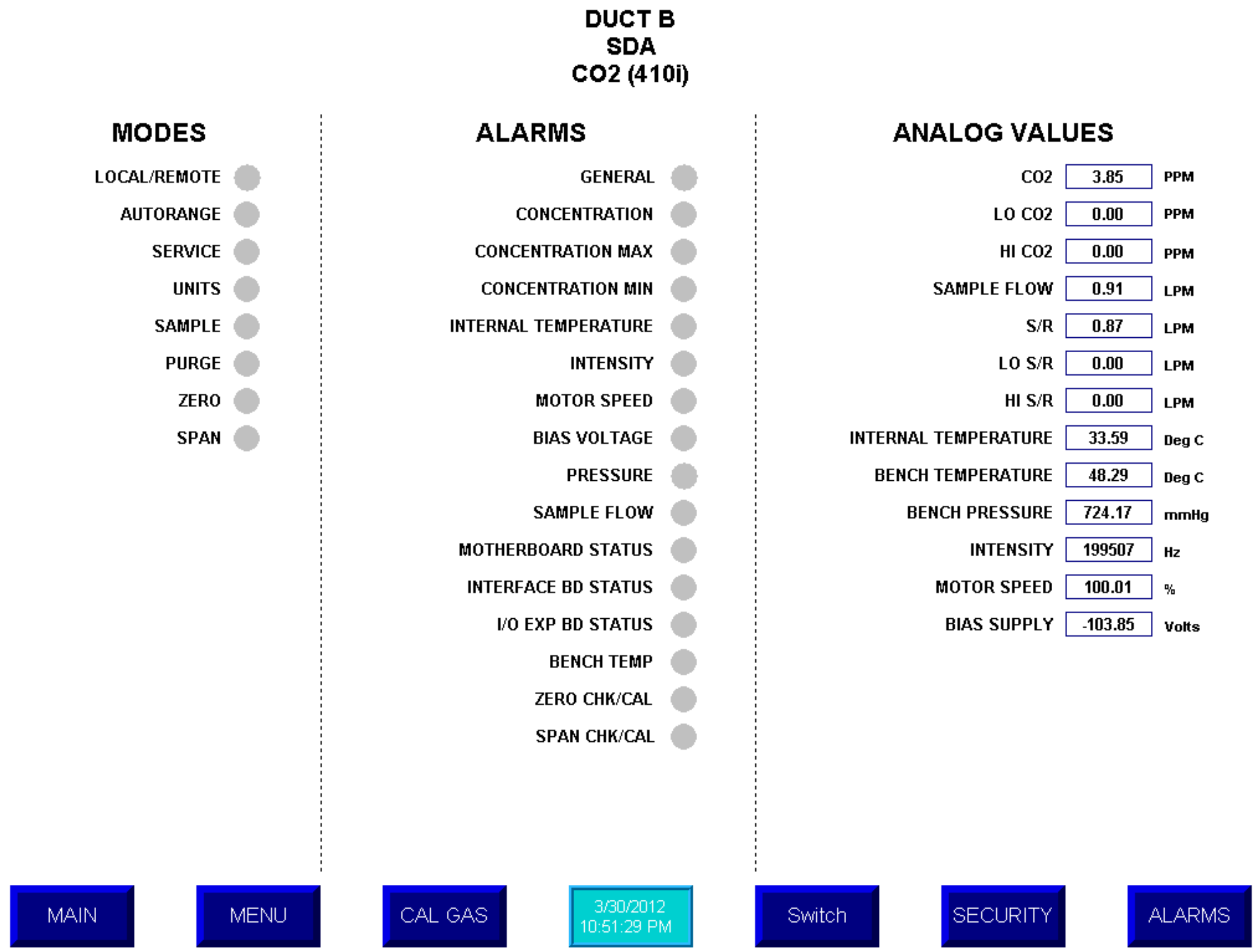

Figure 14: CO_2 Analyzer Parameters

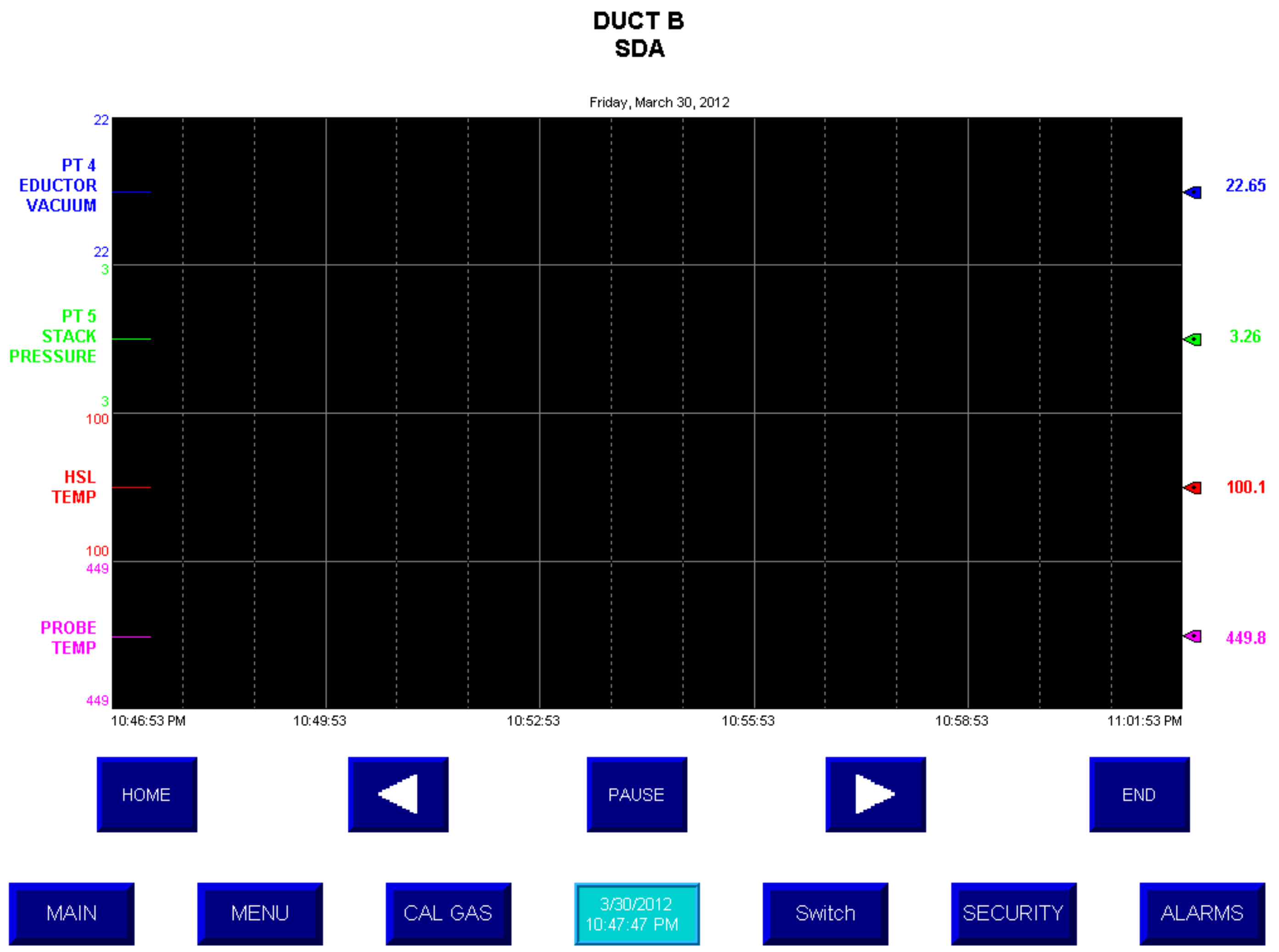

Figure 15: Example Tablet Trend Screen

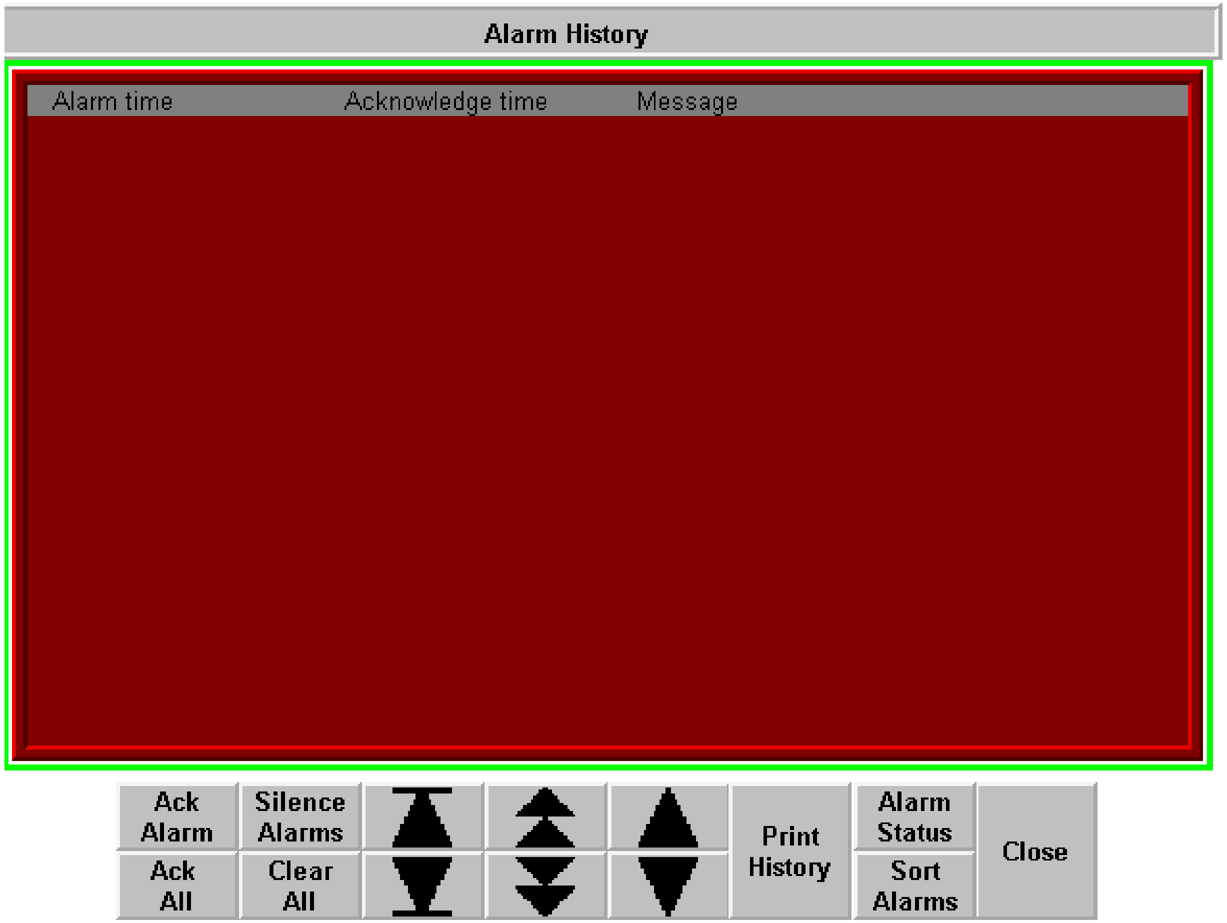

Figure 16: Tablet Alarm Screen