Automatic Environmental Chamber and Gas Control

by

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Category:
Manufacturing Functional Test

Products Used:
FieldPoint™
LabVIEW™ 6.1

The Challenge: To automate carbon monoxide sensors testing process including maintaining predetermined environmental conditions for certain periods of time and control of gas pressure and concentration within an enclosed chamber.

The Solution: Developing a control and data acquisition system using FieldPoint and LabVIEW graphical development environment to monitor and record the test parameters and integrate control of the temperature and humidity with control of the gas concentration and pressure within the chamber.

Introduction

Carbon monoxide sensors tests usually take a long time. The process involves exposing sensors to certain sequences of environmental conditions maintained for long periods of time before and, possibly, during the exposure to different concentrations of carbon monoxide gas.

Traditionally, the operators had to set the current step temperature and humidity on the chamber, manually record them into a paper log, wait till the time of exposure elapses, then set the next step temperature and humidity values, record them and wait again, and so forth. When it was time to expose the sensors to the gas they had to manually switch the necessary valves, turn a pump on, adjust the gas concentration, record the value and wait again till the end of the step to either repeat the procedure for the next step or finish it. Additionally, the gas analyzer instrument used to measure the gas concentration is pressure sensitive, which required the operator to manually maintain pressure with a needle valve in order for the analyzer to provide accurate concentration readings. Periodically the analyzer also needs to be manually connected to a reference cylinder with a known gas concentration and run a calibration sequence, sometimes interrupting the test. This time consuming process introduced many errors, inconsistencies and unreliable data. Providing an automated solution both eliminates data errors and allows for unattended operation.

System Description

A schematic of the system is shown in Figure 1. It consists of the following main components:

- The control system is a PC running a LabVIEW application. It enables the operator to configure, start, view, and stop the test. This computer controls all the instruments and FieldPoint I/O bank via serial connections using a multi-port serial card.
- An Environmental chamber creates and maintains the desired temperature and humidity.
- A Gas Dilution System (GDS) provides controlled injection of the gas into the system from the connected cylinders.
- A CO Analyzer provides carbon monoxide concentration and pressure readings.
- To maintain a constant pressure on the analyzer throughout the test, a Mass Flow Controller (MFC) is used. A special pressure control component of the LabVIEW application controls the MFC using a PID algorithm via a FieldPoint analog output module.
- Switching of all the valves, as well as starting and stopping the pump (not shown) is performed with the help of FieldPoint digital I/O modules.

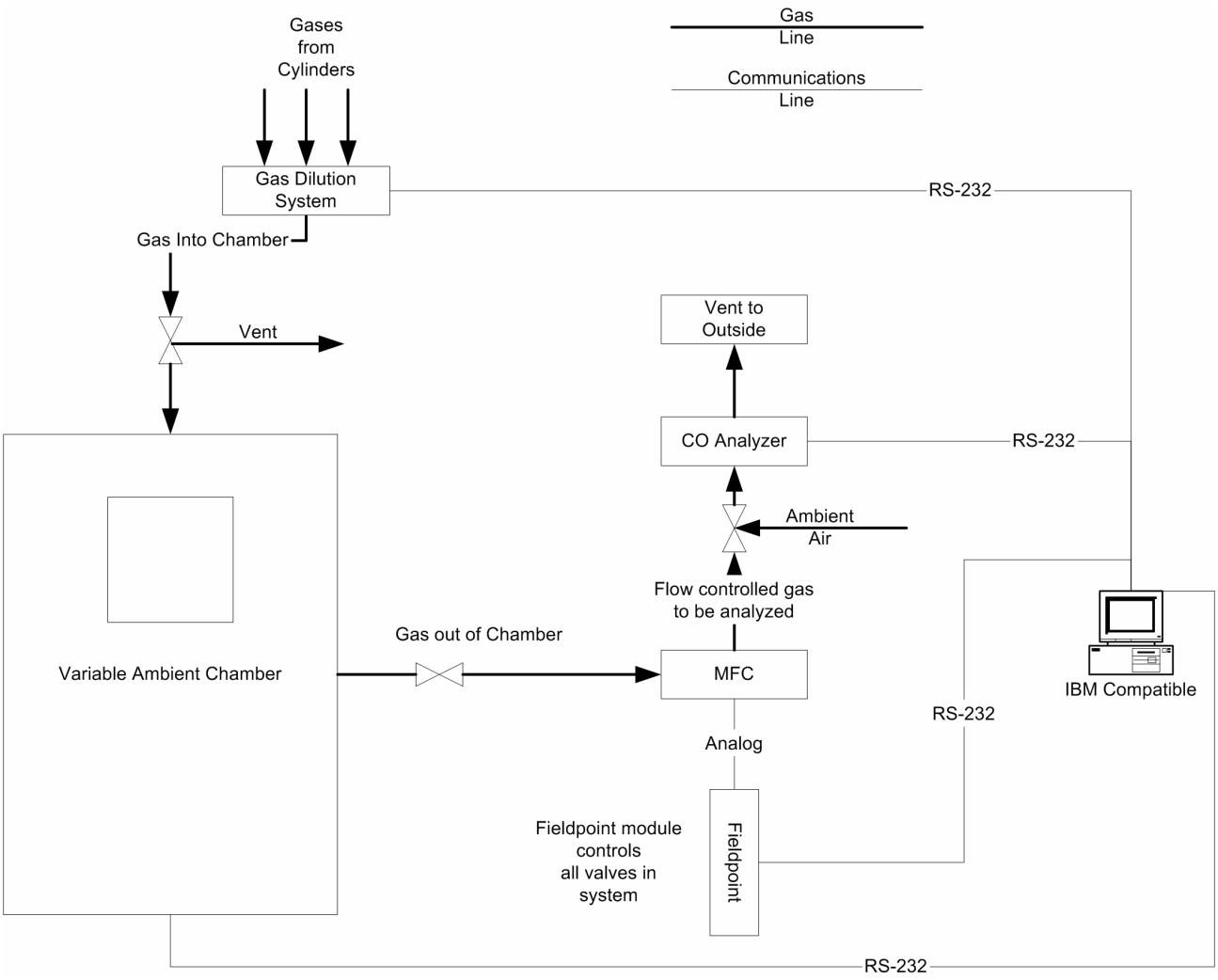

Figure 1: Schematic of the Control and Data Acquisition System for Automatic Environmental Chamber and Gas Control

Choosing LabVIEW as the development tool for the application allowed easy implementation of a rather complex program architecture. Multithreading and synchronization tools in LabVIEW made it possible to create the software as a collection of components that have uniform structure but different purpose. Different components handle different areas of the application functionality. These areas include:

- Valves control
- Pump control
- GDS control
- Environmental chamber control
- Maintaining a constant pressure on the analyzer with the MFC
- Collection of the temperature and humidity data from the environmental chamber
- Gas pressure control
- Concentration feedback from the analyzer
- Overall test logic
- Test data and parameter logging
- User interface (UI) updates

They run independently, providing services to each other and exchanging data via queued messages of a standard structure.

On program start, the operator is presented with the main screen (Figure 2). The GDS system must be configured with gas cylinder types, gas cylinder concentrations and gas flowrates before a test may be setup. The operator then defines a test as a sequence of sets of parameters to be reached at each step. For each step the temperature setpoint, humidity setpoint, and ramp time can be defined. If ramp time is zero, the chamber will try to create the requested conditions as soon as it can. The operator also sets the desired concentration and concentration tolerance parameters if gas is used in the step.

After reaching the target temperature and humidity for each step, the system will purge the chamber with the gas (usually air) from the selected purge cylinder if requested. It then will start creating the requested carbon monoxide concentration by opening the necessary valves and engaging the GDS. Once the desired concentration is reached it will be maintained for the requested dwell time for that step.

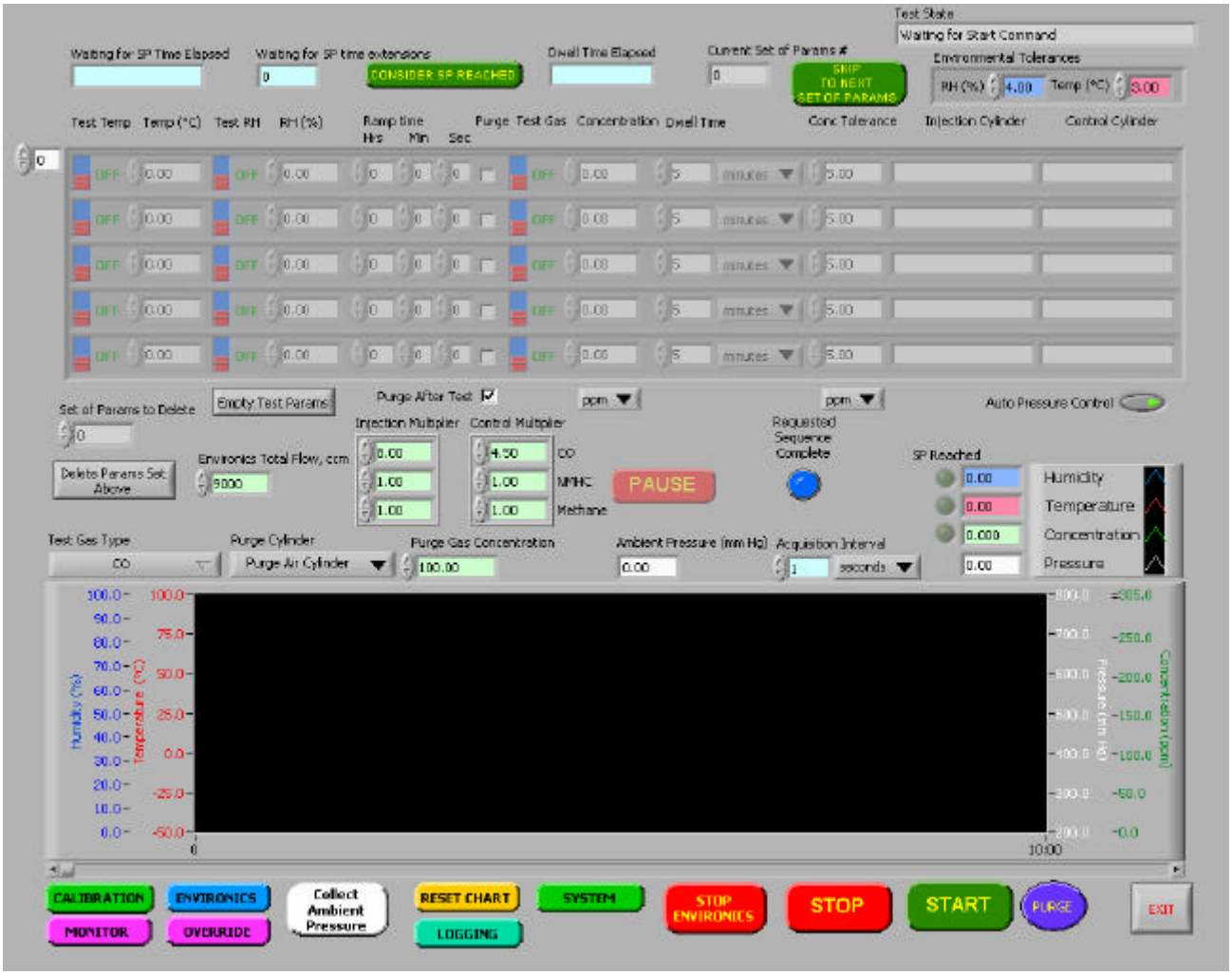

Figure 2: The main program screen.

After all the steps are complete the chamber is purged with clean air. During all the test stages the temperature, humidity, pressure and concentration are displayed on a graph and logged to a selected file at predefined intervals.

The system automatically performs calibration procedure for the CO gas analyzer at predefined intervals or at any other time by operator's request. That includes changing valve states to disconnect the instrument from the chamber and connect it to a reference cylinder with a known concentration and executing the calibration sequence logic in the instrument.

The program also has an Override screen (mode) where the user can manually perform individual valve switching, pump switching and control the GDS. This allows overriding the valve configuration and GDS settings automatically done by the test logic if needed or manipulate them when no test is running.

With the Remote Panels feature of LabVIEW the application can be accessed over the Web. This allows operators to remotely monitor lengthy tests from computers other than the main PC, from the convenience of their office or home.

System Benefits and Conclusion

The manual operation of the previous system was very time consuming and inefficient. The new automation system allows for days to be shaved off of long term tests by allowing unattended operation. Even more time is saved during data analysis because the test was schedule was precisely run by the computer and there are no human errors in the collection of data. FieldPoint and LabVIEW made it possible to quickly create this solution in a way that would have been difficult or impossible on any other platform.