Optimizing the Operation of Legacy Online Gas Chromatographs by Retrofitting Controllers

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ABSTRACT

Gas chromatographs (GCs) are frequently used in pipelines for custody transfer measurement of the energy content in natural gas. Accuracy is determined by calibration-gas quality and how well the technician is able to diagnose and troubleshoot the operation of the GC over long periods of time. A general trend in industry away from specialization has made it difficult for technicians to reach a high competency level in any one area. Chromatography is a difficult field to master on a part-time basis.

Advanced software tools are available to assist and train the technician in how to look beyond the basic functions and fully optimize GC operations. Training is enhanced and accuracy can be improved substantially on legacy-model gas chromatographs. Properly utilized, the potential exists to improve accuracy and extend equipment life.

INTRODUCTION

When a new Emerson Process Management gas chromatograph is initially delivered for field installation, it has passed a series of quality checks at the factory to optimize performance to within +/-.25 BTU repeatability. If the technician installs a primary calibration standard, gravimetrically measured by weights traceable to NIST (National Institute of Standards Technology), operational error can be minimized. If this gas chromatograph is installed and operated correctly, accuracy can approach the same inherent +/-.25 BTU performance level. The longer a gas chromatograph is in operation, the further it can drift from factory settings.

Emerson Process Management's 2350A Gas Chromatograph Controller and complementary MON software were designed to give users a field upgrade so a technician can enhance gas chromatograph performance. Emerson Process Management provides columns, valves, detectors, and other wetted parts from stainless steel for operation in a non-corrosive environment where mechanical or chemical wear is minimal. Solenoids, filters, and valve diaphragms may require periodic maintenance. In natural gas service, older gas chromatographs have the potential to operate as well as new GCs once the electronics (controller) have been updated with the newer, more user-friendly software that optimizes performance.

Manufacturers typically specify instrument repeatability rather than accuracy. Various operational procedures that determine accuracy include:

- Quality of the calibration gas
- Installation of the calibration gas
- Set-up and operation of the gas chromatograph

CHROMATOGRAPHY IN CUSTOMER TRANSFER APPLICATIONS

A gas chromatograph measures the composition of natural gas, usually in mole % units. It does not directly measure physical properties like heating value or relative density. Frequently, a review of heating values by a pipeline technician will include minimal attention to the reported component concentrations. However, the gas chromatograph calculates physical properties from component concentrations. Therefore, improvements in accuracy can be achieved only from optimizing component-concentration measurement.

The primary natural-gas-pipeline measurement provided by a chromatograph is energy content (BTU or MJ) or relative density (specific gravity) derived from quantification of component concentrations. The latter may be used by a flow computer for AGA-8 compressibility calculations which are used to determine a corrected volumetric flow rate.

CHROMATOGRAPH DIAGNOSTICS

A chromatogram graphically depicts the gas chromatograph detector signal. It contains most of the information required to optimize the gas chromatograph performance. When the chromatogram is analyzed along with raw data to compare against the original operational parameters, a wealth of information is available about the internal workings of the chromatograph. The problem that many technicians face is that they don't know what to look for in a chromatogram, nor do they understand how to relate that to a specific problem. Furthermore, historical data in the form of paper is not usually filed in the proper order. Frequently, raw data, chromatograms, analyzer results, configuration reports, and calibration reports are often hard to recover and correlate to each other over time. In short, paper tends to get lost.

Electronic storage of data allows the technician to keep all the information pertinent to a given gas chromatograph on a disk, hard drive, or in the gas chromatograph controller itself. Chromatograms, raw data, and results can be stored as one file and compared against previous data to simplify troubleshooting. By referring to these chromatograms and the associated user description, which offers subtle, site-specific information contained within the chromatogram, the technician can begin to understand what to look for in a chromatogram. Overlay and zoom functions allow direct comparisons of historical and current chromatograms. This can help supervisors and team members to collaborate in examining trends and troubleshooting problems associated with columns, valve timing, helium and calibration gas quality, and changes in carrier gas pressure.

Gradual changes usually occur over time with a corresponding effect on accuracy. The most frequent revision of software allows the user to save a chromatogram and raw data from any run during an alarm. This can be very valuable in troubleshooting intermittent problems if the alarms are configured properly.

Auto-calibration is often considered a fix-all solution for these types of instrument changes. Although calibration can adjust for gradual changes in detector sensitivity and some changes in carrier pressure by tracking new retention times, it can also cover up problems that are not related to calibration at all. GCs can operate in custody transfer installations for years with optimal accuracy if chromatograms and raw data are properly used.

WIRING

Interconnect wiring between the gas chromatograph and the 2350A controller is the same as for the older 2350 and 2251 controllers. Thirteen wires carry four analog (4-20) signals plus a common wire from the GC pre-amp board. Timed events are executed with BCD logic utilizing five VDC levels carried over four wires plus a common from the gas chromatograph decoder board. An additional 5 VDC signal is periodically referenced to ground to perform an auto zero once every analysis; this requires an additional wire . Two wires are dedicated to a low-pressure helium alarm from a discrete N/C contact on a pressure switch located at the gas chromatograph. This makes a total of 13 wires. Additional wires are required to carry optional analog inputs to the gas chromatograph, usually from other analyzers and back to the controller. Removable quick-connect terminations simplify maintenance by allowing the user to easily disconnect field wiring from the termination board without removing existing wire terminals.

MOUNTING

There are three options for mounting the controller:

- Rack mount
- NEMA 4 X-proof (Class I, Division I, Group C & D)
- Panel mount /Retrofit (no keypad)

The panel mount version fits a conventional 19” free-standing cabinet. A keypad and display are optional. It is designed to fit into the same panel cuttout as the older controller with less depth behind the panel. Physical space requirements behind the panel (width and height) are increased to accommodate a plug-in rack and a minimum of five plug-in boards.

COMMUNICATIONS

Four serial communications ports independently support a total of four different field-configurable versions of Modbus protocol. The 32-bit (IEEE floating point) version originally used by Daniel in the 2251 is still supported in the original ASCII format now referred to as SIM 2251.

Register assignments have been kept the same as in the older 2350 and 2251 controllers to simplify host communications; additional user configured registers have simply been added. The 8-bit binary RTU Modbus format is now supported as well. SIM 2251 allows users to poll a single Modbus register for 32-bit floating points or integers. The newer version, User Modbus, refers to the original 16-bit implementation commonly used by control system manufacturers. This version requires two Modbus registers to pass a single 32-bit variable (the 32-bit value is split into two16-bit values). Both versions are field-configurable in ASCII or RTU format with flexible register assignments.

One of the most difficult communications problems with older controllers is the limitation in trying to output gas chromatograph data to several Modbus masters through one serial port. Serial port multiplexers and port-sharing devices have been used successfully in the past to pass data to multiple masters such as flow computers, RTUs, and off-site hosts. The additional serial ports in the controller allow for easy communications to multiple Modbus masters by assigning one master for each serial port. Each serial port is interrupt-driven and will operate independently at speeds up to 19.2 kBaud. A fifth parallel port is dedicated to hardcopy printed reports.

DATA STORAGE

Extensive data storage/retrieval capability assists measurement accounting personnel as well as measurement technicians and operators. Major features include:

- Archive storage of the most recent 1200 cycles (over three days of four-minute cycles) with the ability to trend all calculated results.

- Archive results from the last 400 calibrations (typically over a year of analyses).
- Average 64 components and retain results of the last 64 time units. (For example, 64 units equals a 24-hour average for four streams of N to 2 C6+ with BTU, SG, compressibility, and un-normalized total.) Daily average results from the last 64 days for all 16 components are stored.

This data storage/retrieval capability ensures that if communications or other recordkeeping breaks down, valuable results will nevertheless be available. ASCII files of all calculated values can be created and exported in the format commonly used by most companies. Extensive paper files can be replaced by compact, convenient electronic storage.

Trends can be set up from archive data to display measurement results. A more creative use of trend information as a quality check is to trend response factors for components such as C6+ or retention times for ethane. The use of trending as a tool in diagnosing gas chromatograph problems is almost unlimited, as the data storage capability in the 2350A is very large.

CALIBRATION

Repeatability is even more important when a gas chromatograph is in calibration mode. Generally 3-4 consecutive runs are required with an average value for each new response factor that does not exceed 10% deviation from the previous one. When all response factors and retention times have been updated, particular attention should be given to the response factor deviations on C6+, as well as the component splits between columns. On a Daniel portable GC with a four-minute analysis time, these column splits occur between ethane / propane and normal pentane and C6+. Any deviations in response factors on these components may require small changes in the valve timing for V-2 and V-3 off-times.

A baseline check can be performed periodically to ensure that the GC is operating correctly. A baseline check is simply an analysis run performed without the sample turned on. Peaks will be integrated and stored in raw data, without sample injection. However, the chromatogram should not produce any peaks. Any peaks that do occur will decrease with subsequent analysis runs if they are a result of carry-over from a previous analysis. If a single repeatable peak occurs immediately after the backflush, it may indicate wet off-spec helium is being used. Dry UHP (ultra-high purity) grade helium is required for GC analysis.

This raw area from peaks found during a baseline check can be subtracted from any legitimate overlapping peak found during normal calibration and analysis runs to improve accuracy.

SUMMARY

Several factors can affect gas chromatograph performance and reduce measurement accuracy over time. Retrofitting gas chromatograph controllers can initiate a program to improve accuracy. But this must be followed by extensive use of available software tools for each gas chromatograph in order to monitor trends and know what remedial action to take and when. The newer diagnostic capability, with a number of example chromatograms to initiate the process, can greatly assist technicians in learning the finer points of chromatography. The end result can be improved measurement accuracy and extended equipment life.

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