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Chromatograph Maintenance and Troubleshooting

Class # 5050

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Introduction

Natural Gas is sold as Energy. Gas Chromatographs calculate the Energy value of the Gas (as well as other calculated values used in the Flow Calculation). When there is only a single Gas Chromatograph (GC) on a Custody Metering station, the downtime for a GC must not only be at a minimum but it should be planned ahead of time, rather than occurring only when a failure has occurred.

To allow for predictive maintenance an appropriate maintenance program should be instituted so that analysis problems are identified before they cause measurement errors. Thus maintenance can be performed on a predictive basis, rather than on an ad-hoc or breakdown basis.

This paper will describe the routine maintenance that should be performed on a Gas Chromatograph System, the predictive diagnostics steps that should be used, and finally outline the steps taken to perform an overhaul of the analysis system.

Sample Handling System

When defining the routine maintenance procedures for the Gas Chromatograph System, it must be recognized that the Sample Handling System is crucial to the correct operation of the analyzer, and that most of the physical maintenance operations are actually on the Sample Handling System, and not the GC itself.

The role of the Sample Handling System is to:

- Take a representative sample of the Gas
- Remove particulates and free liquids
- Control the sample pressure, so that it is within the analyzer specifications, usually between 10 PSI (70 kPaG) and 20 PSI (140 kPaG)
- Transport the sample to the analyzer, maintaining it’s gas phase and composition
- Provide switching between Sample streams and the Calibration Gas stream
- Provide venting of the sample to Atmospheric Pressure

If the sample handling system is performing all these functions correctly, then the Gas Chromatograph will operate reliably as designed, and the downtime of the Gas Chromatograph will be reduced to only when eventual wear on the diaphragms can be identified and the overhaul performed on a planned basis. This is often longer than 18 months for a C6+ GC, when the sample is clean and dried correctly by the sample system.

Most modern sample systems consist of:

- Sample Probe – some which may perform primary Solids and Liquids removals, and most which regulate the pressure
- Sample Tubing – Sometimes heated. Note that the latest revision of API 14.1 recommends sample heating for ALL Natural Gas Sample systems.

- Particulate Filter – a filter that removes particles down to at least 5 microns. Even if the Sample Probe has a particulate filter element, the GC should have a filter on the local sample handling panel as the “last line of defense”.
- Liquid Filter and/or Shut-off – A liquid filter which removes all free liquids (water or hydrocarbon), often called a Membrane Filter. Later model GC’s should have a Liquid Shut-off option installed, so that if a large slug of liquid enters the sample system, the sample flow is shut-off and no liquid enters the Gas Chromatograph. These can be retrofitted to older systems. If a Liquid Filter is incorporated into the Sample Probe design, a liquid filter is recommended at the GC Local Sample Handling Panel as this is the “last line of Defense” and provides for a sample “Fast Loop” to reduce sample lag times.
- Sample Selection Solenoids – On older design GC’s these were fitted external to the analyzer oven on the local Sample Handling Panel. On newer designs, these are incorporated into the Analyzer Oven.
- Atmospheric Vent – Often just a large bore tube open to atmosphere above the analyzer shelter, the Vent must allow for the entire sample to be vented without resulting in a raising of the pressure inside the Vent tubing. More complex systems may include Solenoids which allow venting to atmosphere only for the short period required during the analysis cycle, which reduces emissions.

The frequency of the maintenance on the Sample Handling System is somewhat dependant on the location and quality of the gas being measured. Analyzer installations which are inside a Production Facility or on the Export lines are usually very susceptible to contamination as they are exposed directly to process upsets, and will require frequent maintenance to maintain the integrity. Installations which are at the final delivery points on the end of large pipelines will require less frequent maintenance as many of the contaminants will have been removed at the various filter stations along the pipeline. However, as contamination can be introduced (such as pipe scale, compressor oil and valve grease) during transportation, they too will require routine inspection and maintenance. For the purpose of this paper, the frequency of maintenance shall be defined as:

- **Most Frequent** – From daily to monthly, depending on operating conditions and previous history
- **Less Frequent** – from Monthly to 6 monthly, depending on operating conditions and previous history. Checks performed Most Frequently may indicate that all or some of these steps should be performed.
- **System Overhaul** – Preformed when maintenance on the GC is conducted, whether due to predictive maintenance or breakdown. If a breakdown has occurred on the GC due to contamination, all these steps should be performed before the GC is returned to service.

Most Frequent Sample Handling System Maintenance

1. Check Sample Pressure is set as commissioned. Note that a lower than normal sample pressure may be due to blockage on the primary filters of the Sample Probe. The sample pressure at the probe may be set higher than the required pressure at the GC to overcome the pressure drop in the Sample Lines.
2. Check Sample Flows – Watch the Sample Flow Rotameter as each sample is analyzed. While the analysis is not affected by different flow rates or pressures on units which equalize the sample to the atmosphere, a change in the flow rates can be an indicator of the filters becoming blocked. Low sample flow can also indicate a blocked or pressured Vent line.
3. Check Sample Line Heat Trace – confirm that the Sample Line Heat Trace is working. Often all this involves is checking the sample line at the furthest point (usually at the sample probe) is warm to touch.
4. Check Bypass Flow Rates – the Flow Rate through the bypass should be double that of the sample outlet on the Genie Membrane filters commonly used. Check the cleanliness of the glass in the Bypass Rotameter. Contamination here is an indication that the entire Sample Line from the Probe to the GC is contaminated and needs to be flushed.
5. Check Calibration Gas Bottle Pressure – Ensure that the Calibration Gas Bottle Pressure is above the minimum pressure specified on the Calibration Gas Bottle Certificate (Typically 70 PSI or 500 kPaG)

6. Check Carrier Gas Bottle Pressure – Ensure that both Carrier Gas bottles have sufficient pressure to last until the next routine maintenance checks.

Less Frequent Sample Handling Maintenance

1. Remove the sample probe and replace the Moisture Membrane Filter (if fitted) and primary filter
2. Replace the Particulate Filter cartridge.
3. Replace the Membrane in the Moisture Filter/Shut-off.

System Overhaul

1. All the steps described under Less Frequent Sample Handling Maintenance.
2. Flush the entire sample line(s) with Acetone or Isopropyl Alcohol, and dry with Helium.
3. Leak check all the connections throughout the Sample Handling System.

Gas Chromatograph Analyzer

Routine maintenance performed on the Gas Chromatograph Analyzer is primarily performing diagnostics and making small changes to timed events to allow tracking of the gradual increase in the Retention time due to contamination and wear in the Analysis Valves. When the diagnostics indicate a large shift in retention times from the last Overhaul or a dramatic increase in valve noise, then an overhaul of the Analysis Valves can be planned for a convenient time.

The routine diagnostics described here can all be performed over a remote connection (Phone Modem or TCP/IP Ethernet) saving considerable expense in travel times for the Service Engineer. There is now software available which can also perform the mundane collection of the diagnostic information automatically on a routine basis (say every morning at 4 a.m., well before the work day starts) to further save the time taken to perform these diagnostics and provide a full audit trail of the information.

Routine Diagnostics

1. Download and check the following:
    a. Alarm Log – any alarms will be an indicator of an issue and should be followed up.
    b. Event Log – the event log shows any changes made manually, and provides an audit trail of changes made to the system.
    c. Final Calibration Report – The Response Factor Deviations should be checked that they are not excessive. While the GC will normally produce the infamous "RF Deviation Alarm" if the deviation is above 10%, a shift of greater than 5% is an indicator that the analysis is changing, especially if it is only in one component. The order over the response factors should also be checked, to ensure that the Response Factors are in the same order as the Component thermal conductivity (at 80 DegC). This order and possible causes are given in Table 1.
    d. Calibration Chromatogram – Check for a smooth baseline and good detection of the start and end of all the peaks. Confirm that the Retention Times shown in the Component Data Table match the Retention times shown on each peak of the chromatogram.
    e. Sample Chromatogram of each stream – Check the Un-normalized total. Un-normalized totals which change more than 0.5% across streams can be an indictor that the Sample Shut-off valve is not sealing. If the Sample Shut-off Valve is not sealing, then the Un-Normalized total will become dependant on the Sample Pressure.

Table 1 - Response Factor Order (lowest to highest) and probable causes

Order	Component	Response Factor Too Small	Response Factor Too Large
1	Methane	-	- Incorrect Calibration Gas Value entered. - Detection of Nitrogen peak incorrect.
2	Nitrogen	- Incorrect Calibration Gas Value entered. - Incorrect detection of peak start or end. - Dual Column Valve OFF time to late, allowing some Nitrogen to pass through Column 3 before it is trapped.	- Incorrect Calibration Gas Value entered. - Small leak in Calibration Gas lines causing ingress of Nitrogen from the outside atmosphere
3	Carbon Dioxide	- Incorrect Calibration Gas Value entered. - Incorrect detection of peak start or end.	- Incorrect Calibration Gas Value entered.
4	Ethane	- Incorrect Calibration Gas Value entered. - Incorrect detection of peak start or end. - Dual Column Valve OFF time to early, not allowing all the Ethane to exit Column 2 and enter Column 3.	- Incorrect Calibration Gas Value entered. - Dual Column Valve OFF time to late, causing some of the Propane to enter Column 3.
5	Propane	- Incorrect Calibration Gas Value entered. - Incorrect detection of peak start or end. - Dual Column Valve OFF time to late, causing some of the Propane to enter Column 3.	- Incorrect Calibration Gas Value entered.
6	iso-Butane	- Incorrect Calibration Gas Value entered. - Incorrect detection of peak start or end.	- Incorrect Calibration Gas Value entered.
7	normal-Butane	- Incorrect Calibration Gas Value entered. - Incorrect detection of peak start or end.	- Incorrect Calibration Gas Value entered.
8	neo-Pentane	- Incorrect Calibration Gas Value entered. - Incorrect detection of peak start or end.	- Incorrect Calibration Gas Value entered
9	iso-Pentane	- Incorrect Calibration Gas Value entered. - Incorrect detection of peak start or end.	- Incorrect Calibration Gas Value entered.
10	normal Pentane	- Incorrect Calibration Gas Value entered. - Incorrect detection of peak start or end. - Back-flush Valve timing too early, resulting in some of the n-Pentane being back-flushed as a part of C6+.	- Incorrect Calibration Gas Value entered. - Back-flush Valve timing too late, resulting in not all the C6 components being back-flushed.
11	C6+	- Incorrect Calibration Gas Value entered. - Incorrect detection of peak start or end. - Back-flush Valve timing too late, resulting in not all the C6 components being back-flushed.	

2. Compare the current Calibration Chromatogram with a previous Chromatogram. – The current Calibration Chromatogram maybe analyzing perfectly; however the GC may have automatically adjusted itself to small shifts in the retention times. Comparing the current chromatogram to one saved immediately after a Valve Overhaul (or from the factory) will show the total amount of shift in the retention times and other changes in operation. Check for the following:

    a. If the retention times have shifted by more than 10 seconds. If they have, it shows that there is has been an increase in the restriction to flow provided by the analysis valve. Overhaul the Analysis Valves and the Sample Shut-off Valve.

    b. The tail of the Ethane Peak is approaching the end of the analysis time. This is not a sign to increase the analysis time! The restriction to flow has increased, so it is time to overhaul the Analysis Valves and the Sample Shut-off Valve.

    c. The tail of the n-Pentane Peak is approaching the INHIBIT OFF time before the Valve 3 ON event. Once again, this shows the restriction to flow has increased and the Analysis Valves and the Sample Shut-off Valve should be overhauled.

    d. The valve noise from the switching of each of the analysis valves is interfering with the peak detection. If the valve noise is still above the baseline at the beginning of the C6+, Propane or Nitrogen peaks, then the Analysis Valves and the Sample Shut-off Valves should be overhauled.

Adjustments to valve timing and other timed events to overcome the effects of an increase in the restriction can be made and the overhaul of the valves can be performed at a time convenient to the operation of the metering station; however, this is a short-term measure. Once the valves have begun to be contaminated, the shift in retention times will tend to increase at a faster rate.

Maintenance of Gas Chromatograph Analyzer

The normal maintenance of the Gas Chromatograph can be performed on a routine basis or when the Diagnostics have shown that there is an issue.

Approximately 80% of all GC maintenance involves the overhaul of the Analysis Valves and the Sample Shut-off valve, using about US$100 in parts for a diaphragm style valve for a very cost-effective repair. An often overlooked component of this overhaul procedure is the Sample Shut-off Valve. If there is any contamination of the Analysis Valves, then there will certainly be contamination of the Sample Shut-off valve as the sample is flowing through here 100% of the time. Therefore, if the Analysis Valves are overhauled, the Sample Shut-off valve should be as well.

The procedure for the overhaul of the Analysis Valves is beyond the scope of this paper and is better addressed with Hands-On training.

Other maintenance which may need to be performed includes the replacement of the Solenoids (Valve Actuation or Stream Selection) due to electrical failure or mechanical wear.

On **very rare** occasions when there has been a complete and catastrophic failure of the Sample Handling System to remove a large slug of liquids from the sample stream, then an “Oil Change” may be required. This involves:

- Overhauling the Analysis Valves and Sample Shut-off Valves
- Decontaminating the sample system and oven tubing.
- Replacing the Columns
- Replacing the detectors

After any of the Maintenance procedures which require a replacement or overhaul of a component of the Analysis Flow Path, the valve timings and Timed Events will need to be adjusted to account for the change in the restriction to flow. This can be done by the person performing the mechanical repair or by a specialist over a remote link such as a modem.

Conclusion

In conclusion it can be seen that most of the routine maintenance of the Gas Chromatograph System is performed on the Sample Handling System. The reliability and accuracy of the GC Analyzer is totally dependant on the sample being clean and dry, and so most effort should be taken to achieve this goal, rather than spend excessive time and effort dealing with the consequences of poor sample handling.

While some maintenance of the GC is required (due to eventual contamination and mechanical wear), this is usually confined to a simple valve overhaul procedure requiring very inexpensive components or solenoid replacement. Routine diagnostics, which can be performed remotely, is the best indicator of when maintenance is required.