Carbon Dioxide (CO$_2$) Measurement in Natural Gas

**Application**

Emerson Process Management offers Rosemount Analytical gas analyzer technology to provide on-line analysis of CO$_2$ in natural gas. The CO$_2$ concentration is limited by quality standards specified by the major pipeline transmission and distribution companies. If CO$_2$ concentrations are too high, removal techniques like amine washer, polymeric membrane usage, or pressure swing absorption (PSA) are applied.

**Background**

Natural gas mainly consist of methane (CH$_4$ 70–90 %). Other components are ethane (C$_2$H$_6$), propane (C$_3$H$_8$), butane (C$_4$H$_{10}$) and higher hydrocarbons (up to 20 %). Carbon dioxide (CO$_2$) can go from several ppm up to 8 %. Further components are nitrogen (N$_2$), hydrogen sulfide (H$_2$S) and noble gases as helium (He), argon (Ar), and neon (Ne).

Pipeline transmission legislation sets limits for the CO$_2$ content of natural gas. Therefore, CO$_2$ has to be measured and, if necessary, reduced by technical processes.

CO$_2$ measurement in natural gas can be done with complex gas chromatographs (GC), as well as with optical non-dispersive infrared (NDIR) measurement, which allows a continuous measurement.

**Gas Analyzer Application**

Methane, ethane, propane and other hydrocarbons in natural gas are influencing the CO$_2$ measurement. This cross interference is low for methane (approx. 1:700), but larger for ethane (approx. 1:100) and higher hydrocarbons.

### Natural Gas Composition Interferences on the CO$_2$ Measurement

<table>
<thead>
<tr>
<th>Natural Gas Composition</th>
<th>Interferences on the CO$_2$ Measurement</th>
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</thead>
<tbody>
<tr>
<td>C$_1$</td>
<td>90 %</td>
</tr>
<tr>
<td>C$_2$</td>
<td>4 %</td>
</tr>
<tr>
<td>C$_3$–C$_5$</td>
<td>4 %</td>
</tr>
<tr>
<td>N$_2$</td>
<td>2 %</td>
</tr>
<tr>
<td>H$_2$O</td>
<td>0.02 %</td>
</tr>
<tr>
<td>CO$_2$</td>
<td>10 ppm</td>
</tr>
</tbody>
</table>

**High CO$_2$ Content**

If CO$_2$ has to be measured in the percent range, the error from cross interferences by the background gases is negligible. Calibration can be performed with the mean background concentration of the natural gas components. Even calibration in nitrogen might be possible.

**Low CO$_2$ Content**

For ppm CO$_2$ ranges, calibration with mixed background gases or in a nitrogen background is not possible. Varying gas composition in natural gas would lead to varying errors in CO$_2$ measurement, which are too high for ppm measurement ranges.

**Solution for ppm CO$_2$ Measurement in Natural Gas**

To overcome the problem of varying background in natural gas, a special gas analyzer setup with a CO$_2$ absorbing agent can be used.

In an external sample handling system the sample gas stream is split and the CO$_2$ in one stream is removed with a scrubber. This stream is flowing through the reference side. The other stream which still contains the CO$_2$ is applied to the measurement side of the analyzer cell.

**Figure 1 - Sample handling for CO$_2$ measurement with scrubbed flowing reference**
With this configuration, variations in the background of natural gas will affect both sides of the analysis cell and will therefore be cancelled out. The external sample handling system is shown in Figure 1. The left vessel contains the CO₂ absorbing material, whereas the right vessel is a blank vessel filled with glass beads to equalize the flow.

**System Configuration**

Often the measurement of CO₂ in natural gas takes place in hazardous areas. Therefore, the standard product is the X-STREAM flameproof analyzer shown in Figure 2. X-STREAM general purpose analyzers can also be used with this application, by configuring the analyzer properly and meeting safety requirements.

Emerson Process Management provides the analyzer equipped with a valve block and a 3-way valve. The external gas handling with CO₂ scrubber and blank vessel as shown in Figure 1 is supplied separately as an available option by Rosemount Analytical.

**Calibration**

Figure 3 shows the tubing and wiring scheme of the analyzer system. When measuring sample gas, valve 3 is open and the gas stream is divided into untreated and scrubbed (CO₂ removed) gas streams. The blank gas stream is flowing over the 3-way valve (1–2 open) into the measurement side of the analysis cell. The scrubber gas stream is flowing into the reference side of the cell.

For zeroing the analyzer, V3 is closed and V4 is opened. Now the blank gas stream is blocked by the 3-way valve (3–2 open) and the scrubber gas stream is divided to flow into the measuring and the reference side of the cell. For spanning with a CO₂ test gas in N₂, V2 is opened and the system is working in the measuring configuration described above.

**Combination with Other Measurements**

The CO₂ measurement in natural gas can be combined with a paramagnetic oxygen measurement and with a dew point measurement based on Al₂O₃ sensor technique. Please contact Emerson Process Management for details.