APPLICATION NOTE

Sensor Selection for GDS-68SXP Natural Gas Odorant Monitors

Electrochemical Sensors for Natural Gas Odorants

Natural gas odorants are typically composed of blends of mercaptans, tetrahydrothiophene, dimethyl sulfide and other specialized compounds. They must be chemically stable and not react or cause damage to gas components or pipes. Most importantly, their presence should be readably recognizable by the general public at levels that indicate the presence of gas in concentrations well below those that represent a danger of explosion.

The GDS-68SXP Odorant Monitor is designed to directly measure odorant levels in natural gas streams using selected electrochemical sensors. A microprocessor-controlled sequencer periodically applies natural gas to an electrochemical sensor, determines the peak measured value and then purges the sensor of methane to restore the proper oxygen level. Temperature compensation, digital filtering and parameter monitoring are employed to ensure the accuracy of the final measurement.

Measurement of Natural Gas Odorants in Pipelines

Traditionally odorant is injected into natural gas lines at gate stations or other points where gas enters the system, and then confirmation of odorant levels is done using a periodic ‘sniff test’ at defined test points and extremities of the system.

Increasingly, natural gas distribution companies are seeing the value of monitoring odorant levels at intermediate points in their systems using semi-automated or fully automated devices. These monitors do not replace human ‘sniffers’ but rather directly measure the amount of odorant in “ppm” (parts per million), “mg/m3” (milligrams per cubic meter) or “lb/mmcf” (pounds per million cubic feet), depending on the operator and country. Readings from these devices are more consistent and occur many times more often than traditional readings done using human sniffers.

In the past, the level of odorant in the gas entering the system was known or predictable. Today, gas entering a system may have come from un-odorized local sources or continent-spanning odorized pipelines, so in addition to system end-points, measuring the odorant level of incoming gas has become increasingly important to keep from accidentally ‘over-odorizing’ gas in customer’s homes.

Odorants must be stable, must be consumed during the combustion process, must not corrode the pipeline and must have the commonly known recognizable “smell of gas”. They should have good soil permeability to facility the location of underground leaks and must have the proper vapor pressure and freezing points to ensure operation over a wide range of environmental conditions. Ideally, they should not react with the oxidation found inside most pipelines. As a result of these (and other) requirements, only a few compounds meet these requirements.

Common Natural Gas Odorants

Tert-butyl mercaptan (TBM)
One of the most commonly used odorants due to its high oxidation resistance, good soil penetration and recognized odor. It generally cannot be used as a standalone odorant due to its high freezing point and so is most often found in blends.

Tetrahydrothiophene (THT)
THT can be used as a standalone odorant but is more commonly used in blends with TBM to achieve better soil permeability and a more traditional 'smell of gas' in the US and Canada. It is highly resistant to pipeline oxidation.

Dimethyl Sulfide (DMS)
DMS has good soil permeability and oxidation stability and is often used in blends with TBM. It has the smell of stinking garlic and can cause nausea in higher concentrations.

Methyl Ethyl Sulfide (MES)
MES has good oxidation stability and a vapor pressure similar to TBM and as a result blends of TBM with MES are common.

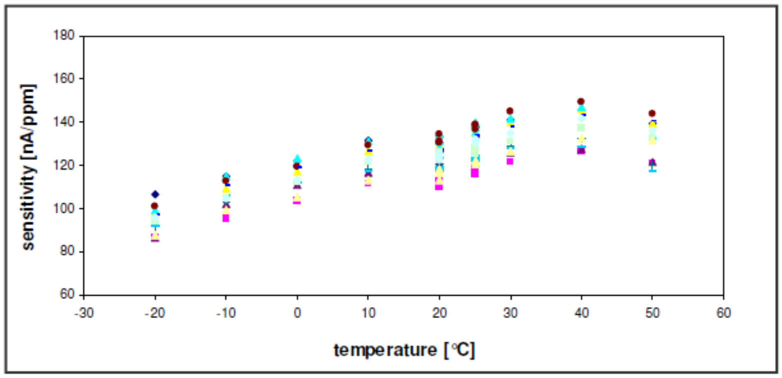
N-Propyl Mercaptan (NPM), Ethyl Mercaptan (EM), Isopropyl Mercaptan (IPM)
NPM has a low freezing point and strong odor but is not used in high concentrations due its low oxidation stability. IPM is the second most resistant to oxidation of the mercaptans, and has a low freezing point. EM is most often used as an odorant for butane and propane. These mercaptans may be present in small amounts and in the following table these are listed as "Other Mercaptans".

Interference & Poisoning Effects

Certain substances, including Alcohols, Ketones and Phenols, Pyridine, Amines, Kerosene or Chlorinated solvents can attack the sensor's housing or electrolyte, resulting in irreparable damage to the sensor.

Temperature, Pressure and Humidity Effects on Gas Sensors

Temperature: Since the rate at which chemical reactions occur is, in general, proportional to ambient temperature, electrochemical sensors require temperature compensation to provide accurate readings across a wide range of temperature conditions. A typical sensor's temperature response is shown below:



As can be seen from the graph, if the output at 20°C is taken as 'normal', then the output of the sensor at +40°C would be about 8% above normal and at -20°C about 20% below normal. Compensating for changes in temperature requires at least a 10-point correction function as well as knowledge of the sensor's actual temperature. The GASMAX CX gas sensor used in the GDS-68SXP provides this temperature compensation.

While temperature compensation can normalize the output, it is important to remember that exposing an electrochemical sensor to extremely high temperatures (> 100°F) or extremely low temperatures (< -20°F) for extended periods of time can result in degraded output or sensor failure.

Pressure: Electrochemical sensors are less affected by changes in ambient pressure and are often specified to operate at sea-level pressure plus-or-minus 10%. Note that an increase is sensor back pressure due to a clogged outlet or excessively long exhaust run may result in elevated or inaccurate readings.

Humidity: Relative humidity is typically not a problem unless the purge air source is excessively moist or extremely dry. Never use compressed & dried 'shop air' as a source of purge air since the low dew point will result in the sensor electrolyte drying out and the sensor failing prematurely.

Response Factor

GDS sensors for mercaptans and THT do not respond to the presence of DMS or MES. When calibrating the GDS-68SXP with custom calibration gas formulated to match the target blend (Ex: Scentinel F-25), the fact that the sensor only 'sees' 75% of the odorant is automatically compensated for by the calibration process.

However, using custom gas blends can be expensive. The GDS-68SXP includes a "Response Factor" setting that allows the unit to be calibrated using pure TBM or THT while still showing a proper value. In the case of the Scentinel F-25 above, the unit would be calibrated using pure TBM and the response factor setting would be set to "1.333" to increase the final reading to compensate for the 'missing' 25% DMS present in the odorant that was not detected by the sensor.

Common Odorant Blends & Recommended Sensors

Typical odorants and the GDS Corp recommended sensor types are shown below.

Odorant Blend	Major Components	Sensor Type	Recommended Calibration Gas	Relative Response
Scentinel A	Other Mercaptans 100%	Type 44	Scentinel A	1.000
Scentinel E	Tert-Butyl Mercaptan 75% Other Mercaptans 25%	Type 43	Scentinel E	1.000
Scentinel F-20	Tert-Butyl Mercaptan 78% Dimethyl Sulfide 20% Other Mercaptans 2%	Type 40	Tert-Butyl Mercaptan	1.282
Scentinel F-25	Tert-Butyl Mercaptan 75% Dimethyl Sulfide 25%	Type 40	Tert-Butyl Mercaptan	1.333
Scentinel F-35	Tert-Butyl Mercaptan 65% Dimethyl Sulfide 35%	Type 40	Tert-Butyl Mercaptan	1.538
Scentinel F-40	Tert-Butyl Mercaptan 60% Dimethyl Sulfide 40%	Type 40	Tert-Butyl Mercaptan	1.667
Scentinel F-50	Tert-Butyl Mercaptan 50% Dimethyl Sulfide 50%	Type 40	Tert-Butyl Mercaptan	2.000
Scentinel N	Tert-Butyl Mercaptan 76% Other Mercaptans 24%	Type 43	Scentinel N	1.000
Scentinel O	Tert-Butyl Mercaptan 10% Dimethyl Sulfide 10% Other Mercaptans 80%	Type 43	Scentinel O	1.000
Scentinel P	Tert-Butyl Mercaptan 10% Other Mercaptans 90%	Type 43	Scentinel P	1.000
Scentinel S-20	Tert-Butyl Mercaptan 78% Methyl Ethyl Sulfide 22%	Type 42	Tert-Butyl Mercaptan	1.280
Scentinel S-50	Tert-Butyl Mercaptan 50% Methyl Ethyl Sulfide 50%	Type 42	Tert-Butyl Mercaptan	2.000
Scentinel T	Tetrahydrothiophene 100%	Type 41	Tetrahydrothiophene	1.000
Scentinel T-50	Tert-Butyl Mercaptan 50% Tetrahydrothiophene 50%	Type 41	THT/TBM	1.000
Scentinel TB	Tert-Butyl Mercaptan 30%	Type 41	Scentinel TB	1.000

	Tetrahydrothiophene 70%			
Spotleak 1001	Tert-Butyl Mercaptan 80% Dimethyl Sulfide 20%	Type 40	Tert-Butyl Mercaptan	1.282
Spotleak 1005	Tert-Butyl Mercaptan 30% Tetrahydrothiophene 70%	Type 41	Spotleak 1005	1.000
Spotleak 1007	Tert-Butyl Mercaptan 80% Methyl Ethyl Sulfide 20%	Type 42	Tert-Butyl Mercaptan	1.250
Spotleak 1009	Tert-Butyl Mercaptan 79% Other Mercaptans 21%	Type 43	Spotleak 1009	1.000
Spotleak 1039	Tert-Butyl Mercaptan 50% Tetrahydrothiophene 50%	Type 41	THT/TBM	1.000
Spotleak 1420	Tert-Butyl Mercaptan 75% Dimethyl Sulfide 25%	Type 40	Tert-Butyl Mercaptan	1.333
Spotleak 1450	Tert-Butyl Mercaptan 10% Dimethyl Sulfide 10% Other Mercaptans 80%	Type 43	Spotleak 1450	1.000
Spotleak 2323	Tert-Butyl Mercaptan 50% Other Mercaptans 50%	Type 43	Spotleak 2323	1.000

GDS Corp Sensors & Part Numbers

GDS Corp electrochemical sensors for odorant blends are shown below. Each sensor is available in three ranges based on parts per million (PPM), pounds per million cubic feet (lbs/mmcf) or milligrams per cubic meter (mg/m3).

GDS-68XP Process Monitor (Odorants)			
Sensor Type	Sensor Part Number	Range	Notes
Type 30	10-9830-R0003 10-9830-R0050 10-9830-R0015	0-3.00 lbs/mmcf 0-50 mg/m3 0-15 ppm	Tert-Butyl Mercaptan (TBM)
Type 31	10-9831-R0003 10-9831-R0050 10-9831-R0015	0-3.00 lbs/mmcf 0-50 mg/m3 0-15 ppm	Tetrahydrothiophene (THT)
Type 40	10-9840-R0003	0-3.00 lbs/mmcf	TBM + DMS Blends

	10-9840-R0050	0-50 mg/m3	
Type 41	10-9841-R0003 10-9841-R0050	0-3.00 lbs/mmcf 0-50 mg/m3	TBM + THT Blends
Type 42	10-9842-R0003 10-9842-R0050	0-3.00 lbs/mmcf 0-50 mg/m3	TBM + MES Blends
Type 43	10-9843-R0003 10-9843-R0050	0-3.00 lbs/mmcf 0-50 mg/m3	TBM + Other Mercaptans Blends
Type 44	10-9844-R0003 10-9844-R0050	0-3.00 lbs/mmcf 0-50 mg/m3	Mercaptans Blends

GDS-68SXP Odorant Monitor			
Sensor Type	Sensor Part Number	Range	Notes
Type 30	10-9930-R0003 10-9930-R0050 10-9930-R0015	0-3.00 lbs/mmcf 0-50 mg/m3 0-15 ppm	Tert-Butyl Mercaptan (TBM)
Type 31	10-9931-R0003 10-9931-R0050 10-9931-R0015	0-3.00 lbs/mmcf 0-50 mg/m3 0-15 ppm	Tetrahydrothiophene (THT)
Type 40	10-9840-R0003 10-9840-R0050	0-3.00 lbs/mmcf 0-50 mg/m3	TBM + DMS Blends
Type 41	10-9941-R0003 10-9941-R0050	0-3.00 lbs/mmcf 0-50 mg/m3	TBM + THT Blends
Type 42	10-9942-R0003 10-9942-R0050	0-3.00 lbs/mmcf 0-50 mg/m3	TBM + MES Blends
Type 43	10-9943-R0003 10-9943-R0050	0-3.00 lbs/mmcf 0-50 mg/m3	TBM + Other Mercaptans Blends
Type 44	10-9944-R0003 10-9944-R0050	0-3.00 lbs/mmcf 0-50 mg/m3	Mercaptans Blends

References

Daniel Tenkrat, Tomas Hlincik and Ondrej Prokes (2010), *Natural Gas Odorization*, ISBN 978-953-307-112-1, InTech