Using a Cross Tox Sensor

Introduction

Cross Tox Sensors are electrochemical toxic-gas sensors designed to detect hazardous gases in industrial and environmental monitoring applications. The **WatchGas** Xs sensor is designed for detecting leaks of various organic gases and vapors. While it does not cover as broad a range of gases as a PID sensor and does not offer the same level of selectivity, it provides a key advantage by detecting certain gases that PID sensors cannot measure.

Unlike PID sensors, which typically require calibration every ~ 30 days, Xs sensors follow the standard six-month calibration interval used for **WatchGas SST** detectors and other electrochemical sensors. PID sensors may also require additional maintenance, such as cleaning the lamp or replacing parts, which takes additional technician time. In contrast, Xs sensors do not require routine maintenance and do not need daily calibration. **WatchGas** recommends using Isobutylene as the calibration gas; however, Carbon Monoxide (CO) may also be used. Before of starting the calibration process, be sure that the gas mixture does not contain components that could produce a response on the sensor, as this would lead to inaccurate calibration results. For the highest accuracy, calibration should be performed using the target gas.

The Xs sensor is an unbiased electrochemical sensor that can be integrated into both the **SST1E** and **SST5** devices, depending on the specific requirements of the customer. The measurement range for isobutylene is 0–100 ppm, with a resolution of 0.1 ppm.

Results & Discussion

To determine the correction factor (CF) and set point, each sensor was calibrated with 10 ppm Isobutylene. After adjustment, a calibration and bump test was performed to confirm proper detector and sensor functionality. The test gas was then applied to the detector and the measured output value was recorded. Between measurements of different gases, an Isobutylene bump test was repeated each time to ensure reliable sensor operation and to verify that the sensor had not been damaged.

Table 1 presents a summary of the gases tested for their response to the Xs sensor in the **WatchGas SST1E**. The correction factor for each gas was determined by dividing the applied concentration by the reading value from the **SST1E**. The applied gas concentrations varied depending on the type of gas, which is why different applied concentration values were used. When the CF is > 10, there is no guarantee of the reliability or linearity of the sensor's response to that specific gas.

The results show that the sensor response varies significantly depending on the gas type. For the reference gas, Isobutylene, the CF is 1.00 at both tested concentrations (10 ppm and 100 ppm), confirming proper calibration and expected sensor performance. For certain gases, such as Acetylene (CF = 1.60) and Carbon Monoxide (CF = 0.93), the sensor response is relatively close to linear, indicating good compatibility and reliable detection. A correction factor value close to 1 for CO, as for Isobutylene, confirms the suitability of calibration using carbon monoxide.

Several gases show higher CF values, reaching up to 8.80 for Ethanol, due to a reduced sensor response compared with the applied gas concentration. Hydrogen and Toluene have a CF > 10, which indicates a deviation from the expected proportional sensor response. At such high CF values, the sensor output may no longer provide reliable linearity, which can lead to inaccurate estimation of the actual gas concentration. Therefore, results for gases with CF values above 10 should be considered preliminary and should not be used with full confidence.

It is important to note that under the tested conditions, some of the gases have no measurable response (N/A), indicating that the sensor has little or no sensitivity, or like in the case of Nitrogen Dioxide the sensor signal is going to overload response.

The CF values may show a fluctuation of approximately ±30%. This is expected because the calibration gas and the target gas being measured are not the same, and the response depends on several factors, including the specific gas, its concentration, environmental conditions, and the possible presence of other gases in the atmosphere. The sensor may also show positive or negative sensitivity to other gases present in the atmosphere. In gas mixtures, the Xs sensor response may be influenced by more than one gas at the same time, so the displayed value can reflect the combined effect of all reactive components, rather than a single gas alone, assuming that the other gases in the mixture are also detectable.

Example:

A sensor with this detection range has applications in industries where multiple gases, especially **VOC**s, may be present, such as paint shops, chemical storage facilities, the plastics industry, and disinfection processes. Its main advantage is that it can function as a universal - early warning detector, enabling rapid identification of leaks or elevated gas concentrations in situations where the specific gas is not known in advance. It provides a practical and cost-effective solution for general safety monitoring in the workplace.

Xs sensor can be used for PH3 detection on vessels, typically in applications were monitoring of the PH3 is essential. Xs sensor should not be used in applications where false positive alarms make occur - due to a combine effect of gases on the Xs sensor mechanism. In such case, a PID sensor is generally the preferred solution due to its higher selectivity. Manual correction of the Xs readings may be applied in the device, however, this approach can introduce variability and may not provide consistent accuracy across different applications.

Recommended Alarm Levels:

Having a broadband sensor often raises questions regarding alarm setpoint selection. In general, the alarm should be set based on the most toxic gas expected, taking into account the sensor's response to that specific gas. Alarm settings should also reflect the gases likely to be present, meaning the most hazardous gas relevant to the specific industry or application should be used as the basis for configuration. These settings can be easily configured using the **WatchGas Device Link APP**, which is fully compatible with **SST1E** and **SST5** devices.

Table 1: Cross-Sensitivities of the Xs sensor, with the suitable CF.

SST1E – Calibration: 10 ppm Isobutylene (C_4H_8)

Gases	Applied Value (ppm)	Reading (ppm)	CF
Acetone (C_3H_6O)	250	N/A	N/A
Acetylene (C_2H_2)	160	100.0	1.60
Ammonia (NH_3)	50	N/A	N/A
Ammonia (NH_3)	100	N/A	N/A
Benzene (C_6H_6)	5	N/A	N/A
Benzene (C_6H_6)	20	N/A	N/A
Butadiene (C_4H_6)	5	8.2	0.61
Carbon Dioxide (CO_2)	5000	N/A	N/A
Carbon Monoxide (CO)	50	53.9	0.93
Chloride (Cl_2)	10	N/A	N/A
Ethanol (C_2H_5OH)	500	57.0	8.80
Ethene (C_2H_4)	300	83.0	3.60
Ethyl Mercaptan (C_2H_5SH)	10	12.5	0.80
Ethylbenzene (C_8H_{10})	650	N/A	N/A
Ethylene Oxide (C_2H_4O)	200	N/A	N/A
Heptane (C_7H_{16})	4500	N/A	N/A
Hexane (C_6H_{14})	1800	N/A	N/A
Hydrogen (H_2)	1000	15.0	> 10.00
Hydrogen Cyanide (HCN)	10	2.2	4.50
Hydrogen Sulfide (H_2S)	10	62.1	0.16
Isobutylene (C_4H_8)	10	10.0	1.00
Isobutylene (C_4H_8)	100	100.0	1.00
Isopropanol (C_3H_8O)	250	48.0	5.20
Methane (CH_4)	1000	N/A	N/A
Methyl Ethyl Ketone / MEK (C_4H_8O)	440	N/A	N/A
Methyl Mercaptan (CH_4S)	10	20.0	0.5
Nitric Oxide (NO)	10	3.0	3.30
Nitrogen Dioxide (NO_2)	5	--OL	N/A
Phosphine (PH_3)	5	19.7	0.25
Propane (C_3H_8)	100	N/A	N/A
Sulfur Dioxide (SO_2)	5	5.6	0.89
Toluene (C_7H_8)	580	2.86	>10.00
Trichloroethylene / TCE (C_2HCl_3)	1800	N/A	N/A
Xylenes (C_8H_{10})	740	N/A	N/A

For additional CF contact WatchGas

Operating Range

The measurement range of the Xs sensor is 100 ppm, based on Isobutylene calibration, before reaching an over-range condition. However, due to the different response characteristics of individual gases, a display reading of 100 ppm does not represent the actual concentration for all gases. Therefore, the maximum measurable concentration for each gas was calculated using its corresponding CF and it is presented in **Table 2** as the “Max Applied Value”.

Graph 1 illustrates the difference between the displayed concentration on a detector and the actual applied concentration. For example, Ethanol can have an actual concentration of up to 880 ppm while still being displayed as 100 ppm on the instrument. This clearly demonstrates the impact of CF values on the interpretation of sensor readings.

Depending on the intended industrial application of the Xs sensor, the values presented in **Table 2** and **Graph 1** are important for assessing and adapting the use of **SST1E** and **SST5** detectors.

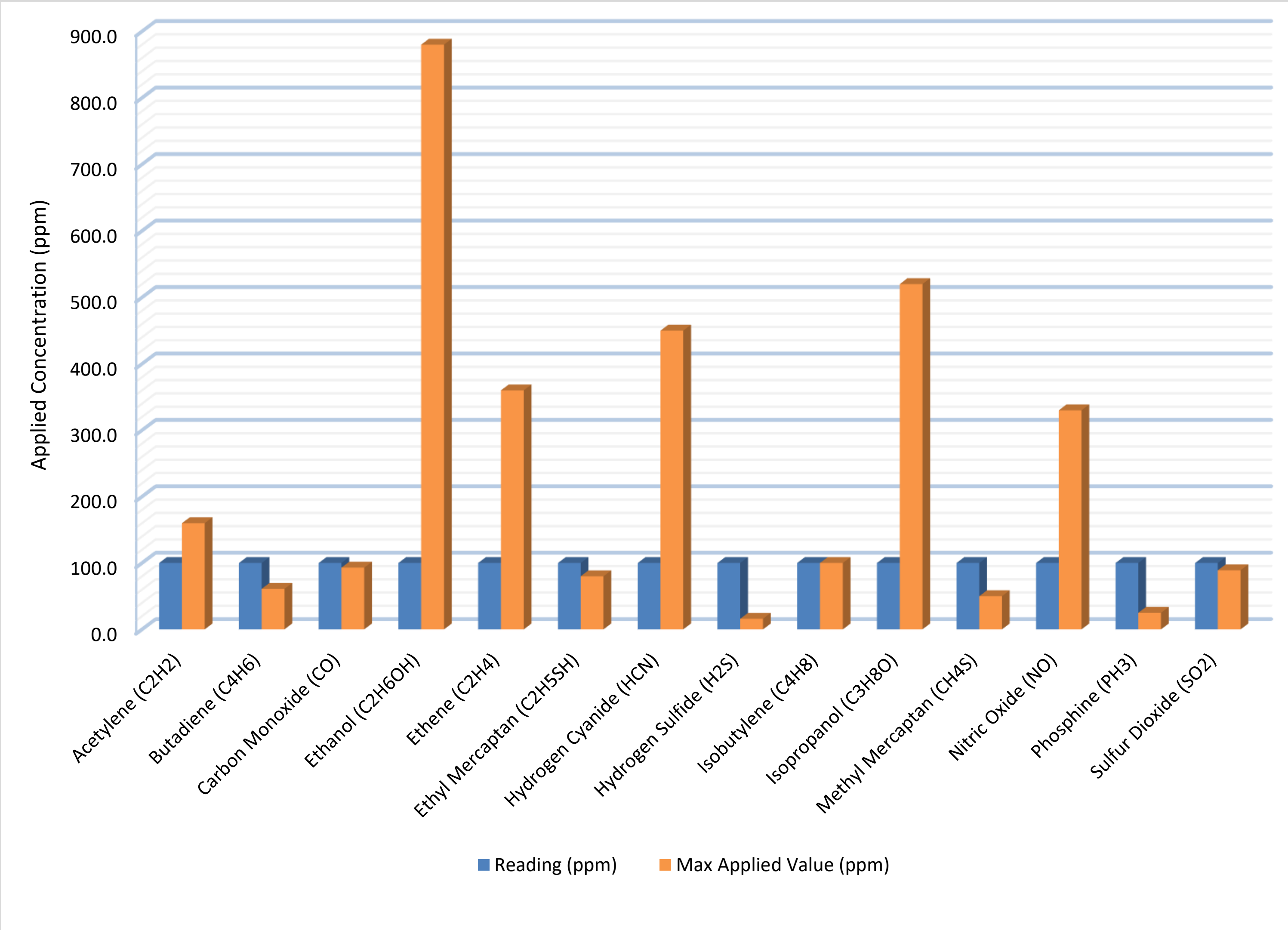
Table 2. Maximum Detectable Concentrations with Xs sensor.

Gases	Max Applied Value (ppm)	Readings on the Detector (ppm)
Acetylene (C_2H_2)	160	100.0
Butadiene (C_4H_6)	61	100.0
Carbon Monoxide (CO)	93	100.0
Ethanol (C_2H_5OH)	880	100.0
Ethene (C_2H_4)	360	100.0
Ethyl Mercaptan (C_2H_5SH)	80	100.0
Hydrogen Cyanide (HCN)	450	100.0
Hydrogen Sulfide (H_2S)	16	100.0
Isobutylene (C_4H_8)	100	100.0
Isobutylene (C_4H_8)	100	100.0
Isopropanol (C_3H_8O)	520	100.0
Methyl Mercaptan (CH_4S)	50	100.0
Nitric Oxide (NO)	330	100.0
Phosphine (PH_3)	25	100.0
Sulfur Dioxide (SO_2)	89	100.0

Example:

The correction factor for Phosphine (PH_3) is 0.25. According to **Table 2**, the maximum applied concentration that can be measured before the SST detector reaches an over-range condition is 25 ppm. If the actual Phosphine concentration is 20 ppm, the SST detector will display 80 ppm. However, if the actual concentration is 40 ppm, the corresponding display reading would be 160 ppm, which exceeds the instrument range. In this case, the detector will enter an over-range condition and no reliable reading will be available.

Graph 1. Maximum Applied Gas Concentration vs SST Detectors Readings.



General Conclusion

The Xs sensor can be used to detect the presence and potential leakage of various gases, making it suitable for general monitoring purposes. For precise concentration measurements, calibration with the target gas is required. Although it is not a PID sensor, the Xs sensor exhibits cross-sensitivity to multiple gases. This characteristic allows it to be used as an economical option, for the **WatchGas SST** range, detecting a fifth gas, as long as the sensor is responsive to it.

When the detector is calibrated to 10 ppm Isobutylene and there is a need to detect other gases, the user can select the target gas from the list (**Table 1**) and apply the corresponding correction factor. Multiplying the measured value by the appropriate CF, the true concentration of the target gas can be obtained, following equation:

$$\boldsymbol{RV\ (ppm) = R\ (ppm)\ \times CF}$$

Where: **RV**-Real Value, **R**-Readings, **CF**-Correction Factors

<u>Example:</u>

After calibrating the detector with Isobutylene, we want to measure the gas concentration in an enclosed space, where we suspect the presence of Acetylene (C_2H_2). The instrument reading is 120 ppm. After applying the Acetylene correction factor (CF = 1.6), the actual concentration is 192 ppm.

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