Laboratory Testing Guide
For the SFA30 Formaldehyde Sensor Module

This application note describes possible measurement setups to assess the performance of Sensirion's SFA30 formaldehyde sensor module. Example measurement procedures and evaluations methods are described to start off easy and straightforward device testing. It is of great importance that all applicable documents (Datasheet, Users Guide and Handling Instructions) are carefully studied before integration, testing and qualification of the sensor.

Content

1 Introduction

This application note describes different levels of testing equipment and procedures to assess the performance of Sensirion's SFA30 formaldehyde sensor module. The first chapter gives some general recommendations on various testing parameters to achieve reliable and reproducible test results and to minimize influences from the test setup or external conditions.
In chapter two, a fast and simple measurement approach is presented which focuses on device-to-device variation analysis and cross sensitivity checks. In the third chapter, a more sophisticated approach with a humidity-controlled gas mixing system and an external reference is presented for highly accurate measurements.

To ensure consistent testing of Sensirion's SFA30 formaldehyde sensor module, the following recommendations should be carefully considered independent of the test setup:

a) **Handling and storage:** Make sure that the test devices are stored and handled according to the instruction provided by Sensirion's SFA30 datasheet and the SFA30 handling instructions.

b) **Sensor history:** Keep track of the life history of the test devices. Especially for stress tests, special care should be taken that the stress history of the sensors can be reconstructed.

c) **Conditioning of sensors:** To minimize startup time, it is recommended that the sensors were stored at moderate temperature and humidity condition (15–30 °C and 35–65 %RH) before the test for 24 hours or more.

d) **Recovery time:** Stress tests are usually designed to evaluate the sensor performance over lifetime in harsh conditions. To shorten the test time, the test conditions are often severely amplified compared to normal operation conditions. To get a realistic evaluation of the sensor performance after such an accelerated stress test, it is strongly recommended to let the sensors recover for at least 72 hours at moderate temperature and humidity conditions (15–30 °C and 35–65 %RH) before any performance reevaluation.

e) **Tests parameters:** For SFA30 testing, it is recommended to only change one test parameter (concentrations, temperature, humidity etc.) at a time. Changing only one parameter at a time makes the measurement evaluation much simpler.

f) **Formaldehyde handling:** Formaldehyde is widely categorized as hazardous to health and to be a human carcinogen. Formaldehyde experiments should therefore be conducted with great care and national workplace exposure limits should be monitored and strictly adhered to.

2 Fast and easy SFA30 testing

For a first sensor evaluation, a fast and easy test setup is often desired. In this chapter, some guidelines are given on how a setup can be designed efficiently and economically.

2.1 Casing

A casing is usually needed to confine the testing atmosphere to a defined volume. As an example, an acrylic glass box can be used for that purpose. The size of the box can be chosen freely depending on the desired test case. Bigger casings offer more flexibility when using auxiliary equipment but in a larger volume homogeneous conditions are more challenging to achieve and the time constant to reach stable environment conditions is generally longer.

For sensor level lab testing, very good results were achieved with acrylic boxes ranging from around 10 liters to 200 liters. Test environments within this size range offer a very good tradeoff between different characteristics: efficient control and monitoring of homogenous environment conditions, fast response time and formaldehyde concentration generation and flexibility for different test arrangement and auxiliary equipment.

For device tests with integrated SFA30 sensor modules, test rooms with several cubic meter volume can also be used. In this case, special care should be taken to check and control the spatial homogeneity of the conditions inside the test rooms, proper sealing and inert wall materials to avoid background from the test chamber walls.

2.2 Formaldehyde source

A stable and reproducible formaldehyde source is usually one of the biggest challenges for a test setup. Some suggestions can be found in the paragraphs below.

POM material

A very easy approach to produce low formaldehyde concentrations is to place some granulated POM (Polyoxymethylene) in the test box. POM is made with formaldehyde and is usually outgassing small amounts of formaldehyde. Depending on the volume of the box, a considerable amount of POM is required to reach formaldehyde concentrations around 100 ppb. A drawback of this method is, that stable conditions are very hard to achieve because of the constant outgassing of formaldehyde by the material. Another challenge with this approach is that exact concentrations are not straightforward to achieve.

Wood fiber board

Similar to POM material, some wood products such as chip board or MDF board outgas formaldehyde. Achievable concentrations depend strongly on the type and age of the product used.

Formaldehyde solution / Paraformaldehyde

Another approach is to use a formaldehyde / water solution (ex the Formaldehyde IC-Standard ICS045) and dispense a small amount of this solution on a hotplate in the measurement box. With an accurately specified solution and professional dispensing material, specific concentrations can be achieved.

As an alternative to the formaldehyde / water solution, paraformaldehyde in powder form can be used. In both cases, the hot plate should be controlled with care and only turned on as much as needed so that the conditions in the test box are affected as little as possible.

2.3 Ethanol cross sensitivity

The ethanol cross sensitivity is an important performance factor for formaldehyde sensors since ethanol concentrations in enlivened rooms can easily be one or two orders of magnitudes higher than formaldehyde concentrations. Hand sanitizers or the consumption of alcoholic beverages are example cases leading to high ethanol concentrations in a real-life situation.

The SFA30 formaldehyde sensor module excels with an extremely low ethanol cross sensitivity which makes it very robust against false positive readings in the field.

A straightforward and very application-oriented approach to test the SFA30 ethanol cross sensitivity is to directly simulate the above described real life events by using hand sanitizer in the proximity to a SFA30 sensor module or placing glasses with alcoholic beverages close to the sensor.

For a more technical evaluation of the SFA30 ethanol cross sensitivity performance, a small amount of ethanol can directly be dispensed in the measurement box or on a hot plate in the measurement box. Sensirion recommends to test ethanol concentrations in the range from 5 ppm to 50 ppm to cover the expected ethanol background in real life situations.

2.4 Auxiliary equipment

Beside from the equipment and material already described in this chapter, one or several fans can be placed in the test box to generate constant air currents in the box and thereby quickly equate possible concentration variations in the test atmosphere.

2.5 Measurement procedure

The setup described in this chapter allows fast and easy measurements with the SFA30 formaldehyde sensor module. In addition to the general testing guidelines from the chapter 1, some recommendations are given below which help to get reliable and reproducible measurements results and to avoid common pitfalls:

a) **Ambient conditions:** It is recommended to place the test setup at a location with stable ambient conditions and to make sure, that the complete system is in equilibrium with is surrounding before starting the measurement. (no temperature or humidity gradients)
b) **Start-up:** Start the measurement and let the sensors run for at least 1–2 hours without changing the ambient conditions or gas concentrations. Check the sensor readings before starting the next phase of the experiment. If large sensor variations are still observable after 1–2 hours, check your test box for temperature, humidity, or gas concentration gradients.
c) **Experiment phase:** Start with the experiment phase when the test devices show a stable formaldehyde concentration. For most comprehensible results, change only one parameter at a time and wait for the sensor response and the ambient conditions to stabilize before continuing with the next step as mentioned in the introduction.

2.6 Data evaluations

A common performance indicator, often called device-to-device (d2d) variation, evaluates the difference between the mean value of a set of sensors and the individual value of each sensor from that set. The formulas for calculating the device-to-device variation is given in equation (1) and (2). Figure 1 and Figure 2 show data from an example d2d test in an acrylic box with POM material as formaldehyde source as described in the previous paragraphs.

$$mean = \frac{\sum_{i=0}^{n} a_i}{n} \tag{1}$$

$$d2d_i = a_i - mean \tag{2}$$

device-to-device variation limits: $\text{if mean} > 100\text{ppb}, \quad \text{d2d}_{\text{limit}} = \pm\, 0.2 \times \text{mean}$

$\text{if mean} \leq 100\text{ppb}, \quad \text{d2d}_{\text{limit}} = \pm\, 20\text{ ppb}$

![SENSIRION]

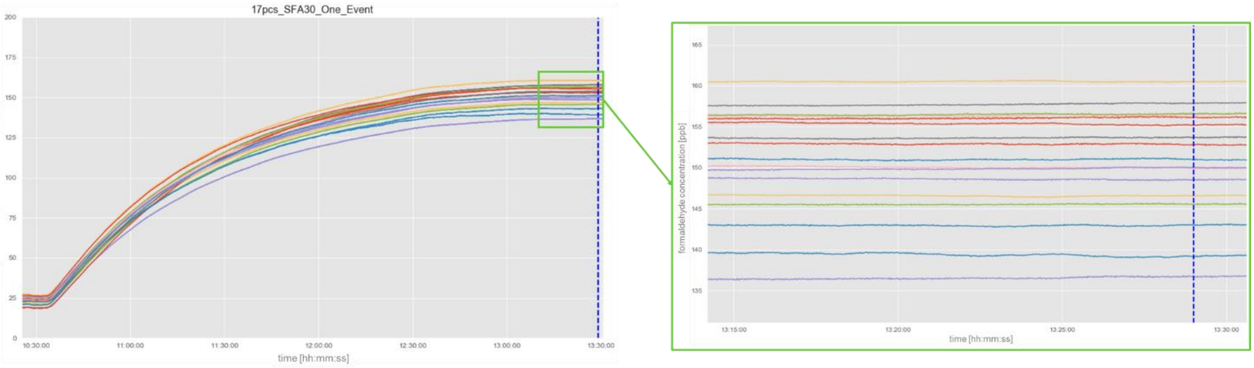


Figure 1 Experimental data and steady sensor response for device-to-device variation analysis

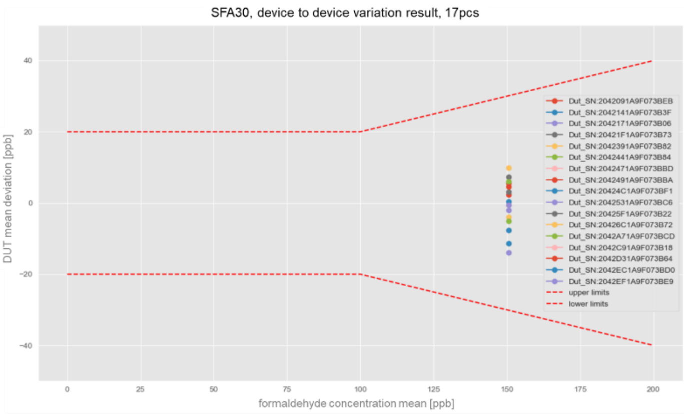


Figure 2 Results of d2d evaluation with specified limits

3 Professional gas mixing system

For highly accurate performance measurements, a humidity-controlled gas mixing station may be used.

Benefits of testing and qualification of gas sensors in a controlled environment via a GMS over testing sensors in the field are:

- Specific and reproducible gas concentrations in the ppb range
- Fast exchange of gas concentrations

3.1 Gas Mixing Station (GMS)

For very detailed accuracy evaluations, a dedicated gas mixing system may be used that is able to provide well-defined gas concentrations of formaldehyde and desired cross sensitivity gases in the appropriate concentration range. In addition, the gas mixing system has to be able to control the humidity of the gas mixture. To allow accurate measurements of ppb gas concentrations, special care must be taken to avoid spurious signals caused by unwanted outgassing of formaldehyde or VOCs from the gas mixing system components or measurement chambers.

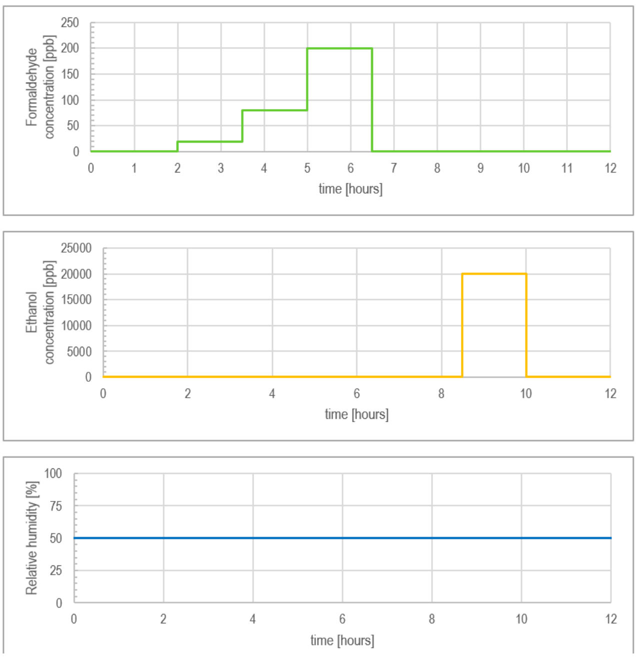
3.2 External formaldehyde references for a GMS system

As mentioned in the previous paragraphs, all realizations of formaldehyde generation feature some challenges. To have very reliable and accurate test results, the usage of an external reference device is recommended. These laboratory grade devices usually use laser infrared spectrometry to measure formaldehyde in the ppb range with high precision. For recommendations on high-end formaldehyde references devices, please contact Sensirion directly.

3.3 Measurement procedure with a GMS system

The general measurement recommendations from chapter 1 also apply for SFA30 measurements with a GMS system. With an accurate and flexible GMS system, various measurement cases with different emphases are possible. An example GMS measurement sequence which allows the evaluation of some key performances indicators is shown in Picture 1.

The example measurement sequence starts with a two-hour waiting time to let the sensor and the measurement system reach completely stable conditions. The formaldehyde performance is subsequently evaluated at three concentration levels for one and a half hours each. At 20 ppb to check the formaldehyde detection performance, at 80 ppb to check mid-level concentration accuracy and at 200 ppb to check high formaldehyde level accuracy. After the formaldehyde steps, a waiting time of two hours is again implemented to let the system get back to equilibrium. The ethanol cross-sensitivity is tested with one step at 20 ppm for one and a half hour. After the ethanol step, the system is set back to air only again for two hours.



Picture 1 Example GMS sequence

4 Important Notices

4.1 Warning, Personal Injury

Do not use this product as safety or emergency stop devices or in any other application where failure of the product could result in personal injury. Do not use this product for applications other than its intended and authorized use. Before installing, handling, using or servicing this product, please consult the data sheet and application notes. Failure to comply with these instructions could result in death or serious injury.

If the Buyer shall purchase or use SENSIRION products for any unintended or unauthorized application, Buyer shall defend, indemnify and hold harmless SENSIRION and its officers, employees, subsidiaries, affiliates and distributors against all claims, costs, damages and expenses, and reasonable attorney fees arising out of, directly or indirectly, any claim of personal injury or death associated with such unintended or unauthorized use, even if SENSIRION shall be allegedly negligent with respect to the design or the manufacture of the product.

4.2 ESD Precautions

The inherent design of this component causes it to be sensitive to electrostatic discharge (ESD). To prevent ESD-induced damage and/or degradation, take customary and statutory ESD precautions when handling this product.

4.3 Warranty

SENSIRION warrants solely to the original purchaser of this product for a period of 12 months (one year) from the date of delivery that this product shall be of the quality, material and workmanship defined in SENSIRION's published specifications of the product. Within such period, if proven to be defective, SENSIRION shall repair and/or replace this product, in SENSIRION's discretion, free of charge to the Buyer, provided that:

- notice in writing describing the defects shall be given to SENSIRION within fourteen (14) days after their appearance;
- such defects shall be found, to SENSIRION's reasonable satisfaction, to have arisen from SENSIRION's faulty design, material, or workmanship;
- the defective product shall be returned to SENSIRION's factory at the Buyer's expense; and
- the warranty period for any repaired or replaced product shall be limited to the unexpired portion of the original period.

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SENSIRION reserves the right, without further notice, (i) to change the product specifications and/or the information in this document and (ii) to improve reliability, functions and design of this product.

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Revision History

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