# Evaluation of fixed point H2S gas detectors intended for use in industrial safety applications

Sébastien Bouchet, Sabine Kasprzycki, Nicolas Lepine, Jean-Charles Morin

## Evaluation of Fixed Point $H_2S$ Gas Detectors Intended for Use in Industrial Safety Applications

*S. Bouchet, S. Kasprzycki, N. Lépine, J-C. Morin*
*INERIS, Parc Technologique Alata, BP n°2, 60550 Verneuil-en-Halatte, France*
sebastien.bouchet@ineris.fr
sabine.kasprzycki@ineris.fr
nicolas.lepine@ineris.fr
jean-charles.morin@ineris.fr

### 1. Introduction and purpose of the evaluation

$H_2S$ gas detectors are used by a wide variety of industrial companies for safety reasons, e.g: Oil&Gas, Chemistry, Water Treatment. The detectors are usually installed where $H_2S$ can be found in ambient air in order to prevent toxic risk.

The tests, requested by the French Ministry for Environment, were conducted by INERIS in partnership with Exera (an association of companies and organizations which invest in instruments, measurement, control and automation systems).

This evaluation was carried out to investigate if $H_2S$ gas detectors can operate efficiently under different operating conditions on industrial sites (temperature, humidity, pressure, interfering species, etc.). The measurement range of the detectors that were evaluated is 0-20 ppm.

The two systems on the market – an electro-chemical system and a semi-conductor system - were tested. Out of fourteen apparatus, three had a semi-conductor cell and eleven had an electro-chemical cell.

This paper presents the results of the evaluation that was carried out from October 2007 to April 2008 on 14 apparatus from 8 different manufacturers according to a test protocol that was specifically defined with the partners and involved over 15 tests. All the tests were conducted in the "detector and safety equipment" laboratory in INERIS' accidental risks department.

Detector and safety equipment laboratory

### 2. Test protocol

The test gas was hydrogen sulphide ($H_2S$) at a concentration of 12 ppm

The following tests were conducted to evaluate the performance of the $H_2S$ gas detectors that were tested:

- Response time and alarm trigger duration (set at 5 and 10 ppm)
- Affect of calibration rate

- Response curve for hydrogen sulphide
- Long-term drift
- Affect of temperature / humidity / pressure
- Response and long-term exposure to other gases ($H_2$, CO, $CH_2OH$, $SO_2$, $NO_2$, NO)
- Response to sulphur compounds ($C_2H_3SH$, $CH_2SH$, $CS_2$)
- Low hygrometry
- Prolonged use with test gas
- High level of hydrogen sulphide

Apart from the drift test which was conducted on 1 additional apparatus, all the other tests were conducted on the same apparatus.

## 3. Results

The following table provides a summary of the results.

Table 1: Summary of results

| Parameters evaluated | 3 semi-conductor detectors (A, B, C) | 11 electro-chemical cells (D to N) |
|---|---|---|
| Power Off storage | NAD | |
| Response time<br>($t_{90}$, Response time) | A: 29 s<br>B: 65 s<br>**C: 82 s** | D: 52 s, E: 16 s, F: 31 s, G: 35 s,<br>H: 13 s, **I: 8 s,** J: 18 s, K: 49 s,<br>L:19 s, M: 76 s, N: 58 s |
| Response curve<br>Test gas: 2, 8, 12 and 18 ppm | A, B: unaccurate and not linear<br>C: accurate and linear | K: unaccuraten and not linear<br>All others: accurate and linear |
| Long-term drift and "standby"<br>Continuous operation for 6 months in ambient air, followed by exposure to test gas | **A, C: complete loss of sensitivity**<br>B: no loss of sensitivity | D, G, H, J, N: no loss of sensitivity<br>E, F, I, K, L M: more or less complete loss of sensitivity |
| Temperature<br>(from -10 to 50°C) | All affected | D: breakdown, E: affected at low temperature, K, M: affected |
| Humidity<br>0 and 50% RH at 20°C<br>83% RH at 35°C | All were more or less affected by a relative humidity variation | |
| Low hygrometry<br>(10% RH - 20°C for 15 days) | A, B: not affected<br>**C: complete loss of sensitivity** | **D: - 50%,** E: - 17%<br>L: - 14%, N: - 19%<br>F, G, H, I, J, K, M: not affected |
| Pressure<br>Tests conducted at 80 and 100 kPa in air and the test gas | All detectors were affected by a depression | |
| Other gas response<br>$H_2$ (50 ppm), CO (50 ppm), $CH_2OH$ (200 ppm), $NO_2$ (25 ppm), NO (25 ppm), nitrogen oxide (25 ppm), $C_2H_3SH$ (1 ppm), $CH_2SH$ | A: no response<br>B: $C_2H_3SH$<br>C: $CH_2OH$ | D: breakdown<br>E, I, L: $SO_2$<br>G: $SO_2$ and NO<br>M: $CH_2OH$, $SO_2$, CO, NO<br>F, H, J, K, N: no response |

| | | |
|---|---|---|
| (1ppm) and $CS_2$ (10ppm) Exposure for 5 minutes | | |
| Prolonged use operating for 3 days based on 8 hours per day with test gas | All detectors had a change in performance | |
| High levels Exposure at 200 ppm to $H_2S$ for 2 minutes | **Recovery time up to 36 times higher** between two apparatus. No sensitivity drift as a result of this test | |

3.1 Unknowns during operation and during tests

One apparatus was supplied broken and after-sales technicians had to visit several times to fix it. Its installation lasted a total of one month. 4 other detectors were defective during the test period, and the installation durations for some of them took up to two months.

3.2 Main lessons

The study of one of the most important parameters for a toxic gas detector, which is response time, showed a difference by a factor of 10 between the slowest machine and the quickest machine. With a test gas at 12 ppm, the response time ($t_{90}$) varied from 8 to 82 seconds.

Another important parameter: “standby”. This is an increasingly critical phenomenon. When detectors are not regularly subjected to a gas, then they go into standby mode (this can occur with detectors for all types of toxic gas). So, for $H_2S$, some detectors that had not been subjected to a gas for a month no longer responded at all. Some, who had not been subjected to a single cloud of $H_2S$ for 6 months were unchanged.

The study of the affect of external parameters such as temperature or hygrometry also showed large differences between detectors. Out of the temperature tests conducted between -10 and 50°C, some were affected by temperature, and others were not affected at all. For example, one detector lost 50% of its response between 5 and 20°C.

For humidity, the detectors were all more or less affected by an even slight variation in relative humidity (RH) (between 0 and 50% at 20°C). And it was even worse in more severe conditions. Therefore, at 83% RH and at 35°C, the response of several detectors was divided by 5. Low hygrometry tests, quite common particularly in winter in heated premises, were also conducted. In an atmosphere with 10% RH and at 20°C for 15 days, 1 detector out of 14 lost all its sensitivity, 1 other lost 50% and 3 others between 15 and 20%.

**3. Statistics relating to data provided by manufacturers**

These statistics are only valid in the context of this evaluation, but do however highlight a general tendency in the area of gas detection. The data provided by manufacturers were compared to the results of tests conducted in this evaluation. It is appropriate to mention that all the results are significant when selecting a detector suited to its use. The statistics are provided in the table below.

Table 2: Statistics for manufacturer data / test data

| Data provided by the manufacturer compared with the tests conducted | Data consistent with the results | Data not consistent with the results |
|---|---|---|
| 34% | 56% | 44% |

Overall, only a third of the results of the tests conducted are shown in the manufacturer leaflets, and one of these data out of two is consistent with the results of this evaluation. Some detectors had restrictive and non-compliant specifications, but were however effective for safety.

## 4. Conclusion

The study conducted on the hydrogen sulphide detectors provided the following main conclusions:

- Different reactions for each detector in terms of response times, long-term stability and “stanby”, response to other gases, temperature, etc.
- All detectors were affected by humidity and depression.
- Leaflets provided by manufacturers were incomplete and sometimes optimistic.

Overall, out of the panel of detectors tested, the electro-chemical detectors seemed to be more effective than the semi-conductor detectors.