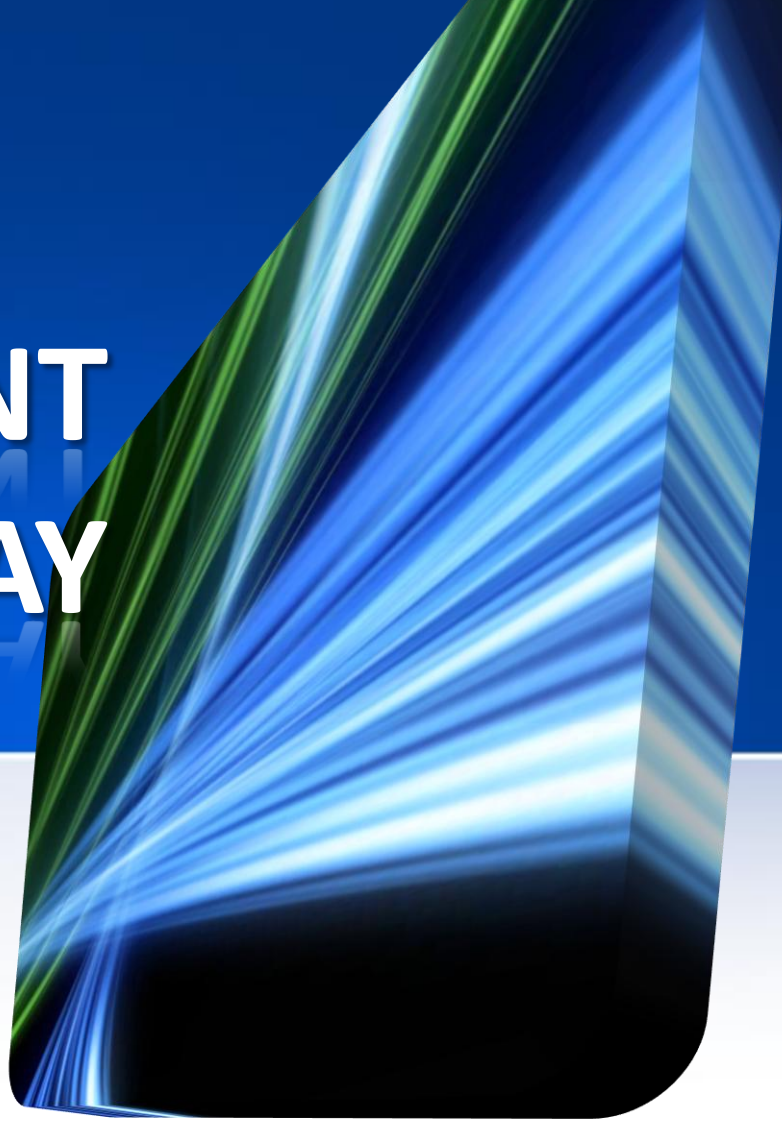
H2S MESUREMENT AT PARIS SUBWAY



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RATP

INGENIEROS ASESORES, S.A.

H2S

Hydrogen sulfide is a pollutant gas which, in low concentrations, has an unpleasant odour and may cause damage to electrical equipments.

It causes a wide range of health effects. Workers are primarily exposed to hydrogen sulfide by breathing it. The effects depend on how much hydrogen sulfide you breathe and for how long. Exposure to very high concentrations can quickly lead to death.

Paris Metro & H2S

A report made by E. Lorans at Paris Metro demonstrated the presence of H2S in several stations.

H2S odour is easily detectable by the users due to the low olfactory threshold (between 8 to 17 ppb)

The presence of high concentration of H2S is also a security concern since it can affect the command material, specially cooper wirings, due to their corrosive properties.

This phenomenon is specially disturbing at line 14 of the Paris Metro.

Some measurements made at Pyramides and Madeleine Stations show average levels about 3 ppm, with peaks up to 7 ppm.

PARIS METRO & H2S

The presence of H2S in the tunnels is due to the nature of the terrain. In fact some tunnels are made in areas of marl and limestones, very permeable materials, with areas of gypsum (Ca SO4) .

Dissolution phenomena cause cavities which require the padding with a mixture of bentonite-fly-ash and cement. That implies an important supply of organic material.

That process promotes the development of bacteria, including anaerobic sulfate reducing bacteria, responsible of the release of H2S. The reactions involved are the following:

$$CaS04(gypsum) + 2C(organic\ materia) \longrightarrow CaS + 2\ CO2$$

$$CaS + 2CO2 + 2\ H20 \longrightarrow Ca(HC03h + H2S$$

Leaks in fittings are the main entrance of water to the tunnels.

H2S MITIGATION STRATEGIES

RATP tested several technologies to reduce the concentration of H2S inside their infrastructure, to:

1. Protect the health of workers and users.
2. Reduce the nuisance due to bad odors.
3. Protect the key electrical equipment against corrosion.

Among these technologies RAPT tested

1. Use of Active carbon filters.
2. Cleaning of bacteria build-ups in tunnels

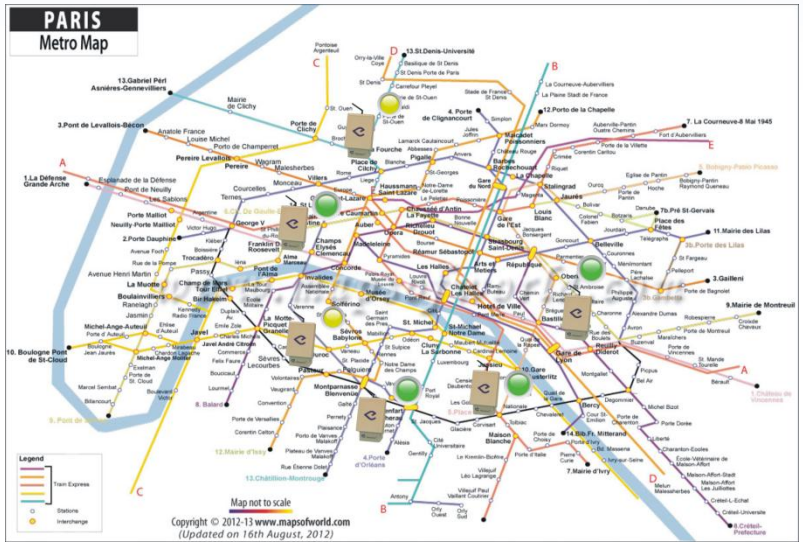
H2S CONTINUOS MONITORING IN PARIS METRO

All mitigation technologies are quite costly . RATP has designed a plan to optimize the cleaning operations by installing real time continuous H2S monitors to detect high levels and act accordingly.

Standard H2S analyzers are expensive, bulky and delicate instruments that need a specific shelter to be installed.

They also need a costly maintenance that made not viable a network of such instruments.

In 2012 I.A., in cooperation with the French company Envicontrol and the Laboratoire essais et mesures Qualité de l'air (RATP), have performed a pilot test to demonstrate the feasibility of the NANOENVI analyzers developed by Ingenieros Asesores S.A. for the measurement of H2S in subway environments.



NANOENVI

Ingenieros Asesores S.A. started in 2006 a line of research and development of new measurement systems based on the advances in sensor technology.

Tailored for the specific application, the Nanoenvi analyzers can be configured with up to 4 sensors (metal oxide or electrochemical cells).

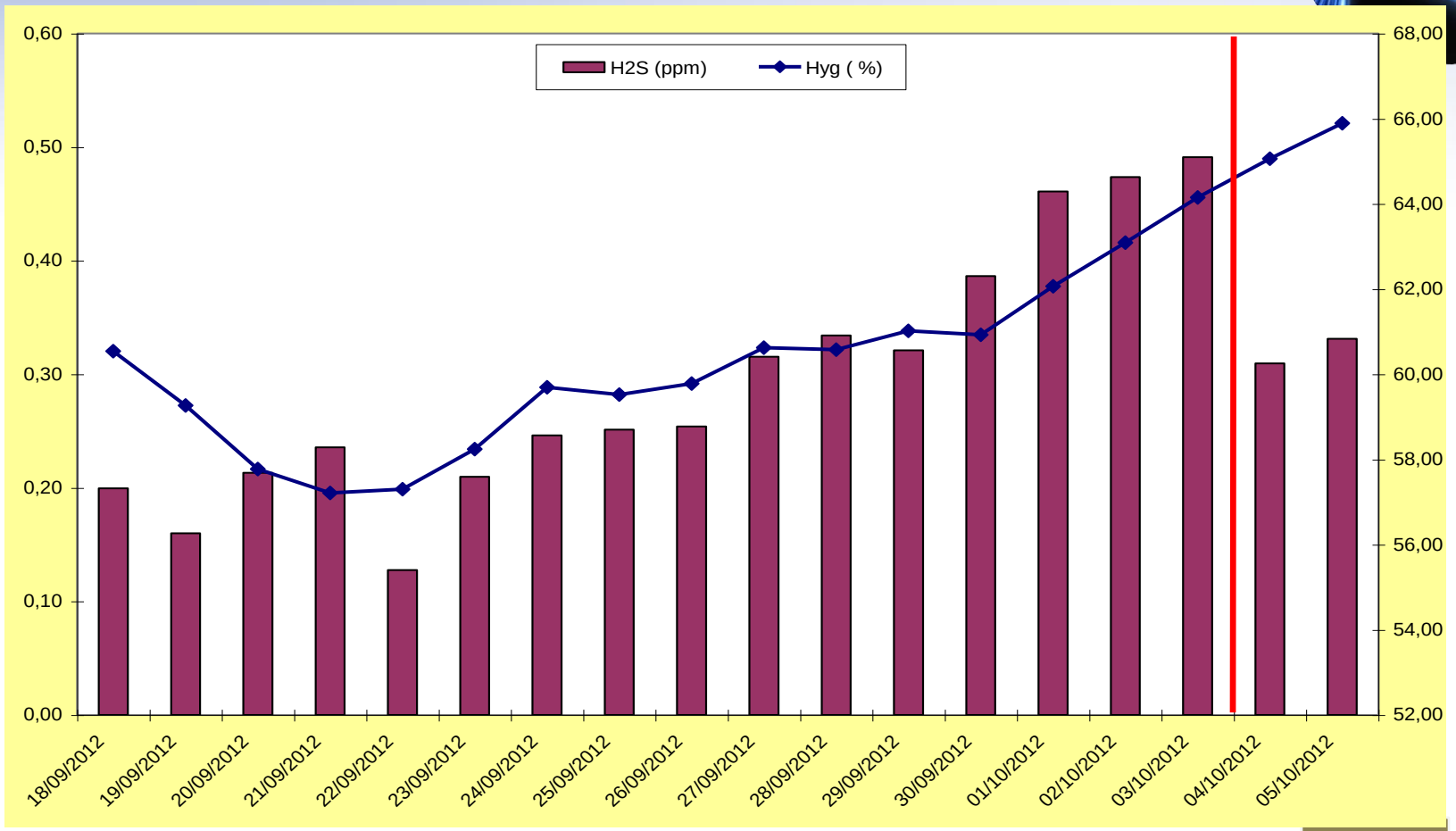
The analyzer has a powerful datalogger with an internal memory with a storage capacity up to 2 years of data.

Self contained in a small IP54 box can be installed almost anywhere.

Paris Metro Specifications

- Dimensions : H = 28 cm ; W = 17 cm ; D= 10 cm
- Range 0 to 50 ppm
- Principles of operation: Electrochemical cell with active sampling pump
- 15 min integrated data, 30 sec sample
- IP54 enclosure
- Power 230 V /50 Hz
- Ethernet (Modbus) communications

PILOT TEST RESULTS



PILOT TEST RESULTS

Pilot test statistics

H2S (ppm)	
Minimum	**0,06**
Moyenne	**0,30**
Maximum	**0,65**
Maximum	**0,65**

Comparison with reference instrument (Photovac)

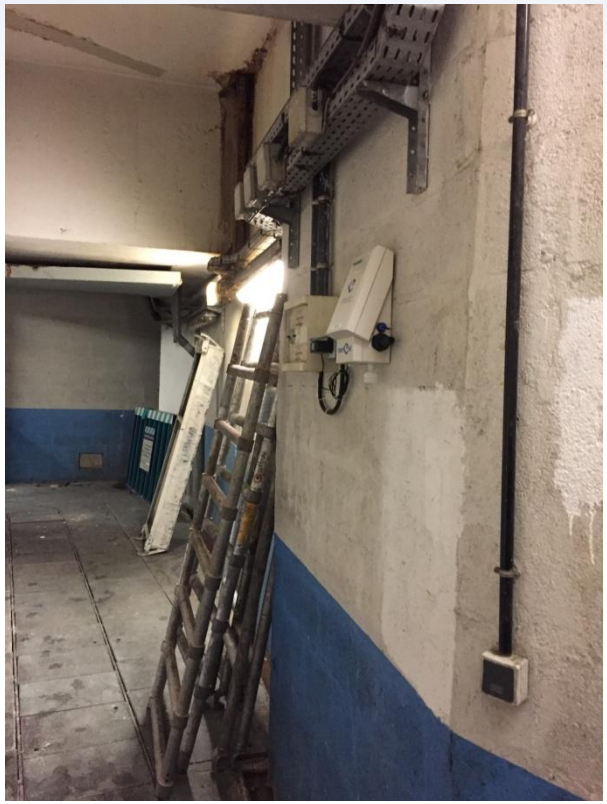
Analyzers	H2S (ppm)	Dif %*
Photovac Voyager	0,37	**0,07**
Nanoenvi	0,40	

CONCLUSIONS PILOT TEST

- Measure as accurate as the reference method used by the LEM (0,7%).
- Pilot test:
  - Maximum 0,65 ppm
  - Most of the measurements between 0,20 and 0,40 ppm
  - The results suggest a correlation between the rate of H2S and humidity (to be confirmed over a longer study).
  - Impact of the cleaning

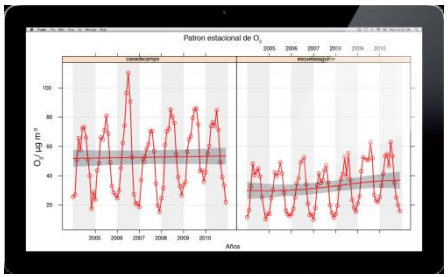
CASE 1. Isolated monitors

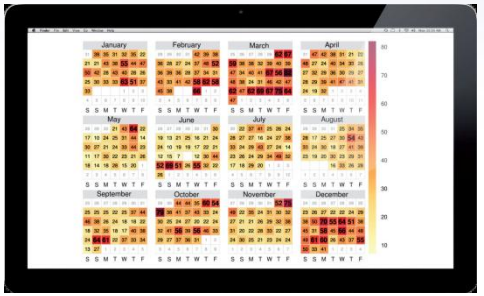
- Measurement campaign possibility to know exactly the changes in the rate of H2S on the measurement premises.
- Continuous measurement but results a posteriori .
- Improved cleaning cycle after data analysis.



CASE 2. Network of monitors

- Real-time alert if threshold exceeded (Mail, SMS etc ..)
- Mapping + Quarterly update on evolution of H2S levels in each measurement point
- Real time data on the premises equipped with NANOENVI
- Improved cleaning cycle + real-time protection of workers and users.





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