BATAILG

TAIL GAS ANALYZER

Rev. 1.1

The Tail Gas Analyzer is part of the **BAGGI BASE® Instruments Series**.
They are the result of combining the latest state-of-the-art-technology with over 60 years of industry experience.

BAGGI BASE® offer solutions for measurement and analysis in gases, solids, liquids, steam and multiphase:
Temperature
Humidity
Velocity – Flow
Pressure
Level – Interface
Components Analysis
Sampling and Filtration
Data Acquisition
Data Communication
Vision systems

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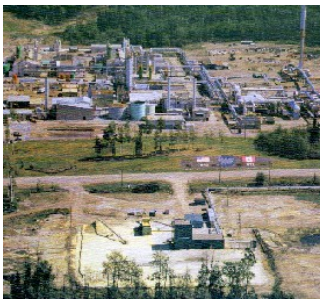
1 Introduction

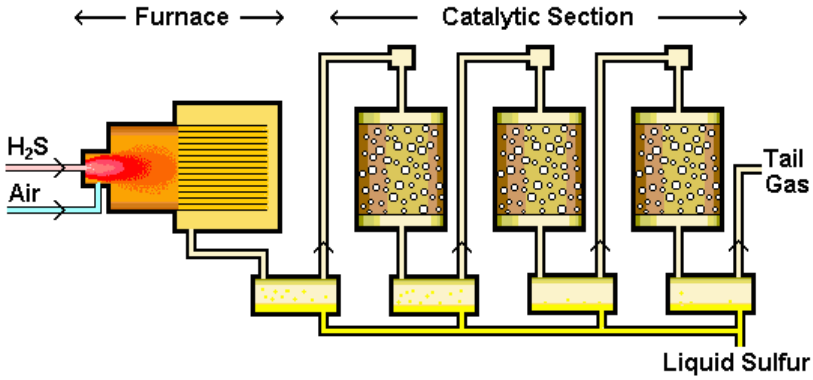
The BAGGI® BASE instrument BATAILG offers accurate measurements of H_2S and SO_2 concentration in the tail gas from a Claus process sulfur recovery plant.



The instrument is based on a Ultra-Violet (UV) spectroscope that provides high wavelength resolution.
The measurement technique relies on the *Beer-Lambert* law.
This one is a relationship that relates the absorption of electromagnetic waves energy to the properties of the material through which the waves are travelling.
The material (tail gas) is introduced in a sample cell of specific optical path length. The UV energy is transmitted to the cell via an optical fiber cable, it passes through the gas space and the residual energy is transmitted to the UV sensor by a second optical fiber.
The analyzer is optimized for the following measurement ranges:

- H_2S: 0 - 2 %
- SO_2: 0 - 2 %
- H_2S to SO_2 ratio: -1 to 1

The typical application is in the Claus Sulphur Process Control (refer to the figure beneath):



The analyzer is also able to calculate the Air Demand output signal, for driving the combustion air to the furnace.
It is suitable for outdoors installation (ATEX zone 2).

Maintenance is reduced to a minimum due to:

- Very long life UV lamp
- Direct mount on the process pipe
- Ruggedized components
- Controlled sulfur condensation
- Cell clean-up with instrument air
- No moving parts
- Self-monitoring
- Calibration facility

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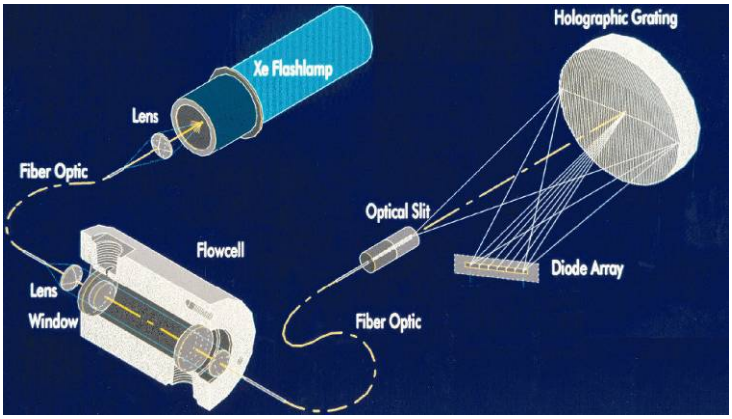
2 Architecture

The implementation of the Tail Gas Analyzer follows the general philosophy of the BASE Instruments Series.
The raw input data from the sensors (UV spectrophotometer) are processed by algorithms provided by BAGGI, running in an embedded computer that is the heart of the system.
The computer, together with the sensors and the power supply, is within an enclosure provided with a protective purge system and a Vortex cooler (connected to the plant instrument air system).
The following figure shows the computer's monitor with the functional keys:

The computer is in charge of:

- Actuating the UV lamp of the spectrophotometer
- Reading the electrical signals from the CCD array (related to the intensity of the absorbed UV energy)
- Calculating the concentration of H_2S and SO_2
- Calculating the combustion air demand
- Actuating the digital/analog conversion for outputting the calculated values over 4…20 mA signals
- Actuating the output relays for indicating possible alarms
- Displaying the measurement output data in a Graphical User Interface (GUI)
- Storing the measurement archives into non volatile memory (Microsoft Office compatible format)
- Interfacing the human operator for system configuration and alarm reporting

The spectrophotomer schema is shown below:



The instrument is composed of an UV lamp and a diode array. The UV beam, after passing through the measurement cell, reaches a holographic grating disk. This one diverts each wavelength composing the beam onto a specific diode of the array. The voltage emitted by the individual diodes is measured and this information is acquired by the embedded computer through a serial line.
There are no moving parts.
The computer knows the amount of UV energy that has been transmitted by the lamp and is able to draw the absorption spectrum. Finally it calculates the concentration of the components.

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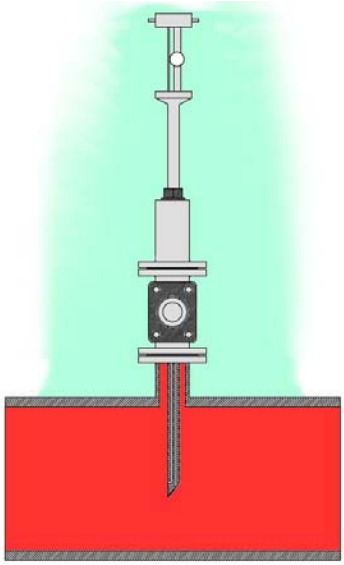
The third main component of the analyzer, in addition to the embedded computer and the spectroscope, is the sample probe.



The sample probe has been designed to solve the common problem of sulphur clogging.
In particular, the sample is taken from a small pipe inside the probe, its temperature is decreased by a heat exchanger to let the water vapor to condensate and fall back into the process.
The sample is then heated to the same temperature of the process and passes through the measurement cell.
The core analyzer (computer + spectroscope) can be mounted near the sample location on a self standing skid.
The connection from the core analyzer to the sample probe is made by two Stainless Steel armored fiber optics cables.

The measurement cell is able to provide the following additional pneumatic inlets and outlets:

- Calibration gases from certified cylinders
- Instrument air for cleaning purposes (optional)

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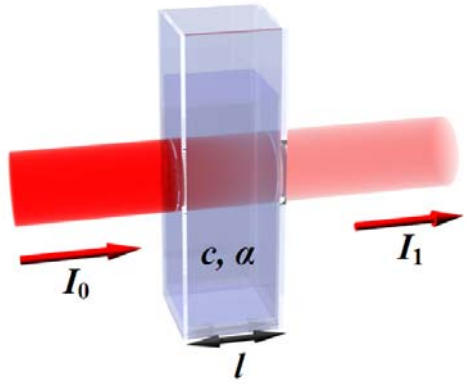
3 Principle of Operation

As anticipated, the measurement is based upon the Beer-Lambert law.
This one is an empirical relationship that relates the absorption of light (or UV waves) to the properties of the material through which the light (UV) is travelling.
The measurement is centered on the wave length where the investigated material has maximum energy absorption.



In the figure, $\mathbf{I_0}$ and $\mathbf{I_1}$ are the intensity of the incident signal and of the outgoing signal, respectively;
l is the length of the path, **c** is the substance (e.g. H_2S) concentration and **α** is a constant related to the substance.
α can be written as:
α = εl
where **ε** is the molar absorptivity of the absorber (H_2S).

The following relation holds:
$I_1/I_0 = 10^{-\varepsilon lc}$

The transmission of the signal through the sample is expressed in terms of "**absorbance**", which is defined as:
$$\mathbf{A = -\log_{10}(I_1/I_0)}$$

This implies that the absorbance is linear with the concentration:
$$\mathbf{A = \varepsilon lc}$$

The analyzer establishes the intensity of the signal transmitted by the lamp of the spectrophotometer and measures the intensity of the signal received by a photodiode array.
The signal is transmitted at wavelenghts where the absorbance of the measured substance is maximal.
Then the application software calculates the concentration according to the measured values and the above formulas.

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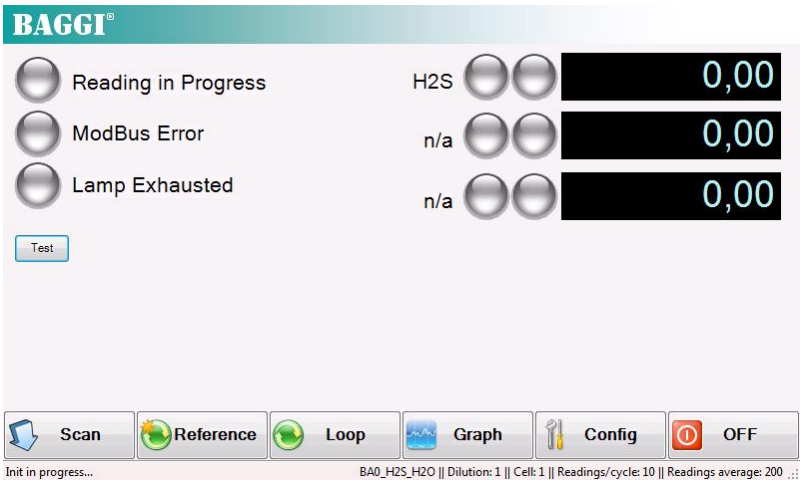
4 Operation and Maintenance

The man machine dialog for O&M is easily performed using the Graphical User Interface provided by the embedded computer.
A few examples are shown hereafter.

4.1 Main Menu

At start up, the Main Menu page is displayed automatically:



The functions associated with the functional keys are shown in the bottom line of the display.

In the left side of the screen there are 3 indicators, shaped like LED lamps:

Reading in progress — If turned on, it indicates the status of the measurement.
The values are:
- *Reading in Progress* (a single shot Scan is being performed on the process sample)
- *Reading Completed* (a single shot Scan has been performed)
- *Reading Spectrum* (a continuous measurement is being performed on the process sample)
- *Reading Reference* (a single shot measurement is being performed on the reference sample)

ModBus Error — When turned on, this alarm indicates that a ModBus error is present

Lamp Exhausted — When turned on, this warning indicates that the spectrophotometer lamp is exhausted

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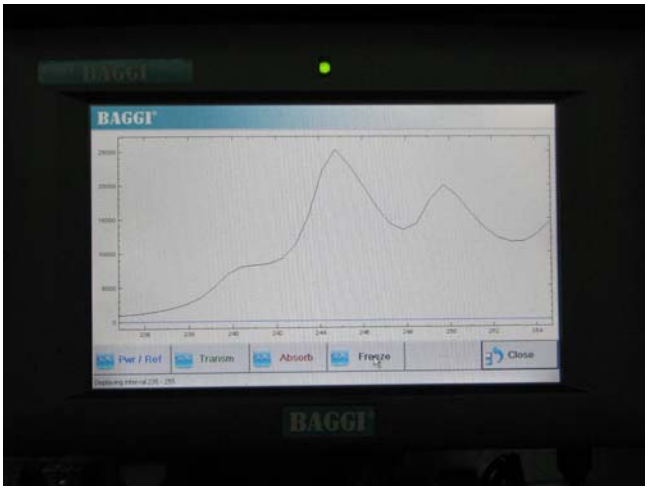
The two indicators, shaped like LED lamps with the *H2S* label, have the following meaning:

H2S (left side lamp)	If turned on, it indicates that the H_2S concentration is below the minimum value of the measurement range
H2S (right side lamp)	If turned on, it indicates that the H_2S concentration is over the maximum value of the measurement range

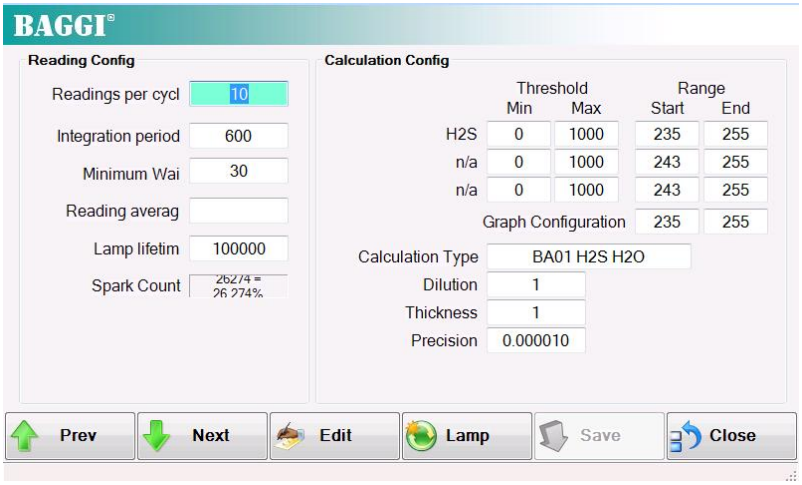
The value of the H2S concentration, displayed next to the above lamps, is calculated averaging elementary read operations (in the *Spectrum reading* mode).

By clicking on the **Graph** functional key, the measurement data are displayed in graphics mode:



4.2 Configuration Menu

This example shows the menu allowing the modification of internal parameters used in the measurement algorithm.



The meaning of the above fields is the following:

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Readings per cycle	The number of elementary read operations performed in a reading cycle
Integration period	The energy applied to the lamp (single light emission duration in milliseconds)
Minimum Wait	Duration of the pause (milliseconds) between two reading cycles
Reading average	Number of cycles used for averaging the measurement values
Lamp lifetime	The total lifetime of the lamp, that is the maximum number of ignitions
Spark Count	The real time counter of the lamp ignitions
H2S Threshold Min	The range low end corresponding to the 4mA analog output signal
H2S Threshold Max	The range high end corresponding to the 20mA analog output signal
H2S Range Start	The range low end of the Spectrum
H2S Range End	The range high end of the Spectrum
Graph Configuration	The range used in the x-axis of a graph
Calculation Type	A string indicating the Application software in use
Dilution	Analyzer internal parameter
Thickness	Analyzer internal parameter
Precision	Analyzer internal parameter

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5 Technical Specifications

Here follow the standard specifications of the BASE Instrument Series.
For specific requirements, please contact the e-mail address below:
info@baggi.com

Instrument Specification

Power:
- Standard: 90-264 VAC, 47-63 Hz; 6A max

Environment:
- 0° to 40°C (32° to 104°F)
- 0° to 55°C (32° to 131°F) with vortex cooler

Dimensions (without sampling system):
- Skid-mount 500mm H x 400mm W x 250mm D
  (19,68" H x 15,74" W x 9,84 D)

Approximate Weight ((without sampling system):
- 15 Kg

Analogue Inputs:
- Four inputs filtered with transient protection

Analogue Outputs:
- Six isolated outputs, 4 – 20 mA

Digital Inputs:
- Six digital inputs

Digital Outputs:
- Eight isolated relay signals

Enclosure Protection:
- IP66

Compliances:
- EN61326, EN61010-1
- ATEX (optional)
  II 2 G Ex px II T6
  II 3 G Ex pz II T6

Tail Gas application

Components range:
- H_2S 0-2%
- SO_2 0-2%

Accuracy:
±1% F.S.

Repeatability:
±0.5% F.S.

Sensitivity:
±0.15% F.S.

Response time:
90% of final value in 10 sec. (typical)

Services required:
- Instrument Air
- Steam pressure

All the specification data are subject to changes without notice

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