Process Analyzer Applications

The Claus sulfur recovery unit (SRU) and tail gas treating unit (TGTU) require a suite of process gas analyzers to operate safely, protect the catalyst/amine at high efficiency and meet environmental regulations for sulfur dioxide (SO₂) emissions.

The development of sulfur recovery for oil refining, gas processing and coke oven plants was largely driven by environmental regulations in the early 1970s, resulting in AMETEK's development of the SRU tail gas analyzer. Optimization of the process and further enhancements gave genesis to numerous other analyzer applications. This application note covers the seven possible analyzer tags that are addressed by AMETEK (see Figure 1, simplified process flow diagram).

The hydrogen sulfide (H₂S)/SO₂ SRU tail gas (air demand) analyzer (AT3) is the one constant – every SRU will employ this critical analytical measurement. If the SRU is followed by a TGTU, there is at least one, and possibly two, additional analyzers located at sample point locations AT4, AT5 and/or AT6.

The feed gas/acid gas analyzer (AT1) is becoming more prevalent, as recent developments provide real-time full composition analysis to mitigate hydrocarbon (HC) upsets. In addition to measuring H₂S, ammonia (NH₃) and total HC, the feed gas analyzer can quantify the acid gas contaminants (BTX, methanol, CO₂).

To identify a potentially explosive environment in the sulfur pit or tank, an analyzer (AT2) measuring H₂S should be permanently installed.

Finally, the emissions analyzer (AT7), in its simplest form, reports the SO₂ emission but can also be used as a process optimization tool if the emission is expressed in mass basis terms.

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**AT1. ACID GAS ANALYZER (SRU Feed Forward Control)**

**IPS-4 UV/IR**
A full composition, real-time analyzer accounts for all O₂ consuming species in acid gas streams. Using a combined ultraviolet (UV) and infrared (IR) “full spectrum” technique, total hydrocarbon (THC) is measured in the IR as “methane equivalent” and H₂S is measured in the UV so the exact amount of air can be added (or subtracted) from the reaction furnace for steady state control.

Benefits of acid gas analyzer include:
- Where transient spikes of HC cause sudden increase in air demand – resulting in an H₂S spike at the tail gas – and when the event is over, SO₂ breakthrough into the TGTU, (see Figure 2)
- NH₃ measurement for (refinery) sour water stripper (SWS) acid gas.
- Additional measurements for quantification of benzene-toluene-xylene (BTX) and methanol (MeOH) contamination in (natural gas processing) acid gas.
- Material balance and mass emission calculations
- Heated Acid Gas (HAG) probe offers a single connection for sample extract and return to process. Always consider adding the HAG probe and sample point at feed stage or SRU outage
- Rated NEMA-4X (IP65) for outdoor installation; a cabinet or shelter is not required

**AT2. SULFUR PIT (TANK) ANALYZER (Lower Explosive Limit)**

**888/930 Pit Gas**
Liquid sulfur contains ~150 parts per million (ppm) of dissolved H₂S and spontaneous degassing results in accumulation in the head space. If the sweep gas is interrupted, H₂S can reach the lower explosive limit LEL (~3.25 %), (see Figure 3).

Benefits of the pit gas analyzer include:
- Computational fluid dynamics (CFD) modeling confirms localized H₂S concentrations can be 16 times the mean value, indicating values of ~2,000 ppm H₂S which may constitute an imminent hazard
- SO₂ is monitored to alarm for a smoldering pyrophoric sulfur fire
- The pit gas analyzer can also be used for mass balance purposes as a sulfur pit vent routed to the incinerator accounts for approximately one-third of the emissions

**AT3. TAIL GAS ANALYZER**

**888/900 Tail Gas**
Measurement of H₂S/SO₂ in SRU tail gas for feedback (trim) control of the process air. Reliability has evolved to the point where the analyzer anticipates and reacts to adverse process conditions. With an installed operating base in excess of 2,000 units, AMETEK offers two types of tail gas analyzers, the Model 888 and Model 900.

Benefits of the 888 Tail Gas:
- Close-coupled (no sample line), mounts directly on the pipe
- Does not require climate-controlled shelter, rated for 60°C (140°F) without external cooling, and automatic flow control

**931/932 TGTU**
The TGTU increases sulfur recovery efficiency up to 99.99% (>100ppm SO₂ emissions) by combining a reduction stage and amine treating to recycle H₂S back to the SRU.

The primary purpose of measuring excess hydrogen (H₂), 0 to 5% is to ensure full conversion of all sulfur compounds to H₂S. The secondary function is the measurement of the residual sulfur compounds. The sample point can be in one of three locations. As H₂ does not essentially change after the reduction reactor, the utility of the sulfur gas measurement varies according to design needs and sample point location. 931 and 932 analyzers, both use UV spectrometry to measure single, and multiple species, respectively.

Benefits of the TGTU analyzer include:
- AT4 – Absorber
  Measurement of SO₂ breakthrough from the reduction reactor to the quench column. SO₂ values in excess of 5ppm can deactivate the amine
- AT5 – Quench Outlet
  Measurement of H₂S (0 to 5%) to quantify the load to the amine treater and provide a material balance on the SRU
- AT6 – Absorber Outlet
  The most common sample point for H₂S (0 to 250 ppm), which is a measure of the amine absorber efficiency and the primary contribution to SO₂ emissions. COS can be measured at the absorber outlet. COS is typically <5ppm but process upsets in the reduction reactor can result in hundreds of ppm, (see Figure 4). A valuable tool to isolate process problems and quantify the contributions to emissions. CS₂ can also be measured at this sample point (Refer to application note F-0229 Reduction/Amine Tail Gas Treating: Model 931/932 Analyzers).

**Figure 4. CO₂ upset data from TGTU absorber**

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For more information, visit ametekpi.com.
AT7. CONTINUOUS EMISSIONS MONITORING (CEM) SYSTEM

909/910/919/920/914 CEM

SO\textsubscript{2} emission, measurement base, and parameters vary according to:

- If SO\textsubscript{2} is reported on a mass basis, requires a stack gas flow rate and “hot-wet” analysis of SO\textsubscript{2}
- If the SRU is followed by a TGTU, the measurement base is typically “dry” basis
- If the TGTU can be bypassed, the SO\textsubscript{2} analyzer can be dual-ranged (0 to 500 ppm/0 to 1% SO\textsubscript{2})
- The 914 is a built-to-order CEM that includes all the components needed for a compliance monitoring and reporting project, using a dry extractive sampling technique
- The 909 and 910 analyzers incorporate gas flow rates. The 919 and 920 do not

SERVICES  Our in-house service centers provide after-sales services to ensure you get the best performance from your system. This includes technical support, certification, calibration, commissioning, repairs, servicing, preventative maintenance and training. Our highly trained technicians can also attend your site to cover planned maintenance schedules and repair emergency breakdowns.