LAND

AMETEK®

ACID DEWPOINT TEMPERATURE MEASUREMENT

APPLICATION NOTE

MEASURING ACID DEWPOINT TEMPERATURE TO IMPROVE EMISSIONS AND EFFICIENCY.

Measurements of the Acid Dewpoint Temperature (ADT) are important for combustion efficiency, environmental compliance and process optimisation on a variety of coal and oil-fired processes. The Lancom 200 portable analyser provides valuable tools for ADT measurement.

SULPHURIC ACID FORMATION

It is commonly known that sulphur dioxide (SO_2) emissions from process plants contribute to acid rain, and that many sites have to monitor or control such emissions.

Problems associated with sulphur trioxide (SO_3) and sulphuric acid (H_2SO_4) emissions, however, are less widely recognised, and sulphuric acid in stack gases contributes to serious and expensive maintenance problems as well.

Most solid and liquid fuels contain some sulphur – the majority of coals, heavy oil, petroleum coke (petcoke) and Orimulsion® bitumen-based fuels typically contain between 0.5% and 3% sulphur by weight.

When these fuels are burned, the sulphur is oxidised to SO_2 and typical flue gases contain between 300 parts per million (ppm) and 3000 ppm SO_2. If sufficient oxygen is available, some of that SO_2 oxidises further to SO_3.

In most cases, the SO_3 forms a small, but significant, fraction of the oxidised sulphur – typically a few percent of the total. Water in the flue gas reacts with the SO_3 to form H_2SO_4 in a reversible reaction, so that there is an equilibrium between the SO_3 and H_2SO_4 concentrations.

The reaction between SO_3 and H_2O is exothermic, so the dissociation reaction is favoured at higher temperatures.

SO_3 also adsorbs onto fly ash. Ash is generally basic and so the acidic SO_3 binds easily to the surface, resulting in low levels of free SO_3.

The ash is removed from the gas stream by the precipitators or the baghouse along with the adsorbed SO_3. This can make it difficult to measure the ADT in a coal-fired process.

THE PROBLEM WITH SULPHURIC ACID

The presence of sulphuric acid in stack gases can lead to a number of undesirable consequences.

Sulphuric acid condenses at temperatures well above 100 °C (212 °F). If the gas temperature drops below the acid dewpoint, sulphuric acid aerosol is formed, and a film of sulphuric acid will form on any exposed surface with a temperature below the dewpoint.

Sulphuric acid aerosols contribute to fine particulate matter (PM2.5) emissions that can affect human health. The aerosol droplets are very small, typically around 1µm in diameter, so they also scatter light very effectively.

APP NOTE

Harmful H_2SO_4 and SO_3 emissions create serious maintenance problems for plants.

BLUE PLUME

If enough sulphuric acid is present in the gases at the stack exit, the condensing aerosol forms a so-called "blue plume". The blue colour comes from the preferential scattering of blue light by the very small aerosol droplets.

Once formed, such plumes are very persistent and can negatively impact visibility a long distance from the source. Air quality managers are increasingly concerned about visibility issues resulting from sulphate aerosol emissions.

In addition, blue plume problems have been linked to selective catalytic reduction (SCR) systems used to reduce NOx concentrations. The catalyst helps promote the SO_2 to SO_3 reaction, leading to the formation of increased amounts of sulphuric acid in the stack exhaust.

APP NOTE

If the gas temperature drops below ADT, sulphuric acid condensation occurs.

EFFECTS OF SULPHURIC ACID IN FLUE GASES

When particulate matter is allowed to build up in the ductwork, agglomerations of particles can form, and the SO_3 adsorbs onto these particles. When such agglomerations become detached, they may be emitted from the stack as acid smuts – highly corrosive pieces of dust that attack the surfaces they land on, including nearby cars, homes and vegetation.

In addition, the ammonia used in SCR systems can combine with the sulphuric acid to form ammonium bisulphate, which is an especially difficult material since it precipitates directly from a gas to a solid at temperatures below 260 °C, leaving sticky deposits on ductwork and cooler surfaces such as heat exchangers.

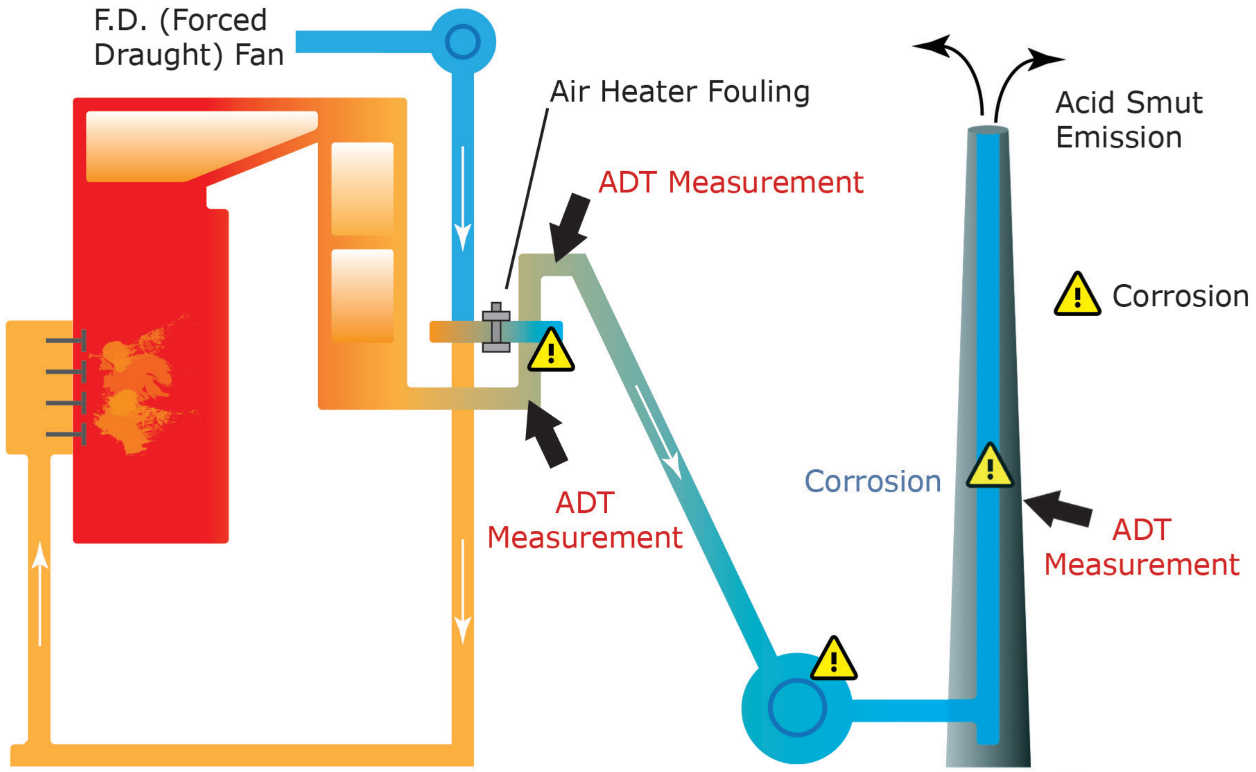
Ammonium bisulphate deposited on the air preheater has a big impact on the heat transfer efficiency, which in turn affects the operating costs of the process.

For plant operators, the most serious consequences occur when the gas temperature drops below the dewpoint within the process. Corrosion is an inevitable consequence whenever hot sulphuric acid is deposited on a metal surface.

Glass-coated surfaces are an option, but are very expensive to install. In general, it is better to maintain the temperature above the dewpoint. This is no trivial matter, since increasing the stack exit temperature decreases the thermal efficiency of the plant and increases fuel costs.

Clearly, there is an optimum operating temperature – safely above the dewpoint but as close to it as can practically be arranged. Cold-end corrosion can occur anywhere the gas temperature drops, or where ambient conditions can lead to surface cooling.

Heat exchangers, exposed ducts and stacks are especially vulnerable.



A portable combustion efficiency monitor using conductive cell technology for accurate, periodic measurements of the ADT.

The Lancom 200 helps reduce pollution emissions and improves thermal efficiency. Knowledge of the ADT is essential for all coal and oil-fired boilers – a direct measurement provides vital information for combustion control and optimisation, with no need for calibration or reference.

LANCOM 200

FOR
ACCURATE, PERIODIC MEASUREMENTS
OF THE ACID DEWPOINT TEMPERATURE [ADT]

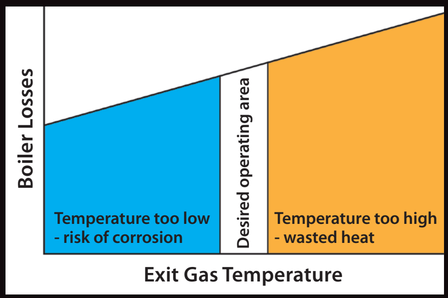
SUMMARY

A NUMBER OF STRATEGIES CAN BE USED TO MINIMISE SO_3 FORMATION AND RELATED EMISSIONS

Wet scrubbers, such as those used to remove SO_2, tend to be ineffective in removing sulphuric acid aerosols, because the droplets are too small to be entrained in the scrubbers' slurry.

One solution is to use fuel additives such as magnesium oxide (MgO) or magnesium hydroxide (MgOH). These react with sulphur from the fuel in the combustion zone, forming solid salts that precipitate from the gas stream. Along with the removal on the fly-ash, this is the principal mitigation strategy for both SO_3 formation and sulphate aerosol emissions.

Another approach is to use a wet precipitator that effectively collects the sulphate aerosol. However, any strategy for dealing with SO_3 and H_2SO_4 requires a method for measuring their concentration in stack gases. This can prove rather challenging.



HOW THE LANCOM 200 PORTABLE SULPHURIC ACID DEWPOINT MONITOR WORKS

Lancom 200 consists of a probe with conductivity and temperature sensors mounted in the tip and a portable control unit that includes an air flow regulator and electronics to measure the conductivity and thermocouple temperature.

Data logging and printing allow successive measurements to be stored for subsequent analysis.

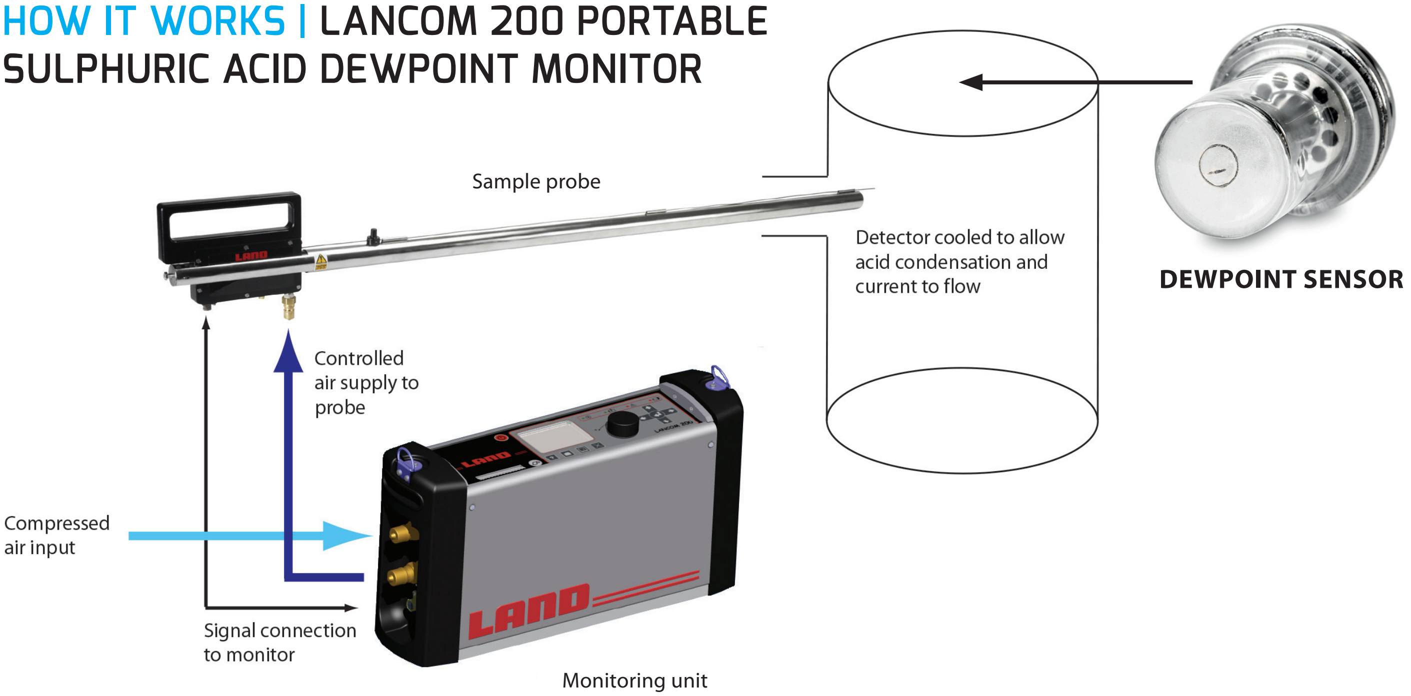
This configuration is very practical because it allows the operator to survey a number of different points on a process plant, logging the data in real-time, before downloading it to a PC for subsequent analysis.

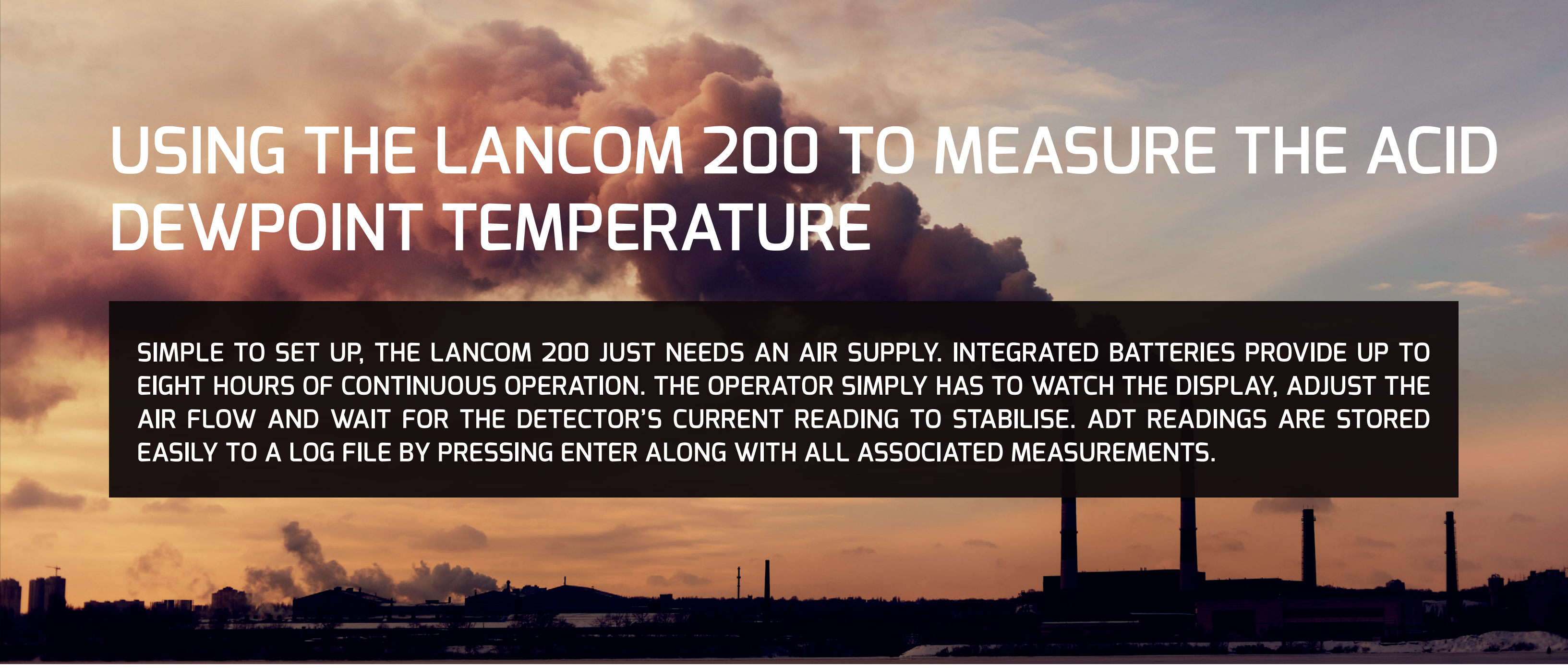
The sensor consists of two platinum electrodes embedded in a borosilicate glass thimble. As the sensor cools, sulphuric acid condenses on the glass and this can be detected by measuring the conductivity between the two electrodes.

The ring electrode is made of pure platinum, but the linear electrode is actually a Type R thermocouple, and this allows the Lancom 200 to measure the temperature of the acid film.

When the rate of condensation is equal to the rate of evaporation, the acid film is in equilibrium and the conductivity is constant. The equilibrium point corresponds to the acid dewpoint temperature.

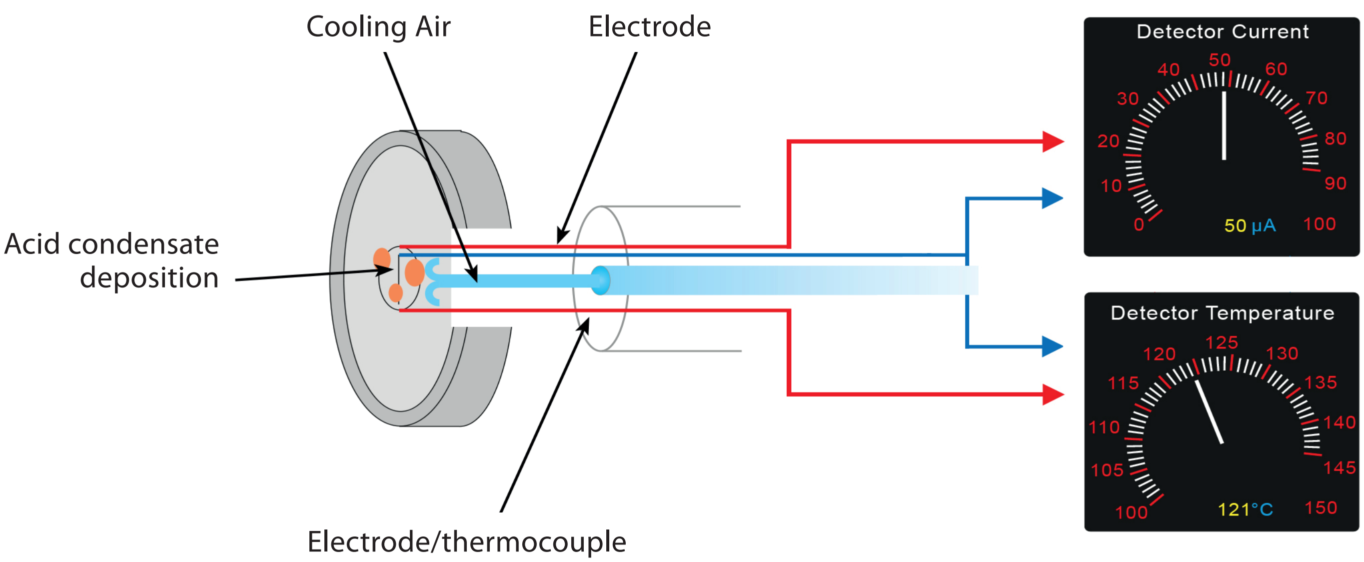
HOW IT WORKS | LANCOM 200 PORTABLE SULPHURIC ACID DEWPOINT MONITOR





USING THE LANCOM 200 TO MEASURE THE ACID DEWPOINT TEMPERATURE

SIMPLE TO SET UP, THE LANCOM 200 JUST NEEDS AN AIR SUPPLY. INTEGRATED BATTERIES PROVIDE UP TO EIGHT HOURS OF CONTINUOUS OPERATION. THE OPERATOR SIMPLY HAS TO WATCH THE DISPLAY, ADJUST THE AIR FLOW AND WAIT FOR THE DETECTOR'S CURRENT READING TO STABILISE. ADT READINGS ARE STORED EASILY TO A LOG FILE BY PRESSING ENTER ALONG WITH ALL ASSOCIATED MEASUREMENTS.



FEATURES

- Measure acid dewpoint temperature
- Calculate SO_3 and H_2SO_4 concentrations
- Fully portable – just requires compressed air supply
- Data logging
- Built-in printer
- Can measure throughout the flue gas path
- Store readings for later analysis
- Hard copy at the measurement point
- Cell can be replaced in the field

BENEFITS

- Optimise flue temperature and improve efficiency
- Avoid cold-end corrosion
- Manage fuel additive use
- Reduce opacity caused by "blue plume"
- Understand where acid condensation occurs
- Reduce sulphate aerosol formation
- Easy to maintain

THE OPERATION OF THE LANCOM 200 IS VERY STRAIGHTFORWARD:

1. Close the air valve on the Lancom 200 Portable Control Unit (PCU) by turning the knob on the front panel fully clockwise. Turn it gently until it comes to a stop. Do not screw it down tight.
2. Ensure that the PCU is connected to a supply of clean compressed air.
3. Switch on the PCU by pressing the red power button.
4. When the red message screen appears, press the Enter key. The display should show two large dials.
5. Insert the probe into the stack or duct. It needs a hole that is at least 50mm (2in) in diameter. Block any gaps around the probe with cotton cloth to reduce tramp air. Use the small knob in front of the probe handle to slide the flue gas thermocouple out beyond the end of the probe.
6. Allow the probe to heat up to the flue gas temperature. The detector temperature is shown on the right-hand dial. The flue gas temperature is in the bottom right corner of the screen. The left-hand dial shows the sensor current measurement. It may increase briefly as some acid condenses on the sensor; then it should return to less than 5µA. Wait until the readings are stable.
7. Increase the air supply slowly by turning the knob anti-clockwise. The air flow rate is shown by the blue bar below the dials. This will get longer as the airflow increases.
8. Increase the air supply until the detector temperature is dropping steadily. Watch the left dial until its reading starts to increase. Reduce the air slightly to slow down the rate of cooling. As the current reading increases, reduce the air further. The objective is to hold the current reading at around 50µA.

   Note: If you know the approximate ADT, you can set the sensor temperature to a few degrees above this value before making the final adjustments. If you reduce the sensor temperature too far below the ADT, the acid film may form very slowly, giving the impression that the sensor is still above the dewpoint.
9. When the current reading has been stable between 40µA and 60µA for about five seconds, press the Enter button to record the ADT. The message "ADT Stored" appears on screen.

YOU SHOULD WIPE THE SENSOR TIP WITH A SOFT CLOTH TO REMOVE DUST DEPOSITS EACH TIME YOU REMOVE THE PROBE FROM THE FLUE (CAREFUL – IT IS HOT!). THIS WILL PREVENT THE ACCUMULATION OF DUST AND OTHER CONTAMINANTS WHICH CAN AFFECT THE DEWPOINT READING.

PRACTICAL CONSIDERATIONS AND LIMITATIONS OF ACID DEWPOINT TEMPERATURE MEASUREMENT

IT IS IMPORTANT TO RECOGNISE THAT THE LANCOM 200 CANNOT MEASURE THE ACID DEWPOINT IN EVERY APPLICATION

SOME CONSIDERATIONS FOR SUCCESSFUL DEWPOINT MEASUREMENT INCLUDE:

- The limits of detection of an Acid Dewpoint Temperature (ADT) sensor is set by the time taken to form a measurable film of sulphuric acid on the sensor. At very low concentrations, the film forms slowly. A lot of patience is needed when measuring ADT below 130 °C (266 °F), and the minimum measurable ADT is around 125 °C (257 °F). That sets the detection limit for H_2SO_4 at approximately 5 ppm.

- Although it is not possible to make an exact calculation of the H_2SO_4 concentration based on the SO_2 content of the flue gas, the concentration is usually between 1% and 1.5% of the SO_2 concentration for a standard application, and may be twice as much after an SCR. Therefore, it is unlikely that an ADT could be measured on a process containing 100 ppm SO_2, but it should be relatively easy to measure on a process where the SO_2 concentration is 800 ppm.

- One of the largest uncertainties is the proportion of the H_2SO_4 which is adsorbed onto the fly ash. As noted previously, fly ash has a high affinity for H_2SO_4 and so there may not be enough free H_2SO_4 to measure if the fly ash concentration is high. In the past, this has been a significant problem when using ADT to estimate the SO_3 and H_2SO_4 concentrations in a coal-fired power plant, but the combination of high-sulphur coal and SCR has increased the amount of free H_2SO_4 in many modern plants, so that the measurement is feasible in many more places than in the past.

- The cooling air must be capable of reducing the sensor temperature below the ADT. The minimum ADT that can be measured (ADT_{min}) depends on the temperatures of the flue gas (T_{flue}) and the cooling air, which is usually at ambient temperature (T_{amb}). Measuring a low ADT in a hot stack can be very difficult; the minimum measurable dewpoint temperature can be estimated using this equation:

$$ADT_{min} = 0.65\ T_{amb} + 0.35\ T_{flue}$$

It is usually quite easy to measure the ADT in the stack, but temperatures before the air preheater are often too high to allow for an ADT measurement.

- Gas velocity and convective forces may have an influence at low H_2SO_4 concentrations – users have reported difficulty in measuring the ADT when the velocity of flue gas is very high, but there are no definite figures available.

APP NOTE

Optimum temperature is safely above ADT while staying as close to it as possible.

ALTHOUGH THE ADT MEASUREMENT DEPENDS ONLY ON THE CONCENTRATION OF H_2SO_4 AT THE SENSOR SURFACE, THE REACTION BETWEEN SO_3 AND H_2SO_4 IS SO FAST THAT ANY SO_3 PRESENT IN THE FLUE GAS IS CONVERTED TO H_2SO_4 ON THE SENSOR.

IT IS IMPORTANT TO REMEMBER THAT THE CALCULATIONS GIVING THE SO_3 AND H_2SO_4 CONCENTRATIONS DEPEND ON THE STACK TEMPERATURE AND WATER CONTENT, AS WELL AS THE ADT, SO THESE CALCULATIONS WILL NOT BE ACCURATE UNLESS THE FLUE GAS THERMOCOUPLE IS READING A REPRESENTATIVE GAS TEMPERATURE, AND THE WATER CONCENTRATION PARAMETER IS SET CORRECTLY.

CONCLUSION

ACID DEWPOINT TEMPERATURE MEASUREMENT GIVES VALUABLE INFORMATION ON THE COMBUSTION PROCESS. IT CAN BE USED TO ESTIMATE THE CONCENTRATION OF SO_3 AND H_2SO_4 IN THE STACK, AS WELL AS GIVING VALUABLE DATA ON PROCESS EFFICIENCY.

AMETEK LAND SOLUTIONS FOR COMBUSTION PROCESSES

LANCOM 4

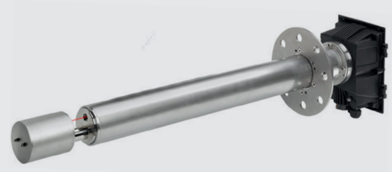
PORTABLE FLUE GAS ANALYSER

COMBUSTION & EMISSION MONITORING

4500 MkIII

COMBUSTION & EMISSION MONITORING

4650-PM



COMBUSTION & EMISSION MONITORING

4750-PM

COMBUSTION & EMISSION MONITORING

WDG 1200

COMBUSTION & EMISSION MONITORING

WDG 1210

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