

### **Introduction**

The recycle gas moisture analyser continuously indicates the moisture content of the recycle gas to facilitate monitoring and control of the water/chloride balance which is essential for optimal catalyst performance.

### **Moisture Analysers**

Historically, there have been 3 main technology types used for continuous moisture analysers in catalytic reforming applications: oscillating crystal, aluminium oxide and electrolysis. These are all “direct contact” technologies in which the sensor is immersed in the recycle gas sample stream. (More recently, a “non-contact” technology using tunable laser diodes has been successfully introduced to the market. These measure moisture by monitoring the absorption spectra generated by an infrared beam from the laser.)

The oscillating crystal type analyser measures moisture by monitoring the vibrational frequency change of a hygroscopically sensitised quartz crystal that is exposed alternately to wet and dry gas. Sample gas is divided into 2 streams, “sample” and “reference” which are alternately passed over the quartz crystal. The standard cycle for each is 30 seconds but operating experience has shown that the reliability of the analyser can be improved if the 30 second “sample” cycle is followed by an extended (eg. 9.5 minute) “reference” cycle. This prolongs detector life by minimising the cell’s exposure to contaminants as well as by removing volatile contaminants from the cell.

The aluminium oxide type analyser contains a sensor probe comprising an aluminium strip which has been anodised by a special process to create a porous aluminium oxide layer. A very thin coating of gold is evaporated over this structure. The aluminium base and the gold layer form the two electrodes of what is essentially an aluminium oxide capacitor. Water vapour is rapidly transported through the gold layer and equilibrates on the pore walls in a manner functionally related to the vapour pressure of water in the atmosphere surrounding the sensor. The number of water molecules absorbed on the aluminium oxide structure determines the conductivity of the pore wall. Each value of pore wall resistance provides a distinct value of electrical impedance which in turn is a direct measure of water vapour pressure. Since the active sensor is aluminium which is sensitive to corrosion by chlorides, the sensor should be replaced every 6 months. When a probe is changed it typically takes 3 – 4 hours to dry down and equilibrate with the gas flowing through the sample loop. The used sensor has to be returned to the manufacturer for recalibration, so it is strongly recommended that a small inventory of spare probes is kept on site.

The electrolysis type analyser uses phosphoric acid ( $\text{H}_3\text{PO}_4$ ). The sensor comprises a round glass body on which 2 electrodes are wound a constant distance apart. A thin film of  $\text{H}_3\text{PO}_4$  is applied between the electrodes and an electric current is passed across the sensor. The current causes the water contained in the  $\text{H}_3\text{PO}_4$  to dissociate to hydrogen ( $\text{H}_2$ ) and oxygen ( $\text{O}_2$ ). The oxygen reacts to form diphosphorus pentoxide ( $\text{P}_2\text{O}_5$ ).  $\text{P}_2\text{O}_5$  is a highly hygroscopic compound which absorbs the water present in the sample stream. An equilibrium is established between the water present in the sample stream and the water formed by continuous dissociation from the  $\text{H}_3\text{PO}_4$ . The current consumed by the electrolysis is proportional to the moisture content of the gas. The sensor requires cleaning and replenishment of the  $\text{H}_3\text{PO}_4$  every 4 – 6 weeks. The flow rate and pressure of the gas sample must be carefully controlled to maintain a constant mass flow of sample into the sensor.

### **Sampling System Design**

The sample point for the direct contact type recycle gas moisture analyser is normally located upstream of the recycle gas compressor to ensure the sample conditioning system cannot be contaminated by lube oil. The sample probe should be installed either in a vertical section of line or on the top of a horizontal section of line to minimise the possibility of liquid entering.

The analyser is normally located as close as practicable to the sample point to minimise the length of instrument tubing required and the risk of condensation or blockage occurring in the sample conditioning system. The sample line should be free-draining back to the process and should contain no pockets. It should be heat traced to around 65 °C and insulated for heat conservation to prevent the gas reaching its dew point (water or hydrocarbon). A bypass with a rotameter should be provided to ensure continuous flow through the sample conditioning system and maintain acceptable dead time. (Analyser dead times may be unacceptably long if no bypass is provided, especially if the analyser is located a long way from the sample point or if the flow rate through the sample line is small). The bypass should include an additional (accessible) valved sample connection to allow independent checking of the analyser reading. A filter should be provided upstream of the inlet connection to the analyser and the bypass connection.

The sample conditioning system, bypass line and exhaust/vent from the analyser are normally constructed from 6 mm diameter electro-polished 316 stainless steel instrument tubing. Joints are sealed with teflon tape.