MOISTURE AUDITS & ANALYSER PERFORMANCE ASSESSMENTS AT

WOODSIDE, KARRATHA

BY MCM Ltd, UK

24TH APRIL -28TH APRIL 2009.

OVERVIEW

Woodside had been experiencing intermittent blockages in 4/5 S1406 LNG trains since September 2008 and had been unable to pinpoint the source of the problems.

Repeated hydrate formations were leading to reduced productivity and the existing process monitoring instrumentation had failed to confirm moisture breakthrough on the beds. The site's existing Panametrics portable moisture analysers had proven susceptible to drift in both use and storage, exhibiting large hysteresis errors. Tests proved they were very slow to settle at the low moisture concentrations of interest making them unfit for such a diagnostic purpose.

A specialist in trace moisture measurement was contracted to carry out an independent moisture audit and performance assessment of the existing process monitoring moisture analysers in order to determine the source of water leading to the hydrate formations.

In order to determine the root cause there was a need to work through the process, starting at the mol sieve drier beds and systematically work downstream in order to quantify the contribution from each stage of the process and validate each test result against a known reference moisture source, before proceeding to the next test.

MCM, the contractor, provided the necessary moisture measuring instrumentation and validation techniques needed to confirm the source and quantity of any unexpected moisture found during the audit.

Woodside's process engineers requested MCM to focus on 3 areas of potential sources of water ingress, these being;

1. The driers which could, if incorrectly packed, lead to channelling in the desiccant;

2. The mercury guard beds and CO_2 scrubbers in the analyser house; as these were known to take a long time to reach equilibrium and may have been put into service prematurely by being insufficiently dried down;

3. The defrost systems on both trains, which, if compromised could be leaking.

TEST SET UP

Nine sample test points were set up and allowed to purge at low flow for at least 24 hours before testing commenced around these key locations to ensure representative sample conditions at each test point.

At the same time, MCM established a validation rig in the instrument workshop in order to provide a continuously monitored zero (dry gas) 'datum' against which any test equipment used on plant could be cross checked prior to, and after, each test run.

This validation set up comprised of a dry gas generator which was continuously monitored by a sensitive reference hygrometer that was calibrated for the exercise.

The validation set up had 2 purposes. One being to provide a 'dry datum' against which MCM's portable hygrometers, used for the field tests, could be cross checked between each test, in order to confirm there was no deterioration in zero value before moving on, and the other, to provide a 'docking' station for drying down the instruments and pipe work in between tests, for consistency.

METHODOLOGY

This methodology of 'bracketed' zero checks was a critical component in assembling significant data since it provided a reliable, precise and convenient mechanism for confirming the repeatability of results before and after each test, at the dry points in question.

All the tests were performed at atmospheric pressure to ensure traceability of results and all necessary precautions were taken during transportation to and from each test location in order to prevent moisture ingress from contaminating data.

After every test the same pipe work used to connect between the sample and analyser was placed on the docking station dry gas to recondition it before its next use.

The portable hygrometers to be used were checked both pre and post test by running the dry reference through them when not in use and recording the dry values to confirm no significant drift was being introduced by gas contaminants or through over exposure to ambient air or poor handling, as any of these could have introduced significant errors, particularly at the dry levels being investigated.

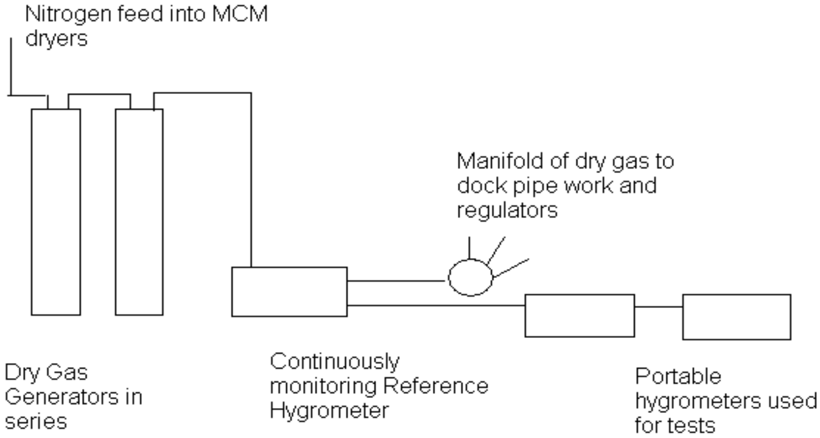
This methodology also provided a mechanism for checking sensor responsiveness, which was critical in establishing that the analyser had settled before recording final values.

Repeatability of results was ensured by use of a patented temperature controlled sensor with a sensor drying feature which raised the sensor temperature above the boiling point of water on demand in order to ensure each measurement was approached from the same dry starting condition. This drying feature was used automatically before each test and again to validate results once readings had settled by ensuring the readings closely agreed before and after drying.

See reference 1. ***Microview test graph and letter***

All gas flows were set at similar values, approx 300 ml/min during testing. The same pipe work was used on each test and identical sample connection and zero check procedures were applied for consistency of method.

All collected data was recorded on a spreadsheet for analysis by site engineers.



MCM Validation System used at Woodside to provide conditioned pipe work and cross check facilities against a continuously monitored dry gas supply.

Activities were centred on LNG trains 4 and 5 which had been exhibiting hydrate formation for several months.

The existing process oscillating crystal moisture analysers were not detecting sufficient moisture increases on the dehydration beds to raise any alarms. A test program was agreed to investigate each stage of dryer changeover working on a continuous shift system of 2 men working 12 hour shifts taking tests every 2 hours throughout the dryer regeneration cycles in order to quantify moisture concentrations during process changes. Additional tests were carried out at the mercury guard beds, scrubbers and defrost circuits during cold and hot operation.

SUMMARY OF RESULTS

Each field test was preceded with a cross check of the portable by comparing its value on dry gas against the zero value being monitored by the reference monitor in the workshop. Once dry values had been logged, the portable was taken to site and a test performed, the unit was then carefully capped and immediately returned to the workshop to cross check against the same reference dry gas to log any discrepancies.

Preliminary checks of all tests points confirmed the beds exhibited only minimal increases in moisture during regeneration cycles, with trains 4&5 (QT007) showing a 0.2 ppmV increase over the reference dry gas ‘datum’ set up in the workshop.

Importantly, printouts for the existing Ametek process analysers showed they did not detect the same quantities as those reported by the audit instruments, raising questions over their loss of sensitivity.

Moisture readings at the mercury guard beds and CO2 scrubbers also showed significant and repeatedly elevated moisture levels (0.8 and 0.5 ppmV).

By far the largest concentration of water was identified in the defrost heaters, which significantly showed much higher values when heating (ranging from 1.3 when cold up to 22ppmV when running hot (exceeding 55Celsius) suggesting leakage from the heat exchangers. See results in excel spreadsheet - already handed over to Woodside.

The data suggested that a water leak was highly probable within the defrost circuit and repairs should be initiated as soon as possible.

CHANGES TO THE SCOPE OF WORK

Once the initial audit work had been completed the test program was modified, as requested, to investigate the possible loss of sensitivity of the process Ameteks.

MCM introduced a trace moisture generator into the on line sample system, immediately after the pressure reducing valve and before the inlet to the Ametek ex D housing. The moisture generator was constructed to add small but significant moisture changes into the sample stream. It was connected in-line with the MCM portable and online analyser in order to investigate whether the online was able to detect the small change being introduced and compare its value with that logged by the portable unit.

The portable unit was cross checked before the test on dry gas and also compared with the generator using the dry gas reference as a source.

Observation

When exposed to a steady 1.1ppmV from the moisture generator the online Ametek on train 4 read a peak value of 0.54ppmV in the control room.

The train 5 unit was already under suspicion by QMI as it had been reported as periodically ‘flat lining’ for some time.

A similar test performed with a slightly wetter generator setting could not confirm if that process monitor’s sensitivity had been compromised because the generator value of 5.4ppm exceeded the process monitors span setting of 2.5ppmv. Consequently, the value at which it settled, and therefore the extent of its sensitivity could not be established, without setting a lower generator value.

Unfortunately, a retest at a lower moisture level was not possible in the time available.

CONCLUSIONS

The moisture audit had identified a range of moisture issues in the plant.

Whilst responsive at levels above 1 ppm, sub ppm moisture contents at the common outlet had been undetected by the plant process analysers due to loss of sensitivity at these trace levels.

The Ametek process analyser, on T4, detected significantly less than 50% of the moisture being injected by the moisture generator, as referenced by the validation system. The sensitivity of the T5 analyser could not be assessed at the time.

If the process monitor's sensitivity had degraded and/or, if their base zero reference level was compromised, then, it is possible that trace water concentrations identified as 0.2 ppm above the 'reference zero datum' could be missed allowing water to leach into the system, eventually leading to hydrate formations.

The construction of the process monitoring systems working under a 1.5 Barg back pressure and using Ex D housings compounded the problem by making practical validation difficult as any measurement at the analyser would require isolation and pressure compensation that invalidates traceability.

The absence of an external validation method by which to validate dry gas levels and check span on the process monitors raises serious implication for Woodside and is the most likely reason for the problems remaining undetected for so long.

Although picked up on audit the higher moisture concentrations detected at the guard beds and scrubbers had not been identified by site. It was not clear if any routine moisture monitoring was performed at these locations.

RECOMMENDATIONS

Portable test equipment
Woodside confirmed they presently operate Aluminium oxide type portable hygrometers for spot checking moisture conditions around the plant at the 20vpm and 60vpm levels.

Aluminium Oxide technology is well documented to have large temperature coefficients, large calibration drift in storage, slow response and high hysteresis.

Even at much wetter levels than those investigated, these characteristics make them unfit for purpose in such field applications within the timescales normally applied by operators. ***See reference 2.- BJ Services report comparing several Al Ox devices.***

Using such instruments without an adequate validation methodology only leads to confusing and unreliable information. Such instruments should not be used on dry LNG applications without the necessary support structure to validate their performance and settling times, particularly at dry levels (below 10ppmV).

This should be carefully considered when reviewing the need for spot check moisture measurement.

A dry down test performed on the Panametrics in the presence of the QMI engineer confirmed they were slow and suffered from significant hysteresis effects. Suitable replacement hygrometers should be identified which can provide faster, more stable and repeatable results in the variable ambient temperature conditions found in Western Australia.

They should be temperature controlled for stability and traceable to appropriate units of measure (Mass if measuring in ppm) in order to provide traceability and auditable results.

They should have fast settling times to minimise sample exposure and to help reduce the risk of contamination pick up.

Validation Issues
Presently all of Woodside's moisture instrument calibrations are traceable to Temperature. It should be noted that in any dispute over accuracy such certificates refer to known conditions of temperature and pressure, normally 23 Celsius and atmospheric pressure.

When operating outside these specified conditions they offer no traceable information as to the analyser's performance under field conditions (if data is collected at different temperature or pressure conditions) or if data is presented in different units of measure to those they were originally calibrated in.

Given the present lack of any validation methods, or suitable portable equipment on site, an appropriate validation system should be installed at the earliest opportunity in order to allow site engineers to characterise performance of any moisture analyser, on demand. Ideally, this should include dry gas and a span value ranged for the applications in question.

Due to the demanding challenges of monitoring at trace ppm moisture levels any online systems monitoring moisture on the common outlet should have the capability to be *independently* validated against an external zero and be routinely checked for any loss of span.

Recommendation; A local validation capability should be installed.

Recommendation; validations should be performed more frequently than currently practiced.

On Line Analysers
The existing process units, being housed in ex 'D' enclosures make frequent validation work impractical, requiring deviations and permits to enable even the simplest of cross checks to be carried out.

As the moisture audit has shown, it is insufficient to rely on an annual recertification of dry gas and span moisture values at these trace concentrations because the acceptable tolerances can be easily compromised within much shorter time periods.

Recommendation; Move towards intrinsically safe systems.

Such intrinsically safe systems can be worked on without powering down and would allow field validations to be performed without the need to seek ‘deviations to operation’ or raising complex work permits.

For the high precision being demanded on the LNG common outlets, daily or weekly validations would be more appropriate for such low level applications.

Recommendation; to consider adopting systems with automated zero and span correction that can be activated on a more frequent basis than are being applied at present.

Recommendation; site to independently monitor and control the integrity of their dry gas reference in order to enable independent validations to be performed on demand

Immediate actions

- Install an in house Validation capability
- Upgrade the portable hygrometers as required
- Install moisture monitors on the scrubbers or monitor with appropriate portables
- Review the on line operating methodology with respect to enabling more frequent and independent performance validations to be carried out by site engineers

Future considerations

Investing in a diversity of analyser technology would be helpful in early detection of such moisture issues.

Woodside may want to consider installing a dual channel intrinsically safe system on the common outlet that offers both on line validation and independent cross checks to be performed on both dry gas and sample in order to act as a ‘catch all’ high accuracy analyser.

REFERENCES

1. ***Microview test graph and letter***

2. ***BJ Services report comparing Al Ox sensors***