

MEDIUM

WATER TODAY

RELEASE

ISSUE 10 / 2012

TYPES OF WATER

PROCESS WATER / INDUSTRIAL WASTE WATER /
BOILER FEED WATER / CONDENSATE RETURN

PARAMETERS

TOC / TC

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On-line Process Analyser for Return Condensate, Steam Condensate and Boiler Feed Water



By use of an on-line TOC-analyser the quality and the organic content of the boiler feed water and the return condensate can be monitored. Obviously, these TOC-analysers should be reliable, easy to validate and of outstanding quality.

By Piet Broertjes

Small impurities in boiler feed can lead to big consequences

A relatively small industrial boiler installation or co-generator produces about 100 tons per hour of High Pressure Steam which is used to drive powerful turbines and gas motors to generate electricity. The boiler systems efficiency is improved by using some of the medium pressure steam to preheat the boiler feed water. Because the medium and low pressure steam still contains more than enough heat and energy it's very profitable to sell and export it to nearby industries, such as refineries and chemical plants. This steam flows through many heat exchangers where all kind of fluids like oils and

chemicals are heated-up. While the temperature and the pressure drop, it ends up as condensate.

As the costs of the production and preparation of make-up water and boiler feed water entail a great deal of expenses it is very lucrative to reuse the condensate and feed it via an industrial high pressure feed pump back into the boiler. Secondly the residual heat of return condensate makes it extra attractive to reuse it. Corrosion in condensate systems needs to be avoided. Iron and copper corrosion products can deposit on boiler heat surfaces, which reduces the heat transfer and could cause even tube failure. If carbon dioxide dissolves in the boiler water it forms carbonic acid. Hot water with dissolved carbonic acid causes the corrosion rate to increase. Therefore, the boiler is protected by use of chemical treatment e.g. oxygen scavengers, neutralizing amines, filming amines, polymers, lime and/or phosphate. As more condensate is returned, less make-up water and costly treatment chemicals are needed.

But there is a reverse to every medal. Heat exchangers can start to corrode with the risk that they can start to leak. The consequence is that chemical products leak into the return condensate and finally will enter into the buffer tank and even the boiler system. Obviously this effects the correct and long term operation of the boiler system. Especially, high pressure boilers are sensitive for impurities because they are the cause of pit corrosion, scaling, loss of efficiency etc. In a



Figure 1: Co-generator

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worse case scenario the boiler unexpectedly shuts down and most processes within the plant(s) also have to be shutdown. It involves the loss of large sums of money. Small impurities can lead to big consequences. By use of a TOC-analyser the condensate return and boiler feed water can be monitored and potential leaks can be detected in an early stage. This can prevent a lot of trouble and save lot of money.

Experiences with the thermal 1200 degree Celsius oxidation TOC-technique

ODS Sampling & Analytical Systems has built many TOC-installations to monitor the purity of make-up water, boiler feed water, return condensate and steam condensate. During the years, all kind of TOC-analyser makes, types and measuring principles are used and tested. Since last five years ODS uses the Quick-TOC-analyser, manufactured by LAR Process Analysers AG, Berlin, Germany. This TOC-analyser is very suitable for the condensate application. It uses an ingenious multi-loop injection system. Firstly, the sample is sucked into a loop. Obviously its volume is precise and constant. Then the sample in the loop is injected into a ceramic reactor tube that is maintained at a temperature of 1200 °C. No catalyst is used. For sure, all traces of organic carbons in the sample are rapidly and completely oxidised to

carbon dioxide (CO₂). A constant carrier gas flows through the reactor. It flows, together with the CO₂-gas, to a Non Dispersive Infra Red (NDIR) CO₂-detector. The measured CO₂-peakarea is linear proportional with the TOC-content in the sample. In case of a very low TOC-range the loop is quickly injected multiple times (multiple loop injections). The batch sample injection principle has the advantage that it automatically compensates for any drift e.g. detector aging, temperature drift, base line drift, etc. Its reproducibility is outstanding. In principle recalibration is not needed. The performance of the on-line Quick-TOC-loop analyser has proved to be outstanding.

Time is money

What actions need to be taken when the TOC-analyser alarms? Obviously somewhere in these production plants a heat exchanger starts leaking and product contaminates the return condensate. The first priority is to prevent that this contaminated return condensate flows into the buffer tank and the boiler. The return condensate flow is high (e.g. 100 tons per hour). Therefore, it is of vital importance that the TOC-analyser system responds very rapidly. It's a matter of minutes or even seconds. Immediately after the TOC-analyser alarms, the plant operation will activate a process drain valve and now all contaminated return condensate is spilled and flushed to drain.

The boiler will continue to operate by using pure water out of the buffer tank. Also extra make-up water is supplied to the installation. But the clock is ticking. As fast as possible



Figure 2: Inspection of a TOC-analyser in ATEX zone 1

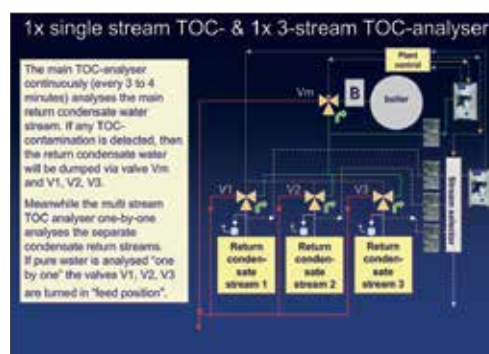


Figure 3: Block diagram: Boiler and TOC-analyser system

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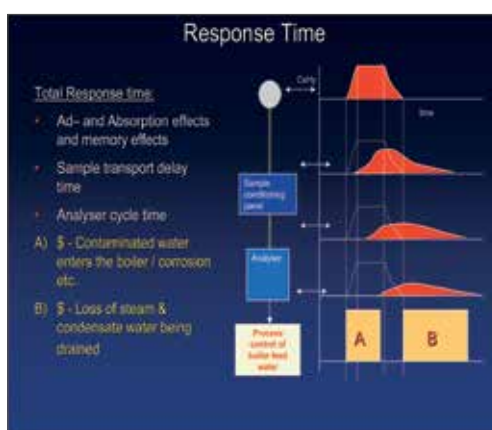


Figure 4: Block diagram Boiler and TOC-analyser system

the problem should be fixed. The plant operators can do the following:

- Search in the process, which of the production plant has a leaking heat exchanger. Ideally the TOC-analyser is equipped with a stream selector that sequentially switches the independent sample streams to the analyser inlet. Such

a multi-stream TOC-analyser can run automatically or via remote control. One-by-one they switch-on the separate return condensate return stream. Then finally, when they know which production plant has a problem, they can start to look to which specific heat exchanger is leaking. The speed of the TOC-analyser installation is of great importance.

- Then they collect grab samples that are manually taken down stream of the heat exchangers. These grab samples can be analysed then one-by-one. Depending of the speed of the analyser, this procedure can take several hours. The on-line TOC-analyser should have a separate input to analyse these grab samples.
- Furthermore, the plant operation will demand the immediate evaluation of the TOC-analyser. Generally that is performed by using a standard solution with a known TOC-concentration e.g. 0.5 ppm (500 ppb). But it can be very problematic to prepare such a standard. These standards are very unstable and the TOC-concentration decreases, even when they are stored in a fridge. The preparation of such a low range wet standard, even under laboratory conditions, can take several hours.

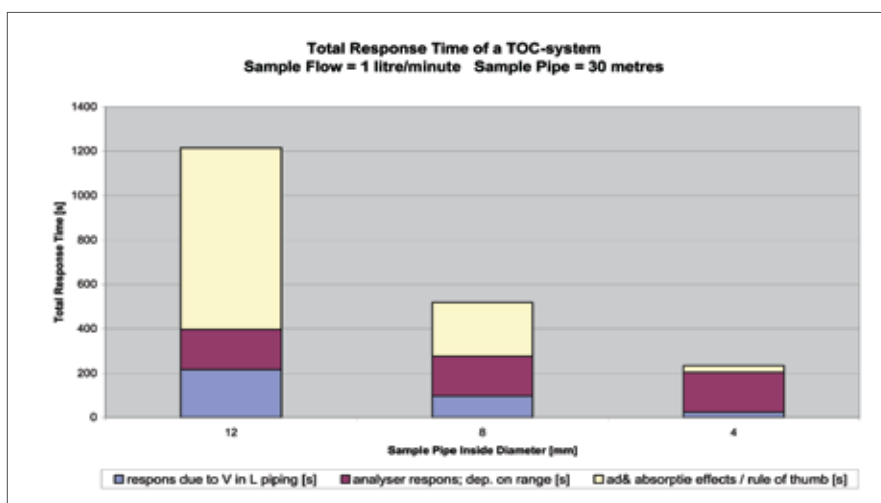


Figure 5: Total Response Time of a TOC-system

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Conventional TOC-analysers and their typical analytical problems

Conventional TOC-oxidation techniques suffer from physical phenomena such as adsorption, memory and carry over. These phenomena cause the analyser to respond slowly and measure incorrectly and inaccurate:

- Adsorption: Traces of organics carbons, especially the sticky types and long chain molecules, easily absorb to all wetted surfaces. This adsorption effect tremendously slows down the TOC-measurement.
- Memory: After monitoring a sky high TOC-peak, e.g. a heat exchanger breakthrough, it can take more than an hour for the measured TOC-value to come down to the correct value. This phenomena is called memory effect.
- Carry over: Hard to oxidise components tend to lead to hysteresis effects. When the TOC-concentration changes stepwise, the high TOC-values are measured too low and low TOC-values are measured too high. This effect is called carry over. Obviously, it leads to incorrect TOC-measurements. This especially is a big concern when the TOC-analyser is used to monitor multiple sample streams or a series of grab samples.



Figure 5: Certified Validation Gas

The features of the new Quick-TOC-condensate

LAR's R&D team has designed, tested and patented a brand new analyser, the Quick-TOC-condensate. Field experiences, as well as the feedback and comments of end users, were inventoried and used for the development of this unique low range TOC-analyser. Its design is bright and clever and well thought out. Some of its unique features are:

- It is rapid and fast. The sample comes in contact with only inert materials like glass and Teflon. Prior to injection all wetted parts are conditioned by rapidly flushing them with the fresh sample. Adsorption, memory and carry over effects are eliminated due to the use of the 1200 °C thermal oxidation technique. Within minutes traces of impurities in the sample will be oxidised. This technique is very suitable for the fast multiple analyses of condensate return streams.
- It is equipped with a grab sample input. Temporarily the analyser can be switched over to a single stream measurement mode and then grab samples can be analysed one by one. Meanwhile, the TOC-signal to the DCS is frozen and a pause contact indicates that the analyser is in the off-line mode.



Figure 6: Quick-TOC-condensate with inject loop and inlet for wet standards or grab samples

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Figure 7: Analyser shelter with 3 each heat exchangers

- It offers the patented gas validation feature. This is really what makes the Quick-TOC-condensate analyser super attractive. Anyone at any moment can easily and rapidly evaluate the TOC-analyser. No wet standard is needed. It is performed by use of a certified gas mixture e.g. carbon

dioxide/nitrogen or methane/nitrogen. The injection loop is flushed and filled with this certified calibration gas. Then the loop content is injected into the reactor. The TOC-analyser responds with a well known, repeatable reference measurement. By use of the multiple loop injection technique several reference points will be measured. The gas validation routine can be triggered by use of a push button or via remote control. Via the routine a series of up to 10 results are measured. Then it calculates the mean concentration and the deviation.

- It also has an input for a wet standard. This feature is offered for those who periodically want to evaluate or calibrate the TOC-analyser by use of a wet standard.

These features match exactly with the needs for the condensate application as described before.

The design of the complete analyser system:

ODS Sampling & Analytical systems has delivered and installed over 25 return condensate and boiler feed water TOC-systems, mainly in the Benelux. We are skilled in the engineering of a

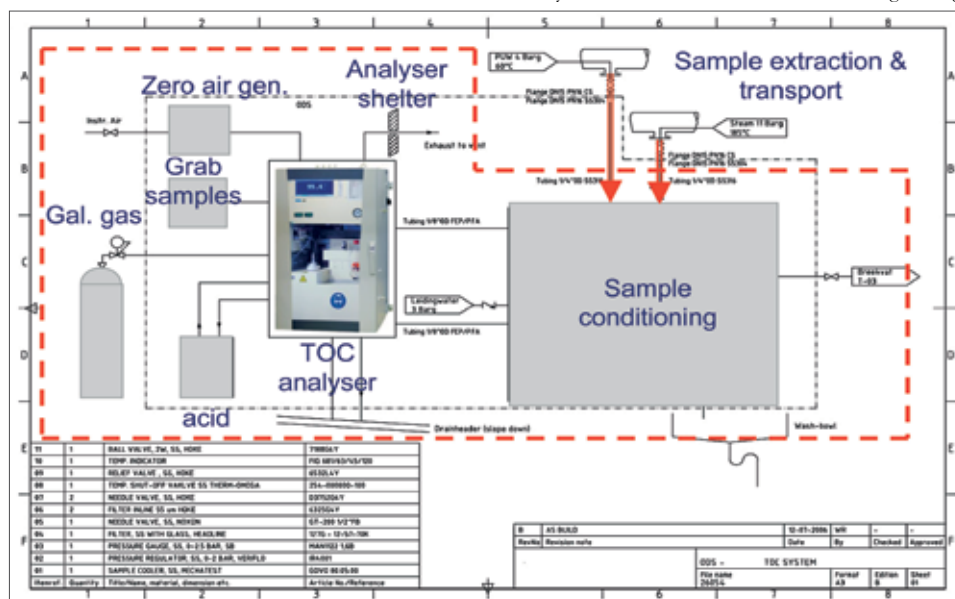


Figure 8: TOC analyser installation

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Figure 9: TOC-analyser model Quick-TOC-condensate

custom made design of the complete TOC-analyser system. It is of vital importance to install the sample probe at the correct location and use the correct size and type of sample lines. The velocity of the sample in the sample line should be at least 1 m/s. The contact time and wetted surface is minimized eliminating adsorption- memory effects and built-up by particles and spongy residues. The sample conditioning system should be capable of reducing the sample pressure and temperature and if needed take out particles. Normally the TOC-analyser is installed in an analyser walk in shelter, if needed equipped with HVAC. If it is placed in a hazardous area the analyser system is supplied in Explosion Proof housings and cabinets.

First weigh the considerations, then take the risk

There is a famous statement, “Many know what it costs, but only a few know what it is worth”. Recently, we have seen a case where the brand new installed TOC-analyser system proved a pay back time of less than 1 month. The analyser system was in operation for just a few weeks when a heat exchanger was damaged caused by fluid hammer. The measured concentration

was rapidly exceeding the analyser measuring range of 50 ppm. It went sky high. The pure water process piping was completely polluted by the product. Thanks to the TOC-analyser the plant operator could switch a drain valve and no other installation parts were polluted. Cleaning and flushing of it took a month. It was a stressful situation so personnel forgot to switch off the TOC-analyser and it measured a concentration of about 4000 ppm for over three days. Then finally demin water was connected to the TOC-analyser’s sample inlet. Within 10 minutes the analyser was measuring normal low ppm levels. This shows the lack of any memory effects. Over the years ODS has learned valuing the specific quality characteristics of the Quick-TOC-condensate analyser. It’s unique in its kind and we gladly use it into these projects.

1. Guidelines for boiler water quality are getting more stringent. Especially when the boiler pressure is high the Total Organic Carbon concentration limit is very low e.g. 0.1 to 0.5 ppm (milligram carbon/litre).
2. By use of an on-line TOC-analyser the quality and the organic content of the boiler feed water and the return condensate can be monitored. Obviously these TOC-analysers should be reliable, easy to validate and of outstanding quality. Also the correct design, construction and implementation of the total TOC-analyser installation are of great importance.
3. It includes the sample take-off point, a fast sample loop and a sample conditioning system. Furthermore the TOC-analyser should have capabilities to be calibrated and validated.
4. The new Quick-TOC-condensate of LAR Process Analysers AG has a unique patented easy to use gas validation feature. Furthermore, this analyser is fast and capable of sequentially analyse multiple streams and/or manual taken grab samples.

ABOUT THE AUTHOR



Piet Broertjes is an environmental project engineer at ODS Sampling & Analytical Systems, Barendrecht, The Netherlands; he has over 25 years of experience in designing and implementing on-line TOC-analyser systems to monitor return condensate and boiler feed water.