FLOWSERVE GESTRA

GESTRA
Special

Conductivity Measurement Equipment for Steam Boilers and Condensate Systems

- *From absolute measurement to BUS-capable 4-electrode measurement compensated for temperature, fouling and polarity with TÜV approval as per VdTÜV bulletin "Water Monitoring 100"*

Experience In Motion

SPECTOR*bus* – One System for All Requirements!

With the bus-capable four-electrode conductivity system of the SPECTOR family, GESTRA AG is already offering the fourth generation of components for safety equipment.

History of the development:

With the introduction of automatic continuous blowdown control at boiler plants and the conductivity monitoring in pressurized hot-water and condensate systems, the equipment initially used was of a type that evaluated the absolute conductivity. A particular drawback for the operators of the plants lay in the quality of the measurement, since the influence of the temperature on the conductivity (rising approx. 2-5 %/K, depending on the medium) completely clouded the measurement results. If, for instance, the technical codes stipulated conductivity values of 10,000 µS/cm, the devices had to be set to 50,000 µS/cm or more, to account for the influence of temperature. This situation repeatedly led to errors in interpretation.

With the increasing modernization and automation of boiler systems as well as the development of new boiler plants, there were increased demands on the precision of the monitoring equipment. In following the progress in boiler construction, the codes demanded ever lower conductivities in the boiler water together with improved quality in the measurement systems.

Continuous blowdown controller LRR 11 of the first generation without temperature compensation

With this unit, only a very coarse setting was possible, i.e. the selector switch was varied from right to left until the indicator light went dark, then adjusted 2 steps higher to give some leeway for the concentration of the boiler water.

What developmental steps were taken?

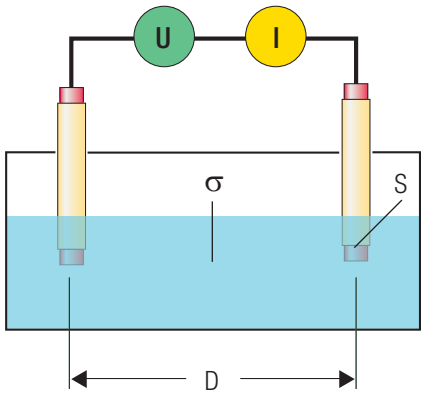
❶ Conductivity measurements without temperature compensation

In the early days of conductivity measurements for steam and condensate systems, the conductive measurement approach was applied, as had already become common for level measurement.

The basis for this approach was provided by Ohm's Law (R = U/I).

In conductive measurement, the resistance is a function of the particular liquid to be monitored, the distance between the measurement surfaces, and the measurement area.

In contrast to level measurement, the influence of surface area is entirely unwelcome, i. e. the electrode must be designed so that only a clearly defined sensing area is used for the measurement result. Solution: the electrode rods are insulated, except for the desired measurement area (cell constant).



U	voltage	σ	conductivity
I	current	α	temperature factor
R	resistance	C	salt concentration
S	area	T	temperature
D	distance	Tx	temperature at working point

$U = R \times I$

$R = D : (S \times \sigma)$

$\sigma = f(C, T)\ S/cm$

$\sigma = \sigma\ 25\ (1 + a / 100\ (Tx - 25\ °C))$

$\alpha = 2 - 3\ \% / K$

$\alpha = 1 / R\ [S / D = 1]$

❷ Conductivity measurement with manual temperature compensation

On the basis of the experience gained in practical operation and with the aim of being able to offer improved measurement systems, the next step was taken – equipment with manual temperature compensation. Here too, the familiar two-electrode measurement procedure was used. With the introduction of manual temperature compensation, there was now the added advantage that the conductivity was referred to the working point of the boiler plant at 25 °C. This was a basis for the demands expressed in the codes. Now the boiler attendant was in a position to set the desired conductivity, referred to 25 °C. A prerequisite for this is, however, proper calibration for the influence of temperature on the measurement result, by means of a comparison measurement using a sample cooler (e. g. PK 45).

This advance was rapidly accepted by the market and implemented in numerous boiler plants. It is still widely in use today. The devices were extended with a 4-20 mA current output, which was used for a remote indicator or for the additional connection of limit detectors (min./max.) in monitoring the entire control circuit for continuous blowdown and conductivity measurement (electrode, cable and valve).

With the advancement of boiler house automation, the more stringent demands on the boiler water quality (with the limit of 6,000 µS/cm as per EN standard) and the need for optimized measurement systems, the limits of this technology were reached. The question that had been posed more and more frequently was: what happens in the case of

- pressure fluctuations and the associated temperature variations
- temperature variations in condensate lines
- plants in which the service pressure is reduced temporarily, and so on.

Such questions always addressed the influence of the temperature on the conductivity measurement.

Continuous blowdown controller LRR 1-5 of the second generation with manual temperature compensation

❸ Conductivity measurement with automatic temperature compensation

In pursuing the objective of always offering the right measurement system to suit both the needs of our customers and the advanced requirements of the technical codes, we considered, during the development of the SPECTOR family, the simultaneous advances in the VdTÜV bulletin "Water Monitoring" (WÜ 100) and incorporated them into the products. This resulted in systems which have a Pt1000 temperature sensor integrated into the electrodes and hence continuously sense the temperature to integrate it into the result of the conductivity measurement. In this way, it became possible to ensure that the displayed and the evaluated conductivity values were always referred to 25 °C independently of any temperature fluctuations. In the previous electrode configurations, the wall of the boiler, vessel or pipe served as the reference electrode. Because of the integrated protection tube, the new electrodes had a defined reference electrode, which led to a further improvement in the measurement accuracy. This enhancement prompted an application for a type examination of the conductivity measurement systems of the SPECTOR family. The basis of the examination was provided by the draft of the now-published VdTÜV bulletin WÜ 100 *), issue date 07/2006. The approval number was already granted in 2001. From the viewpoint of many external experts, this was one of the foundations for 72h operation according to TRD 604.

*) *Water Monitoring 100*

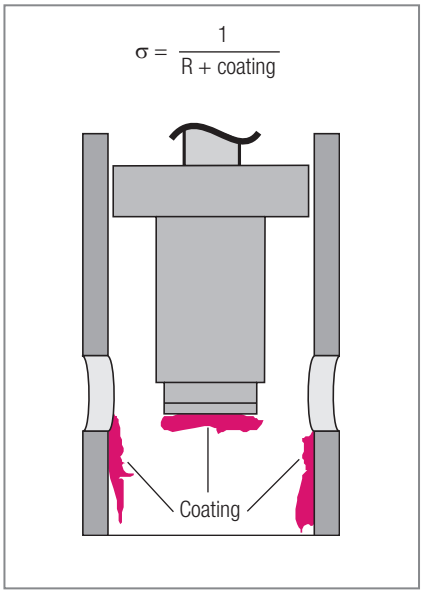
❹ SPECTOR – the future has already begun

With the latest product of the SPECTOR family, GESTRA AG again blazed a new trail in boiler equipment, strengthening its position as a market and technology leader.

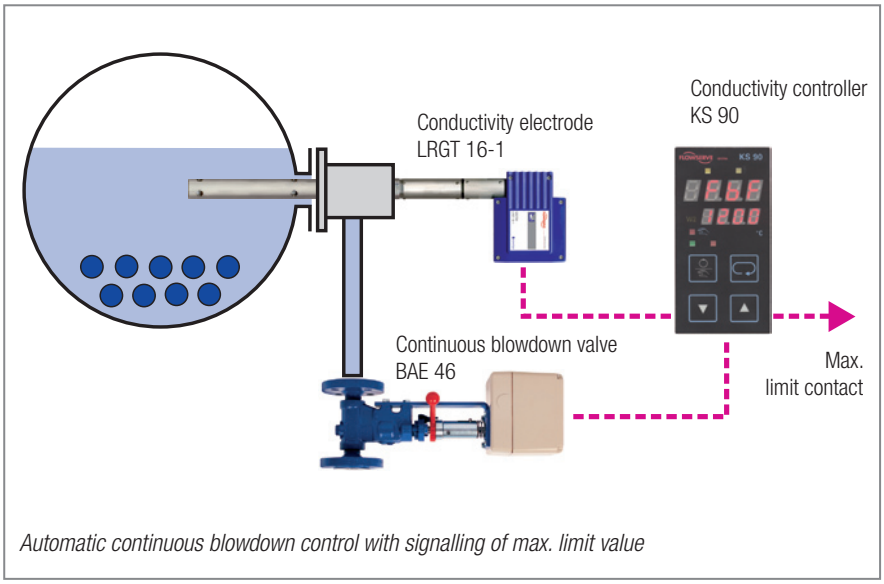
Through the continuous surveillance of our products by the quality assurance section and our laboratory, it was found that there were repeated complaints about the quality of the measurement results yielded by the systems described above. Investigations showed that, as had already been the case in the past, the quality of the water treatment or the handling of the plant and the resulting water quality are the decisive factors affecting the quality of measurement. Electrodes exhibiting various kinds of damage and impairment were submitted as part of the complaints.

If the diagram shown alongside is considered in view of the principle of conductive measurement, it rapidly becomes clear that the deposits will increase the resistance, i. e. the conductivity will appear to decrease.

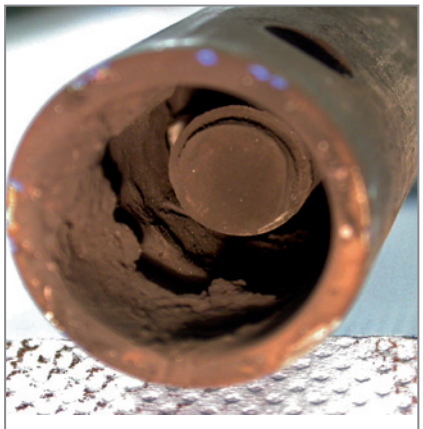
These results and our desire to achieve reliable and accurate measurement convinced us that we had to optimize the measurement system for the conductivity range from 500 µS/cm, as is required in industrial steam boilers, for example.



Insulating layer of phosphate



Automatic continuous blowdown control with signalling of max. limit value



Magnetite deposits

The result provided by our Design and Development Department is the new four-electrode measurement method.

For this system, the conductivity sensing electrode consists of two current and two voltage electrodes. The current electrodes are used to apply a measurement current (U_I) with a fixed frequency to the medium; a potential difference then arises between these electrodes ❶.

This potential difference is sensed by the voltage electrodes ❷ and evaluated as the measurement voltage U_U. The relationship between current and voltage is proportional to the conductance. Any line resistances, polarization effects or fouling of the electrodes are compensated.

Moreover, the electrical conductivity varies with temperature. In order to relate the measurement values to a reference temperature, a Pt1000 resistance thermometer integrated into the electrode rod is used to measure the fluid temperature.

The electrical conductivity is then calculated from the measurement values U_U and U_I and, depending on the set temperature coefficient "Tk", is referred linearly to the reference temperature of 25 °C. After conversion into a current signal that is proportional to the conductivity, the output is available as a current of 4-20 mA (LRGT 16-2) or as the corresponding signal on the bus (LRG 1x-41).

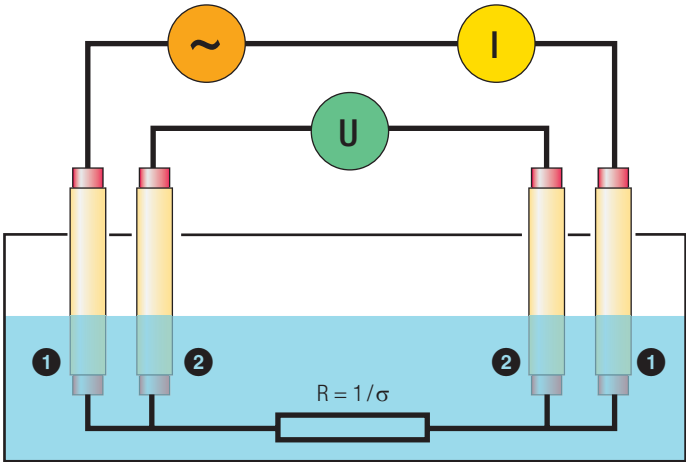
The lines to the measuring electrode and resistance thermometer are checked for interruptions and short circuits; moreover, the electronic circuit board is protected against excessive temperatures in the terminal box.

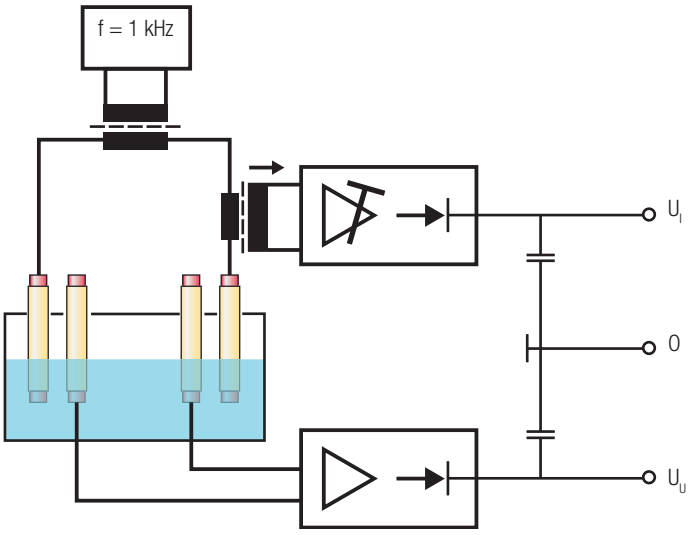
The four-electrode measurement system was type-approved in 2007, also on the basis of the VdTÜV bulletin WÜ 100 *) (issue date 07/2006), in the combinations SPECTORcompact (LRGT 1x-2** / KS 90) and SPECTORbus (LRG 1x-41** / LRR 1-40).

In conjunction with the system enhancements in the control unit, such as:

- the possibility of selecting the temperature compensation mode as Tk-Manu, Tk-Norm or Tk-Auto for optimized adaptation to the water treatment
- 24h purging pulse for the blowdown line / valve
- integrated program-controlled intermittent blowdown with pulse repetition
- an adjustable repetition rate for the intermittent blowdown pulses
- temperature-compensated display of the actual value, and
- the capability of choosing between three-position control (closed / operation / open) and three-position stepping control etc.

measurement systems of a much higher level of sophistication are achieved.





Conductivity (25 °C) = U_I / U_U x MB / (1 + Tk / 100 x T_{op} – 25 °C)

Thanks to the three-position stepping control, there is the possibility of controlling the actual TDS value of the boiler water as close as possible to the limiting value specified by the EN/TRD codes or to the requirements of the boiler manufacturers. The result of this operation mode is an increase in the concentration factor (the relationship between the quality of the feedwater to that of the boiler water) and, associated with that, a reduction in the ensuing continuous blowdown losses.

Continued:

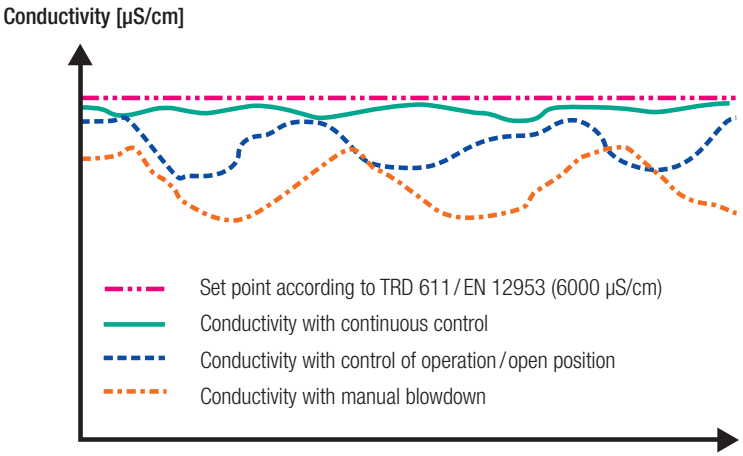
SPECTOR – the future has already begun

A reduction in the continuous blowdown losses will also help to cut costs, because less fresh water will have to produced by the water treatment plant, heated up in the deaerator or boiler, and then later cooled down by cooling water before it is discharged to the sewerage system.

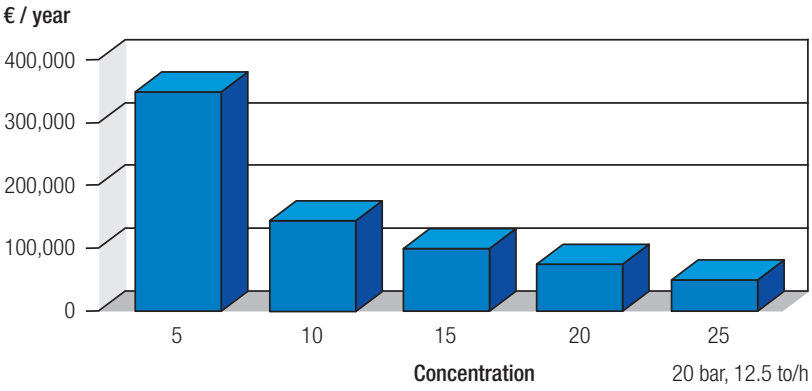
With the continuous blowdown valve BAE 46-40, we now offer – to supplement the measurement functions – a valve which has a CANopen interface in conjunction with the actuator EF 1-40. The signals for communication, driving and feedback (such as valve position, temperature in the body, blockage detection etc.) are sent directly via the CANbus.

You too can benefit from the possibilities of modern and reliable boiler safety technology. Why settle for anything less?

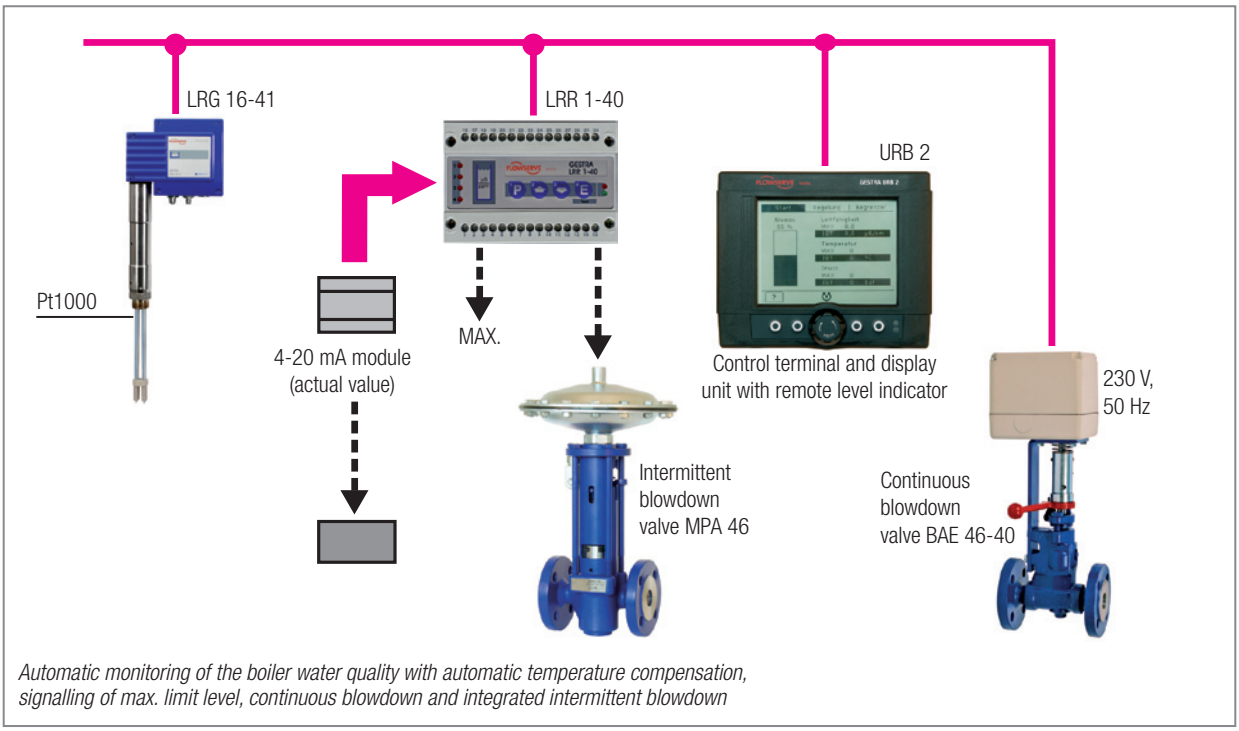
GESTRA – with Energy into the Future



Reducing energy losses by optimizing the continuous blowdown control



Reducing energy losses by increasing the concentration factor



Automatic monitoring of the boiler water quality with automatic temperature compensation, signalling of max. limit level, continuous blowdown and integrated intermittent blowdown

FLOWSERVE GESTRA

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