CONTINUOUS ON-LJNE STEAM QUALITY MONITORING SYSTEM

Ramonito P. Solis, Fermin C. Chavez, Serafin E. Garcia, Adriano C. Cabel Jr., Edgar S. D. Olympia and Ellsworth R Lucero

PNOC Energy Development Corporation, Fort Bonifacio, Makati, Metro Manila, Philippines

Keywords: *Bacman Geothennal Production Field; fluid collection and disposal system (FCDS); steam quality; condensate sampler; intelligent loop processor*

Abstract

In any operating geothennal power plant, steam quality is one of the most important parameters being monitored. In the Bacon-Manito Geothermal Production Field, an on-line steam quality monitoring system have been installled in two operating power plants which provides an accurate, efficient and continuous real-time data which is more responsive to the various requirements of the field operation.

The system utilizes sodium as an indicator of steam purity. Sodium concentration is read by the flame photometer located at the interface after aspirating a sample of the condensed steam through a continuous condensate sampler. The condensate has been degassed through a condensate-NCG separator. The flame photometer analog signal is then converted by a voltage-to-current converter/transmitter and relayed to the processor which is located at the control center through electrial cable to give a digital sodium concentration read-out at the control panel. The system features a high and high-high sodium level alarm, a continuous strip-chart recorder and a central computer for data capture, retrieval, and processing for further interpretation. Safety devices, such as the flame-off indicator at the control center and the automatic fuel cut-off device along the fuel line, are incorporated in the system.

The system is accurate and achieved high precision of ± 0.011 mg/L (± 1.1%) for the 1.00 mg/L sodium standard at full scale and ± 0.003 mg/L (± 2.7%) for the 0.10 mg/L sodium standard.

1.0 INTRODUCTION

In any operating geothermal power plant, the quality of steam is one of the most important parameters being monitored. The availability of a real-time continuous data for monitoring the quality of steam whch is being supplied to the power plant, provides utmost importance to the operators for an efficient operation of the system.

In the Bacman Geothermal Production Field (BGPF), Philippines a new system, the Continuous On-line Steam Quality Monitoring System, has been installed, tested and used in routine fluid collection and disposal system operations at the Bacman-I and Bacman-II Cawayan module power plants. The new system of monitoring steam quality is now integrated into the FCDS control panel, and provides a continuous real-time data which is more responsive for controlling process operations and in meeting the various requirements of the FCDS and power plant operations. This is because the sodium concentration is read and displayed at the control room. The new system is also used in determining the efficiency of the separator vessels and the scrubbing efficiency of the drainpots located along the steam lines during steamline scrubbing efficiency tests. As an additional advantage in cost, the system is designed to be operated without an operator continuously manning the system.

2.0 THE CONTINUOUS ON-LINE STEAM QUALITY MONITORING SYSTEM

The overall system is illustrated in Figure 1. The steam is collected through an isokinetic probe at the steam line and flowed to the condenser (ASTM, 1994). The steam condensate passes through a degasser to degas the flowing condensate sample. The separated gas is vented to the atmosphere. This ensures a laminar flow of the sample, prevent the formation of gas pockets within the sample *stream,* and prevent pressurization within the continuous condensate sampling system, for a more representative and uniform sample nebulization. The degassing process also ensures a stable flame photometer reading and prevent the flame from being extinguished.

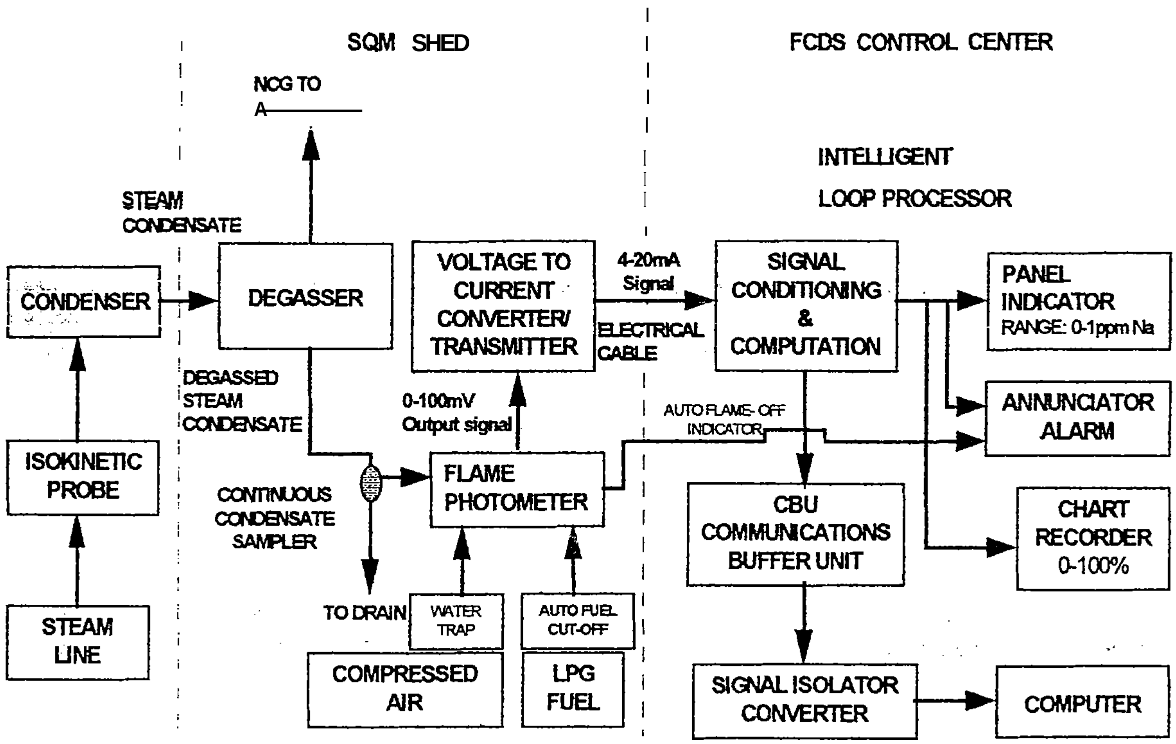

FIG. 1 BGPF Continuous On-line Steam Quality Monitoring Flow Diagram

The system utilizes sodium as an indicator of any water carry-over along the steam line hence, an indicator of steam quality. Sodium concentration is read by the flame photometer after aspirating a degassed stream of sample of the condensed *steam* through a continuous condensate sampler. The *stream* of condensate that passes after the nebulizer goes to the drain. The flame photometer output analog signal in voltage is then converted to a standard instrumentation signal in current by a converter/transmitter. This *signal* is relayed to the intelligent loop processor at the control center located several hundred meters away from the flame photometer through an electrical cable. The processor does the computation and ranging to give a digital sodium concetration read-out in ppm. A typical program loop diagram of the intelligent loop processor for the digital sodium concentration display, chart recorder and annunciator alarm outputs is shown in Figure. 2.

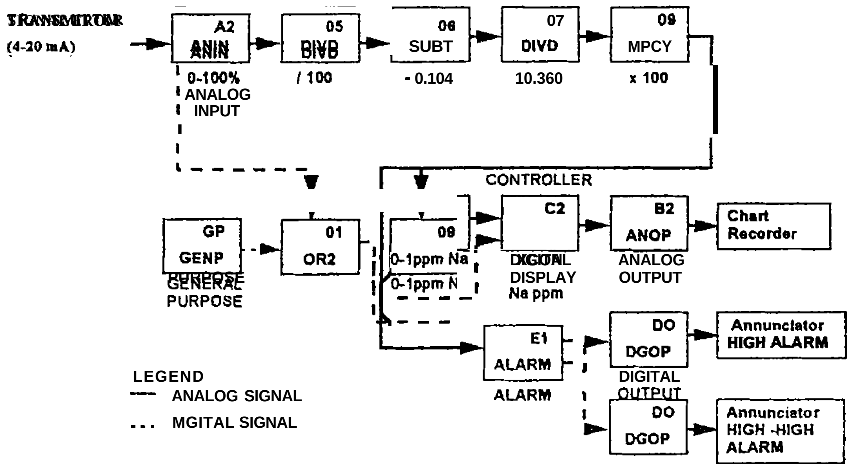

FIG. 2 Typical Program Loop Diagram of the TCS 6382 Intelligent Loop Processor

The system features a visual and audible high and high-high sodium level alarm to alert the operator of any impending *steam* quality deterioration due to system upset, hence remedial actions can be done to prevent further deterioration in the quality of *steam.* The system was developed to be a proactive device such that the alarm levels were set lower than the contractual limit. It also has a strip-chart recorder for continuous data logging and a central computer for perpetual data capture, retrieval, downloading and data processing for further interpretation.

Safety devices, aside from that inherent in the flame photometer instrument, such as the flame-off indicator at the control panel and the automatic fuel cut-off device along the fuel line, are incorporated in the system.

3.0 EQUIPMENT CALIBRATION, PRECISION AND ACCURACY

Four working sodium standard solutions were used during routine calibration of the flame photometer. These are: 0.10 mg/L, 0.20 mg/L, 0.40 mg/L, 1.00mg/L (APHA-AWWA-WPCF, 1976). The instrument is set at full scale using the 1 mg/L standard (Coming, 1984).

Below are examples of calibration runs using the working sodium standard solutions.

Na standard (mg/L)	Digital Read-Out At The Control Room Ave. (mg/L)	n	S. D. (mg/L)	% COV
1.00	1.020	8	0.011	1.1
0.40	0.394	7	0.011	2.8
0.20	0.194	7	0.004	2.1
0.10	0.110	11	0.003	2.7

note: S.D.-standard deviation % COV-coefficient of variation n - no. of data

Figure 3 shows an example of a typical real-time plot of sodium concentrations along the steamline for a 24-hour monitoring period as displayed on the central computer screen at the control center.

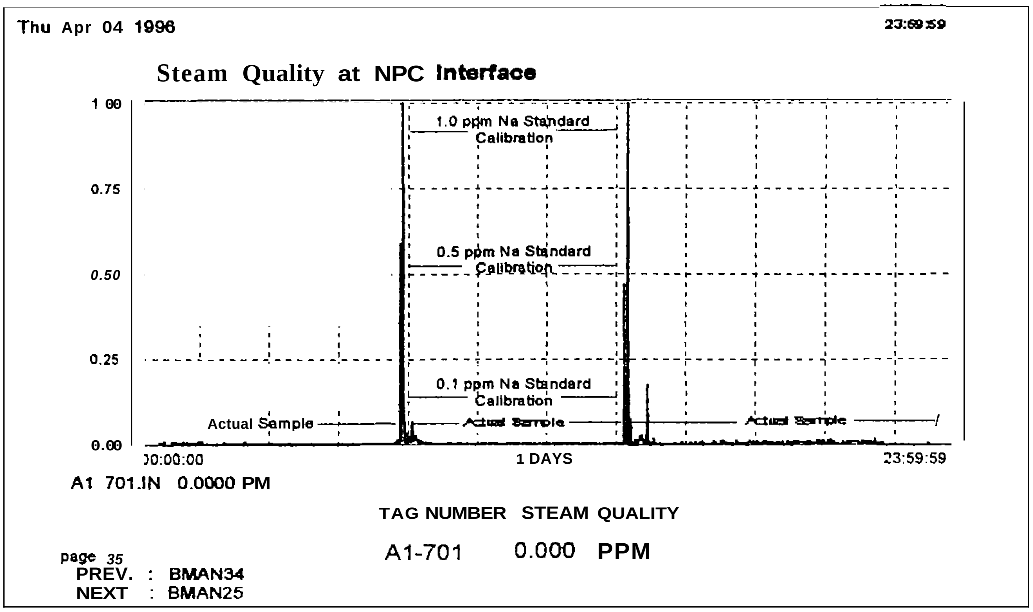

Figure 3 Typical Sodium Concentrations Along Steamline STL-701 and Calibrations Using Na Standard Solutions

4.0 CONCLUSIONS

The installation and application of the continuous on-line steam quality monitoring system is first in the Pfulippines and in the world. The system is applicable: 1) to all geothermal power plants wluch are base- or peak-loaded, 2) in situations where the sampling pints for steam quality are situated far from the control center of the FCDS and 3) to situations where there is poor separation efficiency of the separator, minimal steam scrubbing of water carry-over along the steamline and the absence of a demister before the power plant.

The system is accurate and achieved high precision of ±0.011 mg/L (±1.1%) for the 1.0 mg/L Na standard at full scale and 10.003 mg/L (±2.7%) for the 0.10 mg/L Na standard.

The continuous on-line steam quality monitoring system provides an accurate, fast, efficient and continuous real-time data, which is more responsive in controlling process operations and in meeting the various requirements of the FCDS.

ACKNOWLEDGMENT

The authors would like to thank PNOC-EDC management for permission to publish this work and to the BGPF Project Operations and Geoservices personnel for their support and cooperation during the formulation and design, installation and testing of the prototype system. To Dr. Joselito R Ruaya for editing the text.

REFERENCES

1. 1994 Annual Book of ASTM Standards. Section 11, vol. 11.01, Water (I), ASTM, 1994, pp. 79-82, 219-226.
2. Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WPCF. 14th Ed., American Public Health Association, Washington, D.C., 1976, pp. 250-253.
3. Corning Flame Photometer Instruction and Operator's Manual. Corning Science Products. Corning Limited, Halstead, Essex, England, 1984.