ON-LINE STEAM QUALITY MONITORING, APPLICATIONS, EXPERIENCE AND INNOVATIONS IN THE SOUTHERN NEGROS GEOTHERMAL PRODUCTION FIELD, PHILIPPINES.

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ABSTRACT

The first on-line stem quality monitoring set-up was developed in the Southern Negros Geothermal Project (SNGP) in 1991 in the Palinpinon-I 112.5 MWe power plant. The current system reported in this paper, developed in 1996, and is also now operational in the Nasuji 1x20 MWe and Sogongon-I/II 2x20 MWe modular power plants, is a significant improvement of the original set-up.

The Na concentration readout signal fiom the flame photometer is transmitted to a transducer, and directly recorded and displayed in a strip chart recorder and digital indicator, respectively, in the control room panel. The system is calibrated and equipped with an alarm system at a pre-set Na concentration. This improvement enables an in-situ, 24 hours monitoring capability which provides real time steam quality data. power plant engineers will thus be able to timely respond to any upset in the Fluid Collection and Disposal System (FCDS) that will affect steam quality. The performance of this system has been tested under normal and abnormal steam punty conditions (i.e. during a system upset in the Sogongon-I modular plant last July 1997), in which an adequate response was demonstrated and proven.

1.0 INTRODUCTION

Steam quality monitoring has first been conducted since the commissioning of the respective 1.5 MWe pilot plant, non-condensing turbines of OK-5 and OK-? last 1980 and 1981. Upon the commissioning of the 112.5 MWe Palinpinon-I power plant in 1983, followed by the modular power plants in Palinpinon-II between 1994 and 1995. steam quality became an increasingly important issue in power plant operations, and since then, a major geoscientific activity. The methodology adopted for steam quality monitoring during the first 10 years of Palinpinon-I operations was simply by a manual, four-hourly manual isokinetic steam sampling and subsequent laboratory analysis of the accumulated steam condensate samples (after a 24 hour period) for selected chemical elements, i.e. chloride, sodium, and silica (the main indicator of steam purity as adopted in the operating fields of PNOC-EDC is sodium, being more accurately and promptly analyzed in lower concentrations by flame photometry, compared to chloride).

Operational experience have shown, however, that the serious disadvantage of such methodology is that analytical results are not immediately available. In all past experiences of steam quality upsets, generated data are "historical", and in a transient FCDS system upset, for example, which may introduce poor steam quality, no timely preventive or remedial actions can be initiated. Even when chemical results become available, such events could have already occurred without the necessary corrective action. Such cumulative events with time increases the risk of damage to the steam turbines thru the combined effect of mineral deposition and possibly erosion, from the brine carry-over.

With this disadvantage and the apparent need to obtain real time steam quality data, site geochemists conceived and developed in 1991 the first on-line steam quality monitoring set-up installed in Palinpinon-I, and documented by Barroca et al., 1991. However, this set-up was limited to the continuos readout of Na concentrations in the geoscientific shed only, which is located hundreds of meters away from the control room panel. Communication and relay of the 'data from the shed to the control room using this set-up, however, still involved some time, and was not considered satisfactory in terms of the acceptable response period for the necessary actions. This set-up is shown in Figure 1, and described in the following sections.

2.0 THE ON-LINE STEAM QUALITY MONITORING SET-UP, RECENT REFINEMENTS AND INNOVATIONS.

The on-line steam quality monitoring system consists of a 3/8 inch diameter stainless steel tubing tapped from the isokinetic probe in the main steam line (before entry to the power plant), and into a condenser (straight type in Palinpinon-I, and double cooling coils in the Nasuji and Sogongon modular power plants). where the condensed steam and non-condensable gases are channeled to the flame photometer. The condensate samples are continuosly aspirated where the sodium concentrations indicating steam purity are displayed in the photometers' LED. The condensate before reaching the flame photometer is passed to a mini gas-condensate separator to properly dispose of the gas for safety and health reasons. The sodium concentration readouts were either recorded manually, or logged into an ordinary strip chart recorder. The flame photometer is capable of continuos concentration readout at a real time interval of 3 about seconds.

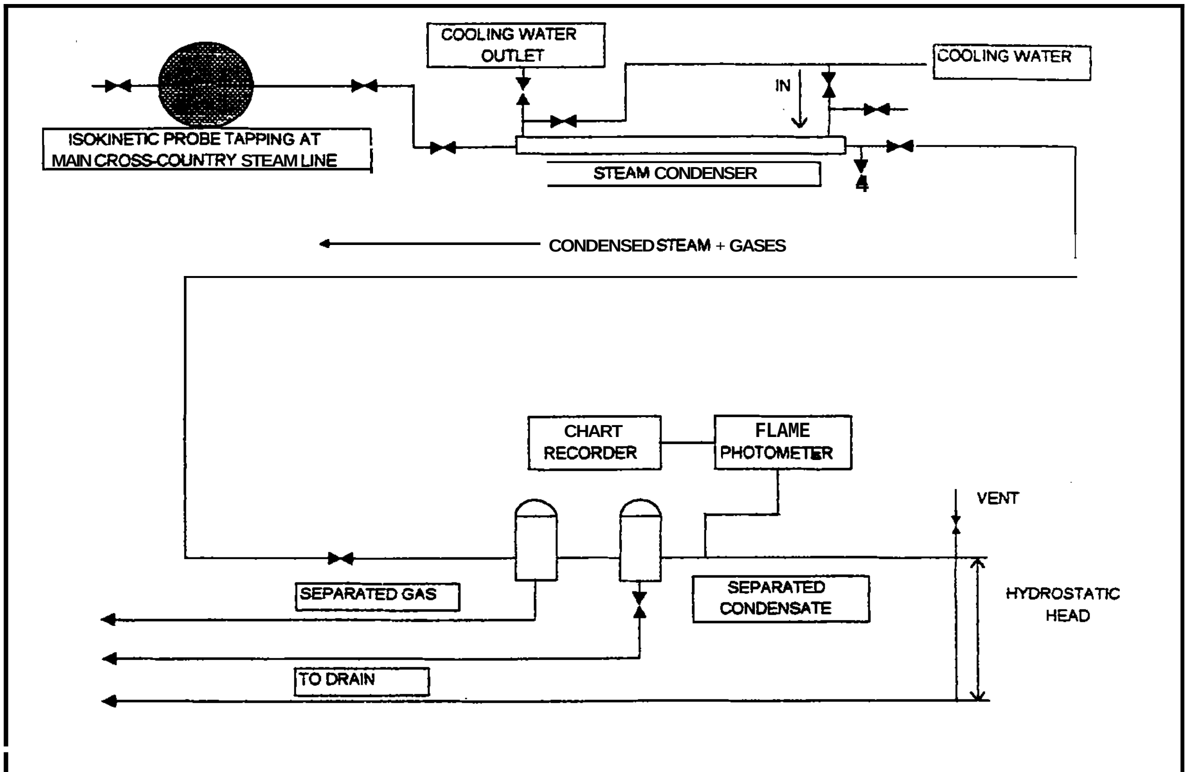

Figure I: Schematic Diagram. On-line Steam Quality Monitoring Set-up, Palinpinon-I 112.5 MWe, Nasuji, Sogongon-I and II Modular Power Plant.

The primary consideration in this on-line monitoring system is that the fluid residence times from the isokinetic probe into the flame photometer should not be more than about 120 seconds, so as to avoid a significant delay between an actual line steam quality and the chemical analysis, and availability of results.

Further improvements have been initiated since 1996, and are as follows: (1.) The readout / millivolt signal from the flame photometer is channeled via an electronic transfer system and data recording directly into the control room panel. (2.) Installation of alarms at pre-set, cut-off sodium concentrations (3.) Installation of a "FLAME OFF alarm and remote control circuit for the igniter, and (4.) Installation of a fuel cut-off switch at the control room. (Section 3.0 is devoted to a brief discussion on the electronics of the Signal conversion, calibration, recording of sodium concentrations, alarm settings, flame-off alarm, and remote controlled ignition and re-igeition).

Such major refinements provided greater operational flexibility and safety. The shift engineer is continuosly appraised with in-situ information regarding steam purity, and, therefore, a timely preventive or corrective action canbe initiated in the event of a steam quality deterioration arising from any upset in the FCDS.

3.0 DATA TRANSMISSION, SYSTEM CALIBRATION AND AUTOMATIC FLAME PEOTOMETER RE-IGNITION.

The output of the flame photometer in millivolts, which is equivalent to the sodium concentration in ppm, is hooked up to a foxboro transmitter which changes the signal to milliamperes, suitable for transmission to the control room. An electronic recorder provides the display, alarm signals and recording facilities. The schematic diagram of this set-up is shown in Figure 2.

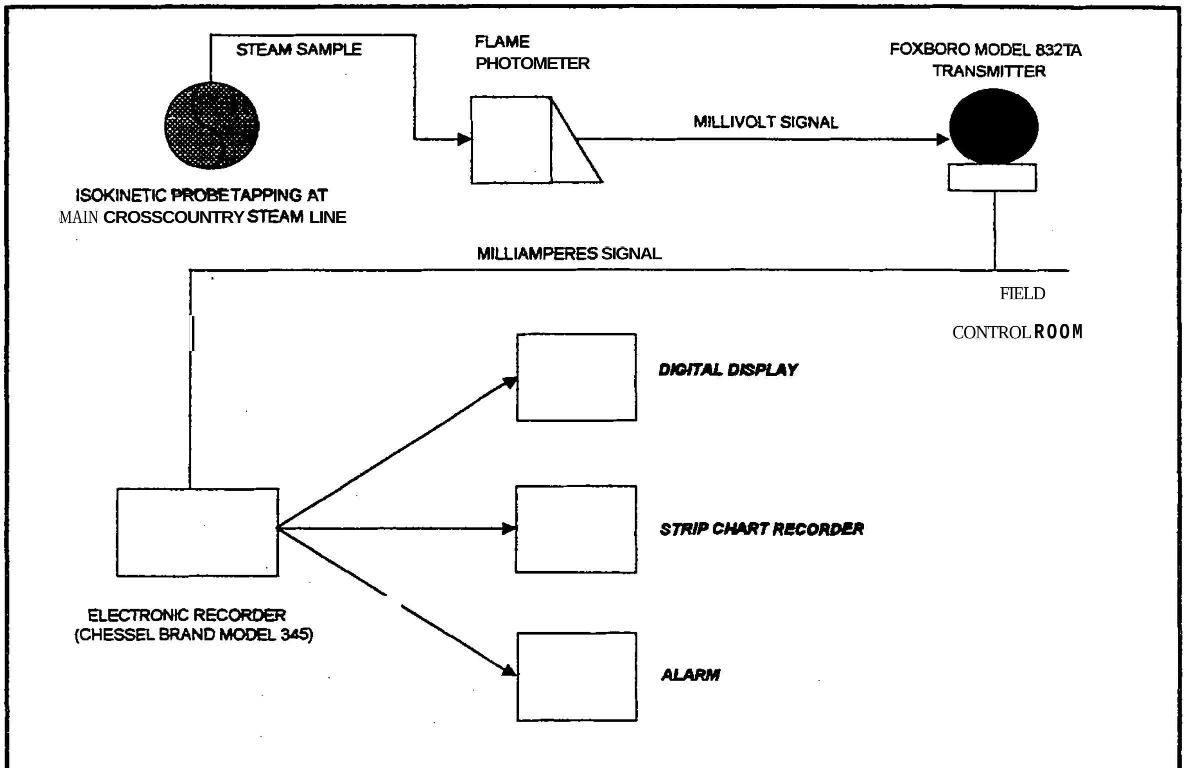

Figure 2 : Schematic Diagram, On-line Steam Quality Monitoring Set-up Showing the Process Flow of Signal Transmission, Recording and Alarm, Palinpinon – I 112.5Mwe, Nasuji, Sogongon – I and II Modular Power Plant.

The system is calibrated using sodium concentrations of 0 and 1 ppm The corresponding generated flame photometer outputs of 3.5 and 13.4 millivolts (mV), including a mid-range sample of 0.50 ppm (8.45 mV), were used to simulate the calibration process of the Foxboro transmitter. The 3.5 mV corresponds to 4 milliamperes (mA) and 13.4 mV is equal to 20 mA output of the transmitter, to effect a 4-20 mA calibration range equivalent to 0-1 ppm. The linearity was tested by applying 8.5 mV which consistently read 12 mA

The signal from the transmitter is sent to the chessel recorder where computation, ranging, indication, and recording is done. The recorder automatically displays the sodium concentration in ppm. Alarm levels are programmed at 0.40 ppm for high sodium content and 0.60 ppm for very high sodium levels. Relays of the recorder drive the Pan alarm to annunciate at these Ievek. Such settings are based on the steam purity cut-off limit of 1 ppm chloride (a requirement of the National Power Corporation - the plant operator and distributor of the electric current to the cooperatives), which is about 0.60 ppm sodium, based on a Cl/Na ratio of 1.3 in the separated brine phase.

Experience in the continuos operation of the flame photometer under the windy conditions of the Palinpinon-I and II areas showed perennial flame extinguishment due to the preferential and forced entry of draft to the flame via the exhaust system. In such events, two problems were further identified, i.e. (1.) Interruption in the SQM operations, (2.) A fire hazard condition is created since fuel supply normally continues even after the flame is extinguished

Thus, further improvements were introduced in 1997 to address this problem. provisions for a "FLAME OFF ALARM", automatic re-ignition, and fuel cut-off switches have been installed in the control room. The schematic diagram of such installations are shown in Figures 3 and 4.

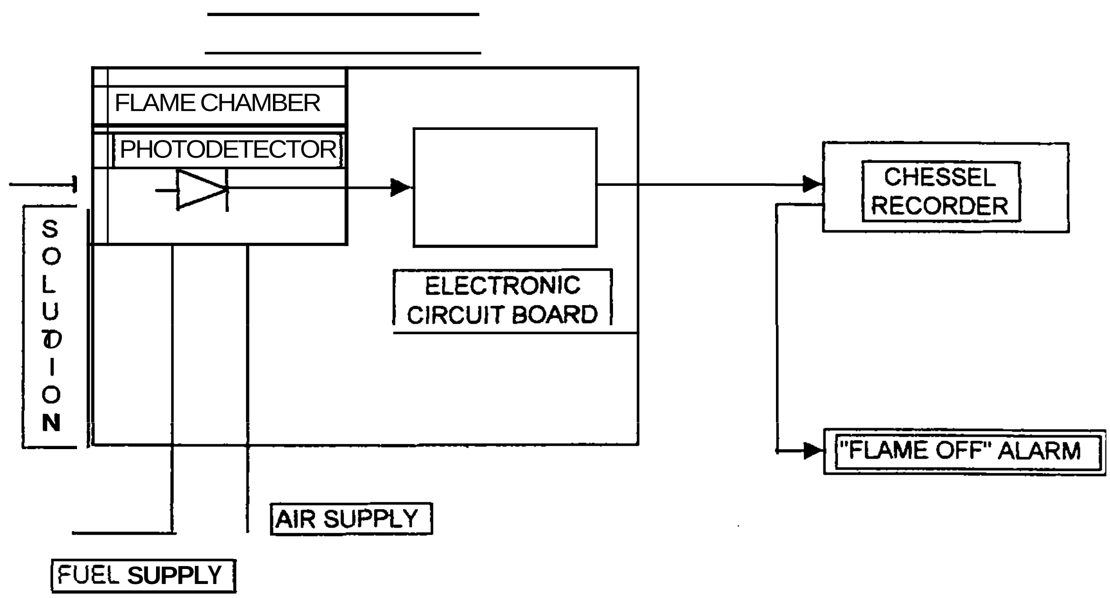

Figure :3 Schematic Block Diagram of a "Flame - Off" Alarm

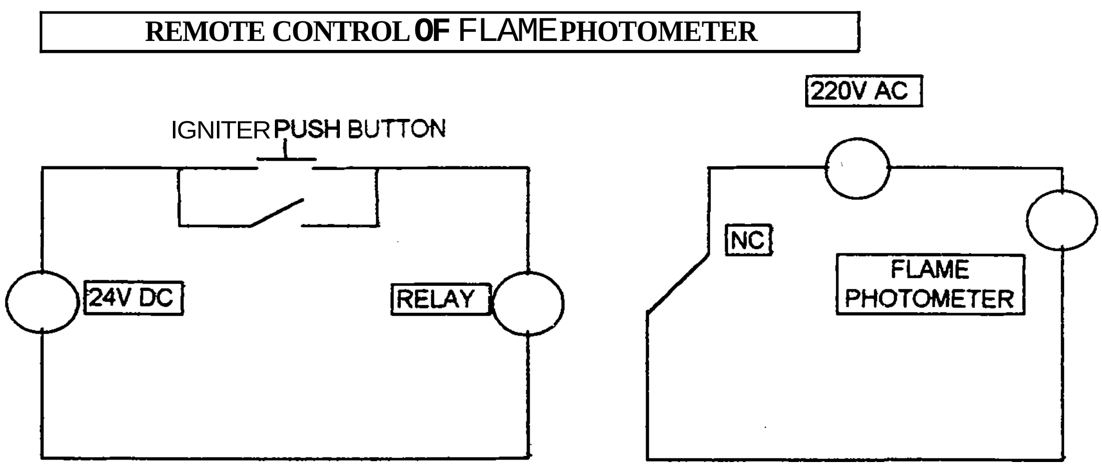

Figure 4: Schematic Diagram, Flame Igniter and Fuel Supply

The "FLAME-OFF" alarm and remote controlled re-ignition switch is designed to alert the *shift* engineers of a flame extinguishment, and to initiate immediate re-ignition from *the* control room (without the necessity of manual ignition) so as not to interrupt the monitoring for a long period. The automatic fuel supply cut-off switch *is* provided to prevent accumulation of the Liquefied Petroleum Gas (LPG) *in case* re-ignition of the unit fails for whatever reasons.

4.0 ON-LINE STEAM QUALITY MONITORING SYSTEM OPERATING PERFORMANCE AND EVALUATION

The main difference between this set-up and that in the Bacon-Manit0 *Geothermal* Production Field (BGPF) earlier reported by Solis and Chavez (1996) and Cabel (1997) *is* that their system is a distributed *direct* control capable of reading mV input, while *in* the Palinpinon control room, a signal *converter* is required to change mV signal to mA, since the control panels *can* only accept 4-20 mA.

The Sogongon-I 1x20 MWe modular power plant on-line *steam* quality monitoring *system* (with this improvement in the electronic transfer and recording of sodium concentrations to the control room) was the first to be commissioned in 1996, followed by Sogongon-II and Palinpinon-I in the last quarter of 1997. The Nasuji 20 MWe modular power plant then followed recently in January 1998, except for the signal transfer system into the control *room,* which is still to be installed. Since these respective periods, the *system* has been continuosly operated 24 hours a *day.* Except for some minor transient interruptions during preventive maintenance and repairs conducted in the igniters of the flame photometer, no major operational problems were encountered with *respect to* the photometer unit and its parts, and also to the electronic data transfer system (transducers, cables and recorders).

A sample of a hard copy of an on-line *steam* quality record under normal Operating conditions in palinpinon-I, and Sogongon-I are shown in Figures 5 and 6. The flame photometer is calibrated at least once every 8-hour shift, and this is also reflected in the chart record in both figures.

PALINPINON – I: (3x37.5 MWe Power plant)

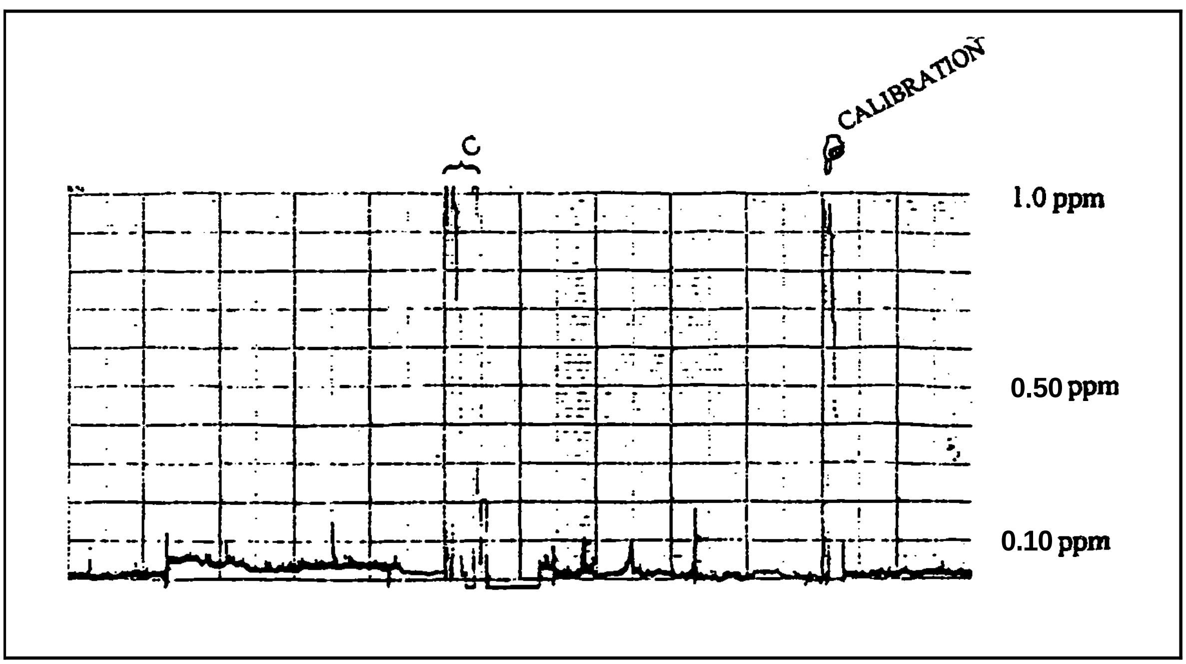

Figure 5 : Palinpinon-I On-line Steam Quality Monitoring, Extract of Hard Copy from the Strip Chart Recorder.

A major FCDS upset in Sogongon-I occurred on July 29, 1997, which resulted to a separator flooding, and consequently, steam quality upset. (A complete investigation and report has been circulated by Jalando-on, 1997, and will not be dealt here. The cause was found to be a defective Current Position Transmitter (CPT) installed at the motorized valve). This upset provided a rare opportunity that tested the response and performance of the on-line SQM set-up. A hard copy of the strip chart record is shown in Figure 7, and the corresponding results of a separate manual sampling and analysis (using the same flame photometer) during such event, is shown in Table 1. The on-line SQM system generated results very consistent to the manual method, although the absolute sodium concentrations were beyond the instrument calibration during the occurrence of the upset. This is also consistent with the occurrence of the high water levels in the 20 MWe separator vessel. The chart shows a lag-time of about 2 minutes between the occurrence of high separator water levels and that of the chemical front (start of increase in sodium concentration). This, however, is expected since the residence time of the fluid from the separator vessel to the isokinetic probes at the cross-country steam lines (where the on-line equipment is tapped), is also about this long.

PALINPINON – II : (Sogongon - I, 2x 20MWe Modular h e r **Plant)**

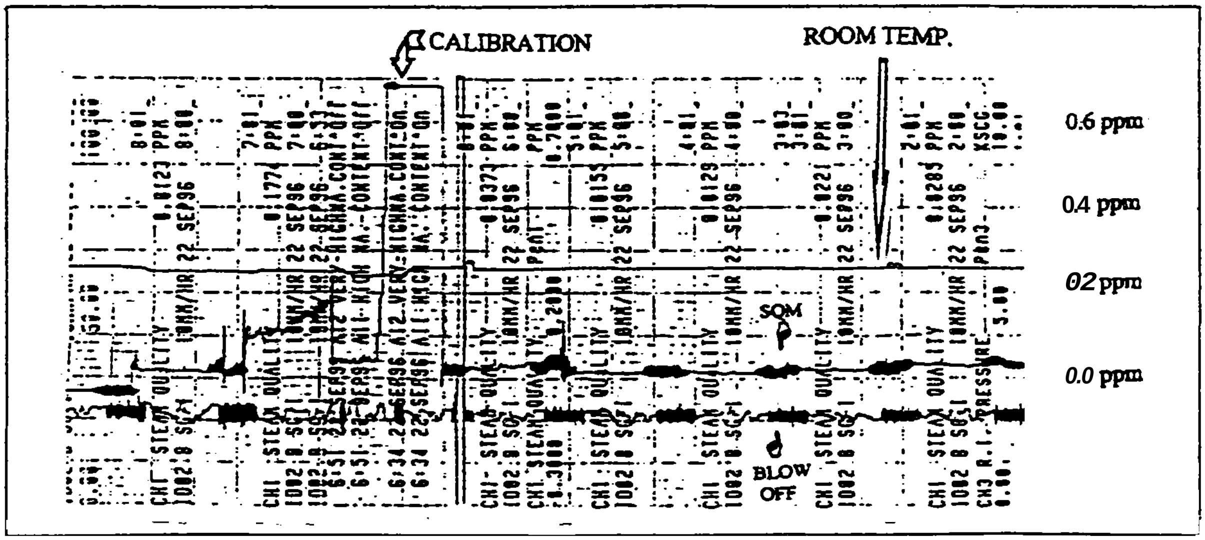

Figure 6 : Sogongon – I On-line Steam Quality Monitoring. Extract of Hard Copy fiom the Strip-Chart Recorder.

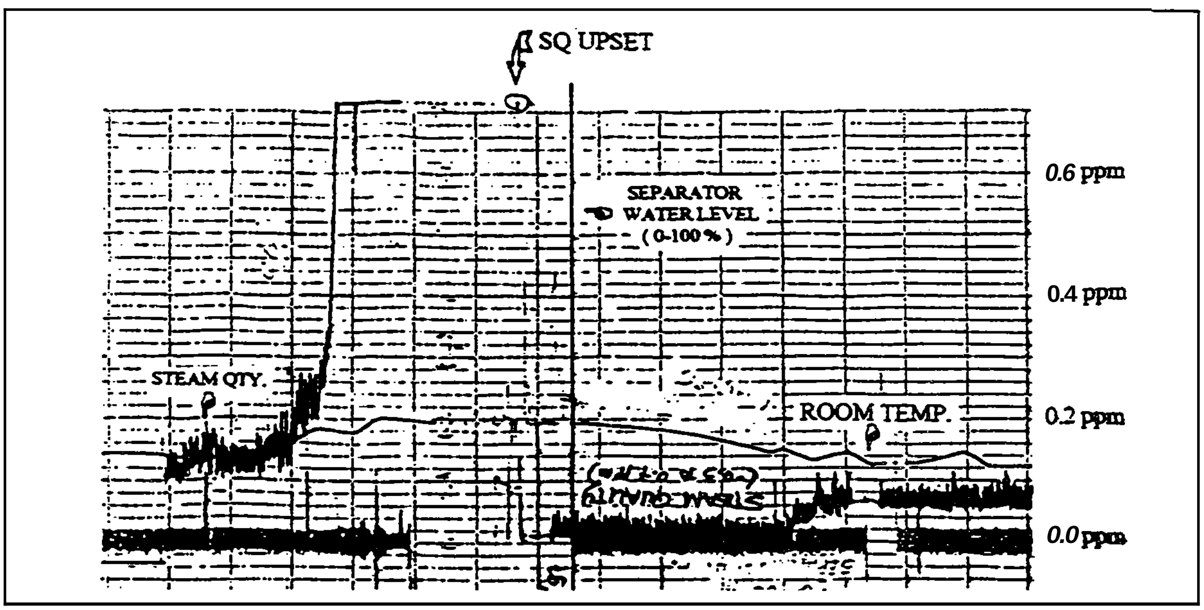

Figure 7 : Sogongon – I On-line Steam Quality Monitoring Record During the July 29,1997 Upset. Extract of Hard Copy from the Strip-Chart Recorder.

TABLE 1

Sodium Concentrations at SG-1 Cross-Country Steam Line, July 27 to 30,1997 and During the July 29 FCDS Upset

DATE	TIME (HRS.)	Na (ppm)	Remarks/Data Source
July 28, 1997	2400-0400	0.02	4 Hourly cumulative sample
	0400	0.02	4 Hourly spot sample
	0400-0800	0.05	4 Hourly cumulative sample
	0800	0.06	4 Hourly spot sample
	0800-1200	0.06	4 Hourly cumulative sample
	1200	0.08	4 Hourly spot sample
	1200-1600	0.08	4 Hourly cumulative sample
	1600	0.10	4 Hourly spot sample
	1600-2000	0.06	4 Hourly cumulative sample
	2000	0.06	4 Hourly spot sample
	2000-2400	0.04	4 Hourly cumulative sample
July 29, 1997	2400	0.02	4 Hourly spot sample
	2400-0400	295.0	On-line SQM unit
	0400	Beyond inst.range*	On-line SQM unit
	0420	1000	On-line SQM unit
	0445	800	On-line SQM unit
	0500	100	On-line SQM unit
	0510	0.75	On-line SQM unit
	0530	0.25	On-line SQM unit
	0800	0.14	4 Hourly spot sample
	0800-1200	0.09	4 Hourly cumulative sample
	1200	0.08	4 Hourly spot sample
	1200-1600	0.07	4 Hourly cumulative sample
	1600	0.09	4 Hourly spot sample
	1600-2000	0.07	4 Hourly cumulative sample
	2000	0.08	4 Hourly spot sample
	2000-2400	0.06	4 Hourly cumulative sample
July 30 1997	2400	0.07	4 Hourly spot sample
	2400-0400	0.03	4 Hourly cumulative sample
	0400	0.03	4 Hourly spot sample
	0400-0800	0.06	4 Hourly cumulative sample

*NOTES: * Beyond instrument range means initial readout was rapidly increasing, then final readout registered no reading as the true sample concentration is beyond instrument calibration/setting for this value.*

5.0 *SUMMARY* AND CONCLUSIONS

The application, experiences, and innovations of the on-line *steam* quality monitoring set-up in the Southern Negros Geothermal Production Field, which was first developed in 1991, and further improved and refined in 1996, to date, demonstrated and proved the acceptable performance of this *system.* There were three (3) significant improvements introduced in 19% to the existing on-line *steam* quality monitoring set-up, namely (1.) Transmission of the flame photometer signal to the control *room,* (2.) Installation of alarms when a pre-set sodium concentration is reached, and (3.) Installation of a "FLAME-OFF" alarm, a remote control circuit for the flame igniter, and automatic fuel cut-off switch in the control room.

The system has been tested extensively and proven to perform under normal, and abnormal steam purity conditions, e.g. during a FCDS upset in Sogongon-I last July 1997. The basis for this conclusion is the very consistent results with that of the manual, 4 hourly isokinetic steam sampling and analysis, still being maintained to date. During the past year of operation no major operational problem was encountered with respect to the performance of the main unit or its accessories, and the signal transmission system. The set-up demonstrated that it can provide the real time sodium data that enables power plant engineers to timely and properly respond in times of upsets in the FCDS. On-line steam quality monitoring is a regular and permanent activity programmed to be fully handled by the Production department with assistance from the Geoscientific group.

REFERENCE LIST

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