Instrumentation Verification with SSA

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ABSTRACT

In February of 1994 a review of the existing SSA installation at Dairyland Power Cooperative (DPC) was performed. SSA was installed at the DPC John P. Madgett station in September of 1992. The objective of the review was to see how well SSA was performing, which included recommendation and implementation of any enhancements. SSA is a pattern recognition software package that is a part of PMAX input validation. The primary use of SSA is to detect unusual instrumentation behavior, including drift, and flag those instruments in an effort to insure the inputs to PMAX are valid.

This paper will discuss the results of the review including problems encountered and solutions to those problems.

INTRODUCTION

The accuracy of any performance monitoring system is only as good as the instrumentation that feed the system. System state analyzer (SSA) is an integral part of the PMAX on-line monitoring package and is used to preprocess measured values that are used in PMAX calculations. To properly use SSA, a reference library of known good operating data must be assembled. After this has been set up, PMAX processes measured values through the pattern recognition algorithms to determine if the current data is consistent with known operating data. In conjunction with the data validation module, IVM, SSA results can be used to replace or flag suspect measured values. The results of SSA analyses can be sent to a PC to view graphically.

SYSTEM ANALYSIS

SSA analysis is performed by "learning" the characteristics of normal system operation and using those characteristics to evaluate the current status of the overall system, its individual components, and each input signal. The "learning" process involves loading sets of data (i.e., system states) which represent good operating practice and well calibrated instruments into a reference library. Subsequent monitored data sets are then compared with those in the reference library for similarity. A group of the most similar states in the reference library that bound the monitored state are stored in the learned domain, completing the "learning" process. The learned domain is then manipulated to develop a mathematical representation of the system given the current operating conditions. When this mathematical representation is combined with the monitored state , a prediction for each signal is calculated. The predicted state is then compared to the monitored state to evaluate overall system operation. In addition, the value for each signal in the monitored state is compared to its corresponding predicted value to identify signal failure, calibration drift, or component performance degradation.

The SSA prediction is only as good as the reference library. If the states contained in the reference library have bad signals or there are not enough states to bound the monitored state then the possibility exists for an SSA prediction that may not represent good system operation. This is the problem that was encountered at DPC.

When the system was installed in September of 1992 there was an archive file that contain thirty days of data. Therefore the SSA reference library was constructed with data from August to September. It will become obvious later in the paper that this created a problem for SSA in its predictions.

The first step in the analysis was to transfer the existing SSA files and current operating conditions to my PC in Idaho Falls, I accomplished this via modem. After I had all the SSA files and current operating data I ran SSA to look at how well it was predicting two years after it had been installed. Figure 1 shows a SSA Bullseye plot of the original DPC data that was analyzed.

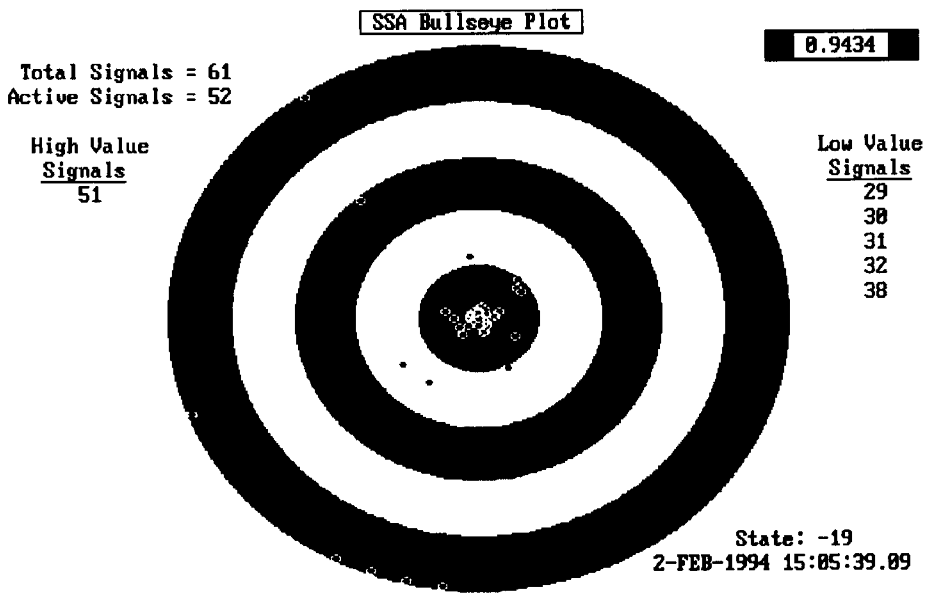

FIGURE 1

With the exception of the five low signals and one high signal the system was operating very well. It seemed strange that for the most part the system was predicting extremely well with the exception of the six parameters shown on the Bullseye plot. Not only were these points flagged but they were at least five deviations from the SSA prediction. The next step was to examine each of the six signals that were flagged by SSA and try to determine the cause of the discrepancy . Figures 2-7 show SSA historical plots of each of those signals. It is important to notice which parameters were flagged and what would affect those parameters.

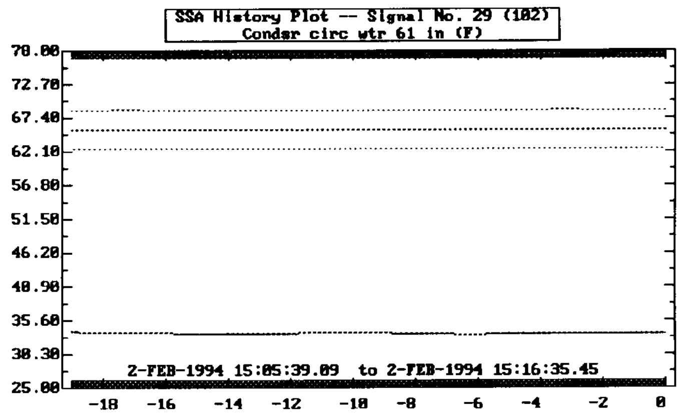

FIGURE 2

The measured circulating water inlet temperature is about 35 deg F and the SSA prediction is about 65 deg F.

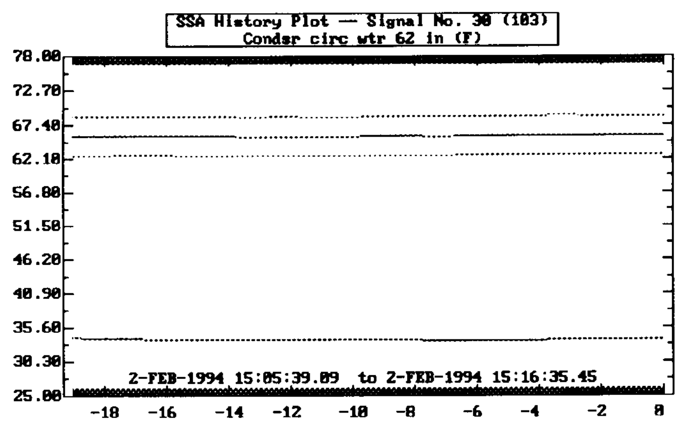

FIGURE 3

The measured circulating water inlet temperature is about 35 deg F and the SSA prediction is about 65 deg F.

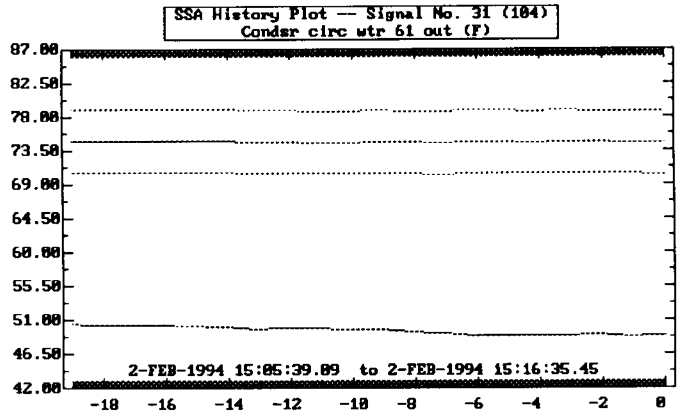

FIGURE 4

The measured circulating water outlet temperature is about 50 deg F and the SSA prediction is about 76 deg F.

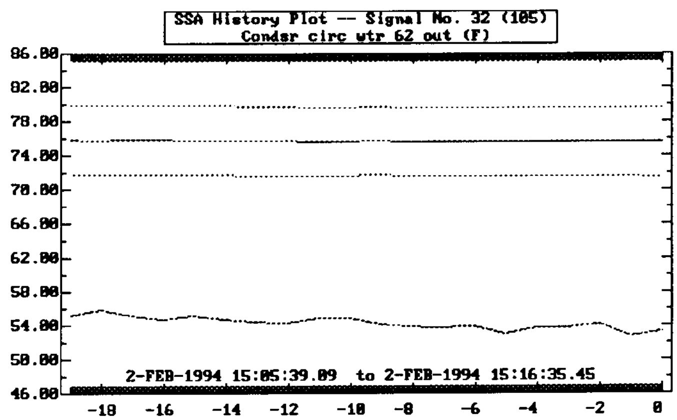

FIGURE 5

The measured circulating water outlet temperature is about 55 deg F and the SSA prediction is about 76 deg F.

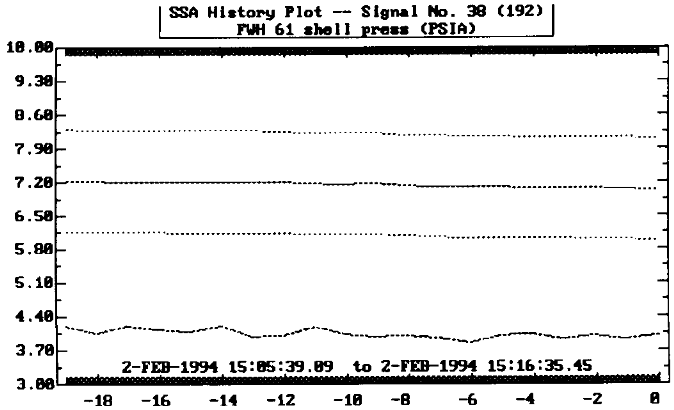

Figure 6

The measured feedwater heater 61 shell pressure is about 4 PSIA and the SSA prediction is about 7.2 PSIA.

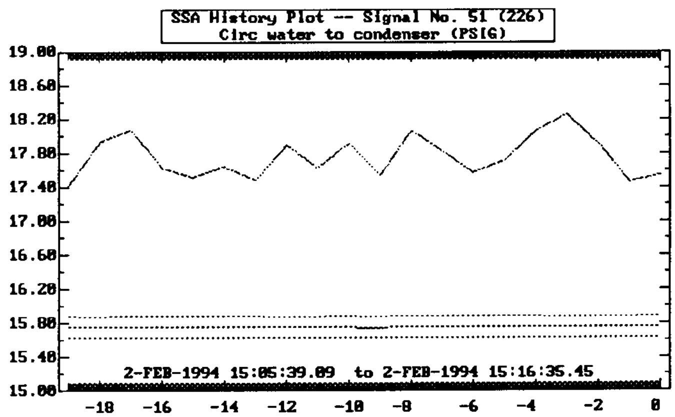

FIGURE 7

The measured circulating water to condenser pressure is about 17.5 PSIG and the SSA prediction is about 15 PSIG.

After reviewing the above points it became obvious that SSA was predicting circulating water temperatures, pressures and low press feedwater heater pressures that were too high. When the system was installed and the reference library built in September the circulating water temperatures were much higher than they were in early February when this analysis was done. A review of the reference library shows that the signals in question were not bounded . Figures 8-13 are the plots from the reference library for the six points in question .

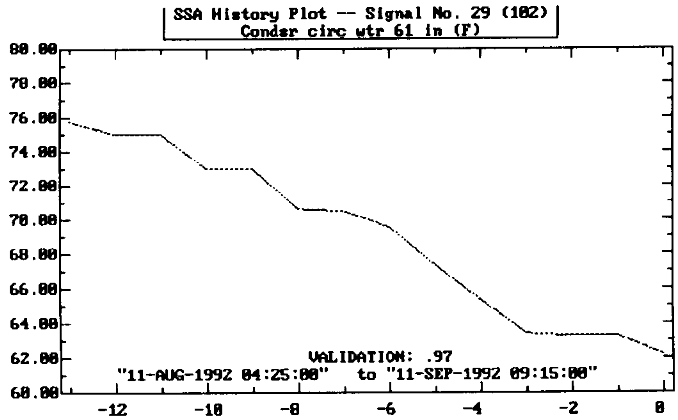

FIGURE 8

Circulating water temperatures that were in the reference library.

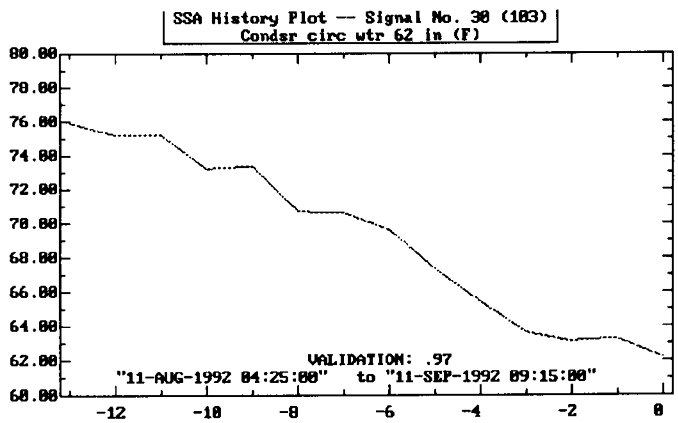

FIGURE 9

Circulating water temperatures that were in the reference library

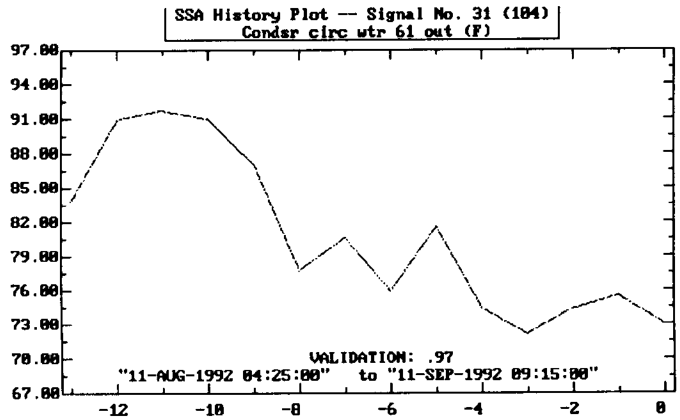

FIGURE 10

Circulating water temperatures that were in the reference library

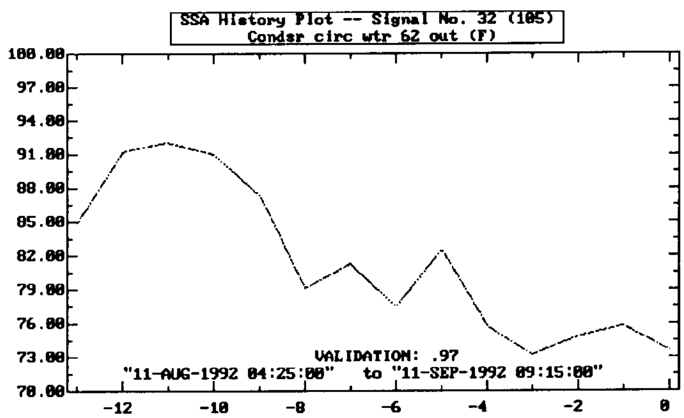

FIGURE 11

Circulating water temperatures that were in the reference library

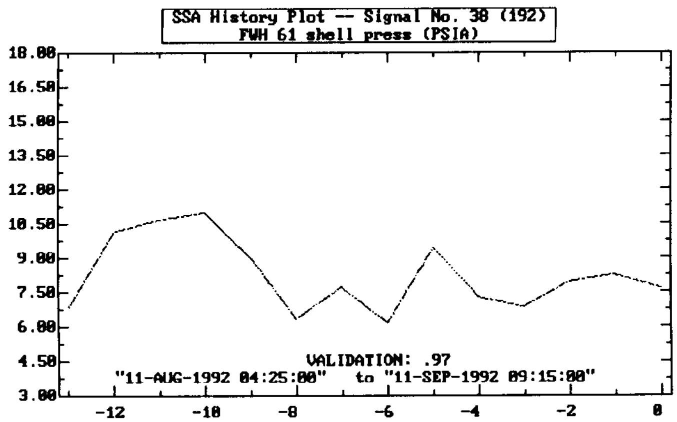

FIGURE 12

Feedwater heater 1 pressures that were in the reference library

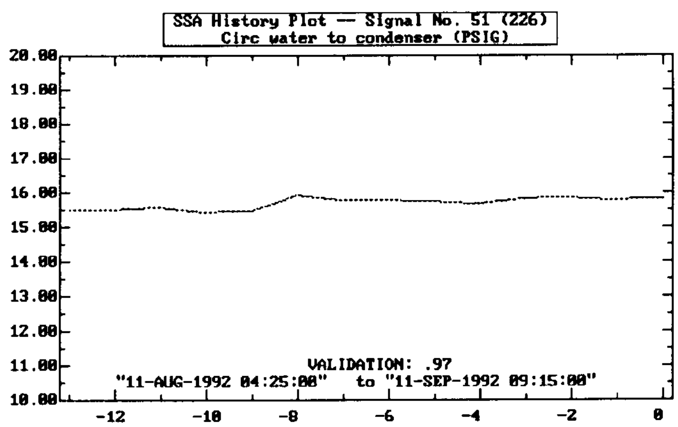

FIGURE 13

Circulating water pump discharge pressure that were in the reference library

SOLUTION

At this point there were a couple of options that could have been taken. The first option was to remove the points that are directly related to seasonal conditions. The other option was to attempt to get a wider range of these points into the reference library. The second option would require adding ambient related points to the reference library throughout the year. Because of time restraints the first option was attempted. I deactivated the six above points from the reference library so that they would not be used in SSA and ran the analysis again. As would be expected the SSA prediction was much better. The overall system validation parameter went from .9434 to .9911. A validation parameter of 1.0 would signify an exact prediction for each signal in the state. Figure 14 is the Bullseye plot of the SSA analysis with the above points deactivated. Although deactivating the six ambient related parameters from the reference library worked well this would not be the recommended way to solve the problem. The correct approach would be to add to the SSA reference library a wide variety of ambient conditions just as you have to load a wide variety of steam flow. You can see that the SSA reference library can become very large. To correctly predict values that are strongly influenced by ambient conditions it is necessary to bound the ambient related conditions and to get representative values over the entire load range at each ambient condition. This can greatly increase the size of the reference library.

SSA has been tied to PMAX Archival File Search (see paper 1993 UGM). If the user has an existing archive file of the points he wishes to validate PMAX can load the use specified states into the SSA reference library. If the user does not have an existing archive file of the points he wishes to validate the reference library can be expanded as ambient conditions change.

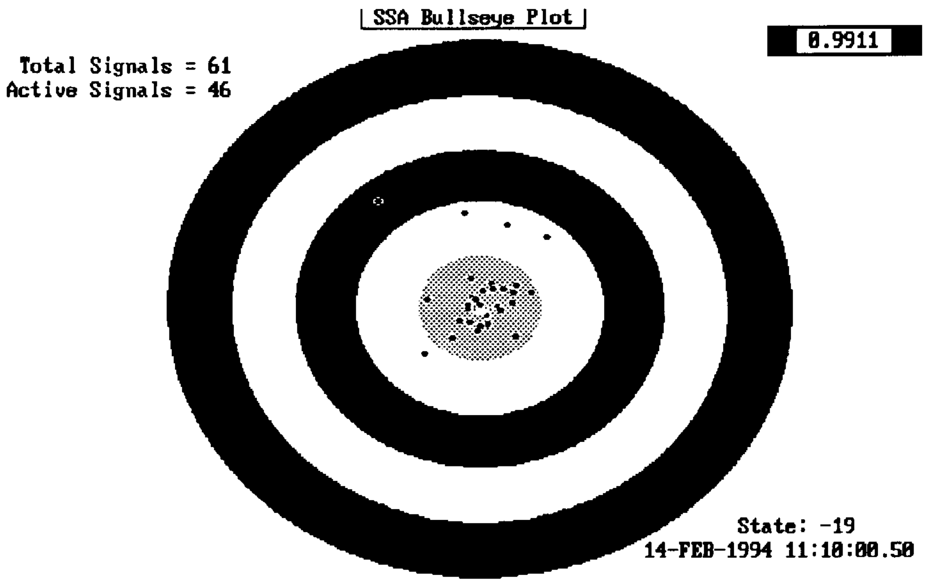

FIGURE 14

CONCLUSIONS

Like all other software SSA is only as good as the information that you give it. The construction of the SSA reference library is critical to its' ability to predict accurately. It has been my experience that the best method of constructing a good reference library is to have a lot of archive data in which to choose from. With Archive File Search the user can filter that archived data and only pick the states that are of interest. Once the reference library has been constructed the user should sort the reference library on a given parameter and plot the signals that are dependent upon that sorted parameter and eliminate any states that are questionable. For example the user should sort the reference library on load and make sure that all feedwater heater pressures decrease as load decreases. It is also very important that each signal be bound as we have discussed above. If the user wishes to implement SSA into PMAX he should start by building an archive file of the parameters he wishes to validate. SSAs' ability to predict is unsurpassed as was shown in this paper. The key is to build a good reference library.