APPLYING STATISTICAL PROCESS CONTROL (SPC) TO AUTOMATED POC SYSTEMS DATA

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ABSTRACT

A recently developed SPC program from Nalco/ Exxon Energy Chemicals, L.P. can significantly increase control of rod pumped wells. The program is applicable to automated pump off control(POC) systems where the controllers communicate with a common host.

The program was derived from a need by Amoco to more effectively monitor paraffin deposition on tubulars in deep commingled wells. These wells experienced severe paraffin deposition resulting in costly well repairs. While the treatment method was important, the lack of an effective monitoring tool was critical. Amoco wanted a predictive monitoring tool that would warn them of paraffin build up before it became a serious problem. Proactive monitoring of this type is one way to add value to automated monitoring systems.

We learned that how well a rod pumped well is performing is a function of the data available from the POC and that applying SPC to this data will result in tighter control and improved operating efficiency.

PROCESS

We began by gathering and inputting the POC data manually on a daily basis. The data was input to a Nalco SPC software package called Trendcheck. Four parameters were determined to be the critical measurement factors in determining whether or not a well is operating within normal operating limits. Those factors are peak polish rod load(PPRL), delta polish rod load(DPRL), card area(CA), and % run time(RT). Through the first six months we were inputting one data point for each parameter per well per day. Even though this process was labor intensive we were able to establish cause and affect relationships between the data and events in the field. In SPC terms this is known as establishing common versus special cause variations. Common cause variations are process variables that you have control over and special causes you have no control over.

To date those causes have been defined as follows:

COMMON	SPECIAL
Paraffin	Mechanical Failure(rods,pumps, tubing, ...etc.)
Pressure	Measurement Problems
Motor Size(too large, too small)	- communication
POC set up(set pt., off time..etc.)	- failed electrical component
Plugged,trashed, gas locked pump	
Fiberglass vs. steel rods	
Fluid level above pump	
Plunger travel, SPM	
Worn belts, shivs	
Air balance performance	

Now that we had an increased understanding of our process we realized that some improvements were needed. Our list of desired improvements was as follows:

* Improve the statistical integrity of our process by increasing the number of data points entered into SPC charts

* Automate the data gathering and input process to make less labor intensive

* Add SPC format for 24 hour averages of each critical measurement factor for each well

* Build in SPC alarm capability so that we only had to look at wells that were operating out of their normal limits

With the assistance of a systems integrator and Amoco's automation support group the desired improvements were implemented. The four parameters are displayed in an SPC format in two forms. First, are actual readings where the four data points are displayed on individual 31 point SPC charts. Each point can represent each reading or some form of averaged readings. This frequency is dependent upon how quickly the POC system scans each well. A typical range is anywhere from every 3 minutes to one hour. Second, are 24 hour average readings. The same four parameters are displayed again in an SPC format with each data point representing a 24 hour average of all readings for each respective parameter.

Once the necessary work processes are implemented in conjunction with the system, the the following benefits are provided:

* Documentation, referencing capability necessary for continuous process improvement(CPI)
* Early detection of paraffin build up
* Immediate failure identification
* Optimization of well cycles

There are many other benefits available. The premise of the system is to determine normal operating range for each well based on the aforementioned critical measurement factors. Once the system, through utilization of SPC analysis detects any performance abnormalities a specific alarm is generated . Each well is basically viewed as an individual process with the output (PPRL,DPRL,CA, %RT) continuously monitored.

EXAMPLES

The first example illustrates how paraffin treatment was optimized by increasing treatment (Figure 1). The graph begins on the left side where monitoring had just begun when a severe paraffin failure occurred in which the rods were stuck in the tubing. The failure is indicated where the PPRL average climbed above the upper spec limit(USL). The actual failure point is indicated with the first flag. The second flag indicates the well being put back on production. As a result of the failure and large volume of paraffin the batch treatment dosage and frequency were increased. Within a week PPRL load averages had dropped below their previous level. With this newly defined operating range we now had a new zone of acceptable operation for the PPRL. Should the loads begin to rise , we could take corrective action before the well reached the point of failure. Figure 2 illustrates the same wells PPRL average 3 months later. The variation between each data point is reduced and the treatment appears to be optimal.

The next example illustrates how the process can be used to optimize paraffin treatment through reduction of treatment(Figure 3). This graph indicates an extremely stable PPRL average. The flagged data point is where treatment was changed to a less expensive chemical. After 3 months the PPRL averages were still extremely stable(Figure 4). The next two data points indicate the next two consecutive batch treatment applications where dosage and frequency were reduced with no negative impact. This new treatment schedule was now at the minimum as determined for this group of wells and through data analysis determined to be optimal.

PPRL is not always the critical measurement factor in detecting an operational abnormality. The next example shows how the DRL average was used to avoid another costly paraffin related failure(figure 5). This graph indicates a tremendous amount of variation from day to day. This variation and frequent rise above the USL prompted a clean up of the well, as indicated by the first flag. The clean up consisted of pumping condensate and paraffin dispersant down the annulus and producing it back. Once the well responded to the clean up, the batch treatment was increased as indicated by the second flag. The next graph is the same well/ parameter 3 months later(Figure 6). The DRL average is more stable and a more capable process. The flag in this graph indicates where a measurement problem occurred(faulty load cell cable).

PPRL was also used to detect a trashed pump which was causing severe load spikes on the actual hourly readings and unacceptable variation in the PPRL average(Figure 7). This well had a history of iron sulfide plugging problems due to incompatible commingled fluids. The flag indicates where a soap/water application was done. The PPRL was relatively stable after this application and eventually the spec limits had to be lowered once the new operating limits were defined.

The next example illustrates the relationship between fluid level and PPRL(Figure 8). In this PPRL actual hourly readings chart the first flag is where a well was put on circulation. This particular well runs 24 hours per day and produces approximately 600 bbls of fluid. Within 2 hours the polish rod load had dropped over 4000 pounds . Once the well was placed back on production it took about 2 hours to return to it's normal operating range. Mechanical well failures will appear the same way. A drastic and sudden load loss will occur. Once the alarm is recognized it is simply a process of elimination to determine the actual problem.

The final example is an example of how the % run time monitoring aspect can be used to detect problems (Figure 9). In this graph the RT average chart begins with the well already above it's spec limit. The flag is where field technicians first checked the well for problems. It took an additional 3 days before a pin hole tubing leak was finally detected. In this case the dynamometer card , SPC load analysis, and downhole valve check had all indicated that the well was functioning properly. Only this slight shift upward on the RT average indicated there was a problem.

Additionally, SPC monitoring of the POC data detected changes in flow line pressure, leaking air balance seals, worn shivs and belts, and was used to reduce well cycling.

It should also be mentioned that the SPC system was based on a WonderWare SPC package with graphics. The stand alone machine received data from the POC host via Amoco's local area network.

The system was piloted on a 150 well lease with a mixture of well depths ranging from 5,000 feet to 12,000 feet.

CONCLUSION

SPC can be used or abused. If this system is used properly it can significantly reduce operating cost through operation optimization. Lease operators can pump by exception. Mechanical , operational, and chemical changes can be monitored on line with real time data.
This allows for data based decisions and total cost optimization.

REFERENCES

"The SPC Book", a user's reference to Statistical Process Control Methods, by Leslie M. Galicinski, P. Eng..

SPECIAL THANKS

Roy Mitchell - Operations Center Manager , Amoco Midland Farms
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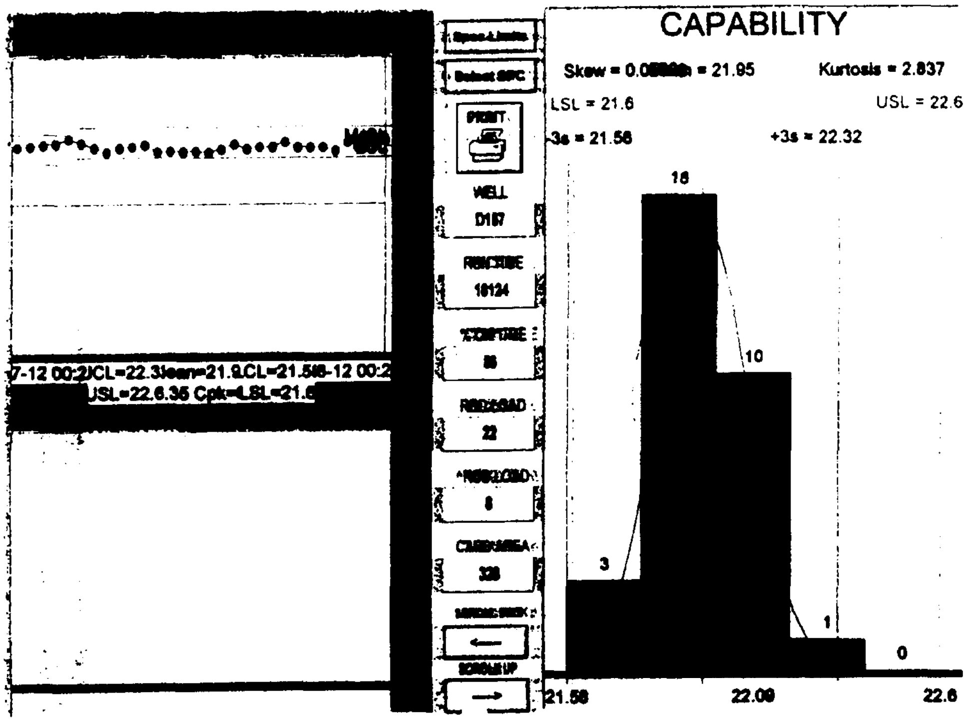
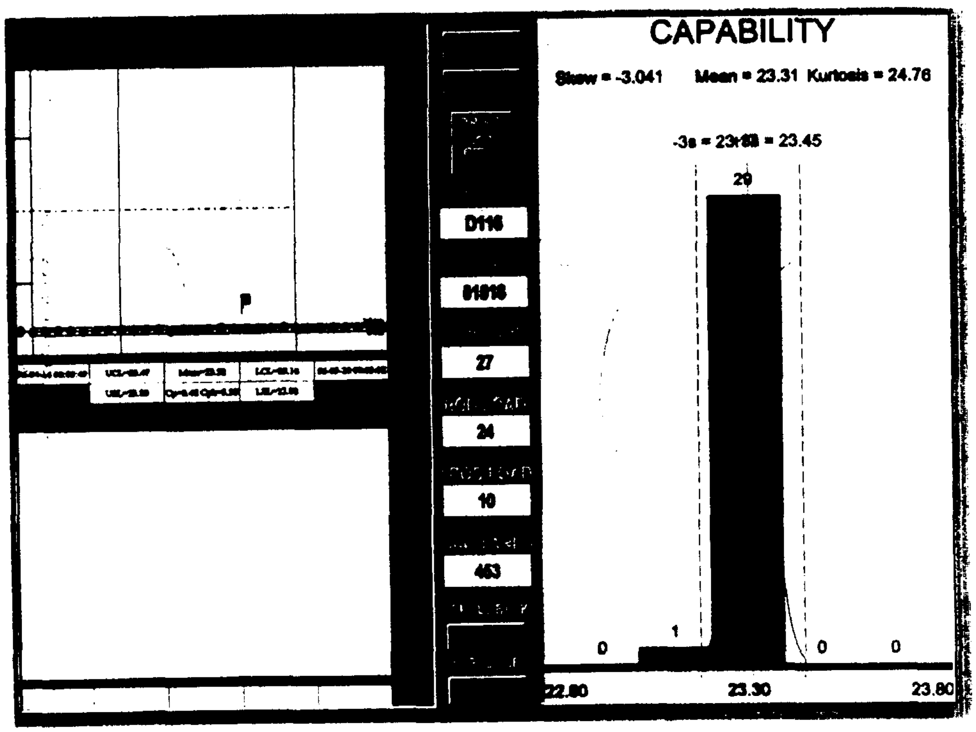


Figure 1



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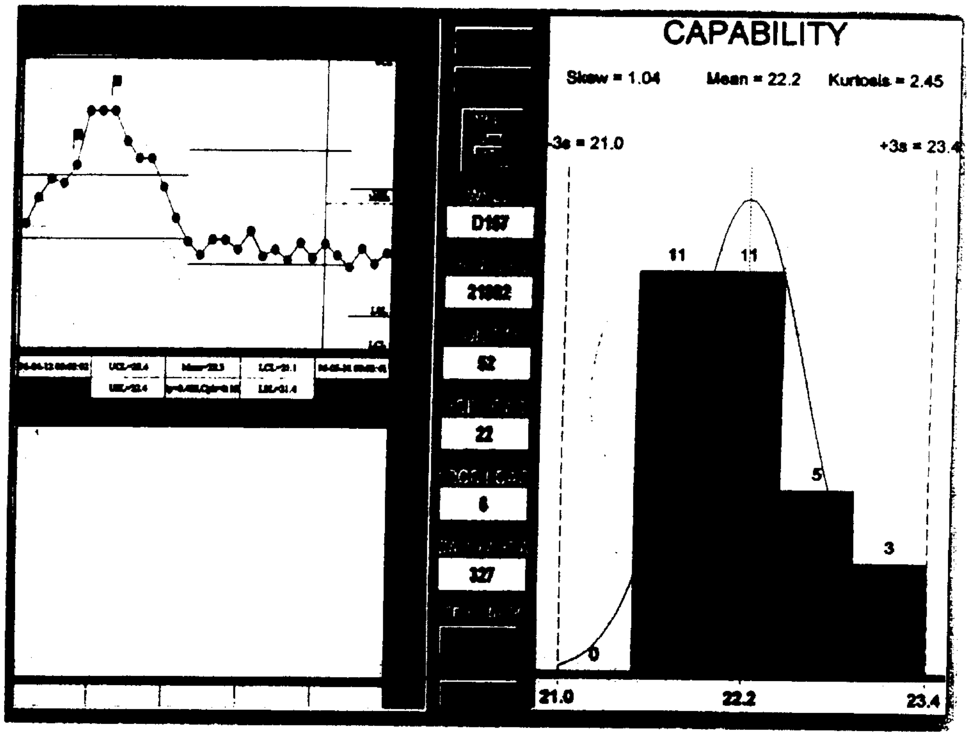

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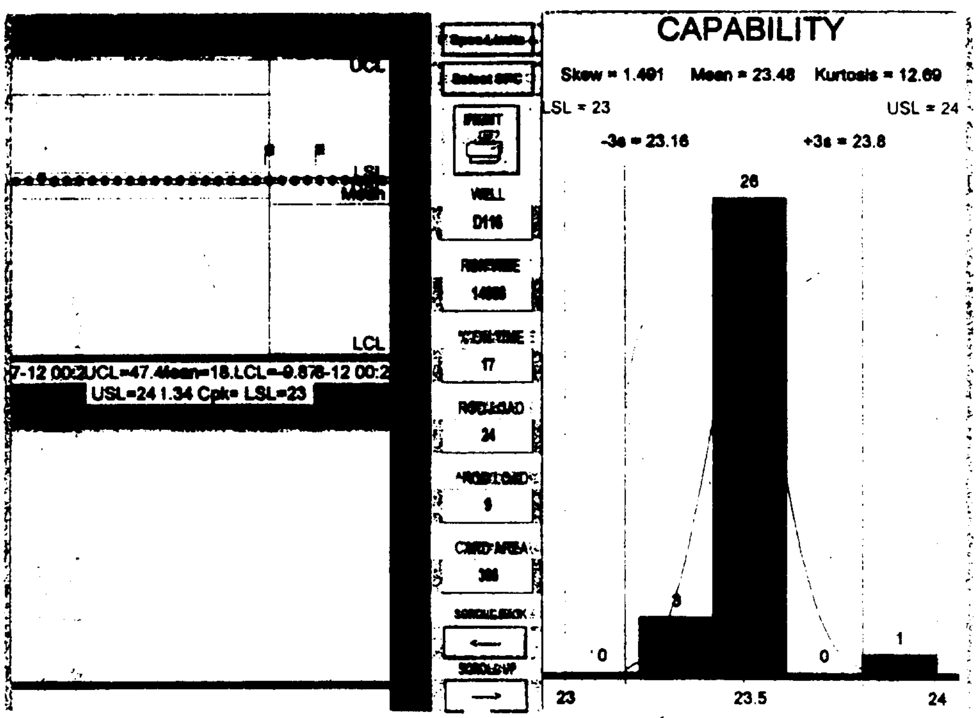

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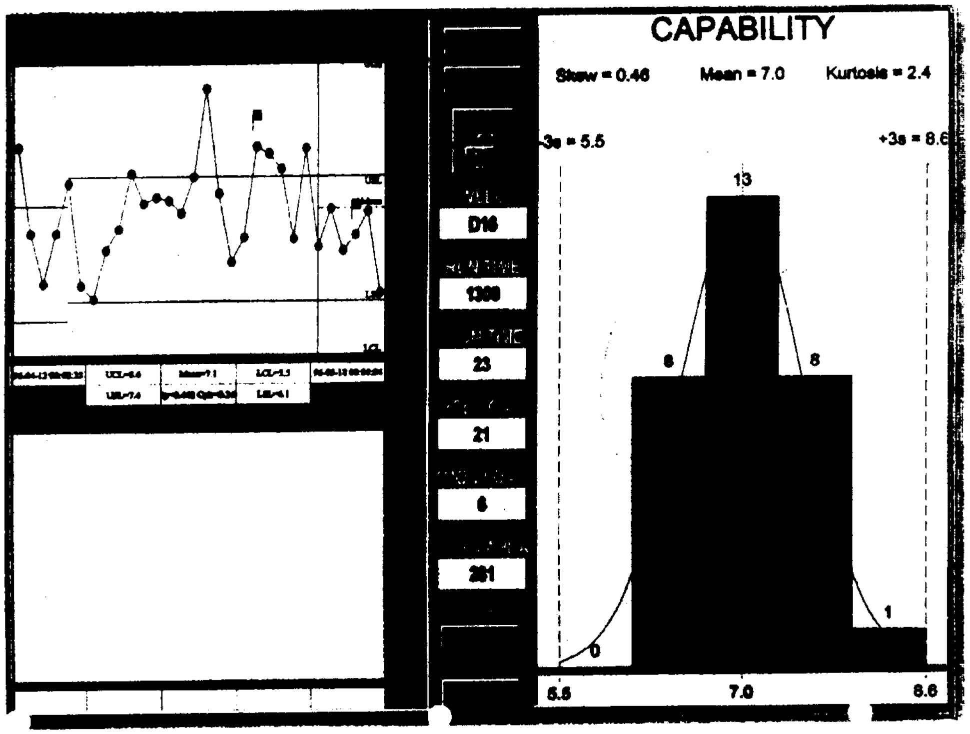

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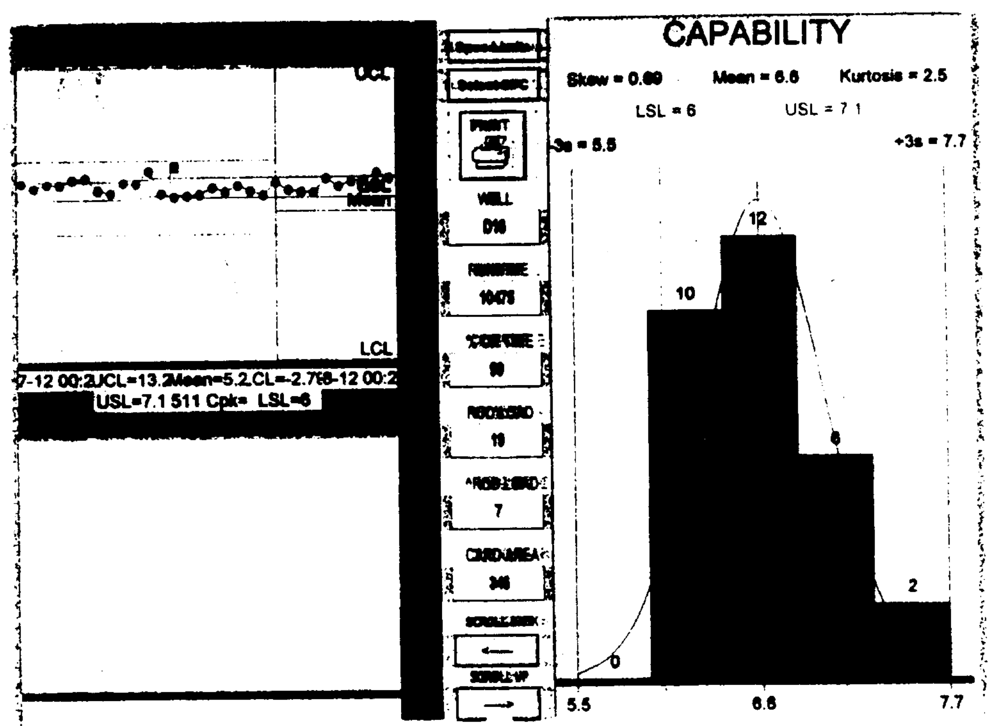

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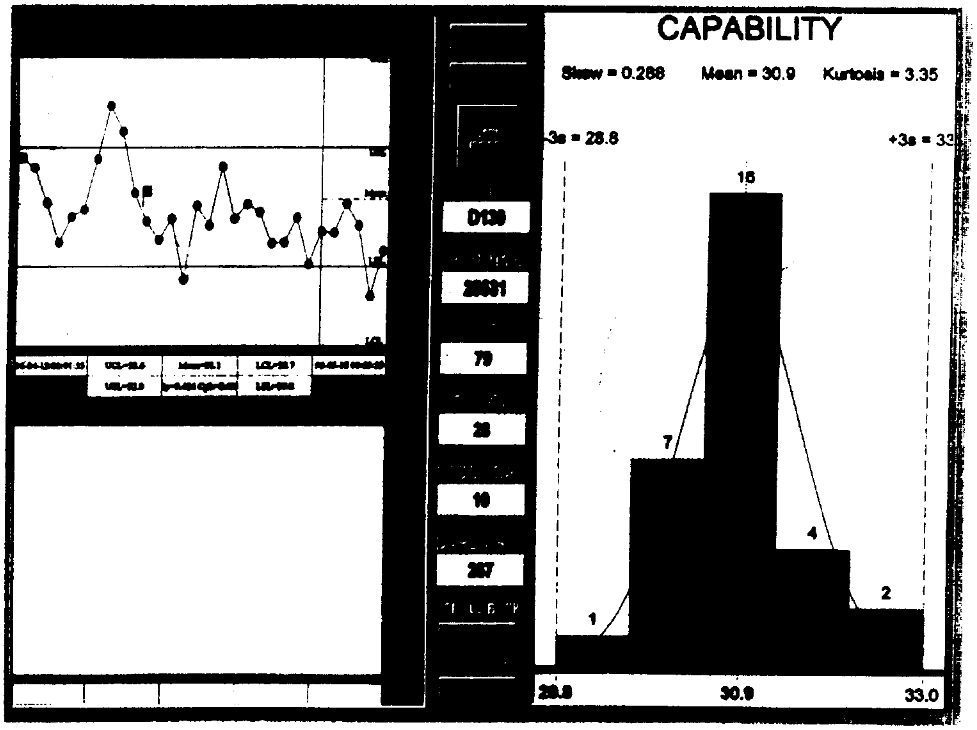

Figure 7

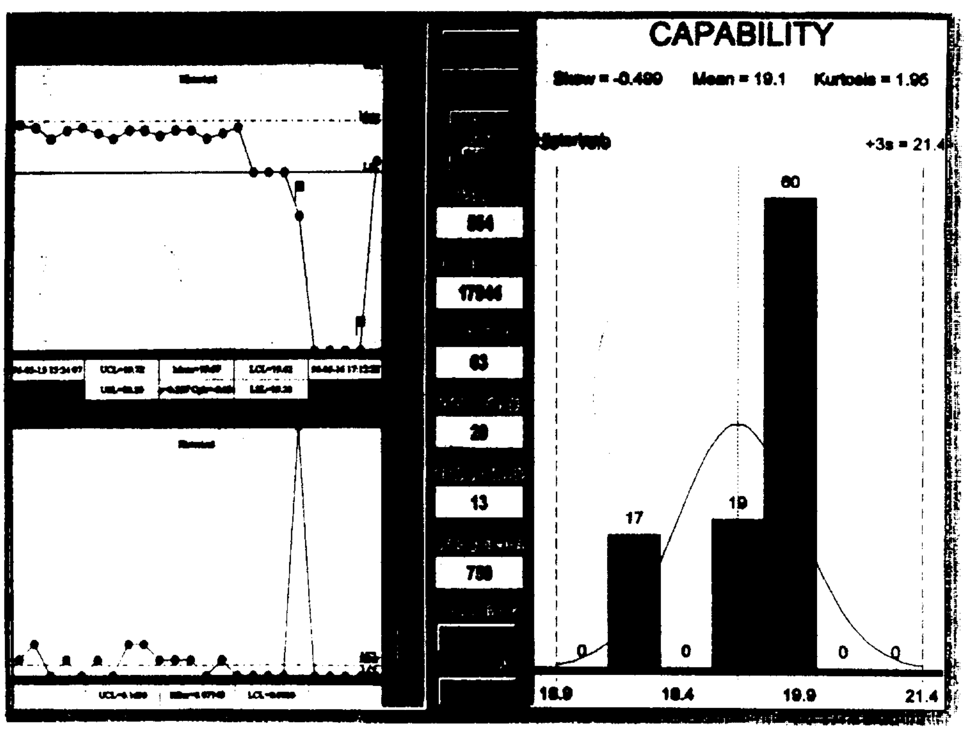

Figure 8

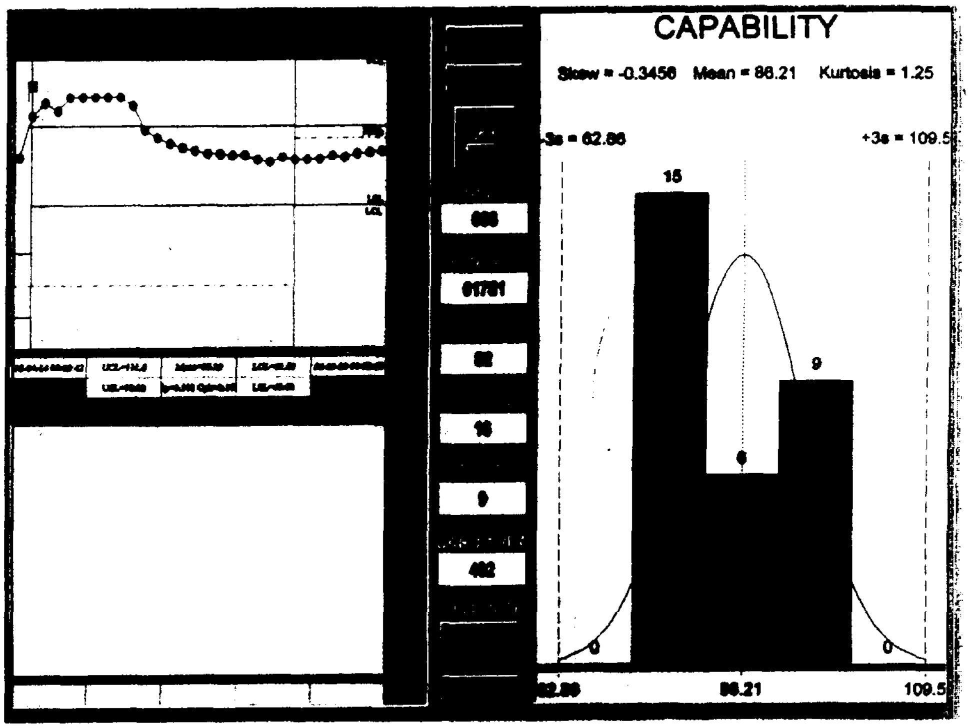
CAPABILITY
Skew = -0.3456 Mean = 86.21 Kurtosis = 1.25
-3s = 62.86
+3s = 109.5
15
9
6
0
0
86.21
109.5

Figure 9