Statistical Quality Control in the Packaging Industries

Statistical quality control (SQC) is a necessary part of the production and use of modern packaging materials. The software chosen to satisfy basic SQC needs will determine whether it is an awkward, intrusive task or a smoothly operating part of the process. SQC software must not only collect quality data and produce control charts, but also provide the capabilities that make it the core of a well run and effective quality system.

The successful implementation of Statistical Quality Control (SQC) begins with the selection of the tools and methods best suited to the company's quality goals. Because manual charting can be burdensome and time-consuming, PC-based SQC using specialized software is preferable for routine charting and essential for process improvement studies. Numerous PC-based SQC software packages are readily available. Most, however, were developed for discrete manufacturing, particularly the automotive sector, and may not suit the diversified needs of modern packaging manufacturers and packaging users. When evaluating SQC software, packaging producers and manufacturers need to be aware of such shortcomings when making their selection.

Limited usability	Will you be able to select one package to meet the needs of all users—from incoming inspection to finished product testing?
Data limitations	Can descriptive, measurement and defect data be viewed in and analyzed from the same data file?
Operator requirements	Can routine charting be automated to reduce training time? Is unattended operation possible?
Rigidity	Can charts be configured to precisely meet internal QC needs and still meet customer and regulatory reporting requirements?
Data isolation	Can the software easily collect process data? Can it accept instrument data? Can it share or exchange data with the corporate or plantwide information systems?
Vendor awareness	Are the software developers knowledgeable about the issues and special requirements of producers and users of packaging?

With the introduction of NWA Quality Analyst in 1985, Northwest Analytical, Inc. (NWA) initially focused on the needs of process industries such as food, pharmaceuticals, and chemicals. As a natural consequence, NWA directed its attentions to the problems associated with packaging, whether in the production of packaging materials or their utilization. As a result, NWA Quality Analyst is now the leading SQC package used in those industries. Its applications range from internal QC and process improvement to vendor certification and regulatory compliance.

Can Flanges

The right software simplifies effective SQC application and enables the production staff to readily use SQC in all phases of the process management. By using NWA Quality Analyst during setup, the engineering staff of a nationally recognized manufacturer of two- and three-piece cans was able to improve can quality by controlling flange width while increasing the rate of production.

The engineers set up a can-forming line producing containers within specification using a routine series of control charts and process capability analysis reports. They discovered that the active use of SQC methods during the setup and tuning period meant more than just improved overall product quality. Since the tuning effort was directed to best performance, the speed of operations was increased as well.

Such results were made possible in part by having SQC software that permitted easy access to a variety of user-defined settings (such as specification limits and calculation methods) and reporting abilities, combined with automated charting capabilities. As a result the engineers got exactly the charting they needed without disrupting the tuning process.

In their initial analysis, the engineers learned the can line was stable and in statistical control. (See **Figure 1**.) However, it was not capable of meeting specifications as shown by the process capability histogram and report; the Cpk—ideally 1.3 or better—was only 0.25. Since the control chart showed the process to be in control, the engineers did not waste their time investigating special causes (e.g., operators, feedstock, shift to shift variation, etc.), but instead focused on process modifications to increase the process capability. In addition to working on the general condition of the machine, centering the flange forming heads proved to be critical to improving process capability.

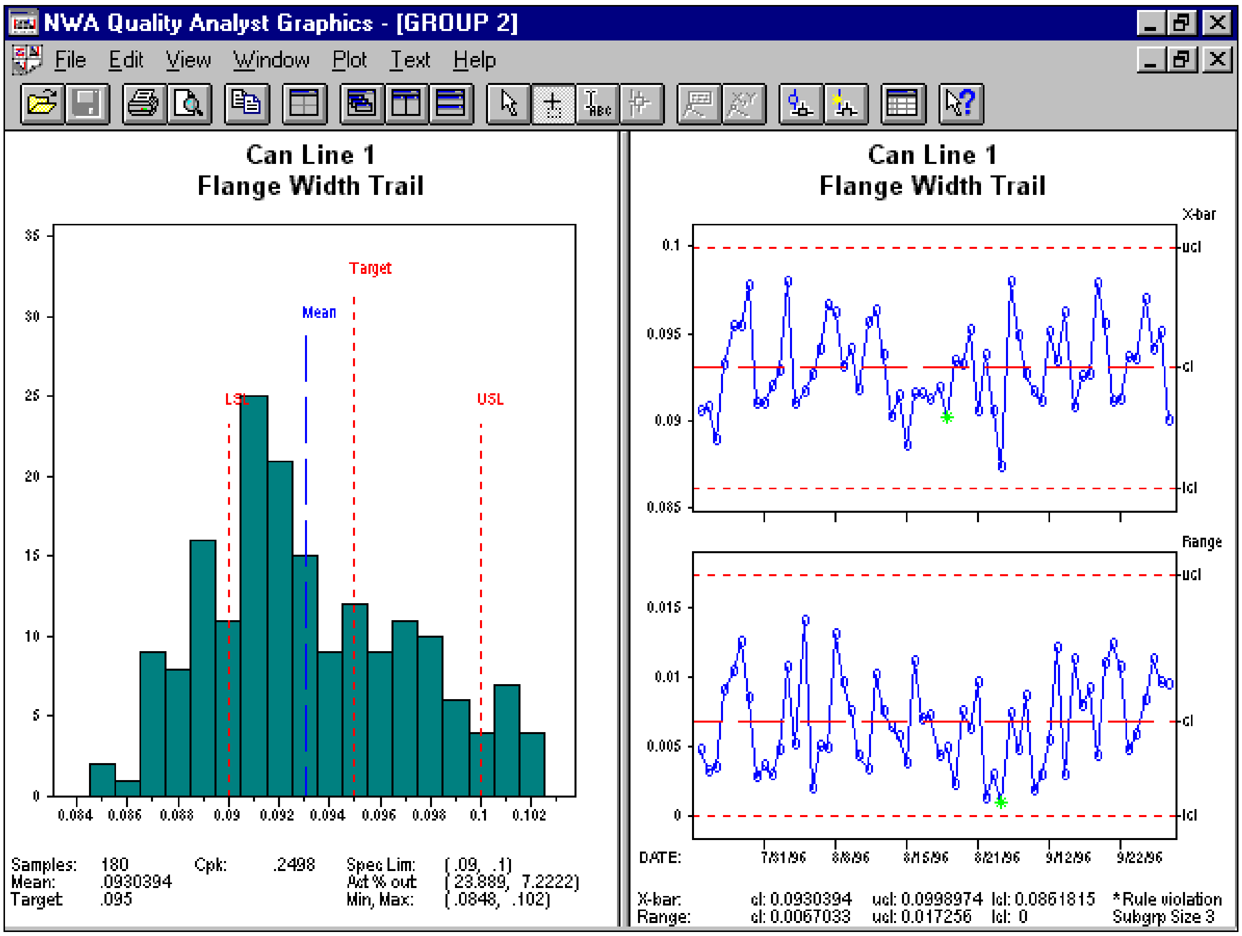


Figure 1
Initial investigation shows the can line to be in statistical control though not capable. Process modification is called for since special causes of variation can be ruled out.

Figure 2 illustrates the line's production after the machine upgrade and head centering processes brought the system into a capable condition. Consequently, the Cpk increased to an acceptable 1.335. Monitoring both the control chart and process capability would continue as part of the standard operating procedures. Since the data files and charting parameters were already established, SQC charting also became a simple and normal part of the workflow for the line operators.

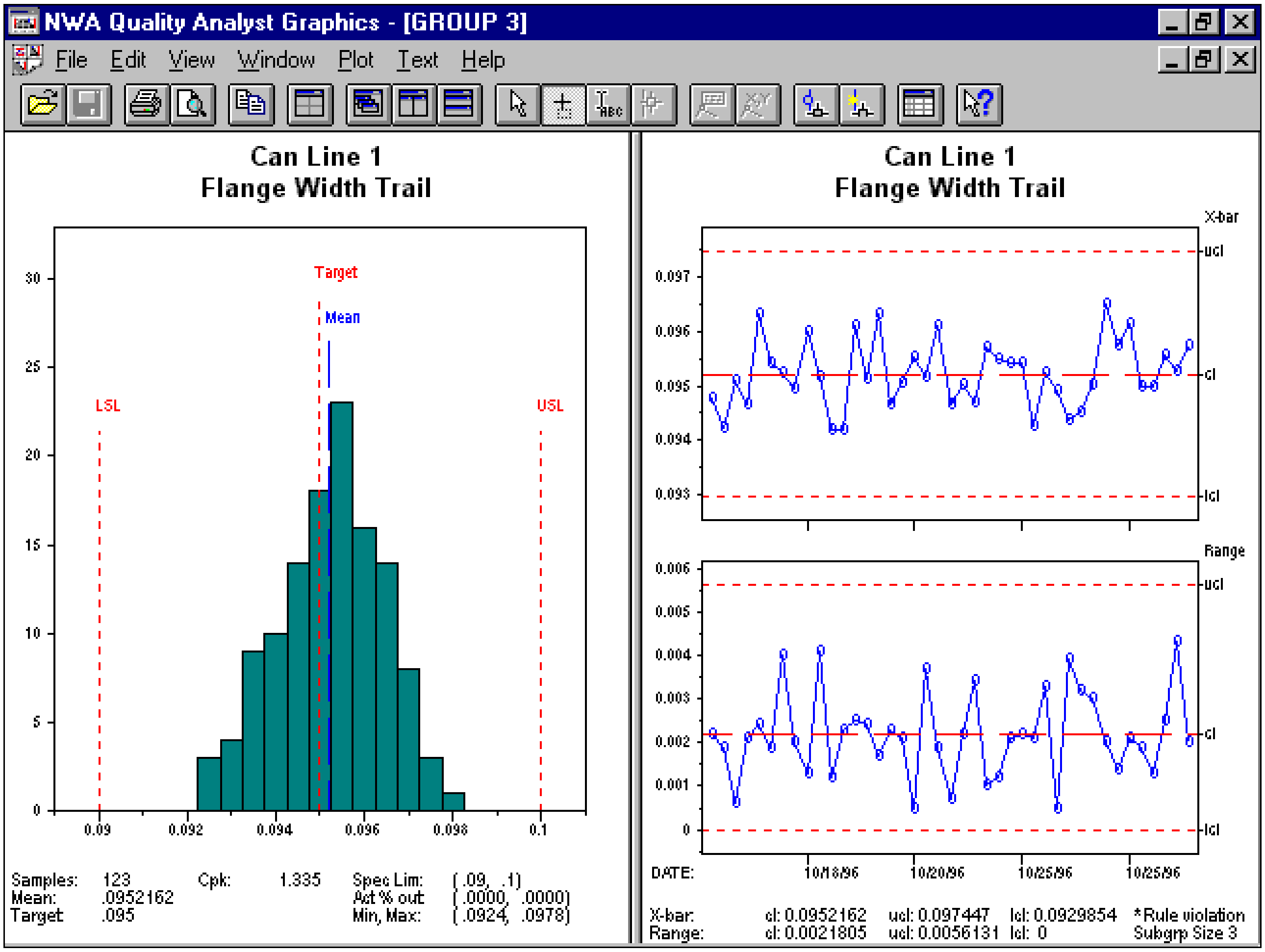


Figure 2
After adjusting the flange machine, the system is brought into a capable condition with the Cpk increased to an acceptable 1.335.

Plastic containers—a bonus use for fill weight control

The charting and analysis demands of high volume package manufacturing and filling can be challenging. In many cases, specialized charting is required for accurate analysis and effective problem solving. Typical examples are the multicavity mold and multihead filling machines, often referred to as "family processes".

Family processes incorporate multiple identical subsystems into a single process, such as the separate mold cavities in a multicavity mold. Each sample from the subsystem plus the overall process must be examined independently. To meet the special needs of family processes, NWA Quality Analyst is unique in offering Median/Individual Measurements (M/I) control charting.

A packaging manufacturer faced daunting data collection and analysis problems meeting vendor certification requirements while manufacturing 6-oz. plastic cups using a 40-cavity injection molding machine. M/I charts allowed them to simultaneously monitor the overall process as well as the behavior of individual mold cavities. The cup manufacturer's use of M/I charts alerted the cups' user, a yogurt packager, to a technique that could also be applied to fill operations with equal success.

Since each cavity is an independent process, it would have otherwise required 41 control charts to completely monitor the cup-molding process—one for each cavity plus one for the overall process. Charts that would have randomly sampled data from all cavities simply would have missed data indicating defective product. On the other hand, M/I charts allowed them to significantly reduce the time, effort, and expense that would have been required by conventional analysis.

M/I charts are easy to read and interpret, and far easier to manage than the alternative of multiple X-bar charts. Cavities regularly producing defective cups—in other words, those exhibiting an out of control process—are indicated on an M/I chart by cavity number. (See **Figure 3**.) Individuals are displayed with control limits based on the behavior of all individuals. The median, representing the behavior of the overall process, is reported by the line moving about the chart's center line, with control limits derived from all median values. This clear, readily understood presentation allowed the manufacturer to focus completely upon problematic cavities, significantly reducing the QC department's burden.

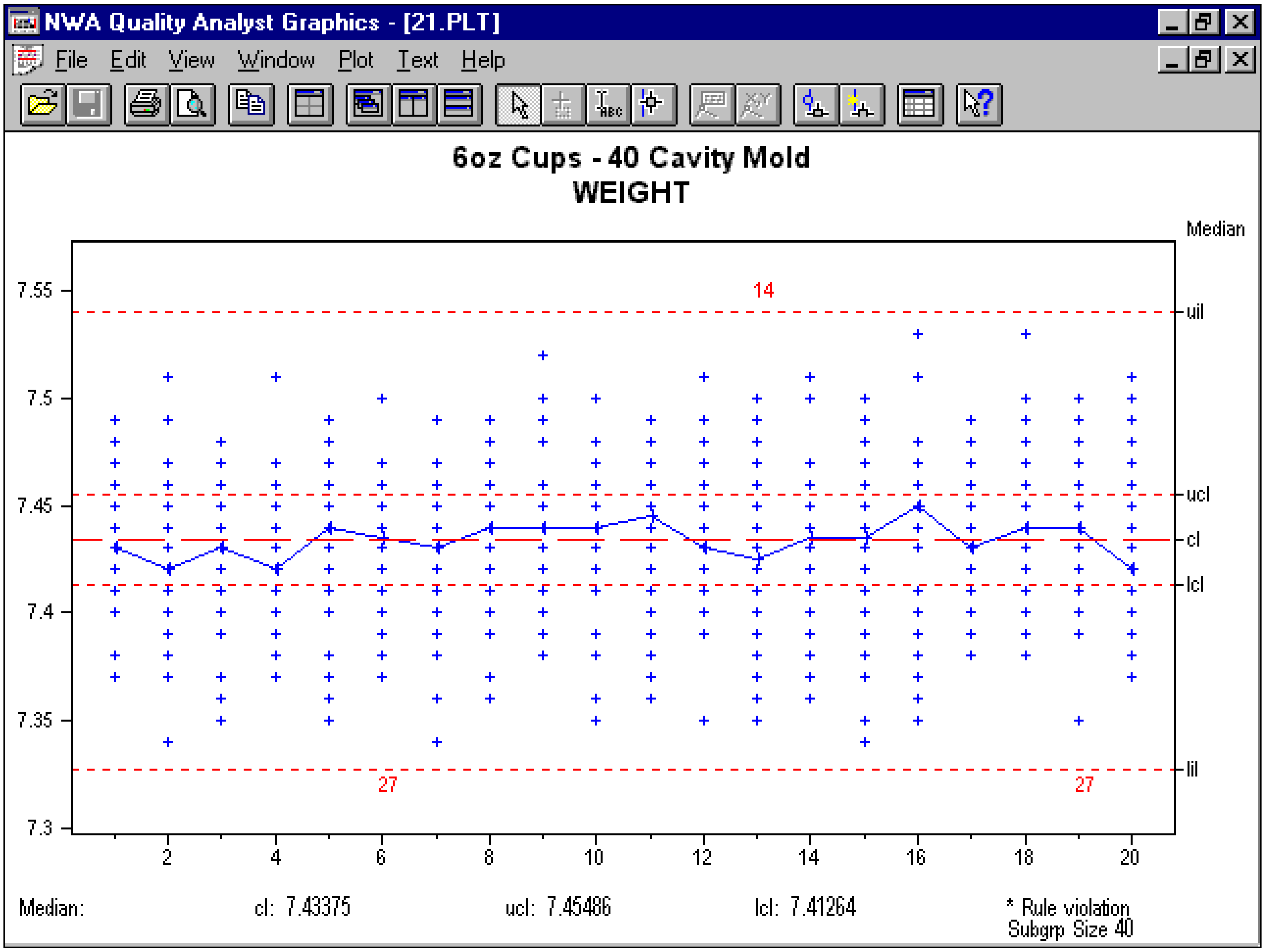


Figure 3
M/I charting displays the behavior of all individual mold cavities; cavities consistently out of statistical control are indicated by a number. The moving line shows the behavior of the overall process.

As shown in **Figure 3**, the overall process (represented by the moving line) is in statistical control, though cavity 14 is above the upper individual control limit once and cavity 27 is out of control twice during the period monitored. It is unlikely that many commonly used control charts would have alerted the engineers to the out of control behavior of either cavity. A typical random sampling from all 40 cavities yields a defect selection probability approaching zero. Further, since cavity 27 is reproducibly producing underweight cups, its own local process is actually in statistical control (see **Figure 4**), though regularly producing defective cups.

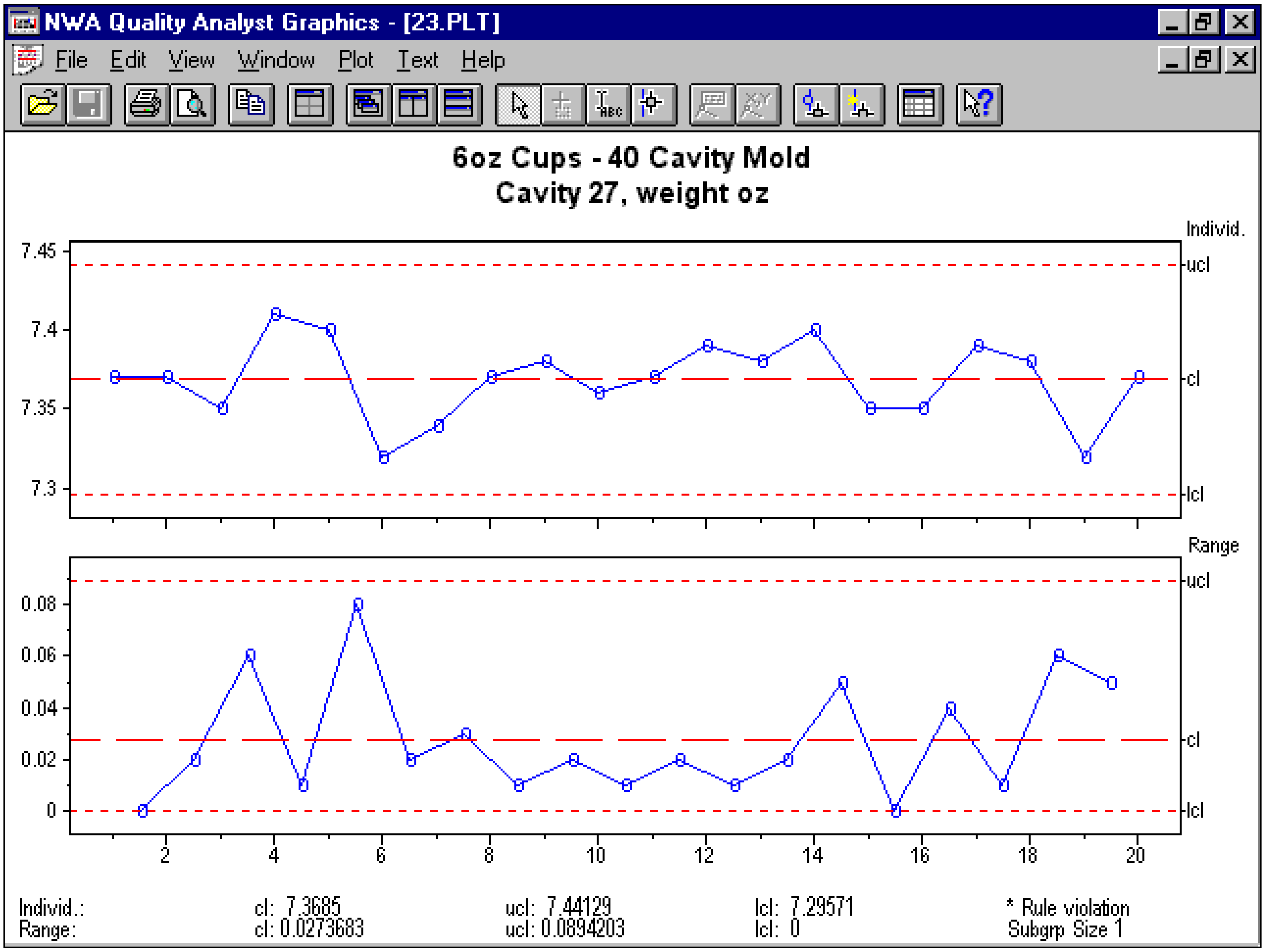


Figure 4
Because cavity 27 produces defective product consistently, it is actually in statistical control, as indicated above. Identification of an assignable cause of variation requires further analysis.

Once the sources of defective cups were identified, the cup manufacturers conducted further analysis. NWA Quality Analyst allowed them to easily and independently select and chart data for the nonconforming cavities, then take corrective action. A comparison of histograms showing weight distributions for cavity 27 alone and the complete group of 40 cavities demonstrated clearly that cavity 27 produced cups of a significantly lower weight. (See **Figure 5**.) The results were then confirmed using t-tests in the general statistics section of Quality Analyst.

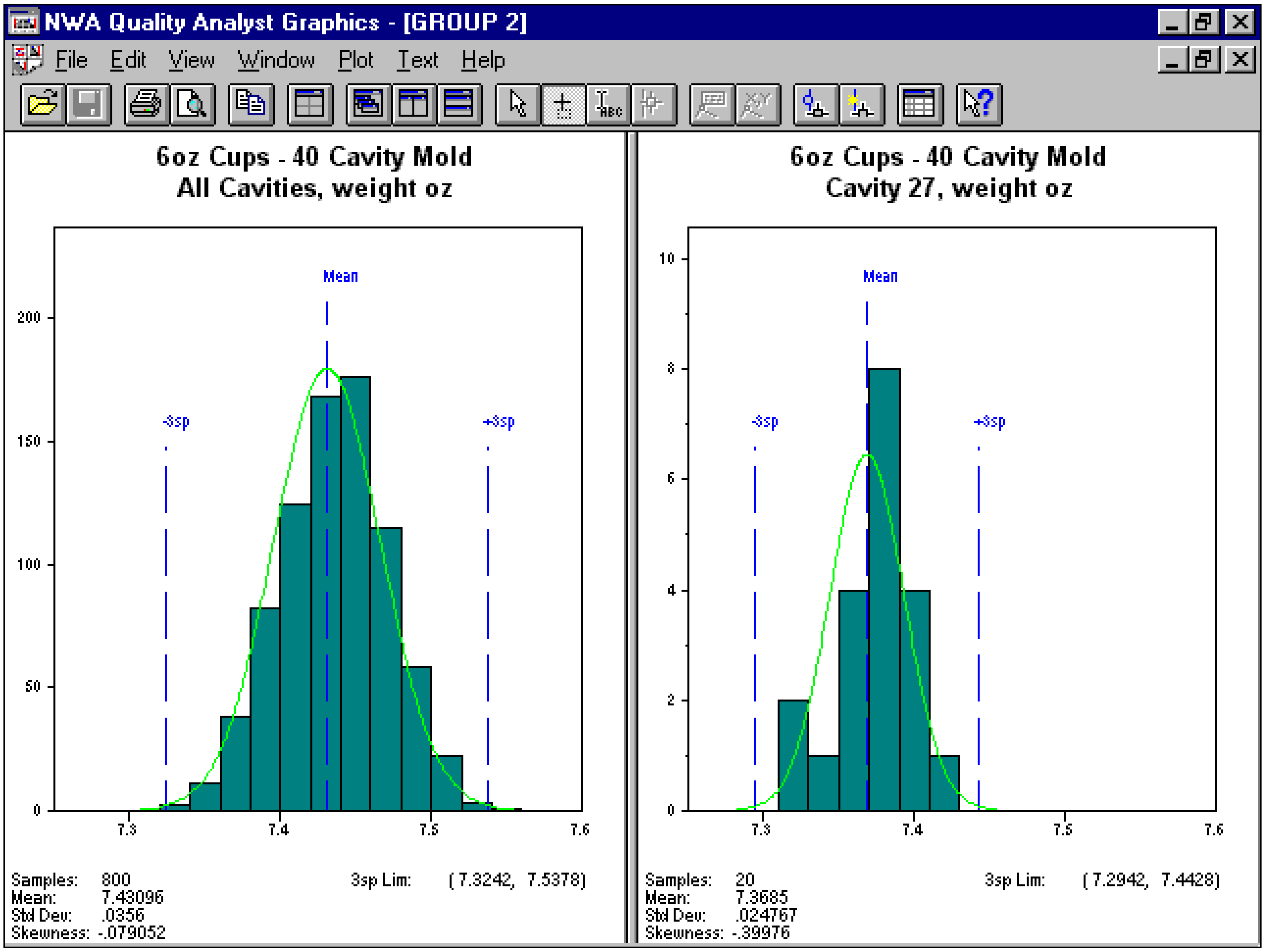


Figure 5
A side-by-side comparison of histograms representing the overall process (left) and cavity 27 alone (right) shows cavity 27 values significantly shifted to the left. In other words, cavity 27 regularly produces underweight cups.

The inclusion of M/I charts with cup shipment to the yogurt processor led to the application of the M/I technique with their multihead filling machines. By successfully monitoring the behavior of each fill head, the processor was able to substantially reduce the amount—and cost—of intentional overfill to guarantee label fill weights. Their analysis was made simpler by Quality Analyst's ease of data integration with check weighers in the exit path of the filling process.

(For an in-depth examination and further examples of M/I charting capabilities and applications, contact NWA for a copy of the booklet "Median/Individual Measurements Control Charting," by Perry Holst and John Vanderveen, developers of the M/I technique.)

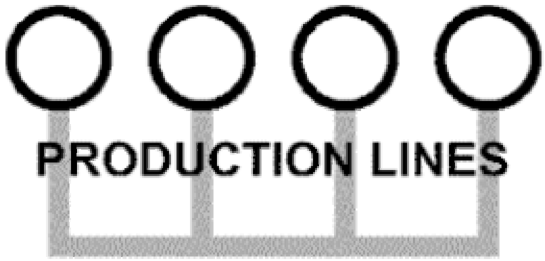
SQC in Data Collection and Plantwide Data Systems

As the use of plant automation increases, manufacturers across all industries are turning to computer-based information systems to collect and maintain production data. However, production data sitting in databases or test equipment data stations can be of limited value if the SQC software cannot easily access the data.

These obstacles can be overcome if the SQC software can move data via file transfer—in an open data structure such as delimited ASCII—or if the SQC software and the data source conform to Microsoft's ODBC (Open DataBase Connectivity) standard. When combined with its automation features, Quality Analyst's data connectivity features make it an obvious choice for integration into test stands and manufacturing information systems. (See **Figure 6**.)

Integration means that SQC charting is produced immediately and is available right at the test stand, increasing the likelihood of effective application. Likewise, Quality Analyst interfaces with other software and systems. In addition, NWA Quality Analyst's Run File utility, using macro-like scripts, automates frequently used and repetitive charting tasks. As more package forming and filling machines use commercial supervisory control systems for operational control, the ability to integrate and automate SQC becomes essential. The combination of data access with automation greatly simplifies the task of producing SQC charts wherever and whenever needed.

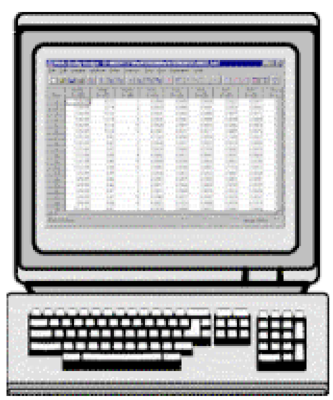
Scroll down for Figure 6…..



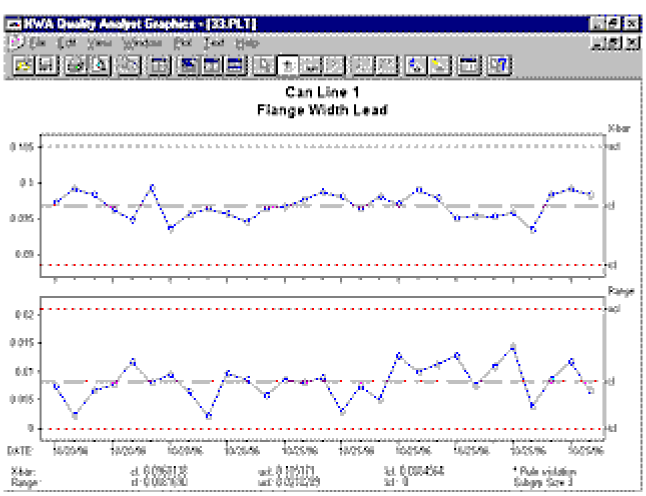
NWA Quality Analyst's connectivity allows free data exchange and analysis. First, production data is collected...

DATE	TIME	HEAD	FWL	FWL	FWL	FWT	FWT
7/26/95	10:13	1	0.0948	0.0959	0.0930	0.0923	0.0917
7/26/95	10:14	2	0.0929	0.0969	0.0941	0.0924	0.0893
7/26/95	10:18	3	0.0891	0.0893	0.0880	0.0877	0.0911
7/26/95	10:19	4	0.0945	0.0962	0.0889	0.0899	0.0989
7/26/95	10:19	5	0.0926	0.0917	0.0970	0.0896	0.0969
7/26/95	10:20	6	0.0941	0.0917	0.0971	0.0885	0.0970
7/31/95	9:40	1	0.1029	0.0889	0.0954	0.1005	0.0922
7/31/95	9:42	2	0.0948	0.0911	0.0923	0.0916	0.0894
7/31/95	9:43	3	0.0934	0.0950	0.0930	0.0892	0.0910
7/31/95	9:45	4	0.0882	0.0933	0.0943	0.0937	0.0909
7/31/95	9:46	5	0.0905	0.0989	0.0916	0.0952	0.0928
7/31/95	9:48	6	0.0902	0.0906	0.0981	0.1010	0.0912

...into a plantwide database. Then,...



...using NWA Database Connectivity,...



...data is mapped into NWA Quality Analysis for charting.

Figure 6