DATA COLLECTION and EVALUATION

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In order to monitor production using Statistical Process Control techniques (SPC), a multitude of data is needed to ensure that the information is a true representation of the process.

Before the advent of computers this data was laboriously recorded, the averages and necessary statistical information calculated and the results plotted. It was then up to the inspector to check for trends or outliers. Problems were not obvious until the results had been plotted and there was a large time delay.

Now with computerisation the data can be collected REAL-TIME and the statistics calculated immediately. Trends are checked for and the average of the sample is compared to the specifications and control limits which have been preset. If the process is out of specification an alarm sounds and a message can be flashed onto the monitor stating the discrepancy.

Because the data is analysed REAL-TIME the scrap produced is kept to a minimum and can be isolated.

EQUIPMENT :

The first essential is a data collection device; these can be

(a) Handheld -	Dataputers
	DataMytes
	These data collectors are robust and can be carried to the workplace and up to three instruments can be directly connected
(b) Portable -	Mitutoyo
	TESA
	Notebook Computers
	These data collectors are not as robust as the hand helds and need to be placed on a secure mounting during use.
(c) Fixed -	Personal Computers

For both (a) and (b) data evaluation is carried out REAL-TIME on a small LCD display and, depending on the connected to a larger monitor or a printer. data that can be collected is restricted and then be down loaded into a PC or storage device on a regular basis.

For (c) depending on the software, the computer is either stand alone or networked.

As a stand alone, the computer is used to collect and analyse the data at one location only, requiring the products to be brought to that location for data entry and evaluation. This system gives a larger storage capacity and is less expensive, but a longer time delay between measurements, evaluation and rectification can occur which could mean more scrap is produced.

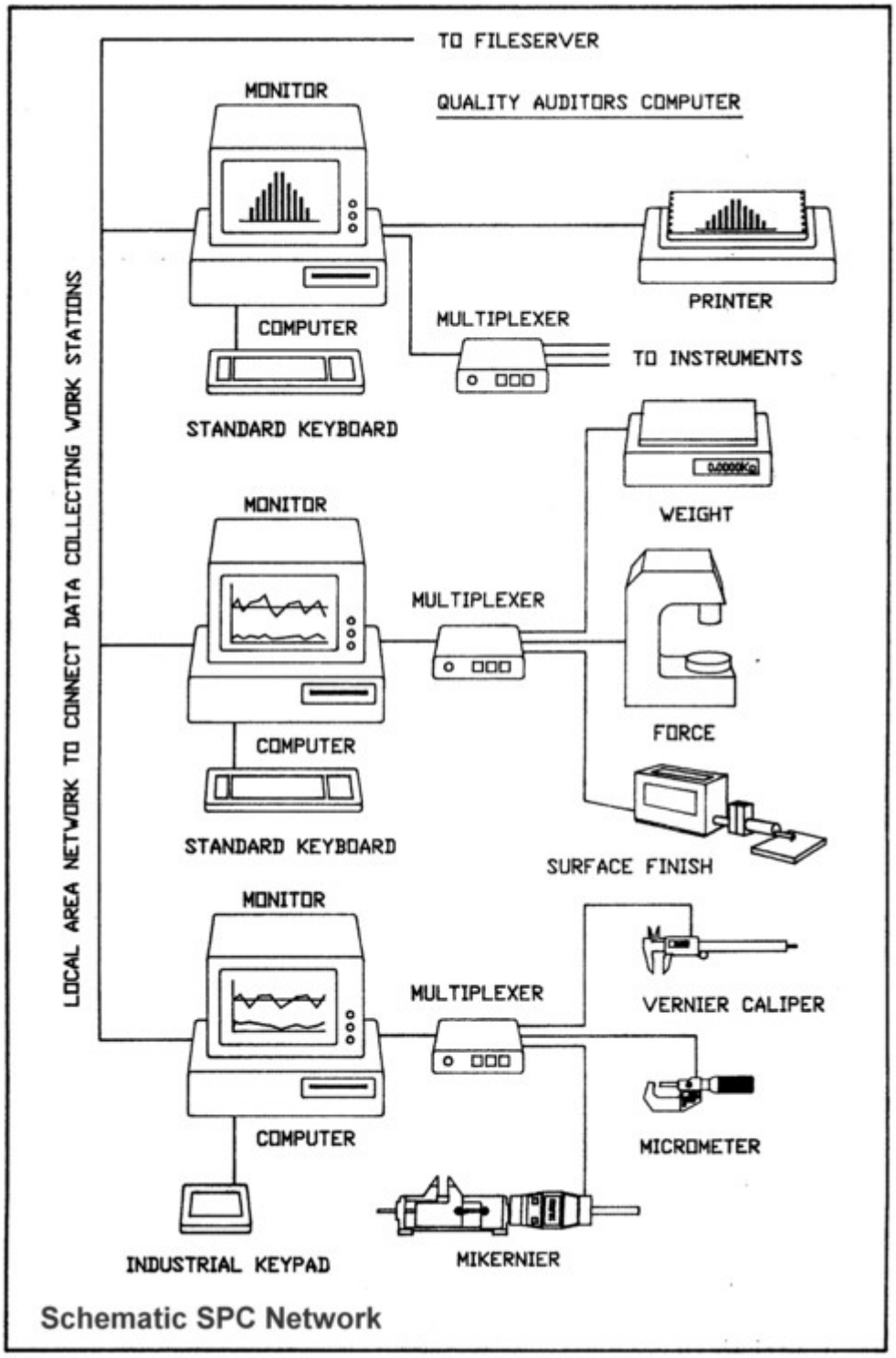
The ultimate solution is to position the data collectors out on the shop floor next to the machines/process which enables the data to be evaluated REAL-TIME and the operator immediately advised of any problems. The data collectors are then connected to a central computer to form a network which allows the data to be stored in a central location. The extra bonus is that the Quality Auditor can monitor the data collection/evaluation from the Quality Assurance Office and only get involved in processes which are out of control and require further investigation.

The data collectors on the shop floor should be capable of displaying X-Bar and R Graphs and Histograms displaying the Process Capability for the process.

If Personal Computers are used as data collection terminals, the keyboard will need to be replaced with an industrial keyboard or have a plastic moulded cover fitted.

There are now hundreds of electronic measuring instruments available -from digital calipers for less than two hundred dollars to complex measuring devices selling for several thousands of dollars. Most of these send out a signal that contains the measurement reading(s). To convert the output from the measuring instruments a multiplexer is required. As each manufacturer of instruments has a different output signal the multiplexer should be intelligent enough to convert the various outputs into a common input for the software.

It should also be possible to manually enter data through the keyboard or other device.



Schematic SPC Network

DATA COLLECTION

Most products/processes have numerous features/characteristics that need to be measured. There is a limit to how many features can be measured cost effectively. SPC requirements must not interfere with productivity and should take no longer than the time normally taken to check the product, the advantage being that everytime the product is measured, the data is automatically stored and evaluated. To keep the number of features down to a minimum, it is important to tool up the process so that multiple features are produced at once using one tool or in the case of CNC equipment ensure that the programme has been written correctly.

The features which are to be measured are then selected and the method of data collection set up in the computer. This is done only once for each feature and stored away for future recall.

Some software packages allow the Quality Auditor to set up daily/weekly schedules to make it easy for the operator to select the correct product and step the operator through the data entry process.

During data entry the software instructs the operator which feature to measure and which instrument to use.

The data collected must also be date and time stamped and preferably have facility for labelling as to which machine, shift, tool, cavity or department it was collected from. This assists when trying to find clues as to why a process is not performing as expected, as each variable, such as individual cavities of a multi-sink die, can be systematically evaluated.

It is important to use an instrument which has a resolution of at least ten times the actual tolerance to be measured to ensure that the results are a true representation of the process.

Instrument	Resolution	Tolerance
Steel Rule	+/- 0.50 mm	+/- 1.0 mm
Vernier Caliper Dial Indicator Digital Caliper	+/- 0.01 mm	+/- 0.10 mm
Bore Micrometer	+/- 0.005 mm	+/- 0.05 mm
Micrometer Dial Indicator Optical Projector Vision System CMM	+/- 0.001 mm	+/- 0.01 mm
Laser	+/- 0.0005 mm	+/- 0.005 mm

SELECTION OF CORRECT INSTRUMENTS

INFLUENCE OF GO/NO GO GAUGES

Before SPC it was common to use GO/NO GO gauges to check whether the product is within specification. These gauges are easy to use but do not tell the operator what the actual size is and whether or not the process is centered on the target dimension. The danger is that product can be produced off centered and if the Process Capability was low a percentage of production would have been out of specification. When ever possible these gauges should be replaced with direct measuring instruments to enable the process to be controlled.

MEASURING THREADS

The above comments also apply to threads as GO/NO GO gauges are the quickest way of checking threads. Direct measurement of the effective diameter is the only way of knowing if the product is correct. This is achieved by using thread parallels, three wires or Ovee Gauges and conventional micrometers or thread micrometers on external threads. By mounting the thread parallels in the jaws of the Mikernier it is possible to measure quickly and accurately the effective diameter of external threads.

Internal threads are more difficult to measure and for direct measurement very expensive instruments must be used. Small internal threads, up to 40 mm are best checked with a plug gauge as usually a tap is used which is a fixed size and the process cannot be altered. The minor diameter should still be directly measured.

Larger internal threads which are screw cut should be directly measured as the process is subject to variation.

DATA EVALUATION

The following statistical tools should be available for data evaluation.

Subgrouped Data	Tabulation (Detail or Summary)
	X-Bar/R Chart
	Run Sum Analysis
	Histograms
	Scatter Diagrams
	Capability Analysis
	Paired Sample Analysis

Individual Data	Tabulation (Detail or Summary)
	X/MR Chart
	Run Sum Analysis
	Process Capability Histograms
	Percent actual out-of-specification
	Percent predicted out-of-specification
	6 & 8 Sigma Limits
	Cpk, Cp & PC
	Skewness
	Kurtosis
	Chi-square Test of Normality
	Scatter Diagram
	Capability Analysis
	Paired Sample Analysis
	t-test

Attribute Data	For p, np, c or u analysis.
	(All analysis in terms of percent defects or
	percent total)
	Tabulations (Detail or Summary)
	Control Charts
	Pareto Diagrams
	Pie Charts
	Run Sum Analysis
	Scatter Diagram

Provided the process is in control, i.e. no trends developing or out of specification product detected, there is no need to plot the results on either X-Bar and R or Histograms.

Some packages available have a monitoring module which allows the Quality Auditor to display on the screen all the features for a particular product at once for a visual check or ask the system to list all the products and highlight those which are out of control.

These out of control products are further analysed to find out why they are wrong and the process is rectified.

These outliers are then earmarked in the database to show that the process has been rectified and data collected from then on is not affected by these outliers.

PROCESS CAPABILITY

This is the ratio between the product tolerance and the actual tolerance of the process (+/- three standard deviations). This is indicated by the abbreviation Cp, and should be greater than 1.33, but this calculation does not allow for the process being off centre. Another equation is used to calculate the corrected capability and is indicated by the abbreviation Cpk which should be greater than 1.00.

These indexes Cp and Cpk are the first indication if the process is operating correctly. Ideally they should be equal. The difference between the target dimension (specification mean) and the overall average (X-Bar) for the collected data is the amount the process needs to be reset by to bring the process back on target.

This only applies if the process is in control and no previous corrections have been made. When the process is reset the database must be earmarked to show this adjustment and the old data not included in future assessment of the reset amount.

If the Cp's and Cpk's are equal but they are below 1.33 and 1.00 respectively, this indicates that the specifications are too tight for the machine/process and either the machine/process is upgraded or the specifications for the product will have to be altered.

The Histogram shows if the process is capable and centered on the target dimension. If the process is in control no further evaluation is required.

The X-Bar and R chart is used to highlight the out of specification products and show when they occurred relative to time. The outliers could be genuine out of specification product or they could be the result of bad measurement. The outliers should be checked and if they are genuine, the process stopped and rectified. Evaluating data is an acquired skill, either gained through text books or formal training.

Experience will make the process easier and more consistent.

Never jump to conclusions, always complete the total evaluation before making a statement on the process.

It is important that the productive staff view the Quality Auditor as an aid to production improvement. The Quality Auditor should discuss the findings of the evaluation with the operators and highlight those areas requiring improvement and praise those areas which are in control.

See paper Statistical Process Control can Pay Dividends for samples of Graphics

Because all the data collected is stored in the computer it is easy to generate reports, covering production, which can be sent to the customer with the goods. When the customer has developed enough confidence in the SPC process, they could reduce their inwards goods inspection and hence reduce their own costs. This system is perfect for Just In Time customers, as the goods can be delivered directly to the production line reducing their inventory and again reducing costs.