Hands-on Management



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Using the Pareto Chart

uality has many functions in business. One of its functions is to provide feedback that expands thinking and encourages evaluation of developing technologies, both current and future, as possible solutions to challenging problems. At our shop, quality is more than the two employees that work in the quality department. We like to think that everyone working for the organization can relate to quality. We're moving toward incorporating a quality paradigm (model) into everyday production pressures. As the quality assurance manager, I have been trying to impress on the operators and supervisors that it is the jurisdiction of production that produces quality. It has become a "running gag" between our production supervisor and me that he has become one of the "quality guys" at Pottstown Plating.

Quality assurance engineers have at their disposal the Pareto diagram one of the most powerful, but basic statistical process control (SPC) tools available. Pareto charting is a deceptively easy, yet effective, way of looking at collected data to help find the root cause of a problem. You may know Pareto charting as the 80/20 rule: 20 percent of your customers are 80 percent of the sales dollars; or 80 percent of the rejects are caused by 20 percent of the parts.

A Pareto diagram is produced by grouping data, ranking an item by the number of occurrences, and plotting it in descending order by any other attribute along the x axis. The y axis is generally the number of occurrences, but sometimes it can be beneficial to plot in dollars to highlight the cost factor. Characteristic xaxis values are:

- Deficiency (trait)
- Time of day (day of week/shift)
- Machining or plating process
- Operator



• Inspector

• Incoming material lot

Let's look at how charting can be used to aid the process with an example from an overview of the printed circuit industry. As the professionals in the circuit board business already know, there are numerous holes in printed circuits, and most need to be metalized. Most commonly, electroless copper plating supplies the initial conductivity to the holes drilled into the laminate. Laminate is the generic name for the copper-clad epoxy fiberglass board from which most general printed circuit boards are produced. The metalized holes in the plated through (the hole) board insures that the electrical components make a good circuit after soldering.

An Example of

Using a Pareto

A PC board manufacturer produces 1,000 boards per day. At the end of one week, 200 rejects had been discovered. This occurred despite the control charts showing the processes to be in control. (Note: Control charts can only show the particulars that are being measured. One cannot easily measure all that can go wrong in any process this complex.) Because percentage generated by the number of rejects per number of boards completed surpassed the company's rate for rejects investigation, a process quality engineer was called in to research the situation. He used Pareto diagrams to pinpoint defects and the number of occurrences (see table).

Defects (traits)	Number of Occurrences
Blown Holes	88
Voids	56
Broken Lines	31
Dimensional Problem	s 13
Thin Plating	6
Miscellaneous	6
Total	200

Now, let's examine the identified defects and their causes:

• Blown holes are caused when the PC boards are heated to fuse (reflow) the solder plating over the copper lines or traces. Fluids from the wet process are trapped between the drilled hole in the laminate and the electroless copper and electroplated metals. Heating the board (reflowing) to the melting point of solder causes the trapped liquid to expand and find a way out, blowing the metal away from the wall of the fiberglass hole.

- Voids occur when the electroless copper does not plate the hole totally or in part. Drilling the hole exposes the fiberglass in the copper-clad laminate. The fiberglass can develop a charge that, without proper conditioning, can prevent the hole from picking up the right amount of catalyst needed to begin the electroless copper plating.
- Broken lines can be caused by nicks in the artwork, in which case the break will be in the same place on the board every time this artwork is used to expose the photoresist. Dust, dirt and copper oxides in the process can cause non-repeating or random breaks in the circuitry.
- Dimensional problems may be produced by mis-registration. Registration is a pinning system that allows for repeatable drilling and routing.
- Thin tin lead plating (less than 180 millionths of an inch) will not reflow. Large ground planes plate at very low current density as compared to the much thinner lines. A balance between over-plating the lines and under-plating the ground plane is needed to ensure quality boards.
- Miscellaneous deficiency is ... who knows? This is PC board manufacturing, and there are a lot of variables.

The engineer gets the biggest return for his time and effort by working on the root causes of the blown holes and voids. It was noted by an inspector that all the blown holes were only found in one large hole size in one lot of laminate. The engineer then noticed that voids were only found in very small holes. The holes in question were small enough to need back-up boards (used to cool the tip to the drill) in drilling. The voids were many small breaks in the electroless copper plating in a random pattern in the hole.

Determining the Cause Both the blown holes and voids could be caused in drilling. While the large holes were being drilled, the heat generated by the point and shaft of the drill passing through the laminate melted the epoxy and created a very smooth hole. The hole was so smooth that the electroless copper failed to form a strong mechanical bond with the board and the hole failed in reflow.

The voids can be caused by small particles being drawn up into the holes as the drill returns to the home position. A vacuum is created when the drill bit reverses direction, pulling fines from the backup boards into the holes. The fines travel with the hole through the pretreatment process of the electroless copper line, but once in the process tank, the gas bubbles float the fines into the bath, leaving the holes with spots that no longer have catalyst to start the electroless process. This leaves a random pattern of voids. The drilling feeds and speeds can effect the electroless plating process. (Feed is the rate the drill point moves through the laminate; speed is the number of revolutions of the drill bit.)

Using a Pareto chart can help make the complex problems of running a business more understandable by stripping away the many possible problems to see clearly the important few.pesp