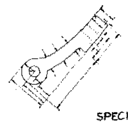

FINE PRINT METHOD

SPECIFYING DETAILS NOT NEEDED FOR PERFORMANCE BUT DEMANDING COMPLIANCE

UMBRELLA METHOD

DESIGNED SO THAT EVERYONE CAN GET UNDER

SHOTGUN WEDDING METHOD

A FORCED UNION ARISING OUT OF A DOMINANCE BY EITHER SIDE

KEEPING UP WITH THE JONES' METHOD

COPYING ANOTHER, AND PERHAPS UNRELATED, SET OF SPECIFICATIONS

GO YOU ONE BETTER METHOD

ELABORATION AND EXACTINGNESS FOR PERSONAL GRATIFICATION

FICTION WRITER METHOD

ANY RESEMBLANCE TO PERSONS OR EVENTS IS ENTIRELY ACCIDENTAL

OSTRICH METHOD

BURYING ONE'S HEAD, UNAWARE OF WHAT IS GOING ON

Statistics for Better Spec's

R. C. MANRING, Monsanto Company, St. Louis, Missouri

PEAS IN A POD METHOD

BELIEVING THAT THINGS DO NOT VARY EXCEPT BY CARELESSNESS

YOU GO YOUR WAY METHOD

ENGINEERING SETS TOLERANCES TIGHT BECAUSE PRODUCTION WILL MODIFY THEM IF IT SEEMS NECESSARY

HAIRLINE METHOD

THE AX FALLS ON A HAIRLINE DEVIATION NO MATERIAL REVIEW COMMITTEE

ACCENT THE POSITIVE METHOD

A GAME OF EXAGGERATION AND COVER-UP. 'SELECTIVE AMNESIA FOR THE FACTS' BROSS

DAMN THE TORPEDOS METHOD

SETTING SPECIFICATIONS REGARDLESS OF MATERIAL OR PRODUCTION COSTS

THE PURPOSE of this report is to point out one or two simple statistical devices which can help to develop better and more meaningful specifications. The principal point of emphasis is to get the facts by calculating "Quality Profile" before setting specifications.

Origin of Specification Limits

In the final analysis, all specifications have their origin in some human need or want. Sometimes these needs or wants are not clearly understood. Sometimes it is difficult to state in concrete terms how they may be satisfied or how the quality characteristics are to be measured. It is small wonder that some specifications are ambiguous or unrealistic. This, I believe, also helps to explain the dynamic nature of specifications, a nature that is often frustrating to the supplier.

More specifically, specification limits are based upon engineering considerations that must be met in order that the product will perform as intended. Unless specification limits must be met in order to fill a human need or want, or to contribute to that end, there is no justification for them. Specification limits that require unnecessary precision of manufacture or insufficient precision cause enormous losses annually in scrap, rework, and excessive costs of manufacture. Note that what we have said so far is independent of the ability to make that which is specified.

Where do we stand in the "today" specification picture?

Each and every one of us is sitting on both sides of the negotiation bartering table. Our companies have thousands of customers and, at the same time, each of us is a customer to hundreds of other suppliers.

In addition, specifications exist both as external publications as well as within your own organizations.

At this point you can see the dilemma developing. We are producers with a process which turns out goods of established quality. The customer is purchasing against some need (real or fancied) and the two may, or may not, correspond.

If accurate costs are obtained, we can make a mathematical comparison to find the best-cost-specification (Fig. 1). "Use Costs" decreases with less variable material, and increase as the variability increases, as shown by the curve labeled "Cost of Use Increases with Loose Specifications."

"Procurement Costs" go up with tighter specifications, simply because it can cost more to make such material, as shown by the curve marked, "Purchase Cost Increases with Close Tolerances."

The real cost is their sum. In the figure, they are added graphically to give the curve labeled, "The Combined Costs Pass Through a Minimum Point Which Can Be Calculated." This minimum is the best specification for the user, and, you will note that it can be missed slightly without serious difficulty.

Parenthetically, as producers we usually know the production cost curve but seldom the other. Now, in detailing some typical statistical approaches toward "Finding the Facts" before setting the specification, I will use only a few illustrations. Each business has its own problems, to which these can only be adapted by one knowing the industry and the customer. I will first mention a few considerations covering the product, then the consuming side (which may be a customer or another department in the same business organization), and finally the producing side (even if only the preceding company department).

Current Methods

Take a brief look at the various methods now used to establish specifications:

The Fine Print Method. Too many specifications include many details not necessary for actual use of the article being specified. Blue prints for manufacture may have many dimensions necessary to develop the article. Too often a specification for compliance includes every dimension on the blue print. Don't confuse a specification detail with a working drawing.

The Umbrella Method. When specifications are the result of a group discussion of standards, they are often drawn so that "nobody is left out." When concerned with a group of producers, it is often set so as to include the weakest number of the group. When concerned with a group of consumers, it is often set to include the tightest specifications desired by any one member.

The Shotgun Wedding Method. Dominance of one side of the agreement results in a forced union. Compare the terms "buyers market" and "sellers market." Each produces a different idea as to specifications

The Keeping Up with the Joneses Method. Sometimes specifications are copied from another source without regard to the suitability.

The Go You One Better Method. Setting tighter specifications, just to gain or maintain a reputation for toughness.

The Fiction Writer Method. So far removed from the needs as to have no resemblance to "persons or events."

The Ostrich Method. Entered into by burying one's head in the sands unaware of what is going on, completely ignoring the subject.

The Peas in a Pod Method. Desired by the perfectionist. He cannot believe in variation—all articles must be exactly alike (but did you ever look at a pod of peas?). This man sets tolerances as the smallest number he can think of, divided by two.

Presented at the AOCS Meeting, Cincinnati, October 1965.

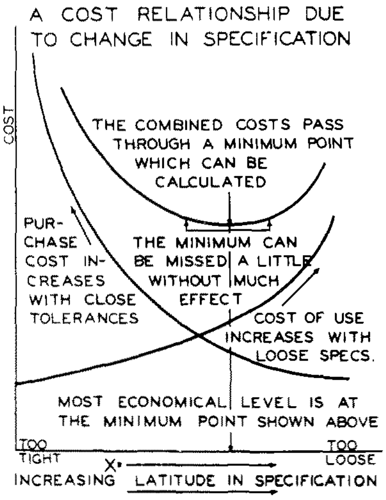

FIG. 1. A cost relationship due to change in specification.

The You Go Your Way Method. Complete disregard of specifications. Often set tight by engineering, hoping that production will come close, or knowing that production will set its own standards.

The Hairline Method. Tolerating no deviation whatever from tolerance even by the most minute amount. No concept of "Average Out-going Quality" and statistics. No "Material Review Committee" to decide on borderline quality.

The Accent the Positive Method. Somtimes based on what Irvin Bross in his "Design for Decision" calls a "Selective amnesia for the facts"—largely exaggeration and cover up by both sides—emphasizing only that which is favorable to the side concerned.

The Damn the Torpedos Method. No regard for the dangerous waters of the increased procurement cost to an unnecessarily tight specification, or the line production cost of using materials procured loose or inadequate specifications—can go either way, in spite of an intermediate channel.

You may find these situations humorous, but when we compare these illustrations with our experience, the humor starts to pall and irony creeps in. We have all bumped into—or run smack into—these approaches at 90 miles per hour.

To this problem, I can only repeat the plea "find the facts before setting the specification." This is the most important point in establishing specifications.

How Do We Get the Facts?

Fact 1. At the outset, we all will undoubtedly agree that too few specifications arise out of the facts of performance—which should be the sole motivating reason for a specification. Too many specifications are based on consensus and compromise of opinion, on mutual distrust or out of the game of claim and counterclaim.

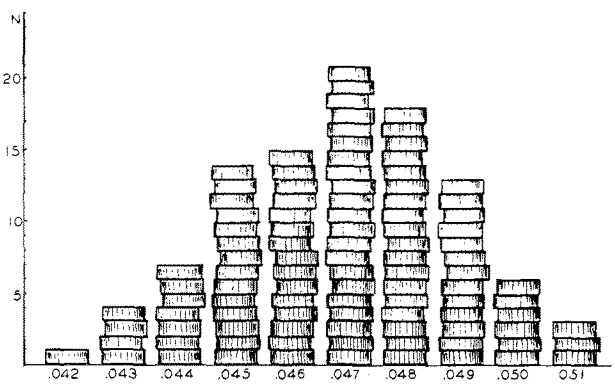

FIG. 2. Thickness distribution of 100 dimes.

I believe that the best specifications are arrived at by a free discussion of needs and, when so established, should take on the aspect of an industrial law, they must be met and enforced.

Fact 2. Early in the 20th century, statisticians and engineers compared notes and discovered that the same laws of probability which applied to dice, cards, mortality and other sociological, biological events were equally applicable to manufacturing processes. In fact, it was possible to characterize process output by a so-called frequency distribution.

Let us first illustrate what is called "frequency distribution." Suppose we took 100 dimes and measured their thickness. Suppose we set up a pile for each increment of thickness, letting the number of dimes in each pile therefore illustrate the relative "frequency" of each thickness (Fig. 14). Such an array is called a frequency distribution, whether an actual pile of the dimes, or by a graph in which the heights of bars or lines, or the positions of a series of dots exemplify the situation.

Such a "frequency distribution" so often presents a regular bell-shaped contour that the individual piles or bars can be shown as though connected by a smooth curve—the "normal curve of distribution." Usually, all this is shown simply by drawing the curve itself, carrying the implications that measurements have been made, and the curve merely connects, graphically, the tops of the piles, with its high point representing the approximate average, and its tails fixing the extent of variation from that average.

In practice, of course, rather than drawing the actual curves, which is cumbersome, we work with the two statistics that characterize the curve. The mean and standard deviation permit us to make probability estimates about the area under the curve. These probability estimates can be considered process capabilities.

This last concept of variability is undoubtedly the most powerful mathematical tool of statistics.

So, from a frequency distribution, or a "Quality Profile," as I choose to call it, we can make numerous observations:

1) Our process will produce material which, if it can be measured, has a central tendency called the average, (or median, mode, mean).
2) The material will vary from the central tendency within certain limits which can be calculated.
3) Once the central tendency and the variation are ascertained, a probability can be established for the occurrence of material in any measurable distance from the central tendency.
4) Whenever material is produced outside the measured limits calculated for the process, we feel sure that chance alone has not caused this change but some real reason is to blame.

From our historical data then, we can prepare these frequency distributions or "Quality Profiles" and compare them to any specification limits and thus estimate a process capability (i.e., the capability of the process to meet the stated limits).

Quality Profile vs. Specifications

Now let us symbolize a relationship between a product of a manufacturing line, and the specification tolerance limits by using the "Quality Profile" and appropriate limit lines. The fact that the curves are broad or narrow does not matter, only their approximate shape (Fig. 3).

Figure 3A shows a "Quality Profile" extending beyond the tolerance limits on both sides. It indicates great variation *with respect to the tolerance limits.*

This is an untenable situation. Either: 1) the fringe lying outside each tolerance must be removed by measuring in detail *every* item produced (a costly procedure at best); or 2) a new and better production method must be found (often a matter of research and delay); or 3) possibly, a new measurement method will be the answer; or 4) some method must be developed to make wider limits acceptable by altering the method of using the product.

(Continued on page 708A)

• *Better Spec's . . . .*

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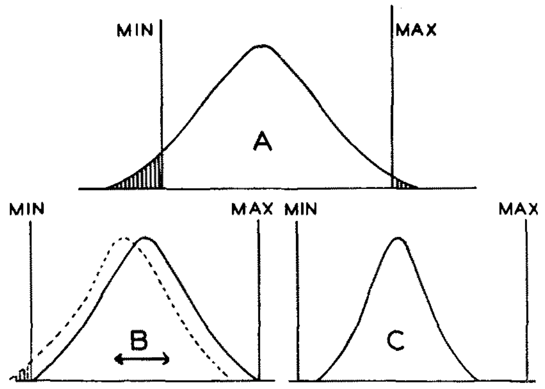

Fig. 3. Some distributional aspects of specification.

From a customer's point of view, there will always exist the probability of increased costs of using the product (remember our cost curve), and this is plus the spectre of an unreliable supplier.

Figure 3B showns the "Quality Profile" just clearing inside the limits on either side. First thoughts might be that this is perfect, but it is far from ideal. No operating variation of any kind is possible, and the dotted lines show how the product will end up partially out of specification by only a slight shift of the average. From the purchaser's point of view, a dangerous situation, unreliable supply.

Figure 3C shows a more comfortable situation, a "Quality Profile" which allows some manufacturing leeway, some degree of catalyst decay or similar variation, and some degree of latitude for combining the product of two or more reactors or mills. Under this condition, one can expect good compliance with a specification. Both the producer and consumer can operate with confidence in such a situation.

Special Selection

These "Quality Profiles" are a great help in an ever recurring situation. Have you ever had the marketing department say, "Well, why can't we select material to meet the limits of this customer?" You can easily use this technique of comparing his limits to your profile to predict the probability of meeting special limits for any one customer, and its resulting affect upon the overall quality level.

These "Quality Profiles" are fine for analyzing historical production. The concept is extended one step further (Fig. 4), to making a moving picture, through the control chart approach to make sure the production stays put, where it was.

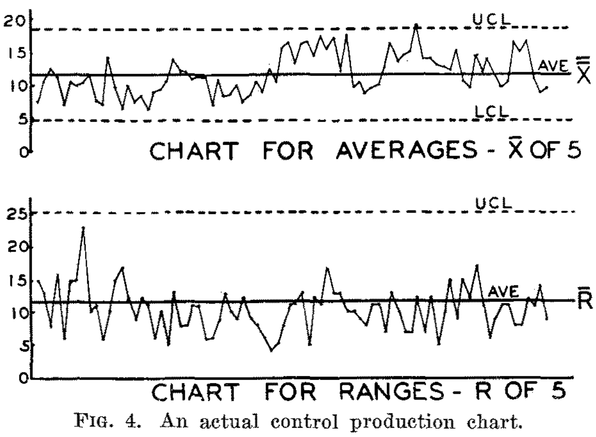

Fig. 4. An actual control production chart.

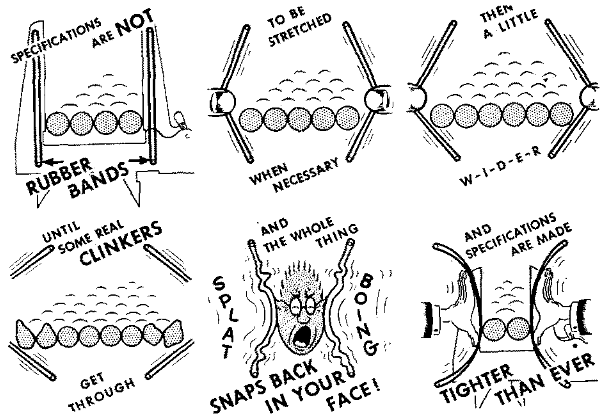

Fig. 5.

Fact 3. Multiple Specification Characteristics: Most of the time, when we are faced with a specification, there is more than one item on it. Possibly one limit on heavy metals, another on assay, a third on isomer distribution, and so on, and on and on.

From the earlier discussion, we discovered how to prepare a "Quality Profile" and estimate a process capability for each one of these characteristics. Way back in the 17th century, on of the Bernoulli Boys taught us that, providing the events are separate and independent, then the probability that both will occur is their product. Thus, the *overall* process capability when we have 3 *individual* process capabilities of 0.90 is their product: $0.9 \times 0.9 \times 0.9$ or 0.73.

I can hear the wheels turning now—you will say "If this is the case, how in the world do I ever meet anybody's specification?" Some of them contain between 15 and 20 different items. The answer is twofold:

First: Many of the limits we see *are not* independent and separate. For example, if equipment corrosion is occurring, both iron and nickel would be high.

Secondly: Some of the characteristics are a lead-pipe cinch. The probability is essentially unity. So there may be only two or three items which are the critical items on a specification and these really determine the overall process capabilities.

Obviously, I have but scratched the surface of statistical approaches. Other studies such as: test method—sampling error—breakdown of process capabilities—regression analysis—all are vital to the specification development. Let me urge you to investigate the statistical techniques of "Getting the Facts Before Setting the Specification." It will save thousands of dollars of unnecessary loss.

Summing Up

Summing up this paper, the correctness of a specification is determined by the mathematical relationships between use and production, together with cost. Specifications fundamentally should be based on fact. The facts must be known first. They must come from a study of the product, of its use, and of its production. One of these three considerations alone, or any pair, is not enough. Therefore, correct specifications mean an open, cooperative effort by maker and consumer. Each must be willing to study the overall problem.

Finally (Fig. 5), "Specifications Are Not Rubber Bands—To Be Stretched When Necessary, Then a Little Wider, and a Little Wider, Until the Whole Structure Falls."

ACKNOWLEDGMENT

J. H. Toulouse, Hemet, Calif., gave permission to use the illustrations in this article.

[Received November 12, 1965—Accepted November 23, 1965]