Right and Wrong Ways to Use Specifications

Sorting or Adjusting?

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Last month I looked at the Secret of Process Adjustment. This column will review the history and purpose of specifications and look at two common ways that specifications are used in practice. Using simple examples I will illustrate the right and wrong ways to use specifications.

THE VOICE OF THE CUSTOMER

About 220 years ago Eli Whitney created a cotton gin with interchangeable parts. The use of interchangeable parts was the technological breakthrough of the day. Shortly after his success with the cotton gin, Whitney got a contract to provide the U. S. Army with muskets having interchangeable parts. In trying to produce large numbers of parts with sufficient consistency to allow them to be used interchangeably he immediately discovered a fact of life that has haunted manufacturing ever since: No two things are alike. So, instead of making things alike, they had to settle for making them similar. As soon as they did this, the question became "How similar is similar enough?" Specifications were created in an effort to answer this question. Obviously, small deviations could be tolerated since the parts would still function. However, as the deviations increased there would come a point where it would be cheaper to scrap the part than to try to use it. And the specifications were intended to define this cut-your-losses point.

Two hundred years ago the economies of mass production were so great that the piles of scrap could be tolerated. By the 1840s the "go-gauge" had been invented. By the 1860s this had evolved into the "go-no-go gauge" which allowed the economic sorting of large numbers of parts. This 1860s technology is still in use today. Specifications were created to separate the acceptable product from the unacceptable product. Whenever the product stream contains nonconforming items that can be identified by nondestructive testing, the use of 100% screening remains a reasonable strategy when it can be done economically. Once you have burned the toast, what can you do but scrape it?

AN EXAMPLE

Figure 1 shows 100 final test values from a production operation along with their histogram and an *X* chart. The values are in time order by columns. The specifications for this test value are 67 to 71. The histogram shows that this process has a first pass yield of 34%, while the *X* chart shows that this process is being operated unpredictably. The specifications allow us to sort the conforming items from the nonconforming items, but a yield of 34% is unacceptable. Something needs to be done.

One popular course of action is to seek to increase the yield by making appropriate process adjustments. Assume that we can adjust the process following each test result and that each adjustment will affect the subsequent items produced. Since we learned last month ("The Secret of Process Adjustment") about the problems of using a P-controller without a deadband, we will use the specification limits of 67 and 71 to define a deadband for our adjustments. That is, we will only adjust the process when we have a nonconforming test result. If say, we have a test result of 65, we will adjust the process up by 4 units, and if we have a result of 75, we will adjust the process down by 6 units. However, if we have a test result of 67, 68, 69, 70, or 71, we will make no adjustment to the process.

69	74	74	72	65	74	76	75	66	75
74	71	77	74	70	74	75	72	69	73
69	70	77	77	69	72	75	76	68	70
72	74	73	72	67	70	75	77	67	70
70	72	73	71	66	73	76	74	65	69
71	71	72	73	66	72	78	72	66	75
67	71	74	75	69	68	78	72	67	74
69	70	76	76	69	69	77	72	63	75
72	73	75	74	70	73	75	78	68	70
73	69	78	73	71	71	77	74	67	73

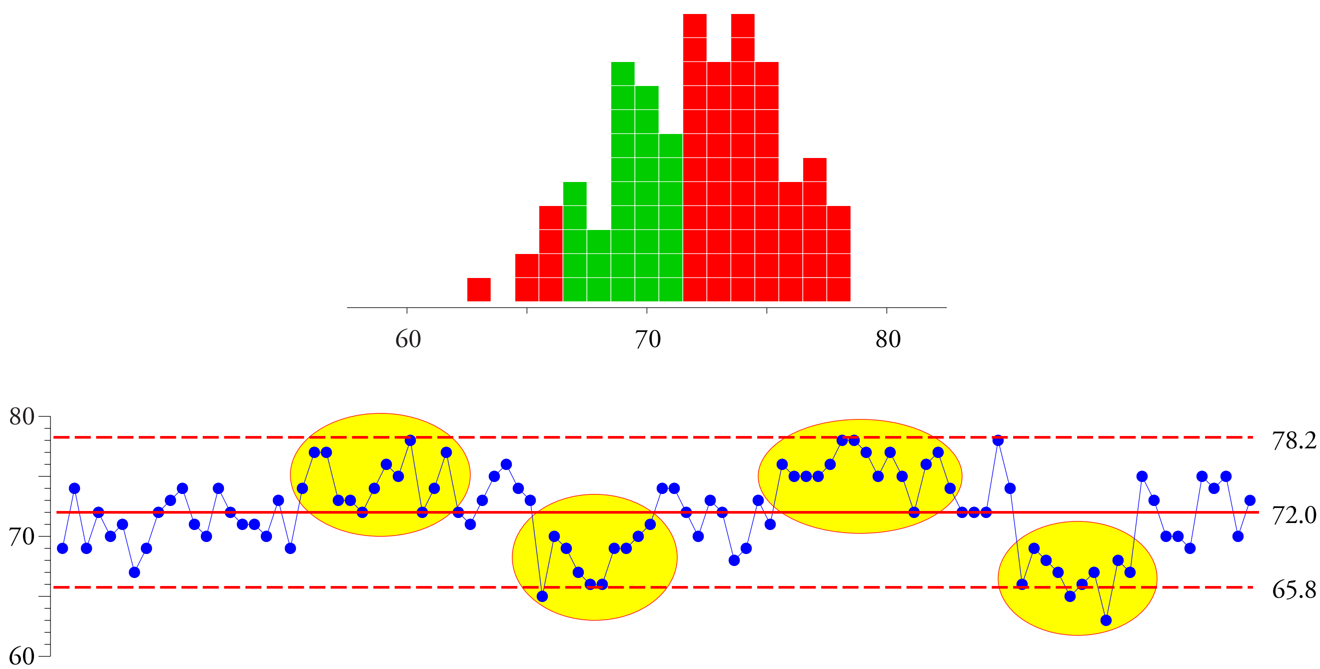

Figure 1: The Original One Hundred Final Test Values

Figure 2 shows how this adjustment procedure would work with the original data of Figure 1. For example, the initial value of 69 will result in no adjustment for the subsequent values. The second value of 74, plus the unchanged aim, yields an adjusted value of 74. This results in an adjustment of –5 for the process aim. The third value of 69 plus the aim of –5 yields an adjusted third value of 64. This results in an adjustment of +5 for the process aim, etc.

X		Aim		New Value		Adjustment
69	+	0	=	69	→	0
74	+	0	=	74	→	–5
69	+	–5	=	64	→	5

X	*Aim*	*New*	*Adj*	*X*	*Aim*	*New*	*Adj*	*X*	*Aim*	*New*	*Adj*	*X*	*Aim*	*New*	*Adj*
69	0	69	0	72	-4	68	0	74	-1	73	-4	72	-7	65	4
74	0	74	-5	74	-4	70	0	74	-5	69	0	72	-3	69	0
69	-5	64	5	76	-4	72	-3	72	-5	67	0	72	-3	69	0
72	0	72	-3	75	-7	68	0	70	-5	65	4	78	-3	75	-6
70	-3	67	0	78	-7	71	0	73	-1	72	-3	74	-9	65	4
71	-3	68	0	72	-7	65	4	72	-4	68	0	66	-5	61	8
67	-3	64	5	74	-3	71	0	68	-4	64	5	69	3	72	-3
69	2	71	0	77	-3	74	-5	69	1	70	0	68	0	68	0
72	2	74	-5	72	-8	64	5	73	1	74	-5	67	0	67	0
73	-3	70	0	71	-3	68	0	71	-4	67	0	65	0	65	4
74	-3	71	0	73	-3	70	0	76	-4	72	-3	66	4	70	0
71	-3	68	0	75	-3	72	-3	75	-7	68	0	67	4	71	0
70	-3	67	0	76	-6	70	0	75	-7	68	0	63	4	67	0
74	-3	71	0	74	-6	68	0	75	-7	68	0	68	4	72	-3
72	-3	69	0	73	-6	67	0	76	-7	69	0	67	1	68	0
71	-3	68	0	65	-6	59	10	78	-7	71	0	75	1	76	-7
71	-3	68	0	70	4	74	-5	78	-7	71	0	73	-6	67	0
70	-3	67	0	69	-1	68	0	77	-7	70	0	70	-6	64	5
73	-3	70	0	67	-1	66	3	75	-7	68	0	70	-1	69	0
69	-3	66	3	66	2	68	0	77	-7	70	0	69	-1	68	0
74	0	74	-5	66	2	68	0	75	-7	68	0	75	-1	74	-5
77	-5	72	-3	69	2	71	0	72	-7	65	4	74	-6	68	0
77	-8	69	0	69	2	71	0	76	-3	73	-4	75	-6	69	0
73	-8	65	4	70	2	72	-3	77	-7	70	0	70	-6	64	5
73	-4	69	0	71	-1	70	0	74	-7	67	0	73	-1	72	

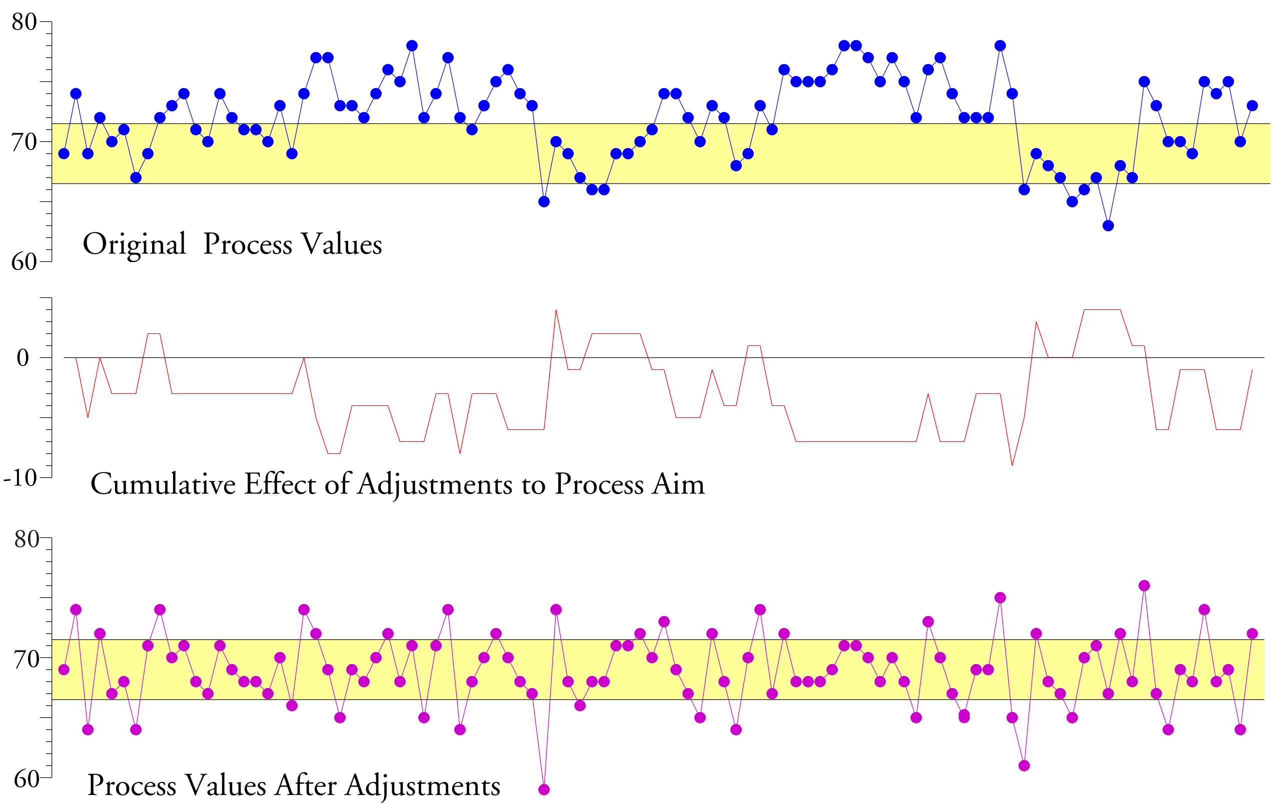

Figure 2: Original Data Transformed by a P-Controller Using the Specifications as a Deadband

So, how did we do? The P-controller using the specification limits to define a deadband has boosted the first pass yield from 34% to 62%. A very impressive improvement. This happened because this process was not centered within the specifications, and was being operated unpredictably. As a result of these two aspects of the data in Figure 1, many of the adjustments were needed adjustments, and consequently the P-controller improved the yield.

However, a first pass yield of 62% was not all that this process was capable of delivering. It could do better. When they identified the assignable causes of the exceptional variation shown in Figure 1, and took steps to control these causes in production, they ended up with the process shown in Figure 3.

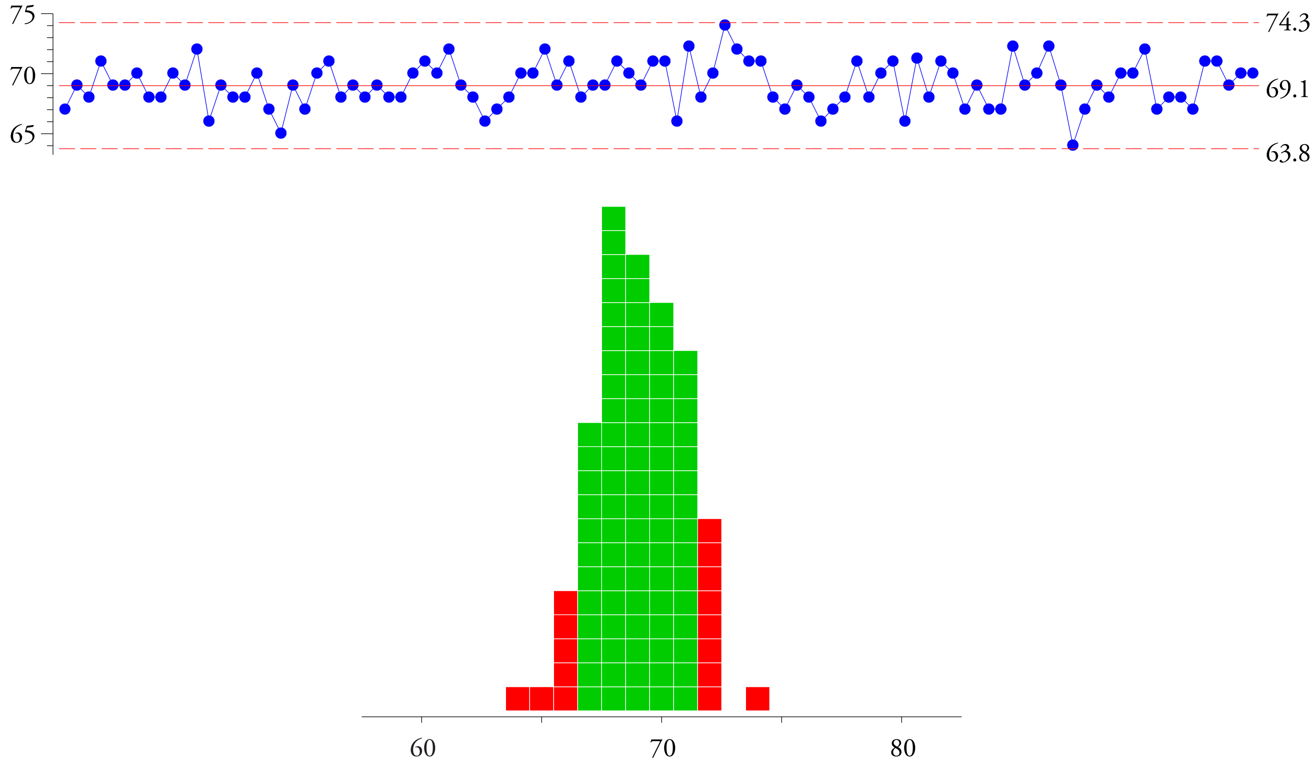

Figure 3: The Process of Figure 1 Operated Predictably

When they began to operate this process predictably and on-target their first pass yield went up to 84%. This is the full potential for this process in its current configuration. Eighty-four percent first pass yield is not some sort of stretch goal, or some impossible target, but merely what this process is capable of delivering when it is operated at full potential. Predictable operation will minimize the variation in the process outcomes, while operating on-target will maximize the conformity of the product produced.

But this process is still not delivering 100% conforming product. Can't we do something about the 16% nonconforming? Well, what if we apply the P-controller with specification deadband to the data in Figure 3? When we do this we end up with the data of Figure 4.

X	*Aim*	*New*	*Adj*	*X*	*Aim*	*New*	*Adj*	*X*	*Aim*	*New*	*Adj*	*X*	*Aim*	*New*	*Adj*
67	0	67	0	68	0	68	0	71	-1	70	0	67	-2	65	4
69	0	69	0	69	0	69	0	66	-1	65	4	69	2	71	0
68	0	68	0	68	0	68	0	72	3	75	-6	67	2	69	0
71	0	71	0	68	0	68	0	68	-3	65	4	67	2	69	0
9	0	69	0	70	0	70	0	70	1	71	0	72	2	74	-5
69	0	69	0	71	0	71	0	74	1	75	-6	69	-3	66	3
70	0	70	0	70	0	70	0	72	-5	67	0	70	0	70	0
8	0	68	0	72	0	72	-3	71	-5	66	3	72	0	72	-3
68	0	68	0	69	-3	66	3	71	-2	69	0	69	-3	66	3
70	0	70	0	68	0	68	0	68	-2	66	3	64	0	64	5
9	0	69	0	66	0	66	3	67	1	68	0	67	5	72	-3
72	0	72	-3	67	3	70	0	69	1	70	0	69	2	71	0
66	-3	63	6	68	3	71	0	68	1	69	0	68	2	70	0
9	3	72	-3	70	3	73	-4	66	1	67	0	70	2	72	-3
68	0	68	0	70	-1	69	0	67	1	68	0	70	-1	69	0
68	0	68	0	72	-1	71	0	68	1	69	0	72	-1	71	0
70	0	70	0	69	-1	68	0	71	1	72	-3	67	-1	66	3
67	0	67	0	71	-1	70	0	68	-2	66	3	68	2	70	0
65	0	65	4	68	-1	67	0	70	1	71	0	68	2	70	0
69	4	73	-4	69	-1	68	0	71	1	72	-3	67	2	69	0
7	0	67	0	69	-1	68	0	66	-2	64	5	71	2	73	-4
70	0	70	0	71	-1	70	0	71	3	74	-5	71	-2	69	0
71	0	71	0	70	-1	69	0	68	-2	66	3	69	-2	67	0
68	0	68	0	69	-1	68	0	71	1	72	-3	70	-2	68	0
69	0	69	0	71	-1	70	0	70	-2	68	0	70	-2	68	

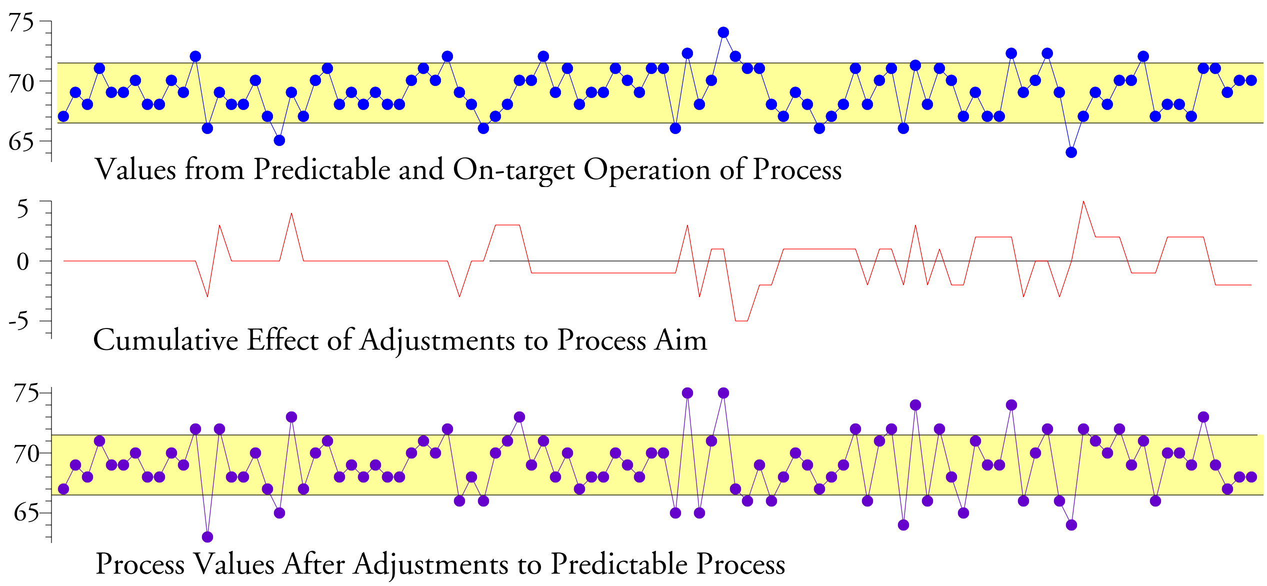

Figure 4: Figure 3 Data Transformed by a P-Controller Using the Specifications as a Deadband

Here the P-controller using the specifications as a deadband converted a process that had 84 percent conforming into one with 68 percent conforming! The fraction nonconforming doubled from 16 percent to 32 percent. Why did this happen? It happened because the P-controller reacted to noise and made inappropriate adjustments. With only a couple of blips in the first 33 values the P-controller started off doing fairly well, but eventually the needless adjustments took the process off-target and made things worse.

In Figure 2 the process was off-target and operated unpredictably. There the P-controller using the specifications as a deadband did improve things. In Figure 4 the process was on-target and predictable. There the P-controller simply added noise to the process which increased the variation in the product stream and made things worse. So what are we to conclude? Can we use the specifications to adjust the process? While using a P-controller using the specifications as a deadband may be better than doing nothing, it does not allow you to get the most out of your process. It never has, and it never will.

Why doesn't the P-controller do as well as operating the process predictably and on-target? Any and all process adjustment mechanisms are inherently reactive. Whether it is a simple P-controller, or a more sophisticated PID controller, it cannot act until it has a perceived signal. Since the original process was unpredictable and off-target, there were many real signals that the P-controller caught. However, there were also some non-signals that the P-controller reacted to, resulting in unnecessary adjustments. Unless the dead band perfectly coincides with the voice of the process, your process adjustment mechanism will result in too many adjustments or too few adjustments. Either way, the result will be increased variation in the product stream. So while using an automatic process controller may be better than doing nothing, it will usually result in more variation than the process is capable of delivering when it is operated at full potential.

"But that means you would not react to values that are outside the specification limits!"

Yes, the nonconforming values of 64, 65, 66, and 72, 73, 74 are all part of what this process produces when it is operated predictably and on-target. Let me repeat. As seen in Figure 3, when this process is operated up to its full potential it will produce product ranging from 64 to 74. Taken one at a time, these values do not constitute a signal that the process is off-target even though they may be outside the specifications. Specifications are for sorting the good stuff from the bad stuff at the end of the line. They are the voice of the customer. They should never be confused with the voice of the process.

"So are you telling me that I should ignore a nonconforming value?"

A nonconforming item should be rejected. But if your process is being operated predictably and on-target, the fact that an item is nonconforming tells you nothing about how to run the process. Of course, operating a process predictably and on-target will not happen without a process behavior chart, so there should be no guesswork involved here. If do not have a process behavior chart, the odds are at least 10 to 1 that you are operating your process unpredictably. If this is the case, then an automatic process controller will only get you part-way to what your process is capable of producing.

SUMMARY

The modern quality movement is about learning how to quit burning the toast. This does not mean that we may not have to scrape the toast from time to time, but it means moving upstream to work on the process rather than simply sorting the good stuff from the bad stuff at the end of the line. So while specifications are still relevant, while they still define the voice of the customer, it is important to differentiate them from the voice of the process. While we do want the voice of the process to be aligned with the specifications, the specifications simply do not provide the right information for operating your process up to its full potential.