Good Limits from Bad Data

What if the Range Chart is "out-of-control?"

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Some authors recommend that you have to wait until you have the Range Chart "in-control" before you can compute the limits for the Average Chart or the *X* Chart. Why this is not true will be the subject of this column.

To illustrate the issues we will once again use the NB10 data. The 100 values are given in the table. These data are the values obtained at the weekly weighings of standard NB10 at the National Bureau of Standards during 1963 and 1964. The values express the weights as the number of micrograms in excess of 9.999000 grams. The Figure shows the *XmR* Chart for these data with three sets of limits.

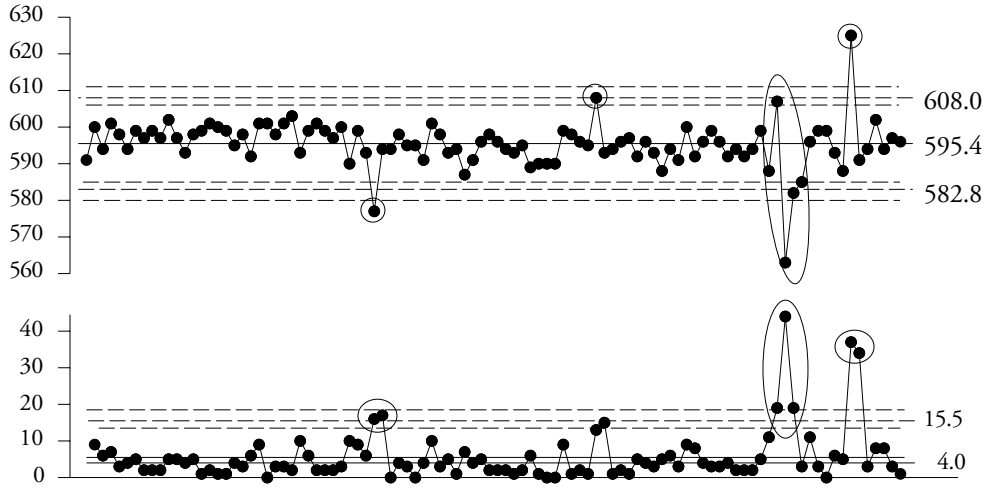

Figure 1. *XmR* Chart for NB10 Values

The widest set of limits is based on the Average Moving Range of 5.73. Dividing by 1.128 gives a *Sigma(X)* value of 5.08, and limits that are 15.2 units on either side of the Average. With these limits we can identify three occasions when there were problems with weighing this standard.

The middle set of limits were based upon the Median Moving Range of 4.0. Dividing by 0.954 gives a *Sigma(X)* value of 4.2, and limits that are 12.6 units on either side of the Average. With these limits we find one additional possible signal. When should we consider using these limits? One guideline is to consider using the Median Moving Range whenever two-thirds or more of the moving ranges fall below the Average Moving Range. Here there are 68 of the 99 moving ranges that are 5 or smaller—only 31 are 6 or larger, hence these data satisfy the guidline.

The narrowest set of limits are those that result from deleting the ranges above the upper range limit, recomputing the Average Moving Range, and revising the limits accordingly. After two cycles this gives an Average Moving Range of 4.02, which results in limits that are 10.7 units

on either side of the Average.

While the details change, you end up telling the same story about this process with all three sets of limits. With the initial limits we found three signals of exceptional variation. Polishing the limits by using either the Median Moving Range or by deleting and revising the Average Moving Range only added one more potential signal. Thus, regardless of which of the correct approaches to computing limits that we exercise, we end up telling the same story about our data. As the name implies, process behavior charts are focused on characterizing the process behavior rather than estimating parameters for some probability model. To this end we do not need high precision, or even perfect data. With the correct computations we can get good limits from bad data. We do not have to wait until we have an "in-control" range chart prior to computing our limits for the *X* Chart or the Average Chart. In fact, it would be a mistake to wait.

100 Weighings of NB10

591	603	596	596
600	593	594	599
594	599	593	596
601	601	595	592
598	599	589	594
594	597	590	592
599	600	590	594
597	590	590	599
599	599	599	588
597	593	598	607
602	577	596	563
597	594	595	582
593	594	608	585
598	598	593	596
599	595	594	599
601	595	596	599
600	591	597	593
599	601	592	588
595	598	596	625
598	593	593	591
592	594	588	594
601	587	594	602
601	591	591	594
598	596	600	597
601	598	592	596