

OPTIONAL TOPIC—*u*-CHARTS

In the just completed discussion of scratches on tile surfaces, a *c*-chart was constructed. This was the appropriate chart because the subgroup size, 6 tiles, was constant. And as long as the subgroup size remains constant, the *c*-chart should be used. However, in some situations the subgroup size cannot be held constant. For instance, at an assembly plant, Ford may manufacture several types of Ranger pickup trucks as well as full-size trucks. In counting imperfections on the finish of each truck, the subgroup size would depend on the truck size. A paper pulp mill will manufacture several grades of paper in rolls of different width. The subgroup size, a roll of paper, will not be constant. In situations where the number of defects is counted, but the subgroup size cannot be held constant, a *u*-chart should be constructed.

Fiberglass Baths—Fiberglass Baths is a rapidly growing manufacturer of fiberglass tubs and shower enclosures. Fiberglass tubs and shower stalls are made by first spraying an epoxy-based paint on a mold and then spraying on a coat of fiberglass. When the fiberglass has dried, the mold is peeled off. Unfortunately, sometimes the process causes a blemish in the paint. The tub or shower stall is then set aside and someone has to buff out the blemish, a time-consuming process.

The company has decided to begin a process improvement effort and has started keeping track of both the number of tubs produced and the number of blemishes buffed each day. This data is shown in the first three columns of Figure 17-2-1. Since the number of tubs produced each day is not a constant, a *c*-chart is not appropriate and the company will need to use a *u*-chart.

A *u*-chart is constructed in the same manner all process control charts are constructed. First, the centerline of the chart is determined, here using Equation 17-A.

FIGURE 17-2-1

**Data and Control Limits
for Fiberglass Baths**

Day	Tubs Produced	Blemishes	Blemishes/Tub	LCL	UCL
1	87	13	0.149	0.026	0.276
2	73	18	0.247	0.015	0.287
3	64	11	0.172	0.005	0.297
4	87	18	0.207	0.026	0.276
5	81	10	0.123	0.021	0.281
6	87	10	0.115	0.026	0.276
7	80	8	0.100	0.021	0.281
8	71	13	0.183	0.013	0.289
9	96	9	0.094	0.032	0.270
10	74	11	0.149	0.015	0.287
11	82	13	0.159	0.022	0.280
12	74	9	0.122	0.015	0.287
13	66	12	0.182	0.008	0.294
14	64	11	0.172	0.005	0.297
15	78	13	0.167	0.019	0.283
16	78	8	0.103	0.019	0.283
17	98	11	0.112	0.033	0.269
18	67	10	0.149	0.009	0.293
19	77	16	0.208	0.018	0.284
20	87	7	0.080	0.026	0.276
21	85	13	0.153	0.025	0.277
22	96	14	0.146	0.032	0.270
23	75	13	0.173	0.016	0.286
24	71	11	0.155	0.013	0.289
25	84	18	0.214	0.024	0.278
Total	1982	300			

Centerline for *u*-Chart

$$\bar{u} = \frac{c_1 + c_2 + \cdots + c_m}{n_1 + n_2 + \cdots + n_m} \quad 17-A$$

where:

$$c_i = \text{defects in the } i\text{th subgroup}$$

$$n_i = \text{size of the } i\text{th subgroup}$$

From the totals shown in Figure 17-2-1 the centerline is at 0.1514 blemishes per tub.
The standard deviation of the *i*th sample is estimated by Equation 17-B.

Standard Deviation for *u*-Chart

$$S_u = \sqrt{\bar{u}/n_i} \quad 17-B$$

The three standard deviation control limits are found using Equations 17-C and 17-D.

Control Limits for *u*-Chart

$$UCL = \bar{u} + 3\sqrt{\bar{u}/n_i} \quad 17-C$$

$$LCL = \bar{u} - 3\sqrt{\bar{u}/n_i} \quad 17-D$$

Notice since the subgroup size can be different for each subgroup, the control limits also change. This is a common characteristic of control charts; when the subgroup size changes, the control limits will also change.

The blemishes per tub and the control limits for each of the 25 days of data are shown in the final three columns of Figure 17-2-1.

While we could construct the control chart by hand, Minitab can be used to construct *u*-charts as seen in Figure 17-2-2. Notice that while the company may not be satisfied with the number of blemishes, the current process is in control.

FIGURE 17-2-2**Minitab *u*-Chart for Fiberglass Baths****Minitab Instructions:**

1. Enter data shown in Figure 17-2-1.
2. Click on the Stat button.
3. Select Control Charts and U options.
4. Enter appropriate data columns in variable and subgroups input boxes.

