Case Twenty

Crouse Fuse Company

Many different companies produce electrical items that require fuses. These fuses act as a safety precaution, to terminate the flow of electrical current to a product if an excessive current starts to flow through it. The fuse prevents the possibility that the excessive current will cause components to burn out inside the product. This excessive power flow can result from various malfunctions inside the product itself, or from problems with the power source.

Crouse Fuse Company (CFC) produces very large amounts of inexpensive fuses for a number of different customers. Manufacturers of strings of outdoor lights use one of its primary product lines. These particular fuses consist of high-resistance thin metallic wires that are mounted inside a small glass tube. The electricity in the circuit is run through the wire inside the protective glass tube, and the resulting heat from any excessive current flow will melt the fuse wire. Once the fuse wire melts, the current flow through the system stops immediately. The diameter of the fuse wire and the makeup of its metallic content determine the current level at which the fuse will "blow out." These particular fuses are produced in very large quantities for various customers.

CFC has been named as a co-defendant, along with a light manufacturer, in a recent lawsuit. The lawsuit resulted from claims that some strings of lights did not shut down when short circuits developed. This resulted in property damage from fires in the homes of several people who were using the light strings for exterior decoration. Needless to say, CFC is extremely concerned about quality control issues.

The management of CFC realizes that their products cannot be perfect. This is particularly true since the market will only pay a very low price for this commodity item. In addition, fuses must be destroyed in order to test them. The testing process runs an electrical current through the fuse, and the fuse can fail testing in two ways. First, it can blow out at too low a level of electric current. That is, for levels of current that would exist during normal usage. If the fuse does not blow out at too low a level of current, the current level is then increased to determine at what level the fuse does blow out, to be assured that this level of power is not too high to meet safety standards. To pass the test, a fuse must blow out within an acceptable range of current levels. Clearly, CFC cannot perform 100% inspection, or there would be no product left to sell.

CFC management wants to establish statistical process control practices to monitor their facility, to be assured that quality control standards are being maintained over all shifts. In order to do this, we need to determine the operating characteristics of the process under normal conditions. To meet this end, CFC carefully monitored one of the shifts at its fuse production facility for one week. During this week of careful monitoring, the system was watched closely to ensure that everything was operating under normal conditions. A random sample of 50 fuses was taken once every 30 minutes during the eight-hour work shifts for five days in one workweek. The 50 fuses were tested, and the number of defective fuses in each sample was noted.

The results of all of this sampling are summarized in Exhibit 20.1. For example, Sample 12 on Day 1 occurred six hours into the shift operation on that day, when 50 fuses were tested to find that 2 were defective. All testing at CFC is done by quality control specialists in a unit that is independent of the fuse production facility, and all quality control test results that are reported can be assumed to be completely accurate. The test results in Exhibit 20.1 also represent normal operating conditions for the fuse-making facility, with output representing quality levels deemed acceptable to CFC, given all of the relevant conditions, customer expectations, and associated costs.

The most critical factor in fuse quality is the metallic content and the diameter of the wire inside the fuse. All shift supervisors were made aware of this situation, given the difficulties CFC is facing. The wire-forming operation can be calibrated periodically to reset its operation to precise specifications for the particular fuses being processed. The wire-forming process tends to "drift" over relatively short time periods, as replaceable components start to wear. This drift is a natural part of the operation, and there is no feasible way to change it. The wire-forming process can be recalibrated by shift supervisors at any time they choose to do so. At this time, the replaceable components are replaced, and other adjustments are made. However, the entire system significantly slows down during the time that recalibration is being done. A natural solution is to have the shift supervisors perform the recalibration before the start of each shift, and then again during an employee break that occurs after the first four hours of work on each shift. It has been made very clear to the shift supervisors that this recalibration procedure is of the utmost importance.

CFC wants to use statistical process control charts to control their fuse production process, and the test results from the monitored week can be used as a basis for establishing control chart limits (95% confidence is required) for future use. CFC runs two work shifts per day, and different shift supervisors are in charge on each shift. Testing has now been performed for both operating shifts for the first week of normal operation after the monitored week, using testing procedures that are identical to the procedures that were used during the monitored week. Testing results from the first and second shifts are given, respectively, in Exhibit 20.2 and Exhibit 20.3.

CFC management wants to see statistical process control analysis applied to the data from their system. This analysis should be based on the proportion of defective units in a sample, and it should be done on the data from both shifts. Any resulting input regarding differences in observations between the two shifts would be very helpful to CFC management, particularly if the observations might be some impact on productivity.

EXHIBIT 20.1
Quality Control Results from Operation during the Monitored Week

Day	Sample	Number Defective	Day	Sample	Number Defective
1	1	0	3	9	0
1	2	1	3	10	2
1	3	0	3	11	2
1	4	2	3	12	0
1	5	2	3	13	0
1	6	1	3	14	1
1	7	2	3	15	1
1	8	2	3	16	3
1	9	0	4	1	0
1	10	0	4	2	1
1	11	0	4	3	2
1	12	2	4	4	2
1	13	0	4	5	0
1	14	1	4	6	1
1	15	3	4	7	1
1	16	2	4	8	2
2	1	0	4	9	1
2	2	0	4	10	1
2	3	1	4	11	1
2	4	0	4	12	2
2	5	3	4	13	2
2	6	2	4	14	0
2	7	2	4	15	3
2	8	3	4	16	2
2	9	1	5	1	0
2	10	1	5	2	0
2	11	2	5	3	2
2	12	0	5	4	0
2	13	0	5	5	1
2	14	1	5	6	2
2	15	1	5	7	3
2	16	2	5	8	3
3	1	0	5	9	0
3	2	1	5	10	0
3	3	0	5	11	0
3	4	0	5	12	2
3	5	3	5	13	1
3	6	1	5	14	1
3	7	1	5	15	3
3	8	2	5	16	1

EXHIBIT 20.2
Quality Control Test Results from the First Shift

Day	Sample	Number Defective	Day	Sample	Number Defective
1	1	0	3	9	0
1	2	1	3	10	1
1	3	0	3	11	2
1	4	0	3	12	2
1	5	1	3	13	0
1	6	1	3	14	2
1	7	0	3	15	2
1	8	2	3	16	2
1	9	0	4	1	0
1	10	0	4	2	2
1	11	0	4	3	1
1	12	0	4	4	2
1	13	1	4	5	0
1	14	0	4	6	1
1	15	2	4	7	1
1	16	3	4	8	3
2	1	0	4	9	0
2	2	0	4	10	0
2	3	1	4	11	1
2	4	1	4	12	0
2	5	1	4	13	1
2	6	1	4	14	3
2	7	3	4	15	1
2	8	0	4	16	2
2	9	0	5	1	0
2	10	1	5	2	1
2	11	1	5	3	0
2	12	2	5	4	0
2	13	1	5	5	0
2	14	1	5	6	1
2	15	3	5	7	2
2	16	2	5	8	3
3	1	0	5	9	0
3	2	2	5	10	1
3	3	1	5	11	2
3	4	1	5	12	0
3	5	1	5	13	2
3	6	2	5	14	1
3	7	3	5	15	3
3	8	2	5	16	2

EXHIBIT 20.3
Quality Control Test Results from the Second Shift

Day	Sample	Number Defective	Day	Sample	Number Defective
1	1	0	3	9	0
1	2	0	3	10	0
1	3	1	3	11	0
1	4	0	3	12	1
1	5	1	3	13	0
1	6	1	3	14	0
1	7	1	3	15	0
1	8	2	3	16	1
1	9	0	4	1	0
1	10	1	4	2	1
1	11	1	4	3	1
1	12	1	4	4	1
1	13	0	4	5	0
1	14	0	4	6	0
1	15	2	4	7	1
1	16	2	4	8	1
2	1	0	4	9	0
2	2	1	4	10	1
2	3	0	4	11	1
2	4	2	4	12	2
2	5	0	4	13	0
2	6	1	4	14	0
2	7	1	4	15	0
2	8	1	4	16	1
2	9	0	5	1	0
2	10	1	5	2	0
2	11	1	5	3	0
2	12	2	5	4	1
2	13	0	5	5	0
2	14	1	5	6	1
2	15	2	5	7	1
2	16	1	5	8	2
3	1	0	5	9	0
3	2	0	5	10	0
3	3	0	5	11	1
3	4	1	5	12	1
3	5	0	5	13	0
3	6	0	5	14	0
3	7	1	5	15	0
3	8	2	5	16	1