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Abstract: The specific element addressed in this project was control and reduction of the incoming material inspection Through-Put-Time. The current process is described in this paper. TPT measurement has been gathered and charted and the results analyzed to determine areas for improvement.

Statistical Process Control for Incoming Inspection Through-Put-Time

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TQM Project: Statistical Process Control for Incoming Inspection Through-Put-Time

INTRODUCTION

The Materials Management Department at Fujitsu Computer Products of America (FCPA) is interested in reducing the inventory within the facility. One specific area is in reducing the amount of time it takes for material to move from receiving, through inspection, and into the storage location. The long term goal is to have daily deliveries by the supplier directly to the work area that will utilize the material. The incoming inspection function would then be eliminated and replaced by source inspection, or supplier quality control. There are many aspects of this to be considered, such as the distance to the factory from the supplier, the quality of the material, the cost of the material, etc.. This goal cannot be easily obtained in the short term, but will be reached by small interim steps with each supplier. Since in many cases, inspection is still required, the incoming inspection process needs to be controlled and improved. The specific element that this project will address is controlling and reducing the incoming inspection Through-Put-Time (TPT). The current process will be described, TPT measurements will be gathered and charted, and the results will be analyzed to determine areas for improvement.

PROCESS

The general flow for all purchased material is as shown in figure 1. Material arrives at the receiving dock and is logged in. The material handler then moves it to the inspection area. The Inspectors record the lot information, including arrival time, in the history file. In the history file there is an inspection plan that directs the Inspector on how to perform the inspection. Some material does not require inspection if it is on a skip-lot, or ship-to-stock inspection plan. This material will be immediately logged out and moved to stores. Other material will be inspected according to the inspection plan. The results will be recorded, including the completion date, and the material will be sent to stores if it is acceptable. If it is not acceptable, it will be held for Engineering review.

At FCPA, due to the influence of the Japanese parent company, the incoming inspection methods have been very thorough and the sample sizes very high. This was mainly due to lack of experience with, and confidence in American suppliers. As the confidence has been gained and the quality levels improved, the sample sizes are reduced. As a result of this, the inspection TPTs can be very high for some materials, and very short for others. This has made it very difficult to predict the TPTs so that the Material Planners can properly order material. The goal is to order it early enough so that there will not be a production shortage, but not so soon that it sits in the warehouse.

Methodology and Tools

In order to improve the TPT of the inspection process it is first necessary to determine the current TPT. I feel that it is necessary to determine what the historical results have been, so that there will be a baseline from which to begin improvements. The goal is twofold. First, it is to get the inspection TPT under control so that it is consistent, and the Materials Planners will know in advance how much time to allow for inspection when they are placing orders for material. Second, it is to reduce the TPT in order to reduce the amount of material in the FCPA facility The long term goal is delivery of material directly to the production floor.

The tool that will be used to measure the TPT will be X BAR and R charts. These charts will not only show the TPT for a period of time, but will also tell us if the process is in control or out of control. Out-of-control points may indicate problem areas that can be focused on to improve consistency, and possibly reduce TPT.

Each lot of material that goes through the incoming inspection area is recorded into a database. The data includes the date of receipt, inspection date, supplier, part number, inspection results, and others. For this project, data was extracted from the database for a twenty week period, starting in November and ending the beginning of April. The last two weeks in December were ignored as the plant was shutdown and no inspections were performed.

The data that is in this database is a combination of all the different commodities that are inspected. Examples of commodities are sheetmetal, cables, lockers, and Active ICs. All together there are approximately 16 different commodities. Initially, all of the commodities will be looked at as a group. Next, several of the higher volume commodities will be separated out.

It was decided that five samples from each week would be selected. This was selected as the sample size because of the recommendation of several textbooks. The <u>Statistical Control Handbook</u> recommends 5 to 10 samples for X BAR and R charts. [1,p.191]. Armand Feigenbaum in <u>Total Quality Control</u> gives a range of 2-20 for X BAR and R charts. He recommends 5 as the most popular, while 2 and 3 are rarely used due to inaccuracy and 6-20 are used occasionally. [2,p.417].

The five samples were selected by sorting the database records, for all inspected material, by receipt date, and then grouping them by week. The number of records were counted for a week, and a table of random numbers was used from <u>Tools and Methods for the Improvement of Quality</u>. [3,pp.589-593]. A column was selected from the table of random numbers and a number selected. The number selected from the table would be used, to identify a data sample, if it fell within the range of records for the week. If the number selected were outside of the range for the week, the next number in the column would be selected, until a valid number was found. This was repeated until five samples were selected for each week. The samples selected are shown in figure 2a.

The X BAR and R charts were then constructed from the data in figure 2a. The Upper and Lower control limits for both X BAR and R were calculated and the charts were made. The X BAR and R Charts are shown in figures 3a and 4a. The data table and the charts were drawn using Excel. Following the charts for the combination of all commodities, are additional charts for individual commodities. These are for active ICs, cables, lockers, and passive parts. Several out of control conditions were investigated and the results are shown in figure 17.

Results

The results of the TPT for the combination of all commodities are shown in figures 2a, 3a, and 4a. On the R chart, the data point for week 3 is out of control. After investigation it was found that during this week there was one lot of sheetmetal that was finally released after it had been in the inspection area for 56 days. The reason it was in the inspection area so long was that it was on hold for documentation. The material was for a prototype and the drawings had not yet been released from Document Control. The time this material was waiting for the drawing should not be counted as inspection time. In the future, material waiting for documentation will be placed on Engineering hold, and the time will not be counted against Inspection. This one data point will be removed and the chart redrawn. The results are shown in figures 3b and 4b. The R chart now indicates that the data point for week 9 is above the upper control limit. Investigation again found that a lot of material was on hold for several reasons. There was no entry in the Approved Manufacturers List for this part number, there was no drawing, and after inspection it was found to be under spec for length. Since the time material is on Engineering hold should not be counted against inspection time, this data point should be removed. The new charts are shown in figures 3c and 4c. These new charts now show that the process is in control.

In addition to the combined charts, individual charts were created for active ICs, cables, lockers and passive components. The X BAR and R charts for the active components, figures 6 and 7, show that the process is in control. From week 10 on the data appears to indicate a downward trend. Additional weeks need to be collected to determine if this continues.

The TPT for cables is charted in figures 9 and 10. In this case the data point for week 8 is above the upper control limit on the R chart. The X BAR chart shows that for week 9, the data point is above the upper control limit. Investigation shows that there were three lots of material released in weeks 8 and 9 that had a very high TPT. Checking the history file indicates no abnormal reasons for the long TPT for 2 of these lots. The other lot was defective and needed rework. The TPT for this lot should be ignored, since the time was spent in rework, and not counted against inspection.

Next, the TPT for lockers was charted and the results are shown in figures 12 and 13. Both charts show an out of control condition for week 8 due to the data points being above the upper control limit. On the R chart the data point for week 2 is also above the upper control limit. Investigation shows that for both weeks 2 and 8, there were lockers that needed rework due to defects. The material required Engineering time to determine whether it should be reworked or replaced, and then time was required for the supplier to do the rework. This is similar to the cases above, and the time taken due to Engineering evaluation and supplier rework should not be counted against inspection. These data points should be ignored.

The TPT time for passive components is shown on the X BAR and R chart in figures 15 and 16. The R chart shows an out-of-control condition at week 8, since it is the 8th datapoint in a row below the centerline. The X BAR chart shows out-of-control conditions at weeks 1, 2, 14, and 15. The lots of material during these time frames were investigated, but only one abnormal condition was found. This was one lot that was held for Engineering review due to wrong operating voltage, but it was still usable and was released to production. After talking with the Inspectors it was found that the TPT for passive components depended greatly upon the volume. The volume was low for weeks 1 to 7, but then increased after the start of the new year in week 8. Also there was a reduction in force around week 14 that had an impact on the inspection area. More recently the volume has begun to drop.

In the 8th and 9th week on several of these charts, the TPTs have increased. These two weeks were the first two weeks of the new year after a 2 week shutdown. During the time the facility was closed, no inspections could be performed. Also, upon return from the shutdown, material had accumulated at receiving and the amount of material needing inspection was higher than normal. These reasons contributed to the higher TPT at this period. Since no inspections could be performed during the 2 week shutdown, this time should not be counted.

Plan for continuous improvement

The first step in the improvement process would be to change the way in which the TPT is measured. If material is on hold, has been rejected, or is being reworked, the time should not be counted as inspection time. The system is already in place to do this. When material is in the inspection area, the material tracking system on the computer indicates that it is in the "IQC" location. If material is under Engineering review, it should be in the "MRB" location. MRB stands for Material Review Board. If material is being reworked it should be in the "MRB.RWK" location. Since this system is in place, it needs to be followed. The time that would be included in the inspection TPT would then only be the time the material is in the inspection area. This would eliminate the periodic high TPT readings that occur, thus giving a more consistent number that could be used by the Material Planners.

The second part of the plan would then be to look for ways to reduce the throughput time. There are many points on the charts that are much lower than others. Further investigation is needed as to why these are low, but some of them are now known to be lots that are already on a ship-to-stock, or skip-lot inspection. Skip-Lot (SL) inspection is where the material is of high quality, and only every fourth lot is inspected. Ship-To-Stock (STS) is where the supplier's manufacturing and inspection process have been certified to meet FCPA's standards of high quality. The material goes directly from the receiving dock to stores. A proposed improvement plan would be:

A. Identify all materials that meet the requirements of SL inspection or STS.

B. Place all qualified material on SL.

C. Certify suppliers of qualified material for STS.

D. If the supplier does not meet the requirements of the STS criteria, develop an improvement plan to assist them in meeting the criteria.

E. If the material or the supplier is not qualified for SL or STS, determine the feasibility of source inspection.

By following this plan, the inspection TPT could be reduced, with some suppliers having the incoming inspection of their material completely eliminated.

Conclusions

By using the data collected over a 20 week period and plotting the sample data on the X BAR R charts, I have been able to establish baseline TPT measurements for the incoming inspection area. I have also been able to identify special causes that result in out-of-control conditions. By eliminating the causes of these problems, the TPT can be improved and a more consistent value will be obtained. Other criteria have been identified that also causes variation in TPT, such as fluctuations in volume, facility shutdowns and the recent reduction in force.

As the continuous improvement plan is implemented, the X BAR and R charts can be used to monitor the process. The downward trend that appears on the charts should be followed to determine if it continues. The control limits must be periodically revised as the trends move continuously downward.

Additional work should be done to carry this project further. The two week shutdown time should be removed from the TPT of the material received before the shutdown, but not completed until after the shutdown. This would give a more realistic value of TPT, but would be very time consuming. All commodities should be charted individually, and all out-of-control points investigated. The root causes for all of these should be found, and the problem fixed so that it does not occur. The datapoints could then be removed and the charts redrawn.

Works Referenced:

1. Feigenbaum, Armand V. Total Quality Control. 3rd ed., New York: McGraw Hill, 1983.

2. Small, Bonnie B., et al., Statistical Quality Control Handbook. Charlotte: Delmar Printing Co., 1985.

3. Gitlow, Howard S., et al., Tools and Methods for the Improvement of Quality. Homewood: Irwin, 1989.

Appendix

Tools Used in This Project:

1) All data tables and charts were generated use Excel software on a 386 PC in a Windows environment.
2) Summary table of out-of-control points was generated by using Word Perfect software.
3) The data used for this project was entered into a DBASE file. DBASE was also used to sort and group the data.

INCOMING INSPECTION PROCESS FLOW CHART

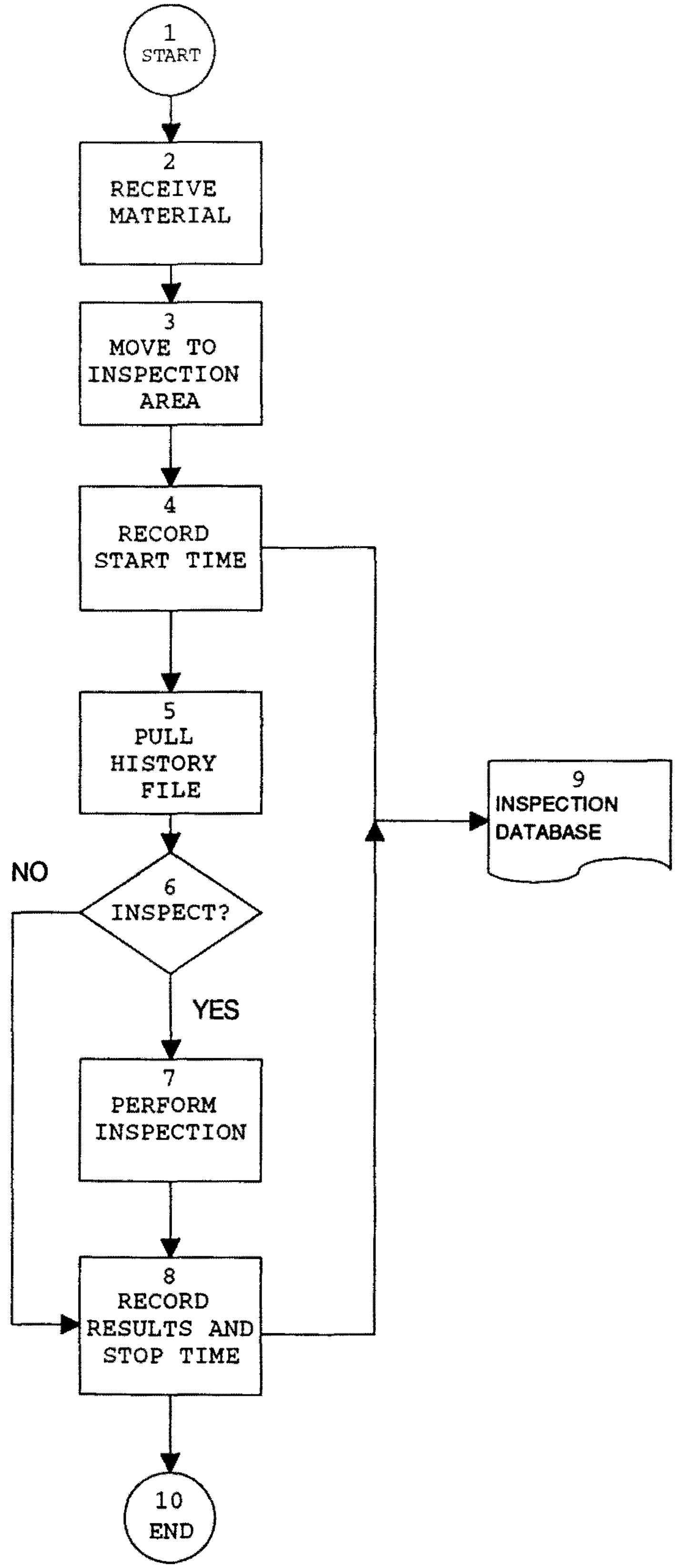

Figure 1

THROUGH-PUT-TIME SAMPLE DATA
All Commodities

WEEK	DATA 1	DATA 2	DATA3	DATA 4	DATA5	X-BAR	R
1	6	18	2	1	2	5.80	17
2	4	13	9	7	3	7.20	10
3	56	6	23	1	2	17.60	55
4	14	14	5	12	1	9.20	13
5	24	1	12	1	5	8.60	23
6	14	1	9	6	1	6.20	13
7	7	14	12	15	16	12.80	9
8	1	1	20	30	2	10.80	29
9	6	33	2	27	27	19.00	31
10	33	47	8	15	2	21.00	45
11	5	3	8	1	6	4.60	7
12	3	1	8	10	16	7.60	15
13	31	22	20	17	2	18.40	29
14	18	1	1	6	1	5.40	17
15	4	1	5	9	28	9.40	27
16	29	1	1	11	1	8.60	28
17	3	1	11	2	3	4.00	10
18	26	1	16	3	8	10.80	25
19	14	6	2	1	7	6.00	13
20	3	6	2	6	5	4.40	4
					Grand Totals =	9.87	21

Figure 2a

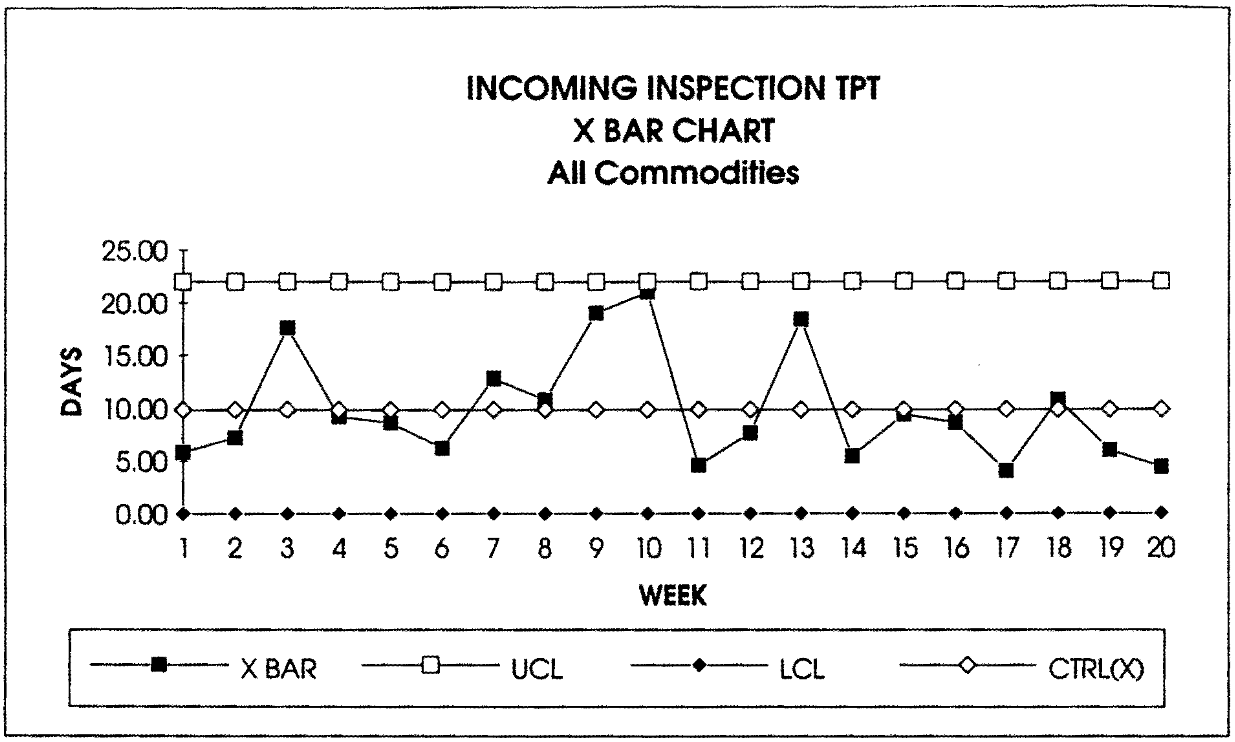

Figure 3a

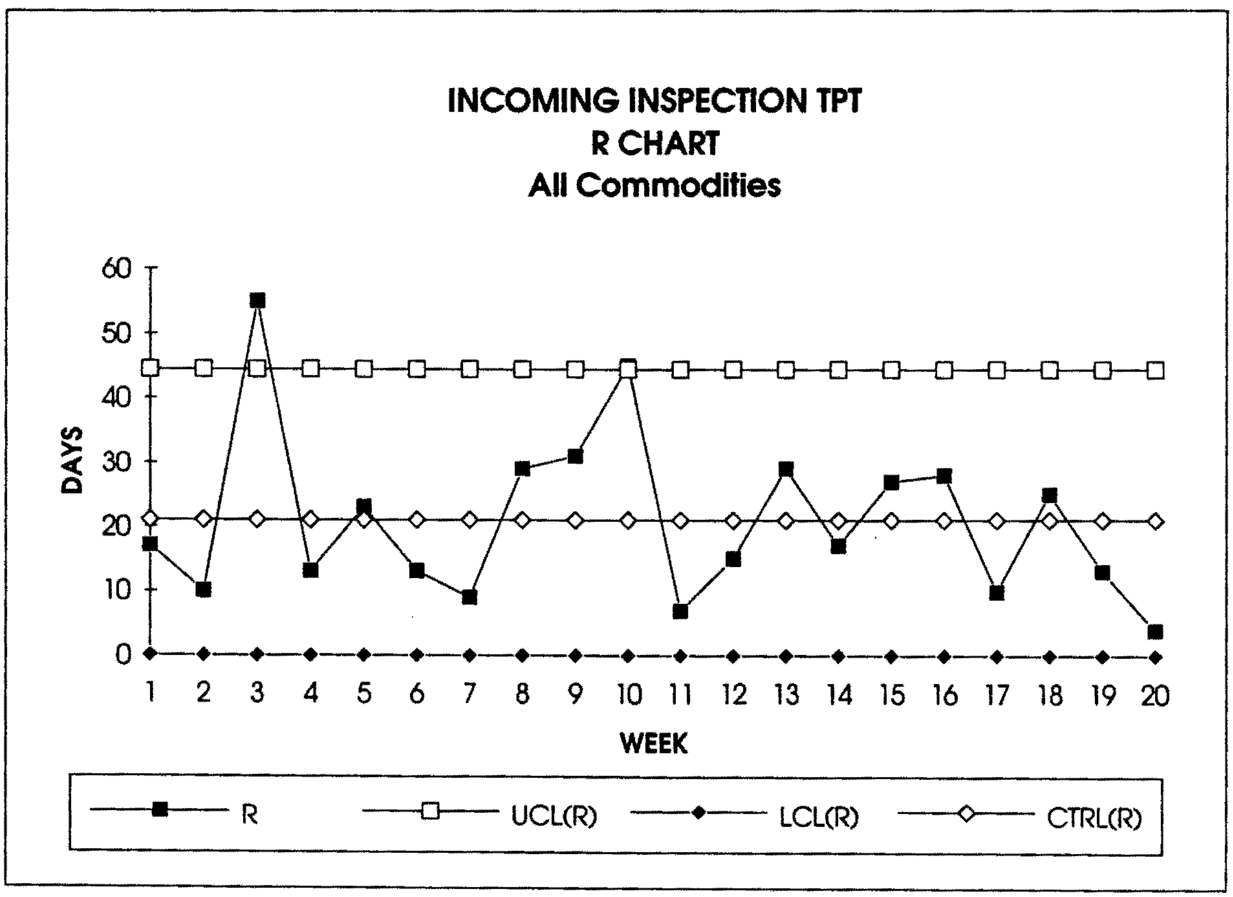

Figure 4a

THROUGH-PUT-TIME SAMPLE DATA
All Commodities

WEEK	DATA 1	DATA 2	DATA3	DATA 4	DATA5	X-BAR	R
1	6	18	2	1	2	5.80	17
2	4	13	9	7	3	7.20	10
4	14	14	5	12	1	9.20	13
5	24	1	12	1	5	8.60	23
6	14	1	9	6	1	6.20	13
7	7	14	12	15	16	12.80	9
3	1	1	20	30	2	10.80	29
9	6	33	2	27	27	19.00	31
10	33	47	8	15	2	21.00	45
11	5	3	8	1	6	4.60	7
12	3	1	8	10	16	7.60	15
13	31	22	20	17	2	18.40	29
14	18	1	1	6	1	5.40	17
15	4	1	5	9	28	9.40	27
16	29	1	1	11	1	8.60	28
17	3	1	11	2	3	4.00	10
18	26	1	16	3	8	10.80	25
19	14	6	2	1	7	6.00	13
20	3	6	2	6	5	4.40	4
					Grand Totals =	9.46	19.21

Figure 2b

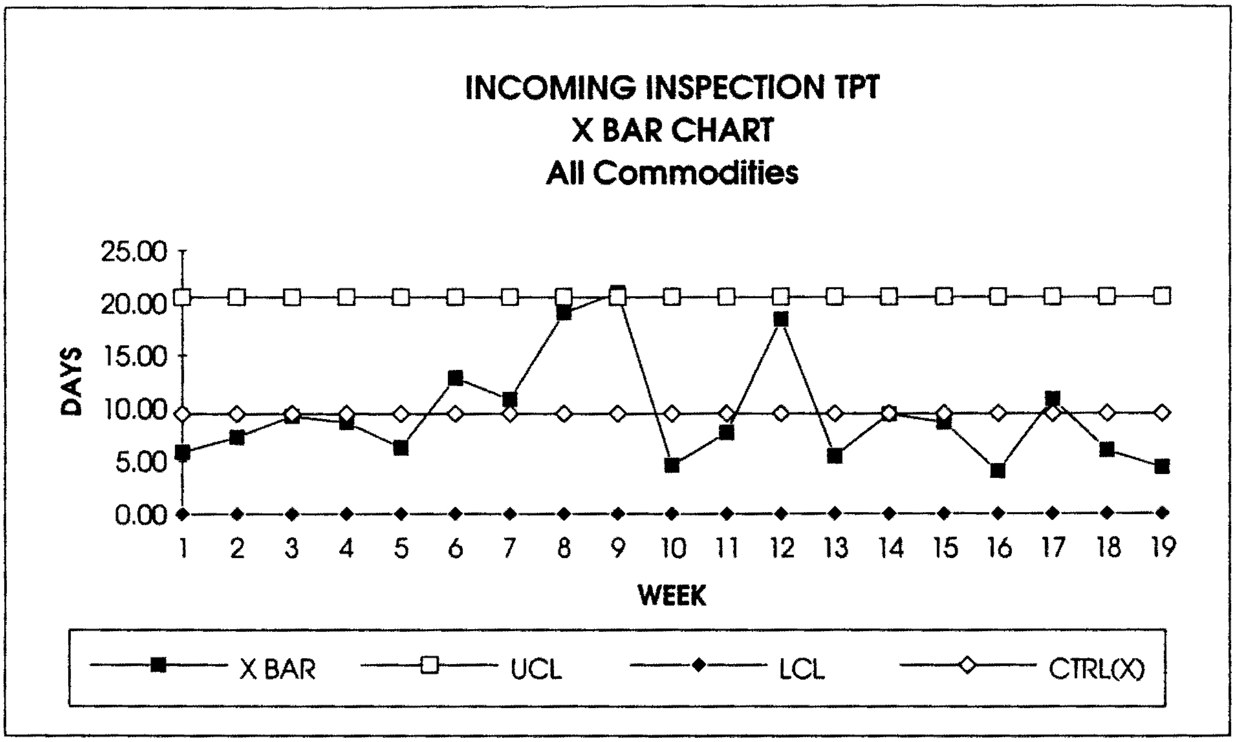

Figure 3b

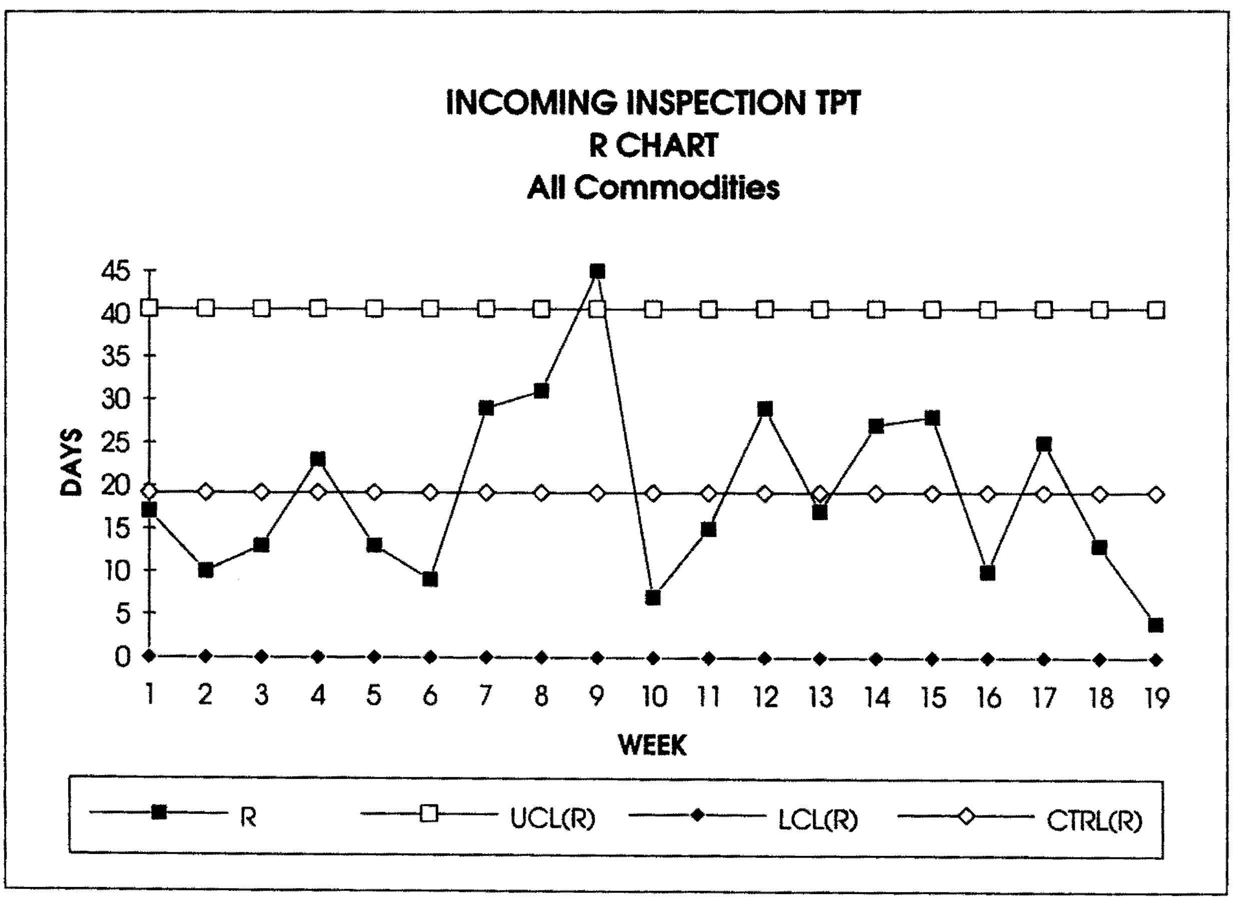

Figure 4b

THROUGH-PUT-TIME SAMPLE DATA
All Commodities

WEEK	DATA 1	DATA 2	DATA3	DATA 4	DATA5	X-BAR	R
1	6	18	2	1	2	5.80	17
2	4	13	9	7	3	7.20	10
4	14	14	5	12	1	9.20	13
5	24	1	12	1	5	8.60	23
6	14	1	9	6	1	6.20	13
7	7	14	12	15	16	12.80	9
8	1	1	20	30	2	10.80	29
9	6	33	2	27	27	19.00	31
11	5	3	8	1	6	4.60	7
12	3	1	8	10	16	7.60	15
13	31	22	20	17	2	18.40	29
14	18	1	1	6	1	5.40	17
15	4	1	5	9	28	9.40	27
16	29	1	1	11	1	8.60	28
17	3	1	11	2	3	4.00	10
18	26	1	16	3	8	10.80	25
19	14	6	2	1	7	6.00	13
20	3	6	2	6	5	4.40	4
					Grand Totals =	8.82	17.78

Figure 2c

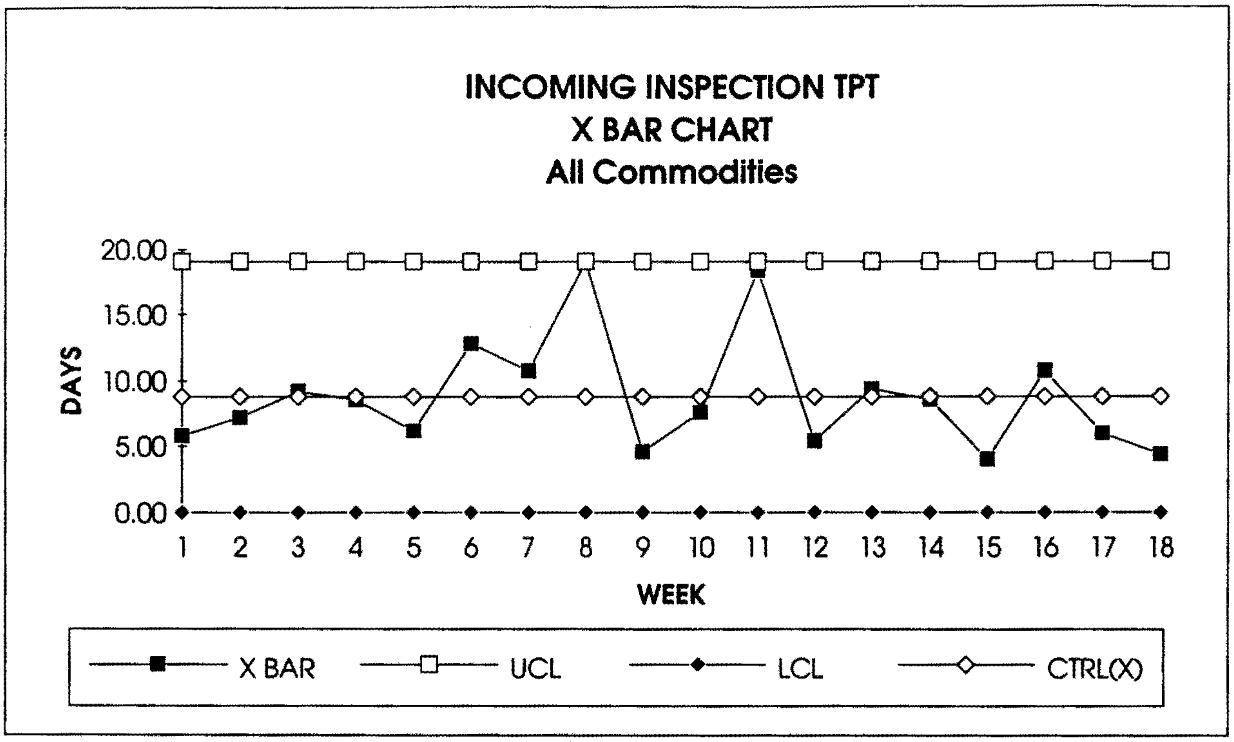

Figure 3c

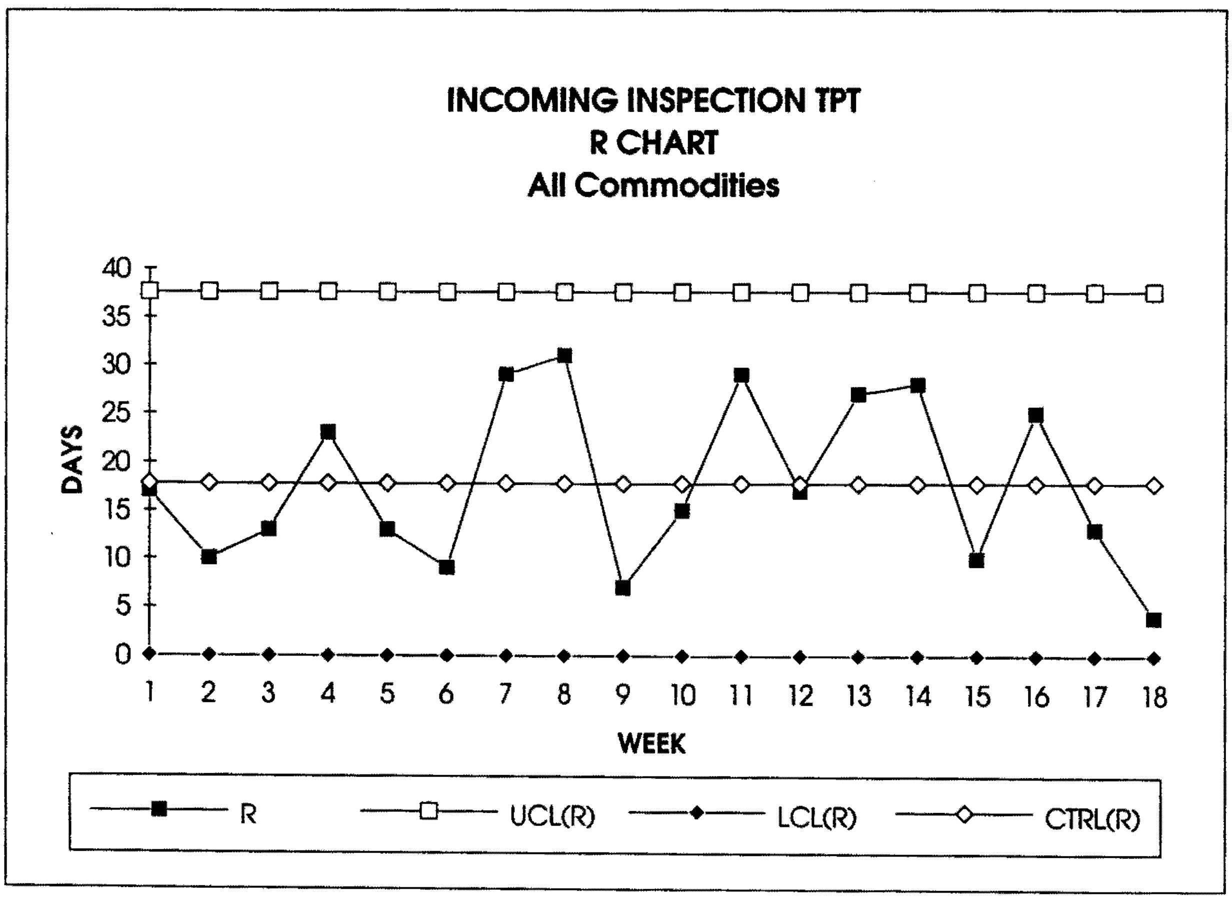

Figure 4c

THROUGH-PUT-TIME SAMPLE DATA
Active Devices

WEEK	DATA 1	DATA 2	DATA3	DATA 4	DATA5	X-BAR	R
1	12	3	29	20	8	14.40	26
2	1	7	9	3	1	4.20	8
3	13	1	1	21	3	7.80	20
4	3	3	19	11	5	8.20	16
5	14	1	1	2	28	9.20	27
6	6	1	2	1	11	4.20	10
7	7	7	6	15	1	7.20	14
8	34	23	1	29	4	18.20	33
9	3	6	5	43	1	11.60	42
10	3	16	34	1	14	13.60	33
11	6	5	9	10	1	6.20	9
12	28	8	3	10	10	11.80	25
13	15	1	2	2	39	11.80	38
14	4	1	1	1	1	1.60	3
15	20	3	1	5	15	8.80	19
16	1	28	1	3	1	6.80	27
17	6	1	2	2	3	2.80	5
18	4	1	2	1	16	4.80	15
19	6	20	1	2	1	6.00	19
20	4	5	2	3	1	3.00	4
					Grand Totals :	8.11	19.65

Figure 5

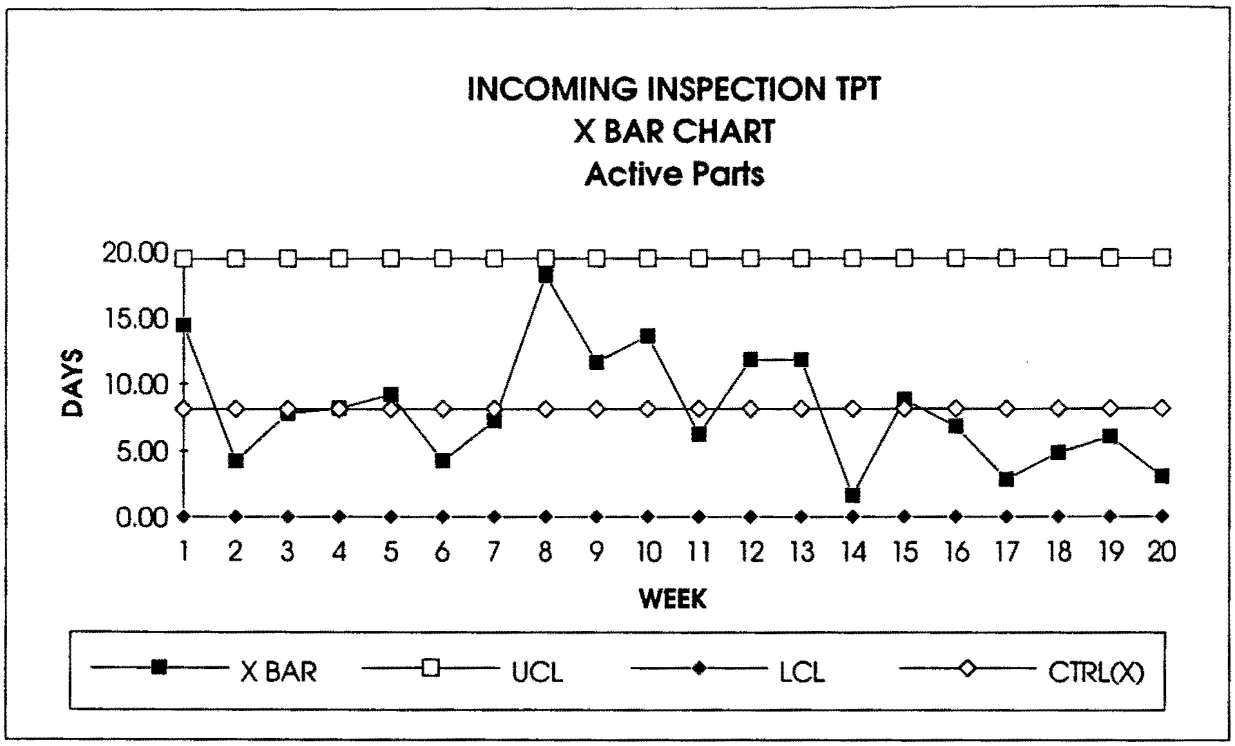

Figure 6

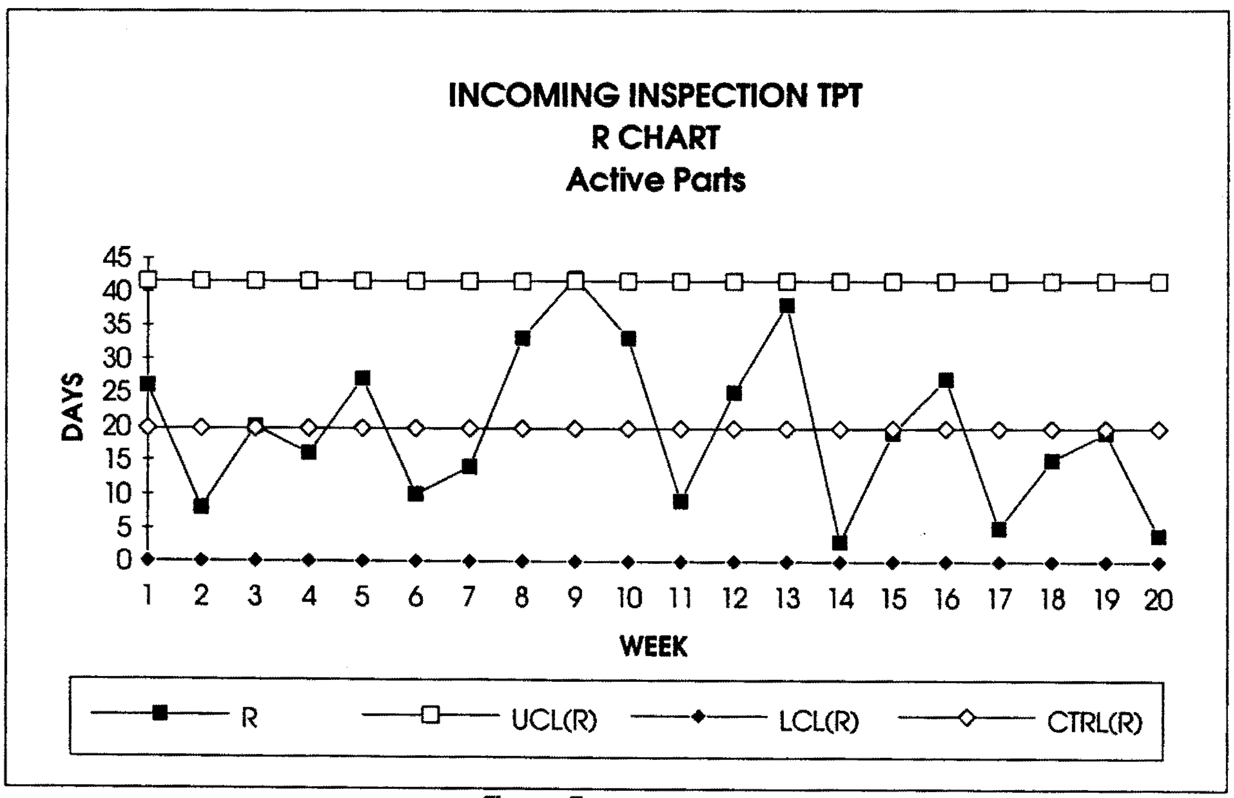

Figure 7

THROUGH-PUT-TIME SAMPLE DATA
Cables

WEEK	DATA 1	DATA 2	DATA3	DATA 4	DATA5	X-BAR	R
1	17	5	9	1	2	6.80	16
2	4	8	8	22	8	10.00	18
3	18	13	35	15	18	19.80	22
4	13	12	12	7	14	11.60	7
5	14	14	19	9	19	15.00	10
6	18	4	9	1	4	7.20	17
7	7	12	5	1	17	8.40	16
8	17	1	35	31	2	17.20	34
9	38	27	29	10	29	26.60	28
10	3	5	9	10	11	7.60	8
11	3	6	4	1	4	3.60	5
12	13	1	17	2	1	6.80	16
13	1	6	1	8	4	4.00	7
14	18	22	1	10	11	12.40	21
15	15	15	9	4	3	9.20	12
16	1	8	2	3	11	5.00	10
17	3	1	4	2	2	2.40	3
18	5	6	4	3	7	5.00	4
19	6	4	4	1	1	3.20	5
20	4	8	5	6	2	5.00	6
					Grand Totals =	9.34	13.25

Figure 8

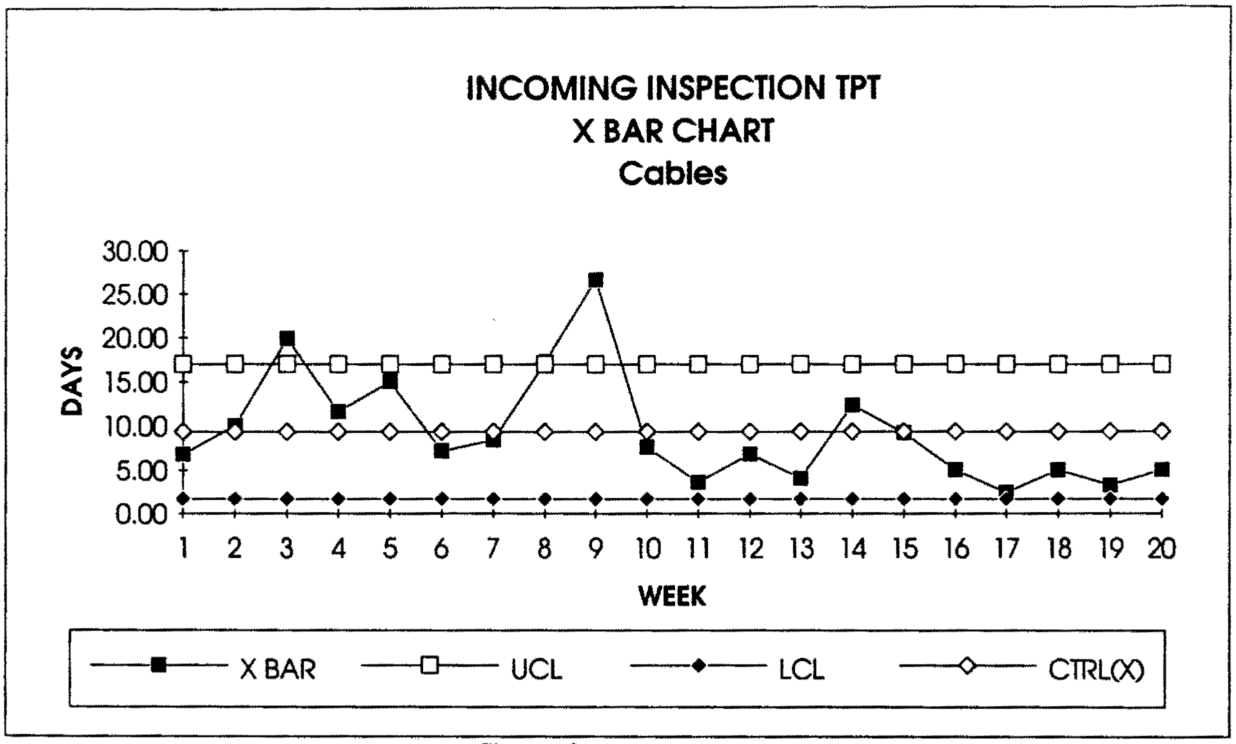

Figure 9

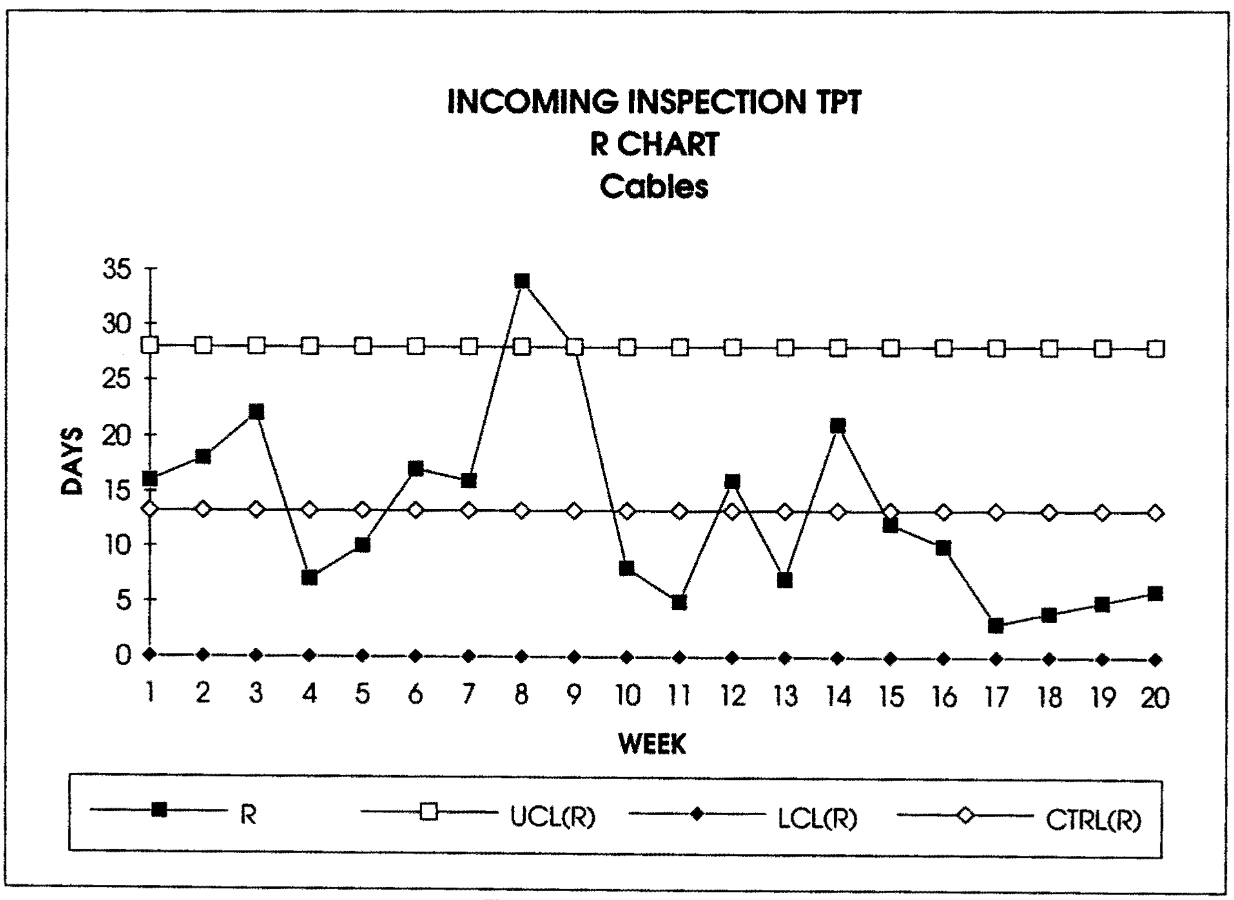

Figure 10

THROUGH-PUT-TIME SAMPLE DATA
Lockers

WEEK	DATA 1	DATA 2	DATA3	DATA 4	DATA5	X-BAR	R
1	4	4	1	1	7	3.40	6
2	1	1	15	1	5	4.60	14
3	1	1	1	1	1	1.00	0
4	3	1	1	1	1	1.40	2
5	7	7	1	1	5	4.20	6
6	1	1	1	1	1	1.00	0
7	7	1	1	1	1	2.20	6
8	1	1	2	2	26	6.40	25
9	1	1	1	1	1	1.00	0
10	7	1	1	1	2	2.40	6
11	1	1	1	1	1	1.00	0
12	3	6	6	1	1	3.40	5
13	1	7	1	1	1	2.20	6
14	8	1	1	1	1	2.40	7
15	1	1	1	1	1	1.00	0
16	2	2	2	2	1	1.80	1
17	1	1	5	1	1	1.80	4
18	1	1	1	1	1	1.00	0
19	1	1	1	1	1	1.00	0
20	1	1	1	1	1	1.00	0
					Grand Totals =	2.21	4.4

Figure 11

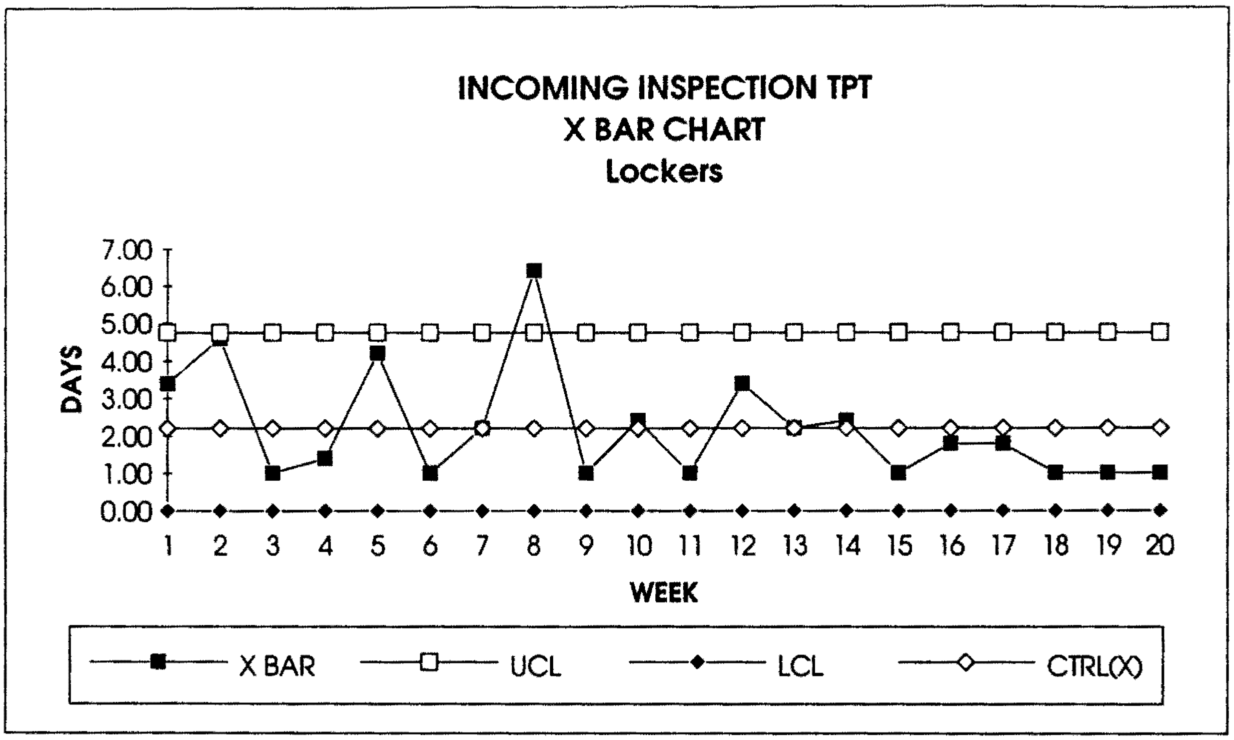

Figure 12

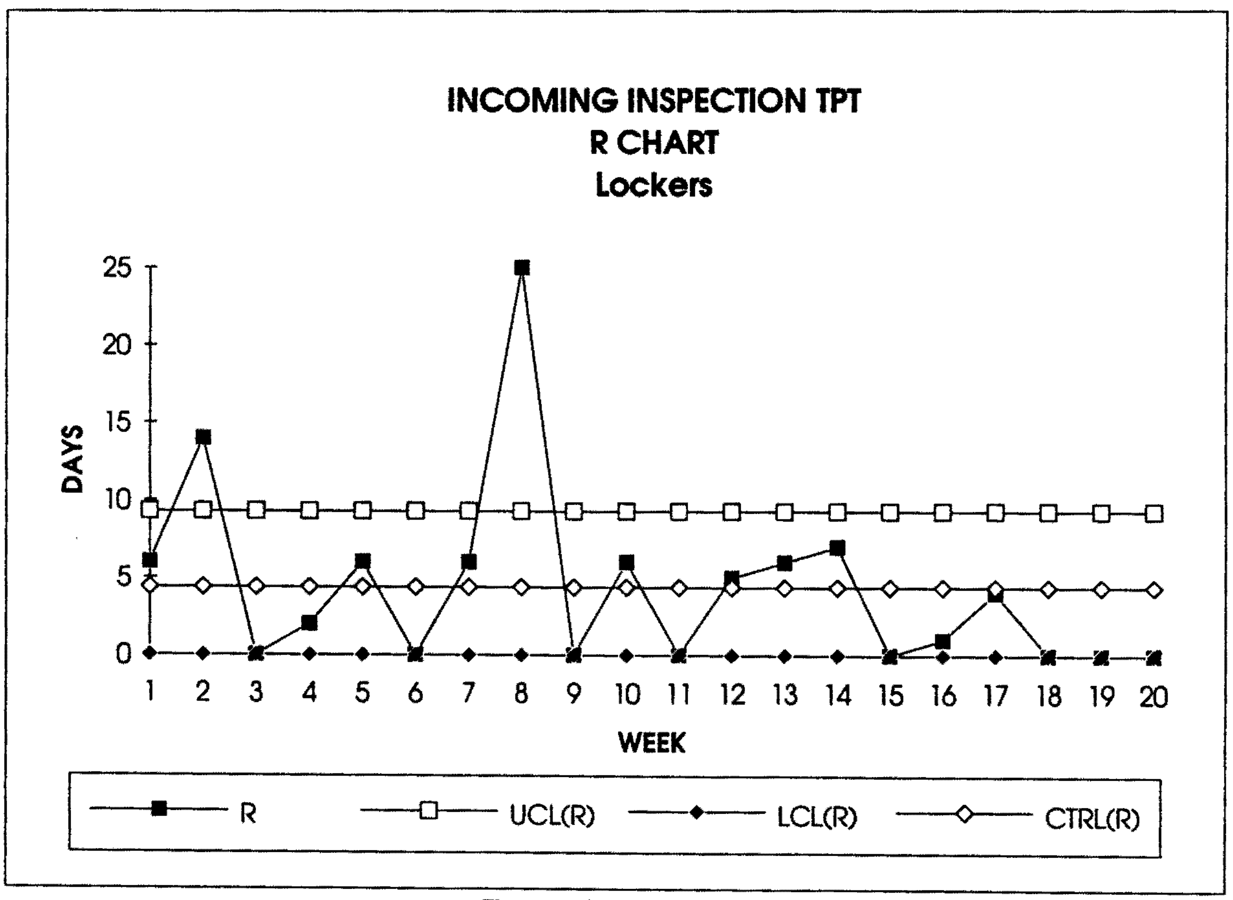

Figure 13

OUT-OF-CONTROL-POINT SUMMARY

ITEM	FAMILY	SUPPLIER	PART #	TPT (days)	COMMENTS
1	Sheet Metal	Triax	CG80000-056902	56	Material held until release of documentation
2	Cable	Icontec	FS146013-001	47	Material held until release of documentation, supplier was not on Approved Manufacturers List.
3	Cable	SEI	201248-001	35	No problems
4	Cable	Acacia	CG001598-001	35	Defective material, 100% screen & supplier rework
5	Cable	SEI	00248-002	38	No problems
6	Locker	Koei	CG006833-001	15	Defective material, supplier rework
7	Locker	Natter	CG0000-150501	26	Defective material, supplier rework
8	Passive	Matsushita	C42L-0104	44	No problem
9	Passive	HP	C50L-6090-0007	42	No problem
10	Passive	AVX	C42L-0159	42	Wrong voltage, received 100V, s/b 50V, Deviation signed to use as is.
11	Passive	FME	CG000508-001	45	No problem

Figure 17