Quality Report Round 3
Extra Credit

GSCM 469
LEAN MANAGEMENT

Date: 28 November 2018

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Executive Summary

This summary provides an overview of the production processes of the Lean Machine company, with an analysis of the production, runs, percent good (acceptable) products, the number of bad (unacceptable) products, and the deviations within each area of production as shown in x-bar, r-charts and p-charts. The data is collected from three rounds in the GSCM 469 Lean Management Quality Lab and used for comparison of process changes and monitor overall team improvement in production quality. Each of the control charts is done with a sample size of n = 4. For simplicity, figures 3 and up in this report consistently follow this format: Figure #a: {Name of Process} Round 1; Figure#b: {Name of Process} Round 2; Figure #c: {Name of Process} Round 3. So a figure with the letter "c" after the number is ALWAYS for Round 3, even if there are no figures provided for the other rounds.

Our observations in Round 3 were a disappointment compared to Round 2. While still substantially better than the first round, quality dropped from being mostly at or above 94% to less than 79% good. The reason for the drop in quality was mainly due to the confusion of a line worker when management failed to properly coordinate the visual management cues provided and he mistakenly produced several copies of a non-specified product, which needed to be discarded. Important note: QC discarded some of these items without first measuring them. Why is unclear.

Quality Key Process Indicator (KPI) Report

This KPI report presents the quality data collected from all three rounds of the Quality Lab as produced by the team Lean Machine.

Process Diagram

Below are the original process diagram, followed by the updated process diagram indicating our adjustments between the first and second round.

Figure 1: Process Diagram

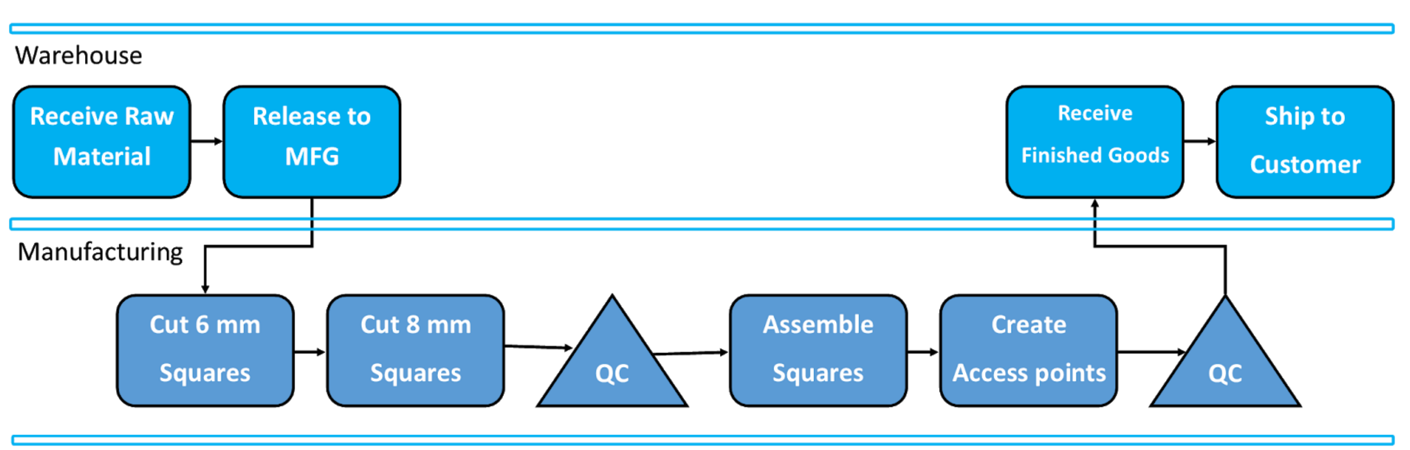
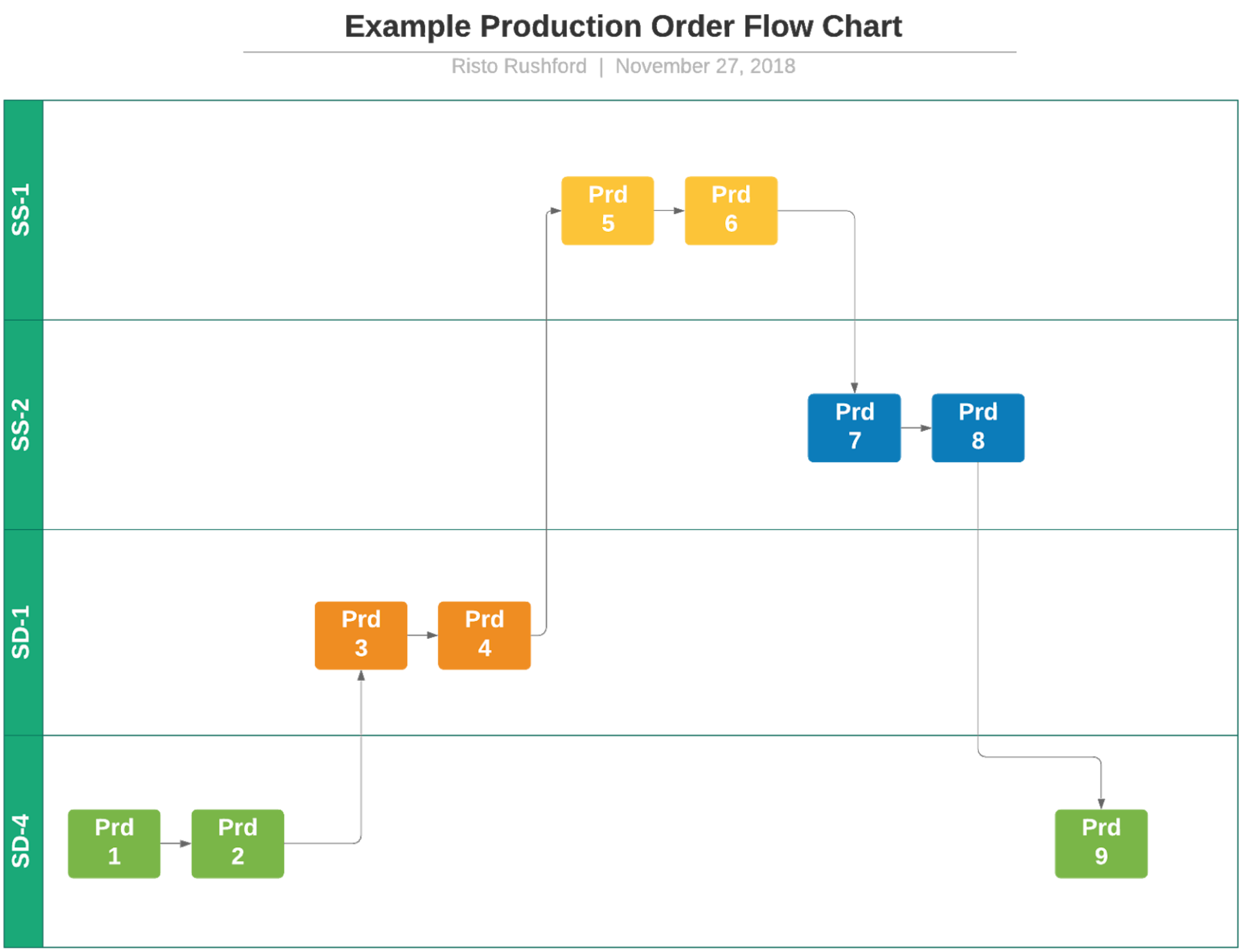


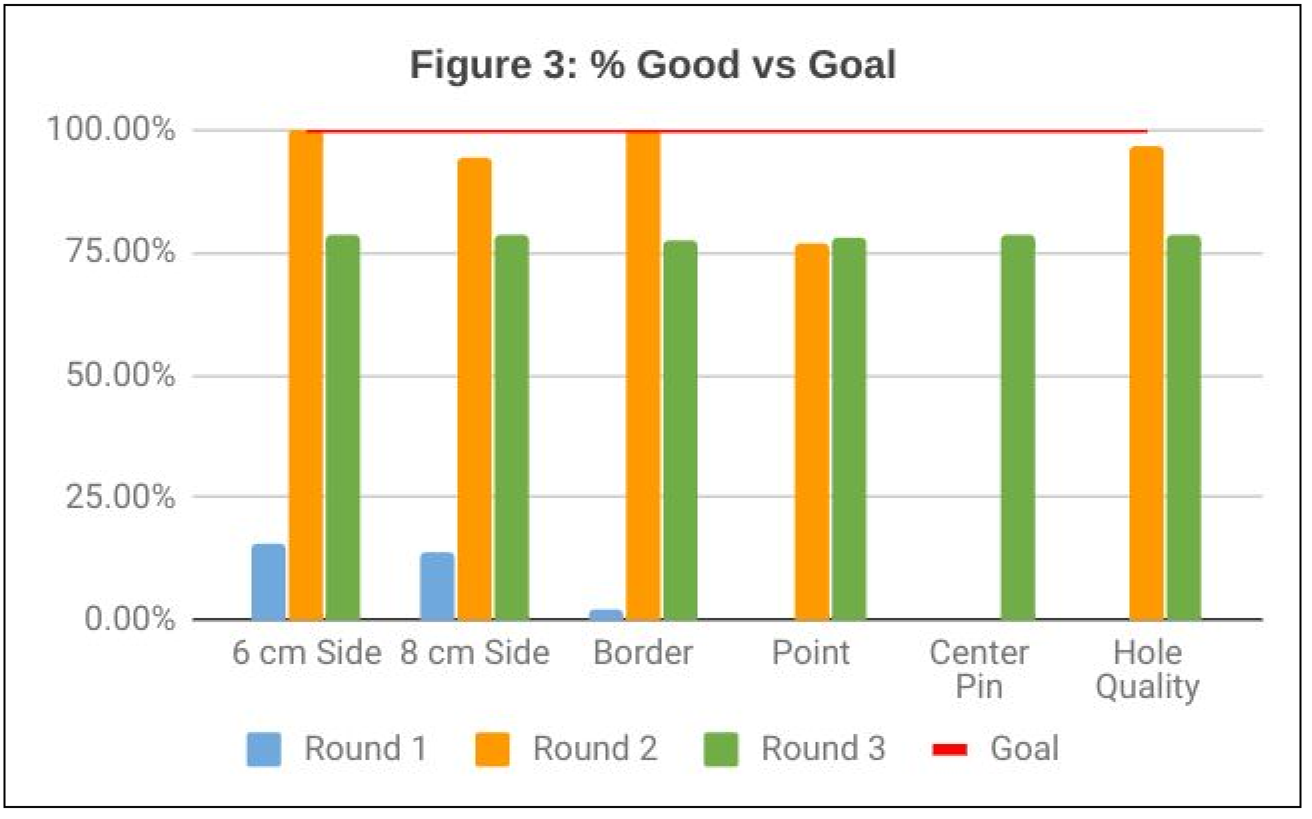
Figure 2: Production Flow Chart



The above flowchart provides an example of the production line, note that it moves from one product type to another in fairly short order. When not managed carefully, the nature of this system can cause confusion among workers, leading to non-salvageable defects.

Section 1: Percent Good and Number Good/Bad

Summary	While the percent good in Round 3 was not nearly as high as in Round 2, it was still much better than in Round 1. It is also worth noting that in spite of the decrease in overall quality, a much better job was done of tracking the quality data for each type of quality measurement. We are now able to report quality data for the four required data points, as well as the two additional data points for center pin placement and hole quality.
Recommendation	Similar to how there was confusion in Round two when switching between products, there was a similar issue during Round 3, but with a different line worker and at a different part of the process. While the visual management aids produced after Round 2 seemed helpful at first, management attempted to fill in where absent team members were missing and failed to properly coordinate changing over the visual cues with each shift from one product type to another. The recommendation is that management or a delegate be in charge of monitoring visual cue changeovers to avoid confusion.



Estimated % Good Tables, Round 3

The Percent Good tables are shown below. Calculations for Percent Good are shown for quality measurements of these data sets: 6 cm side, 8 cm side, border, point, center pin, and hole quality. Overall quality was consistently at about 95% or higher except for the point measurements. This is, of course, minus the data for the discarded mis-products.

6.0 cm % Good	Percent Good Calculations					
	Target =	6.000	Z Score		% Good	
	USL =	6.100	Upper =	2.014		97.799%
	LSL =	5.900	Lower =	-2.014	-	2.201%
	X-dbar =	6.000	sigma =	0.050	% Good =	95.597%

8.0 cm % Good	Percent Good Calculations					
	Target =	8.000	Z Score		% Good	
	USL =	8.100	Upper =	2.517		99.409%
	LSL =	7.900	Lower =	-2.235	-	1.272%
	X-dbar =	7.994	sigma =	0.042	% Good =	98.137%

Border % Good	Percent Good Calculations					
	Target =	1.000	Z Score		% Good	
	USL =	1.100	Upper =	2.141		98.386%
	LSL =	0.900	Lower =	-2.997	-	0.136%
	X-dbar =	1.017	sigma =	0.039	% Good =	98.250%

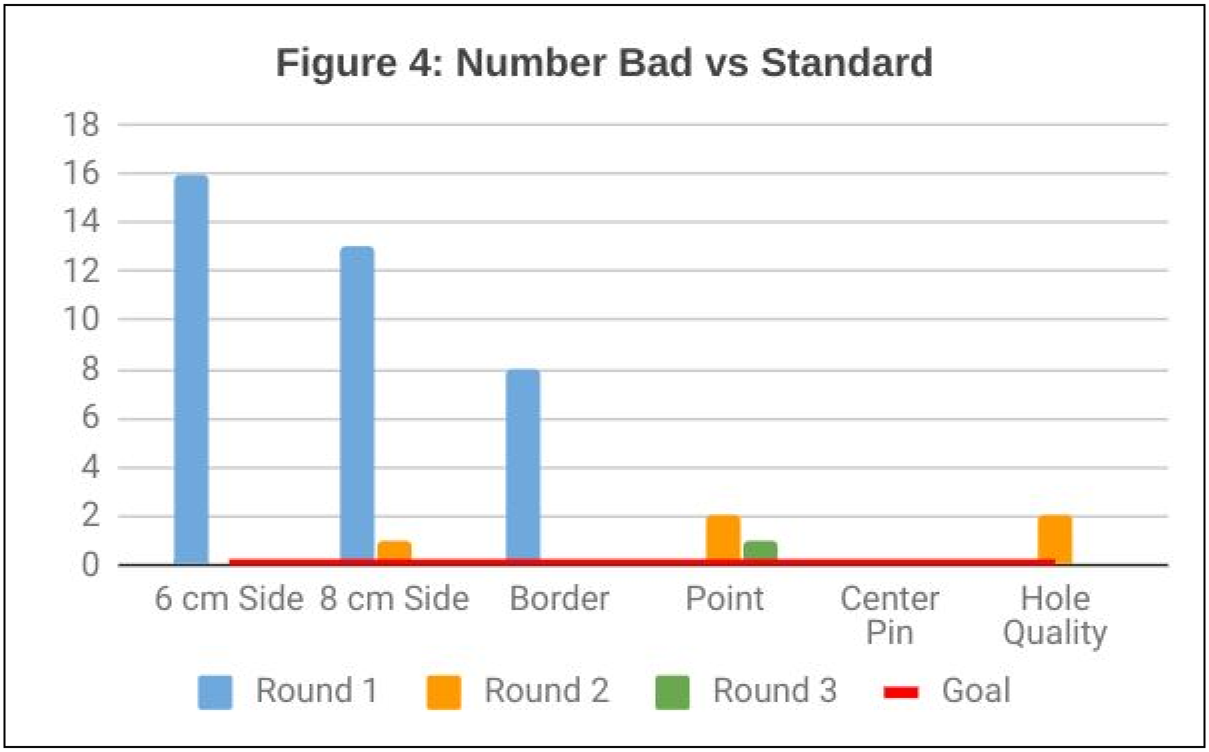
Point % Good	Percent Good Calculations					
	Target =	4.000	Z Score		% Good	
	USL =	4.100	Upper =	1.382		91.658%
	LSL =	3.900	Lower =	-1.145	-	12.602%
	X-dbar =	3.991	sigma =	0.079	% Good =	79.056%

Center Pin % Good	Percent Good Calculations					
	Target =	4.000	Z Score		% Good	
	USL =	4.100	Upper =	2.064		98.050%
	LSL =	3.900	Lower =	-2.244	-	1.242%
	X-dbar =	4.004	sigma =	0.046	% Good =	96.808%

Hole Quality % Good	Percent Good Calculations					
	Target =	1.000	Z Score		% Good	
	USL =	1.100	Upper =	2.612		99.549%
	LSL =	0.900	Lower =	-2.544	-	0.548%
	X-dbar =	0.999	sigma =	0.039	% Good =	99.001%

Section 2: Number Bad vs Standard

Summary	The Standard (or Goal) for Number Bad is zero. It would appear that Lean Machine did significantly better in Round 3 than Round 2 and most of these metrics. However, since several products were apparently discarded with no measurements taken, this information is not reliable.
Recommendation	While QC improved excellently in making measurements for the most part, the non-recorded discards pose a problem and may have affected these measurements if the data was collected. QC should be briefed on this so that the data is reliably tracked in the future.



Section 3: Process Capability

Summary	Even though there has been a significant improvement in each of the processes, in terms of capability there are still improvements to be made. The6 cm cutting process is well within capabilities, however, the 8 cm process and the assembly processes still have much room for improvement.
Recommendation	A conjecture as to the reason of the incapability of the 8 cm cutting process, being so similar to the 6 cm process, is that the slightly larger paper size is a little more difficult for the cutters to handle precisely. Additionally, the cutters are approaching the 6 and 8 cm cutting in batches, and it could be that they are fatigued when they begin cutting the 8 cm pieces. To improve, we will have the cutting teams alternate between the two cutting size as much as possible, and take their time to get the cuts correct regardless of the sheet size.

Process Capability Tables

The Process capability tables are shown below. None of the processes are considered capable based on the measurements taken during this round. When we get to the later parts of the report, we will see this demonstrated frequently in the R-charts.

Table 7: 6.0 cm Process Capability	Process Capability			
	Cp =	0.414	CpkU =	0.414
	Cpk =	0.414	CpkL =	0.414

Table 8: 8.0 cm Process Capability	Process Capability			
	Cp =	0.414	CpkU =	0.438
	Cpk =	0.389	CpkL =	0.389

Table 9: Border Process Capability	Process Capability			
	Cp =	0.414	CpkU =	0.345
	Cpk =	0.345	CpkL =	0.482

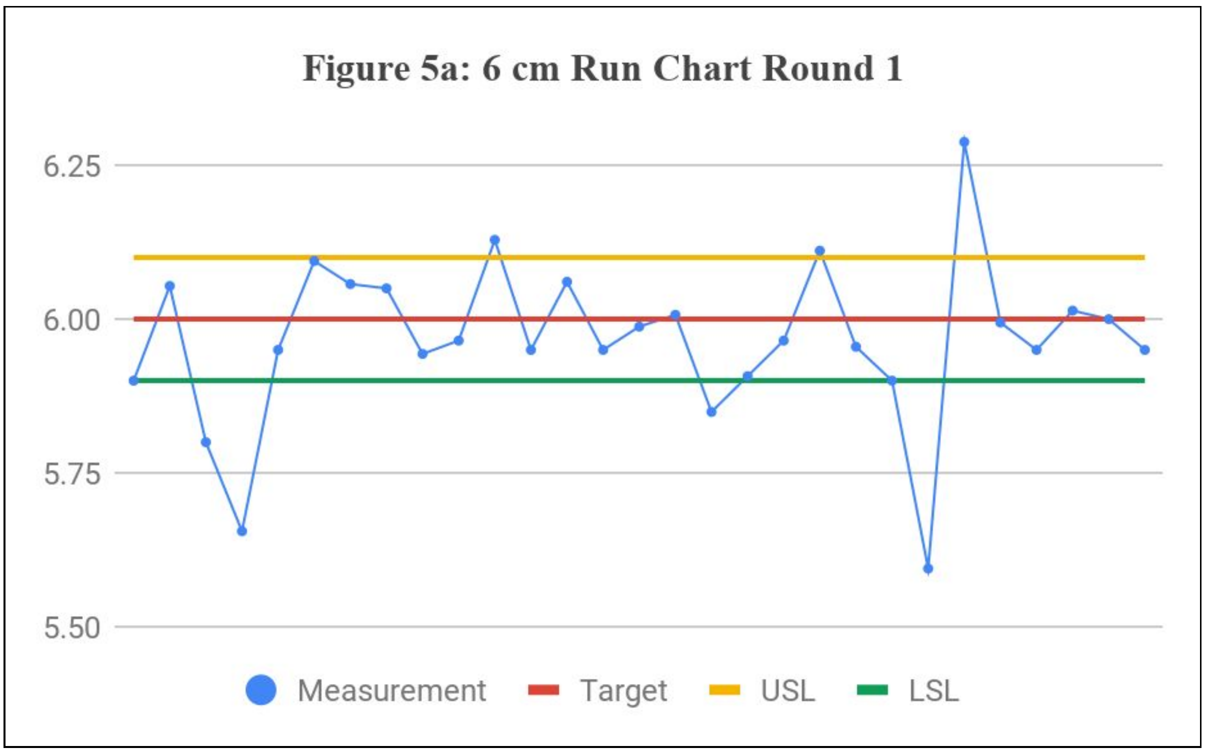
Table 10: Point Process Capability	Process Capability			
	Cp =	0.414	CpkU =	0.452
	Cpk =	0.375	CpkL =	0.375

Table 11: Center Pin Process Capability	Process Capability			
	Cp =	0.414	CpkU =	0.396
	Cpk =	0.396	CpkL =	0.431

Table 12: Hole Quality Process Capability	Process Capability			
	Cp =	0.414	CpkU =	0.419
	Cpk =	0.408	CpkL =	0.408

Section 4: 6 cm Production - Run Charts and Control Charts

Summary	The measurements of the 6 cm squares in Round 3 show a renewal of the high variability exhibited in Round 1 for the first half. While none of these measurements are outside of the specification limit, the high variability is telling. This may be due to the cutter trying out a new tool (box cutters) instead of scissors for the first part of the lab.
Recommendation	In the previous report, I actually recommended using a straightedge and a cutting surface to improve cutting time, because this was a significant bottleneck at the start of production. However, this process also requires some practiced skill as well as reliable tools, neither of which were available for this lab. Note the greater precision of the cutting for the latter half of Round 3 (see the run chart in Figure 5c) done after the toolset used was changed back to scissors. After this, I recommend staying with whichever method the cutter feels most sufficient at.



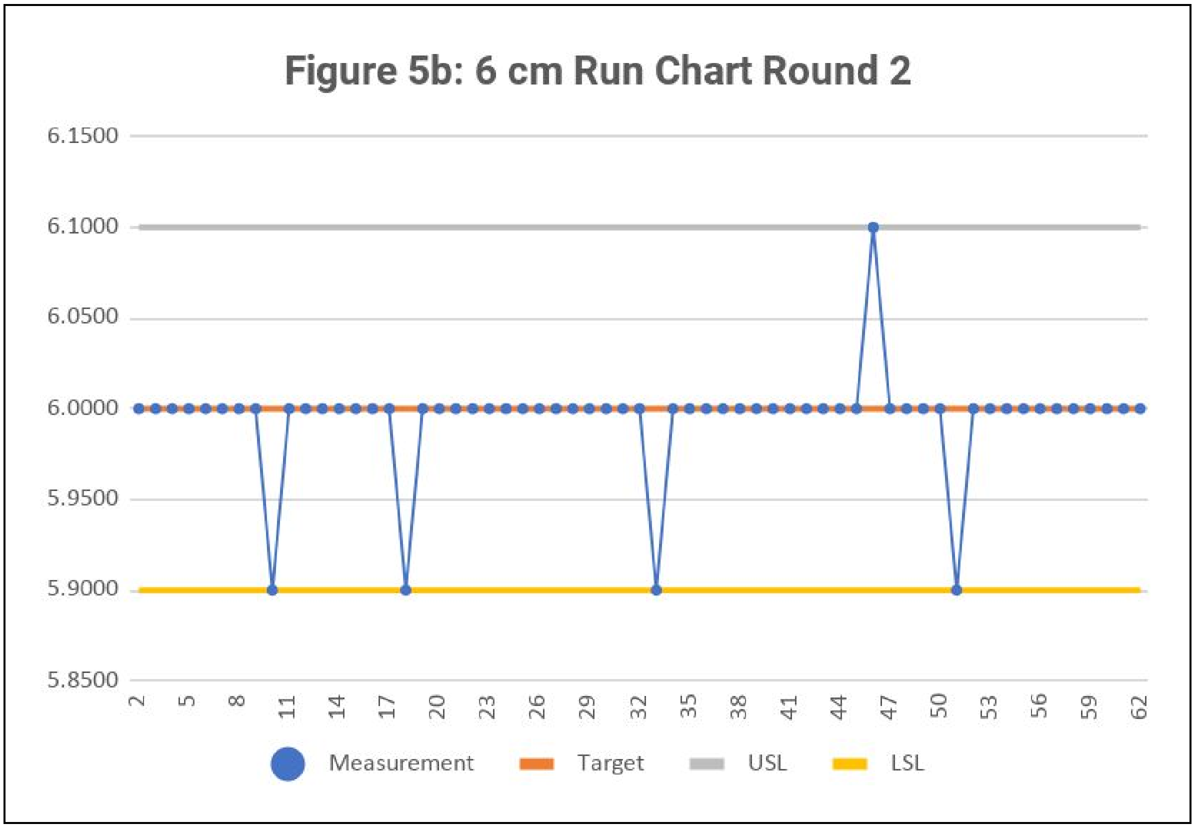


Figure 5b: 6 cm Run Chart Round 2
6.1500
6.1000
6.0500
6.0000
5.9500
5.9000
5.8500
2 5 8 11 14 17 20 23 26 29 32 35 38 41 44 47 50 53 56 59 62
Measurement Target USL LSL

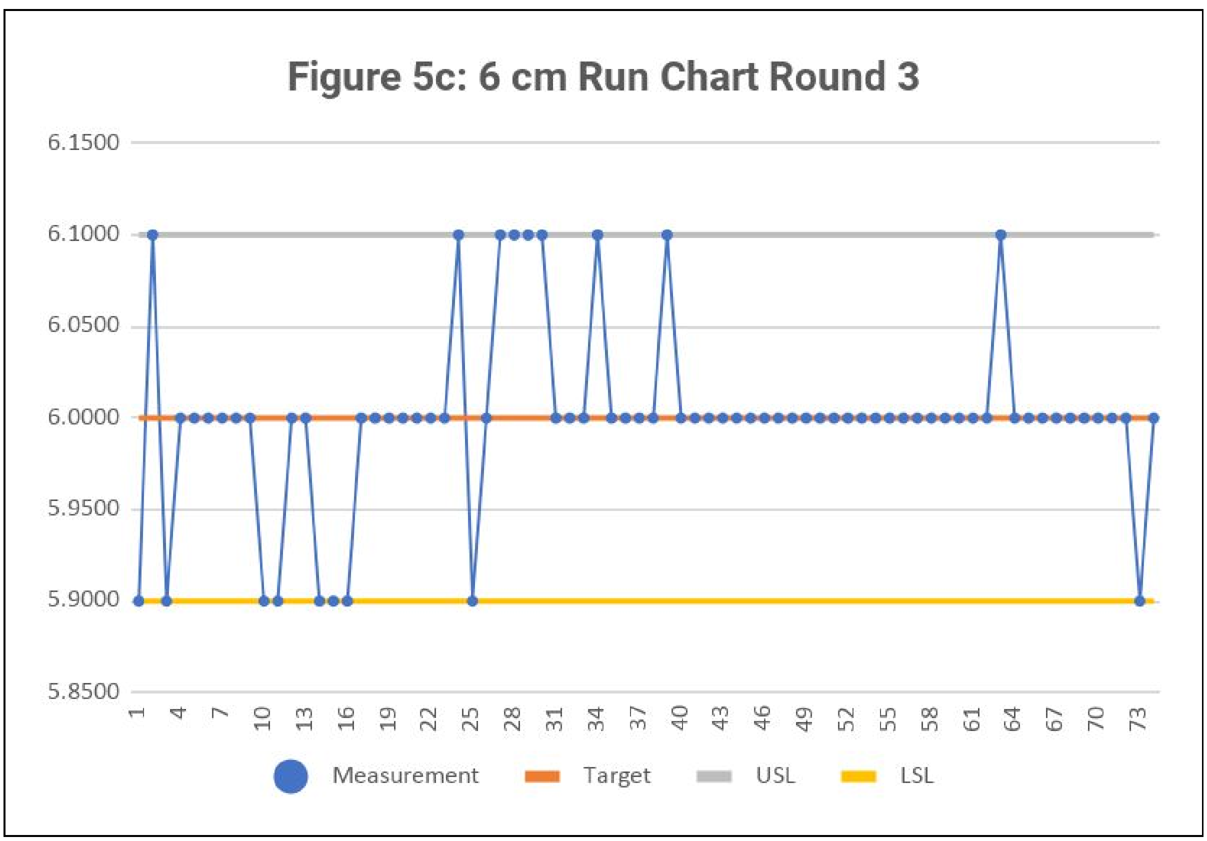


Figure 5c: 6 cm Run Chart Round 3
6.1500
6.1000
6.0500
6.0000
5.9500
5.9000
5.8500
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73
Measurement Target USL LSL

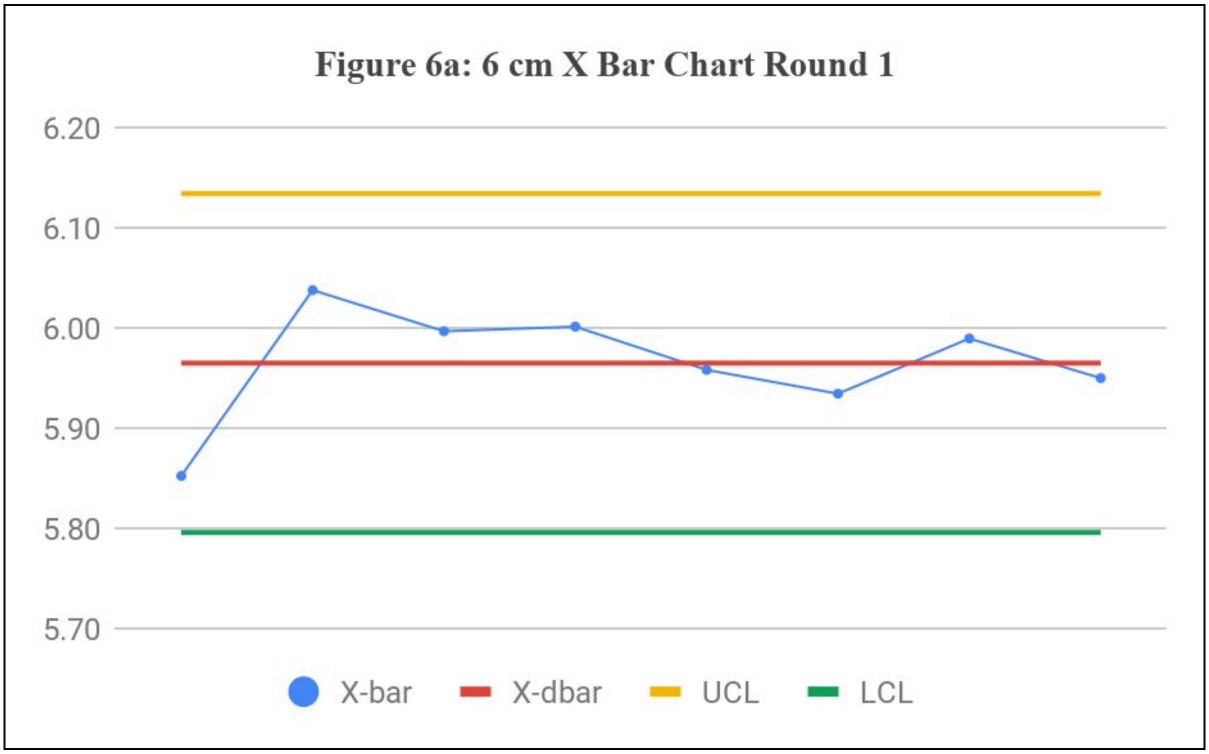


Figure 6a: 6 cm X Bar Chart Round 1
6.20
6.10
6.00
5.90
5.80
5.70
X-bar
X-dbar
UCL
LCL

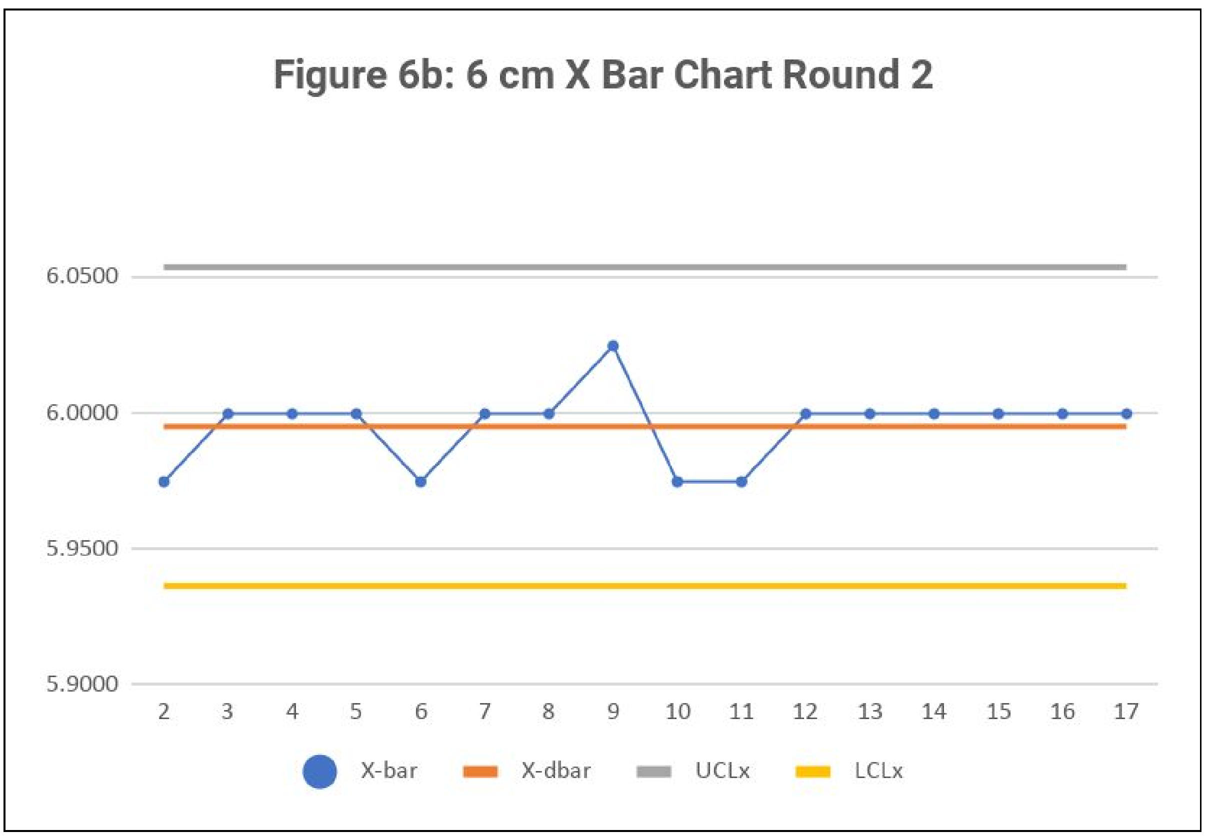


Figure 6b: 6 cm X Bar Chart Round 2
6.0500
6.0000
5.9500
5.9000
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
X-bar
X-dbar
UCLx
LCLx

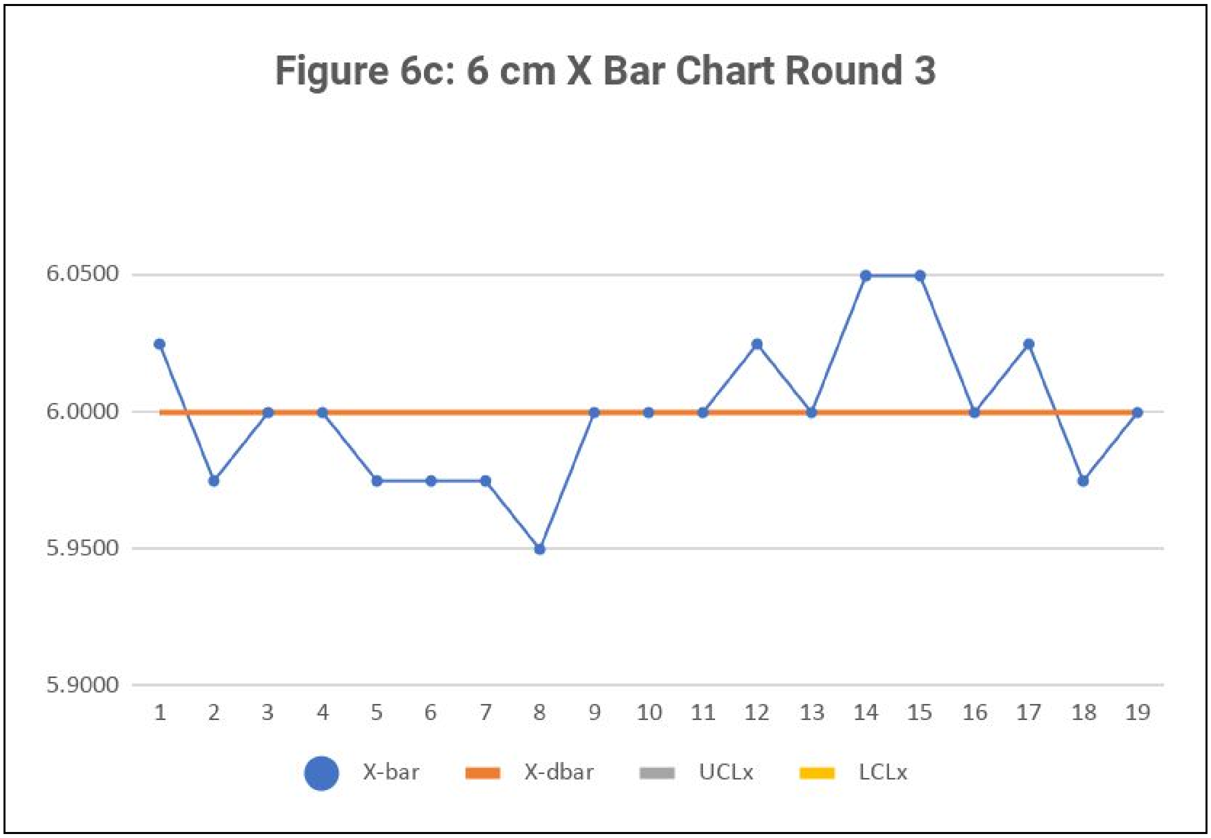


Figure 6c: 6 cm X Bar Chart Round 3
6.0500
6.0000
5.9500
5.9000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
X-bar
X-dbar
UCLx
LCLx

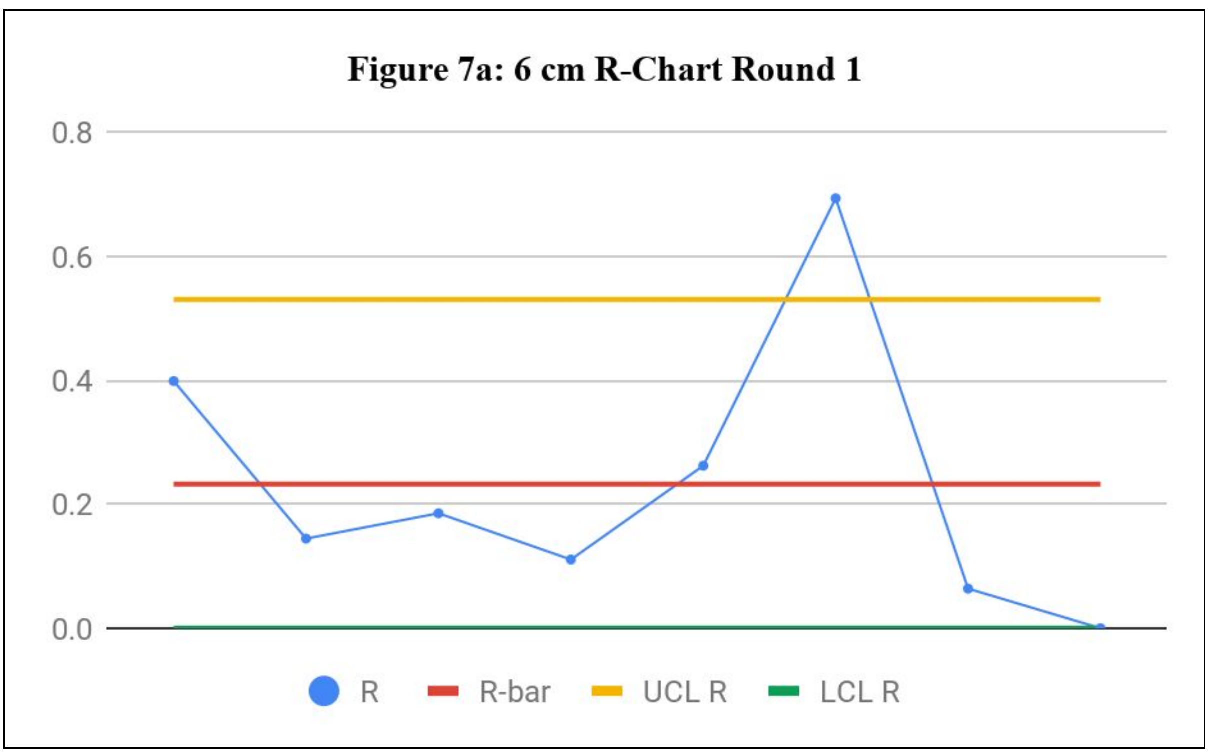


Figure 7a: 6 cm R-Chart Round 1
0.8
0.6
0.4
0.2
0.0
R
R-bar
UCL R
LCL R

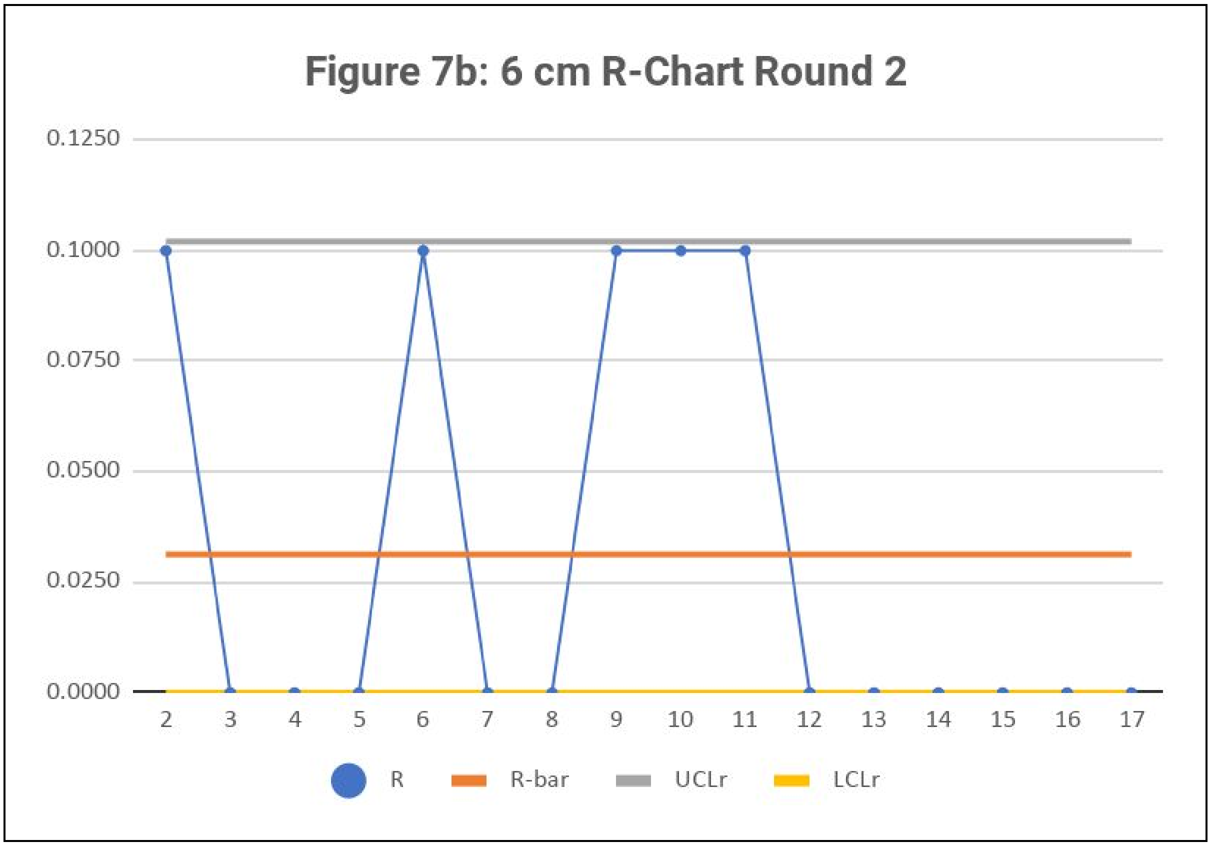


Figure 7b: 6 cm R-Chart Round 2
0.1250
0.1000
0.0750
0.0500
0.0250
0.0000
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
R
R-bar
UCLr
LCLr

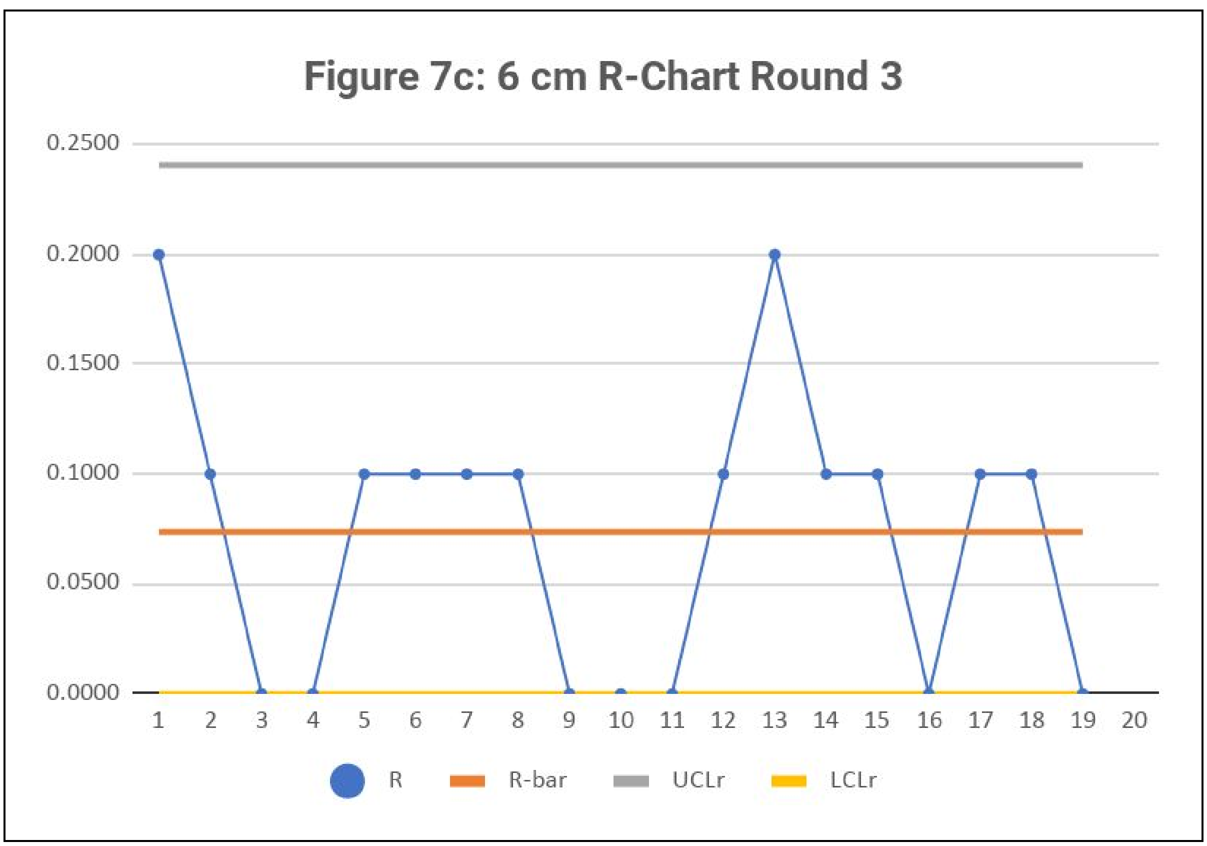


Figure 7c: 6 cm R-Chart Round 3
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
R
R-bar
UCLr
LCLr

Figure 8a: 6 cm P-Chart Round 1

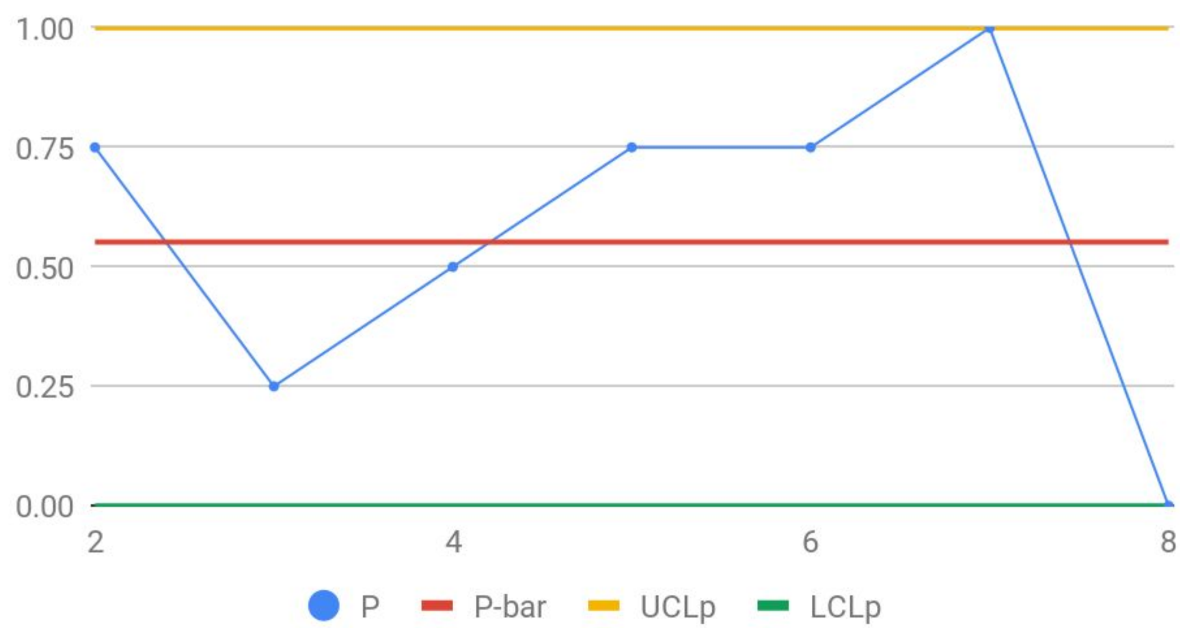
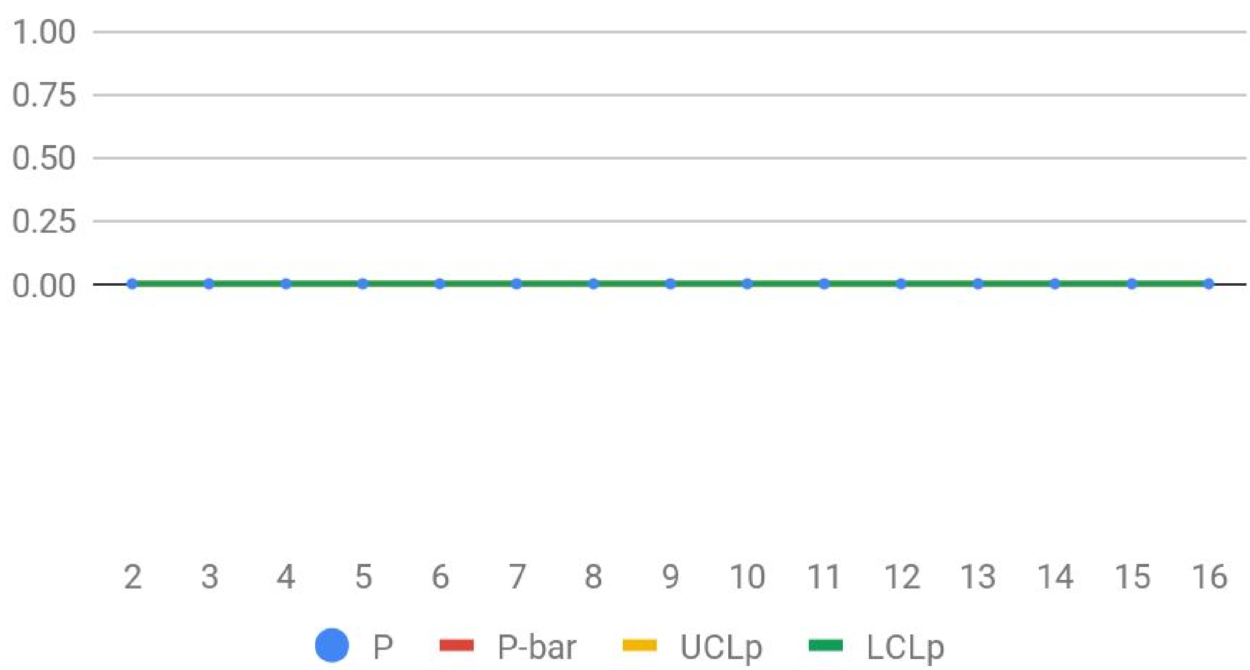


Figure 8b: 6 cm P-Chart Round 2



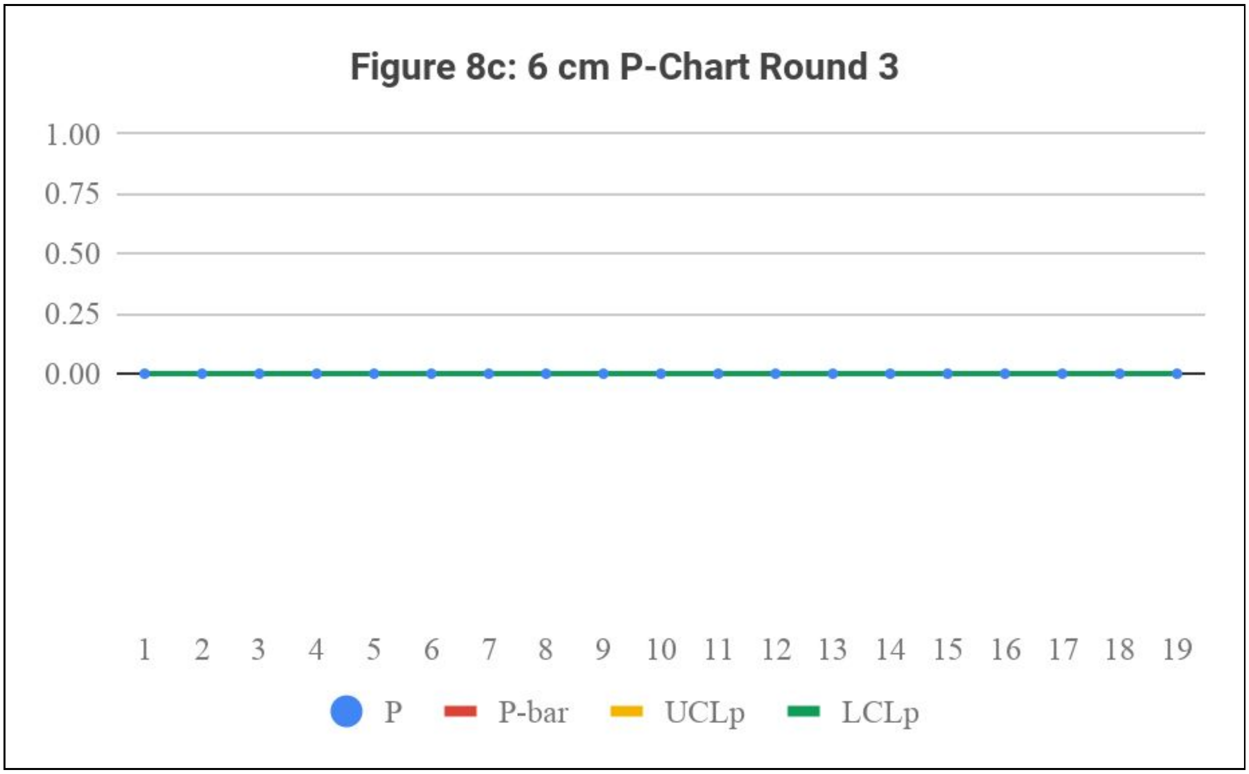
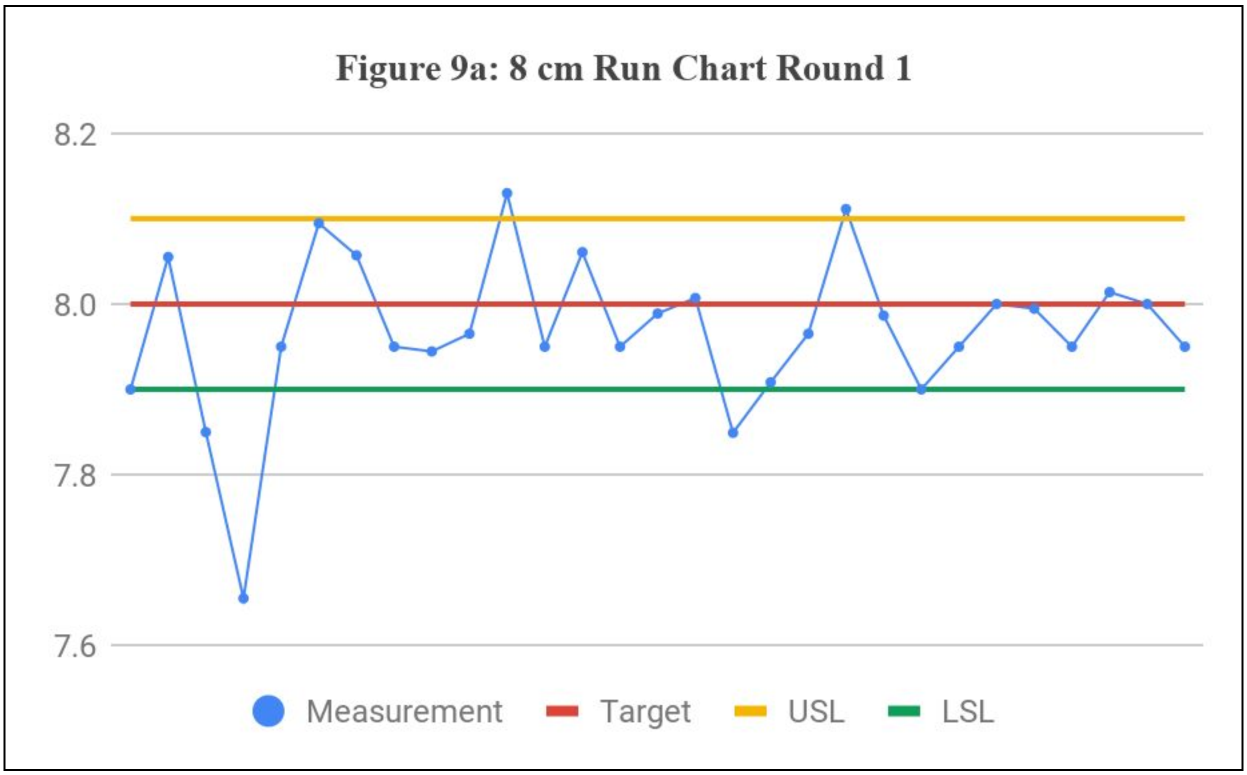


Figure 8c: 6 cm P-Chart Round 3
1.00
0.75
0.50
0.25
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
P
P-bar
UCLp
LCLp

Section 5: 8 cm Production - Run Charts and Control Charts

Summary	As with the 6 cm measurements, we see a lot of variability in the 8 cm measurements as well. Even though there was an increase in precision for the last half for the 6 cm cuts, this effect didn't happen for the 8 cm cuts due to the cutter proceeding in a "batch processing" type fashion. He overproduced the 8 cm squares significantly before he had changed tools.
Recommendation	The same recommendation for the 6 cm cuts would apply here, but another important recommendation based on this data is that a continuous, one-piece-flow should be maintained as much as possible. While the paper stock used necessitated producing some squares simultaneously, focusing on doing large batches to get ahead cost the team time and money, because cutting was also a significant bottleneck before assembly could begin. Also note that the variability is so great in these measurements that the R-Chart displays this process to be clearly out of control both from the imprecision and a product being out of the control limit.



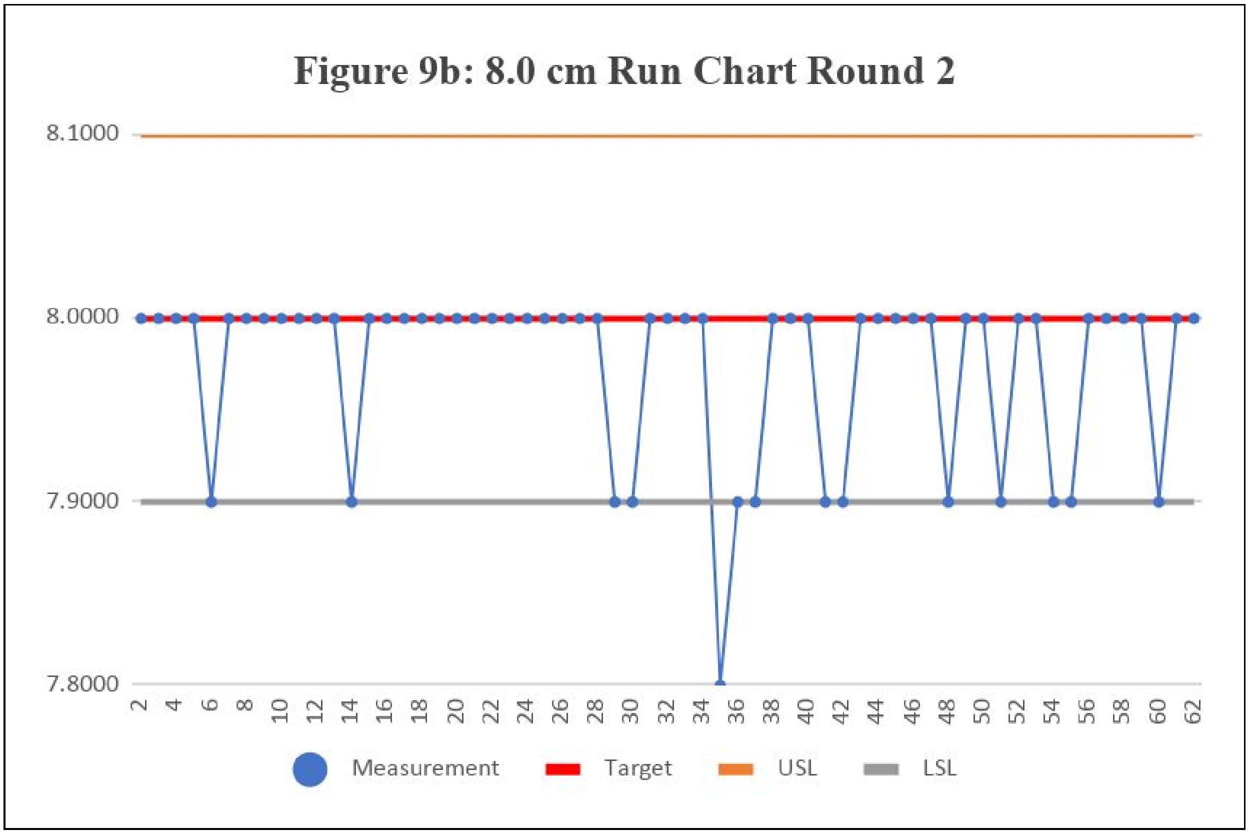


Figure 9b: 8.0 cm Run Chart Round 2
8.1000
8.0000
7.9000
7.8000
2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58 60 62
Measurement
Target
USL
LSL

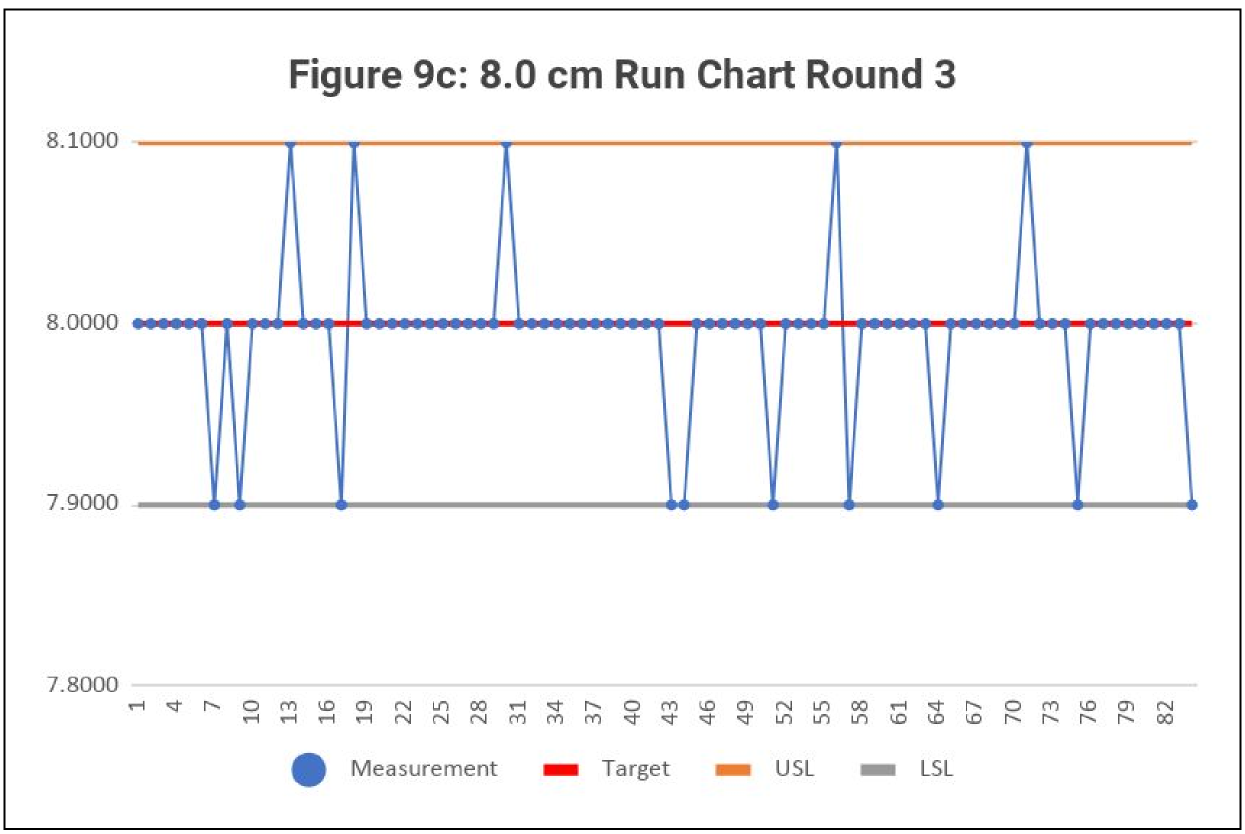


Figure 9c: 8.0 cm Run Chart Round 3
8.1000
8.0000
7.9000
7.8000
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73 76 79 82
Measurement
Target
USL
LSL

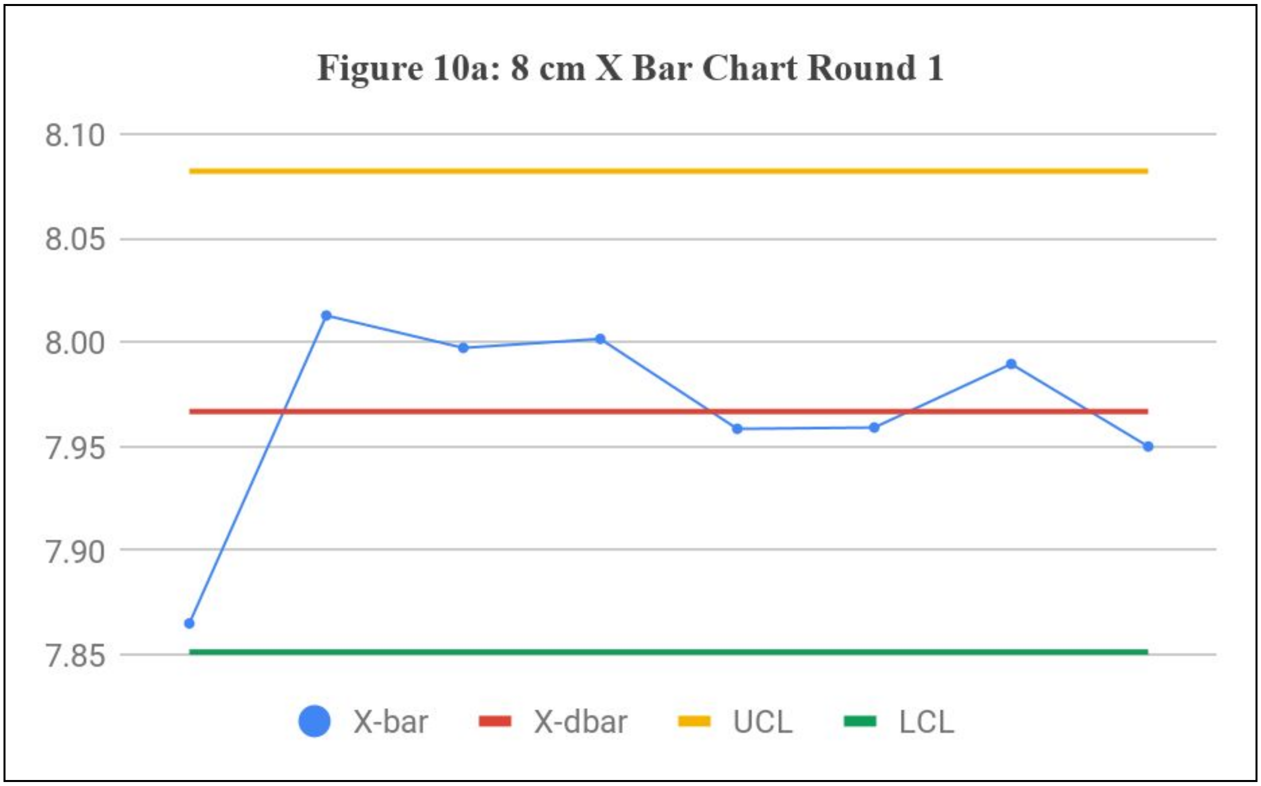


Figure 10a: 8 cm X Bar Chart Round 1
8.10
8.05
8.00
7.95
7.90
7.85
X-bar
X-dbar
UCL
LCL

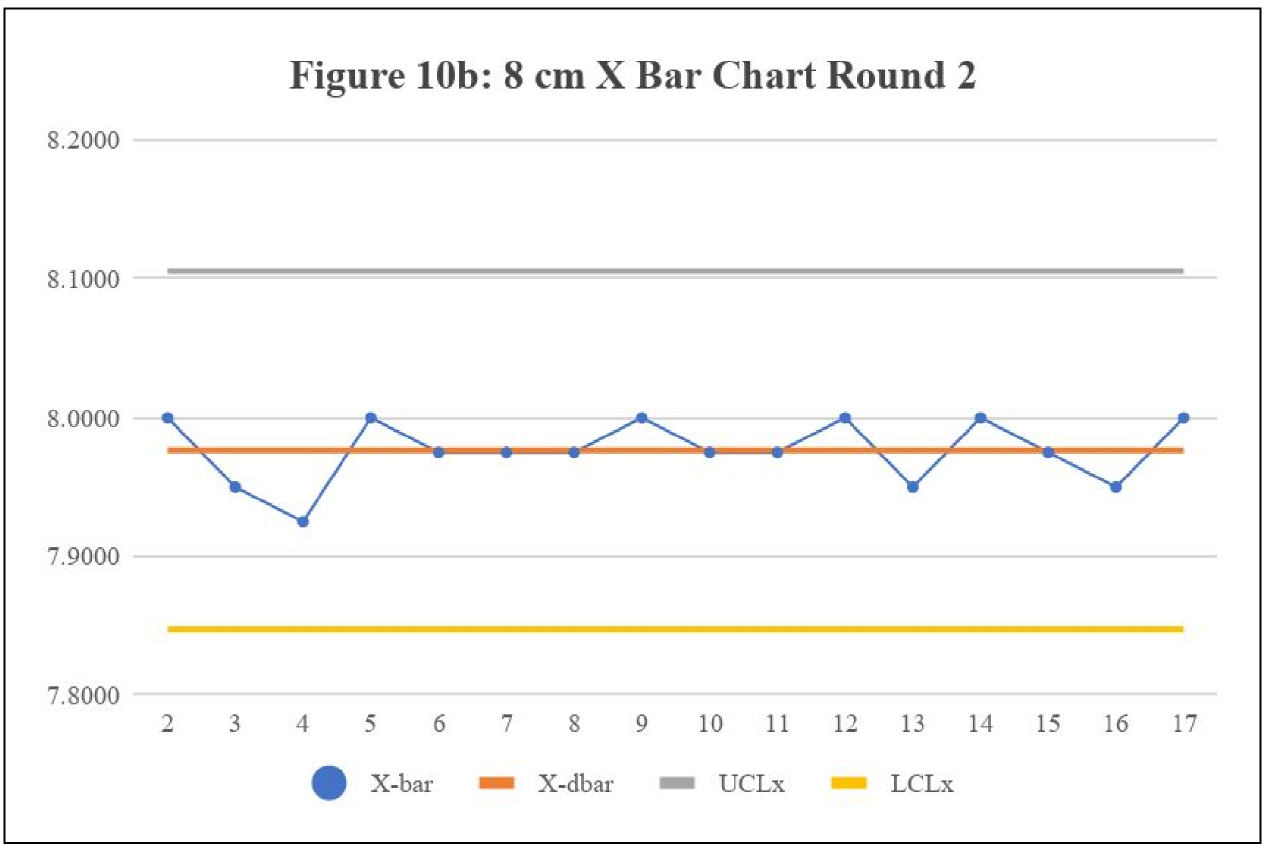


Figure 10b: 8 cm X Bar Chart Round 2
8.2000
8.1000
8.0000
7.9000
7.8000
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
X-bar
X-dbar
UCLx
LCLx

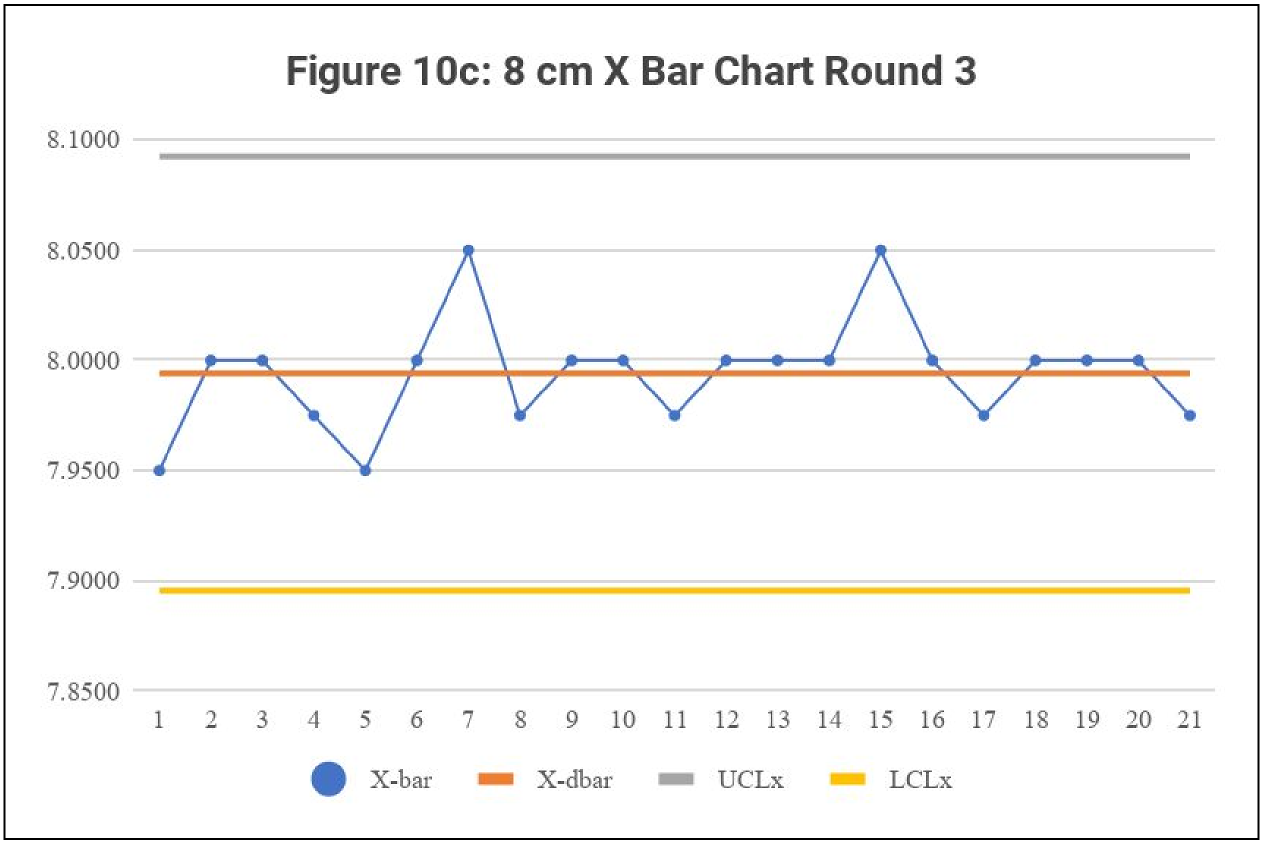


Figure 10c: 8 cm X Bar Chart Round 3
8.1000
8.0500
8.0000
7.9500
7.9000
7.8500
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
X-bar
X-dbar
UCLx
LCLx

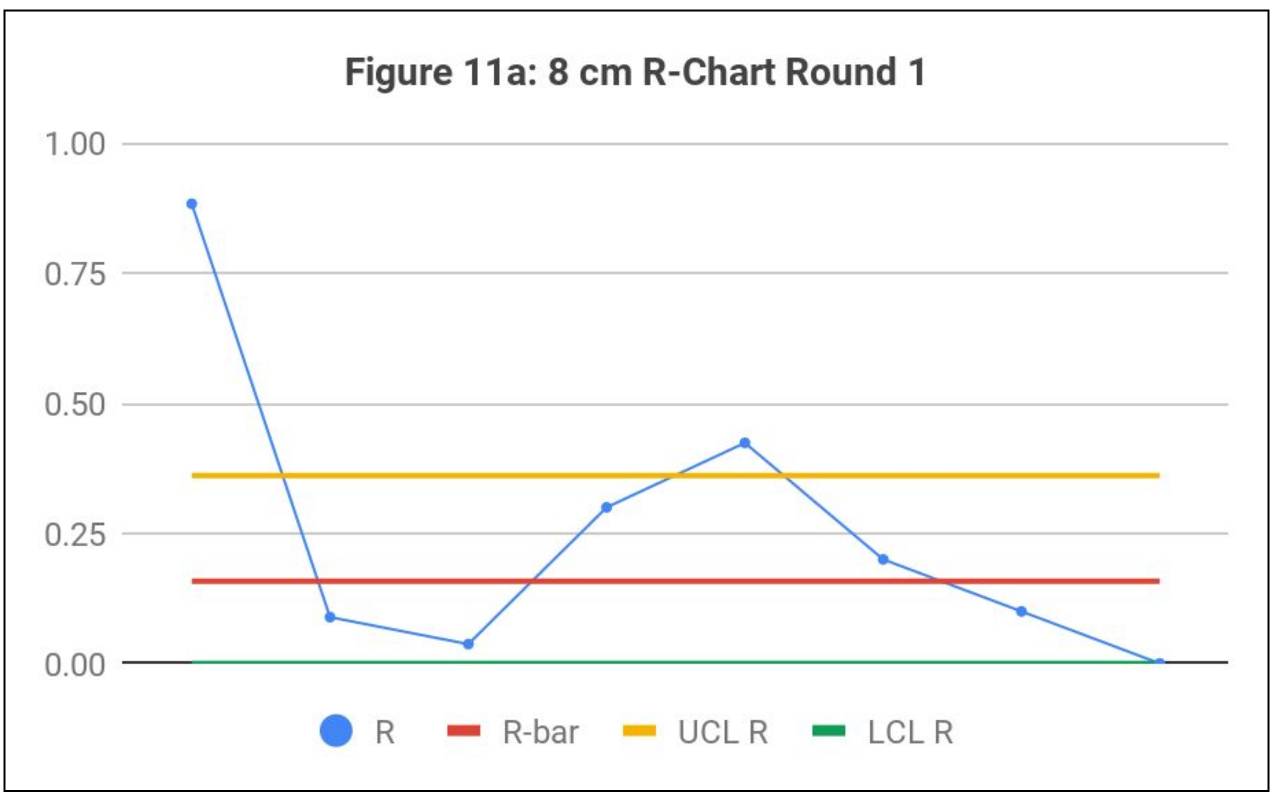


Figure 11a: 8 cm R-Chart Round 1
1.00
0.75
0.50
0.25
0.00
R
R-bar
UCL R
LCL R

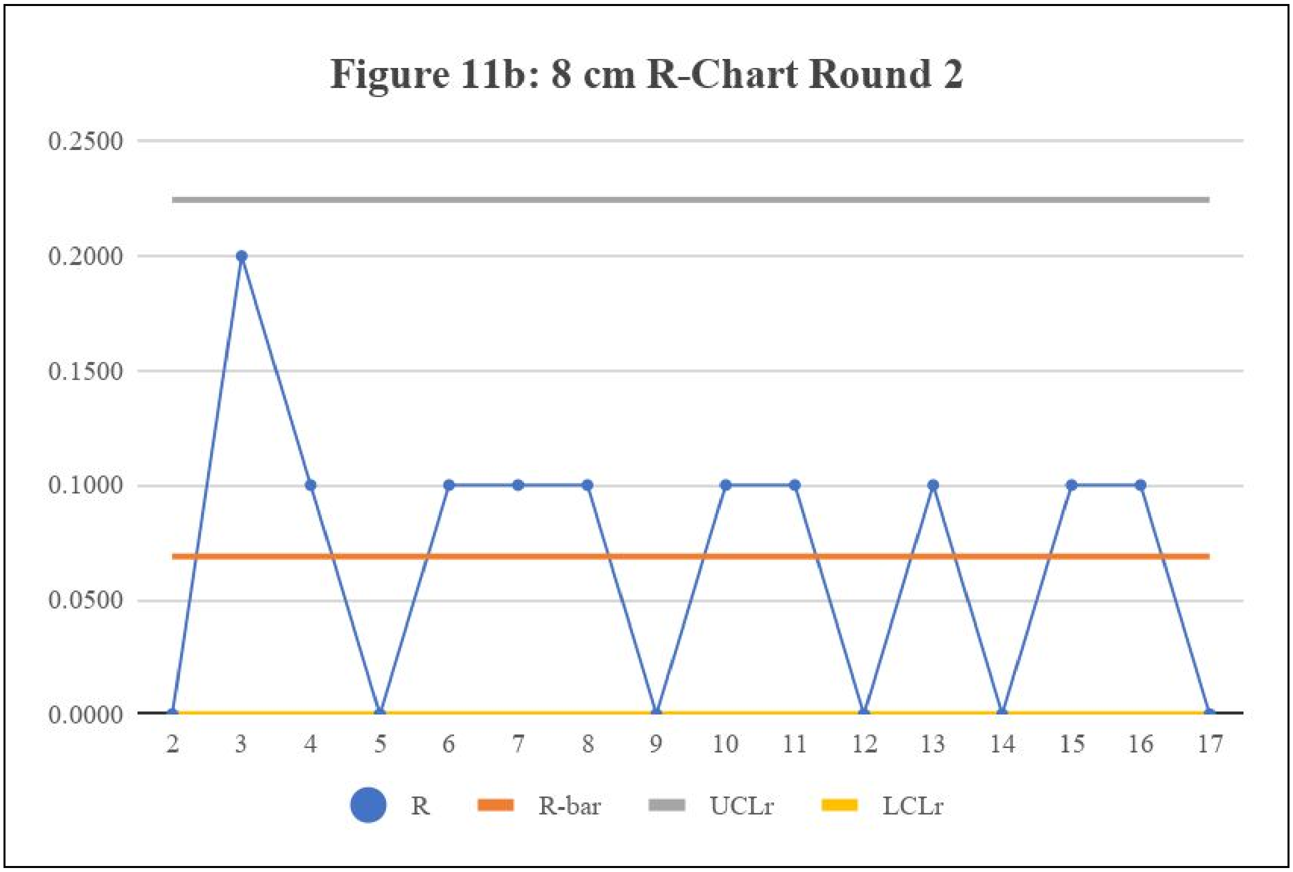


Figure 11b: 8 cm R-Chart Round 2
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
R
R-bar
UCLr
LCLr

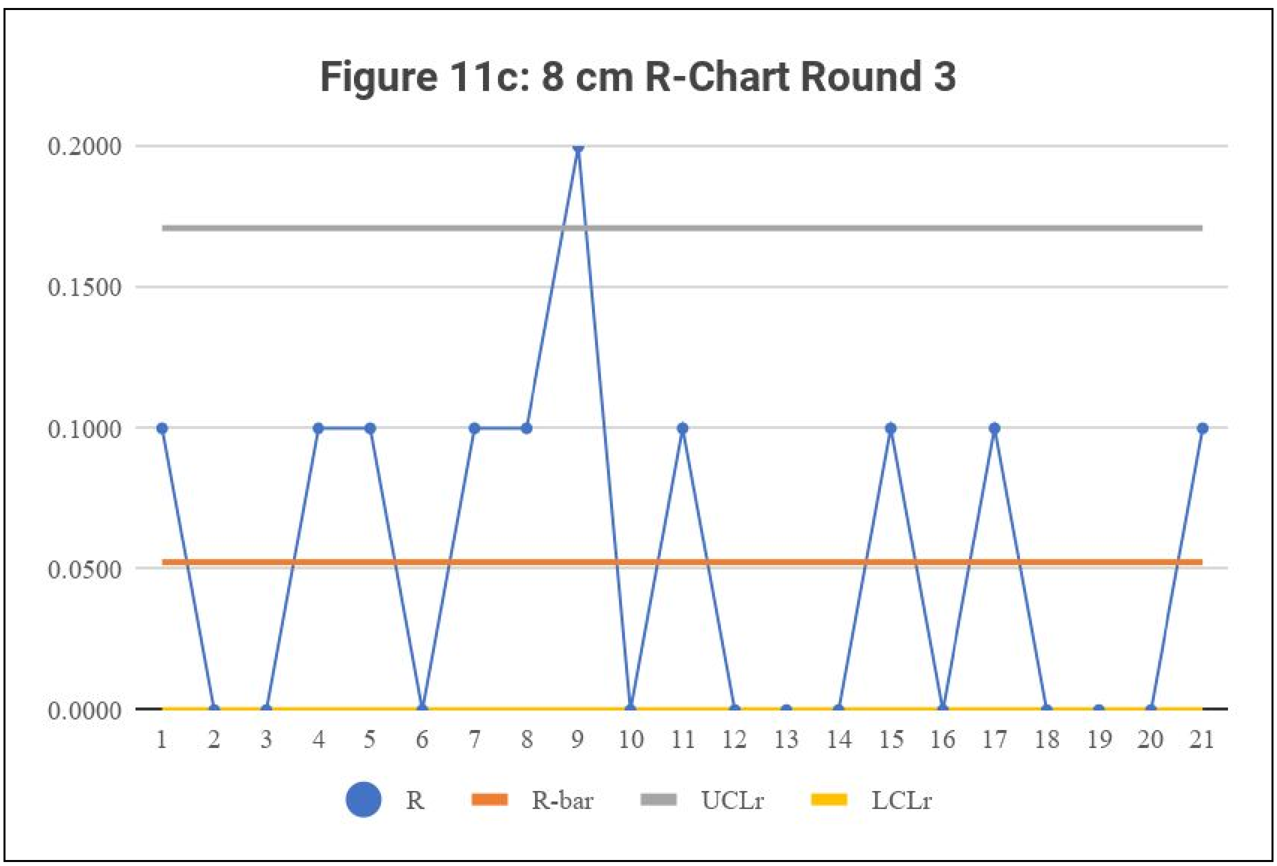


Figure 11c: 8 cm R-Chart Round 3
0.2000
0.1500
0.1000
0.0500
0.0000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
R
R-bar
UCLr
LCLr

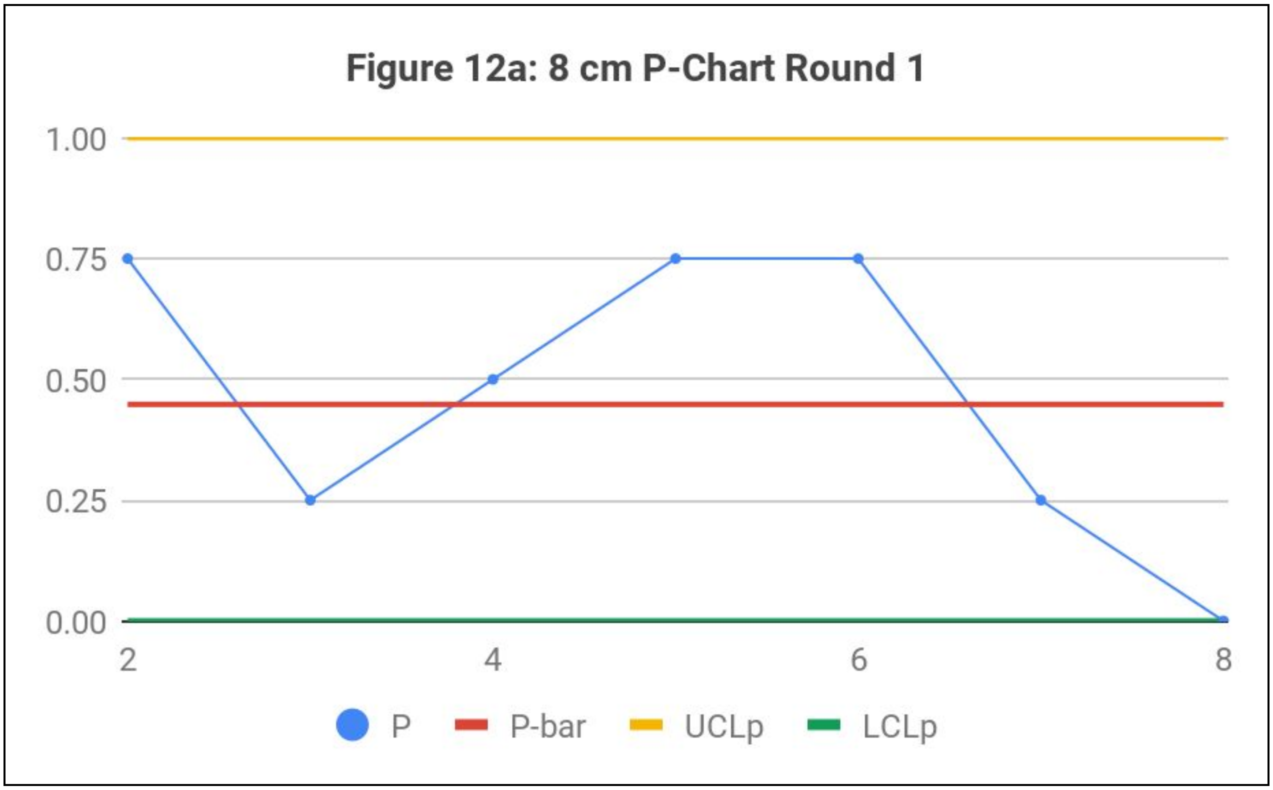


Figure 12a: 8 cm P-Chart Round 1
1.00
0.75
0.50
0.25
0.00
2
4
6
8
P
P-bar
UCLp
LCLp

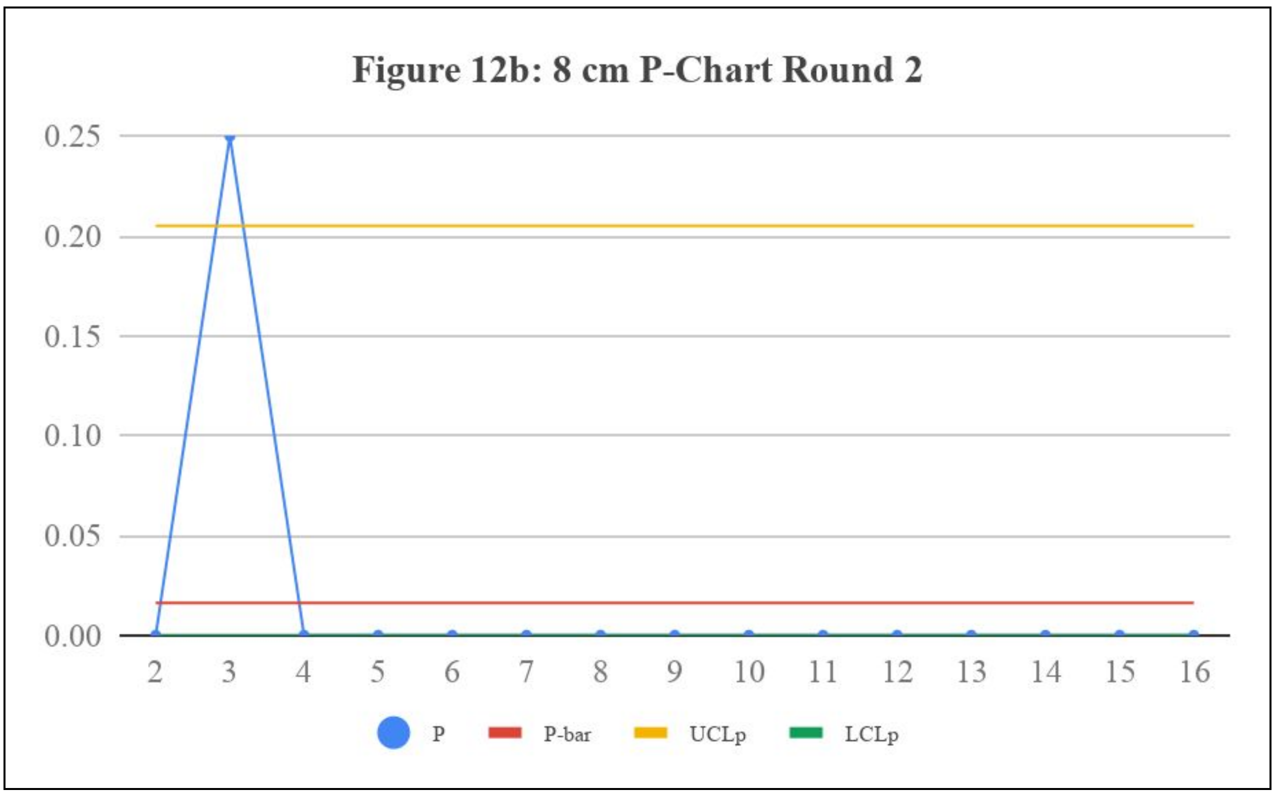


Figure 12b: 8 cm P-Chart Round 2
0.25
0.20
0.15
0.10
0.05
0.00
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
P
P-bar
UCLp
LCLp

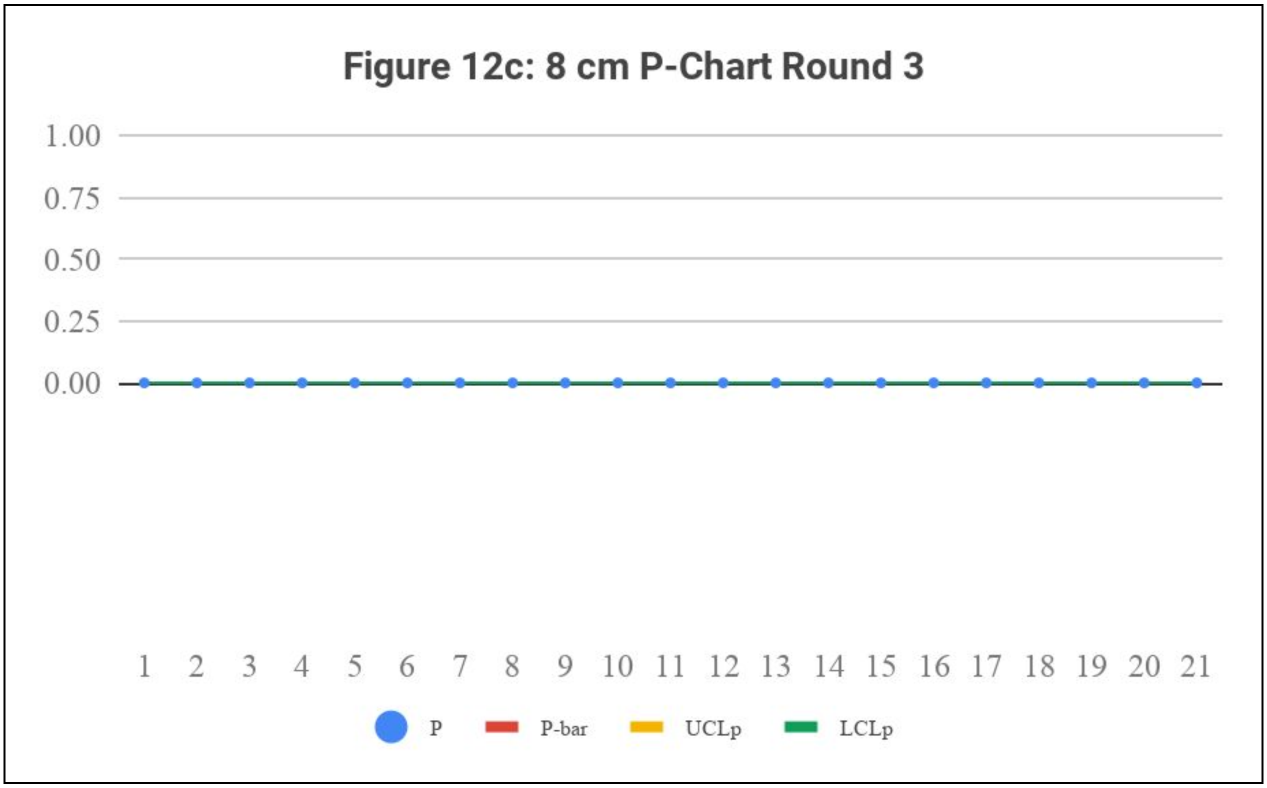
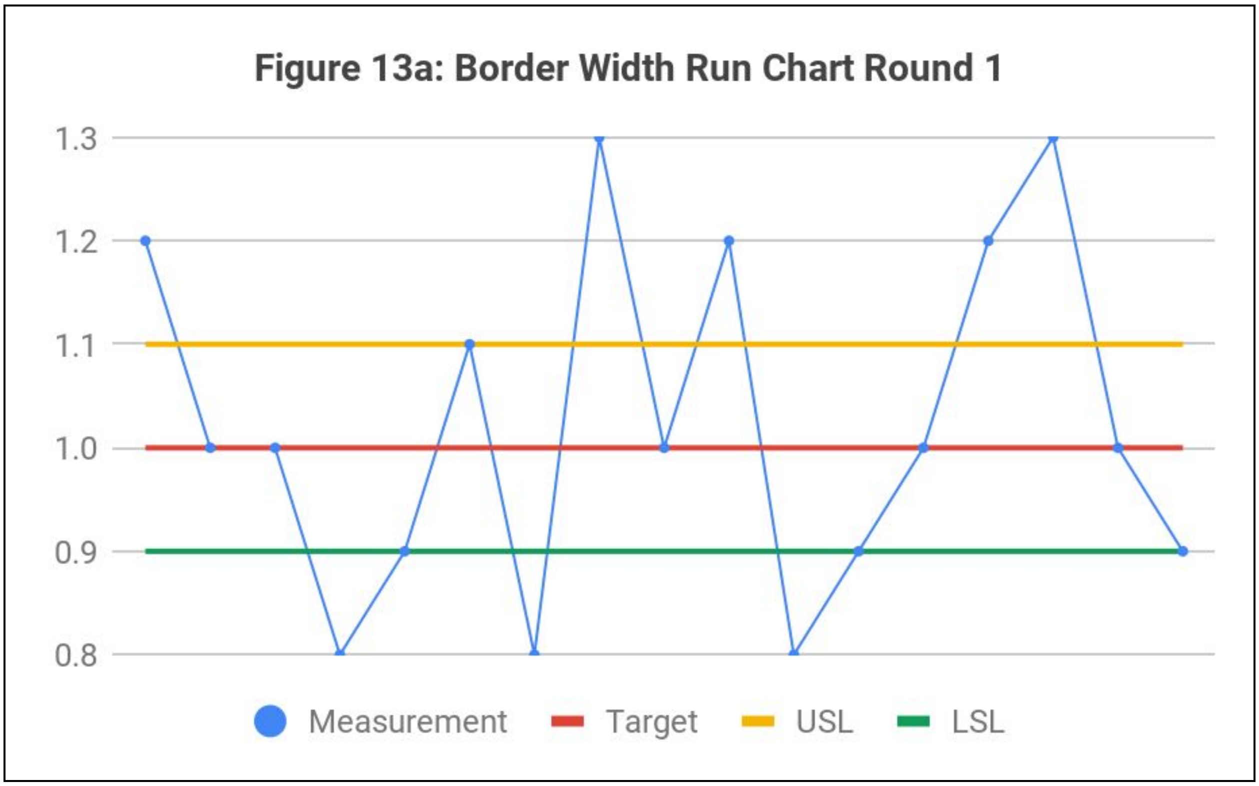


Figure 12c: 8 cm P-Chart Round 3
1.00
0.75
0.50
0.25
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21
P
P-bar
UCLp
LCLp

Section 6: Assembly - Border Width Run Charts and Control Charts

Summary	Lean Machine did not collect usable data on point placement for Round 1, or for border width for Round 2. However, they did collect the point measurements for all products of Round 2, and for the most part collected excellent data for Round 3 (including some datasets that were not required). The assemblers did an excellent job of placing the inner square in the center of the larger square.
Recommendation	Note what the assemblers are doing for standardization purposes and encourage them to continue to refine their method.



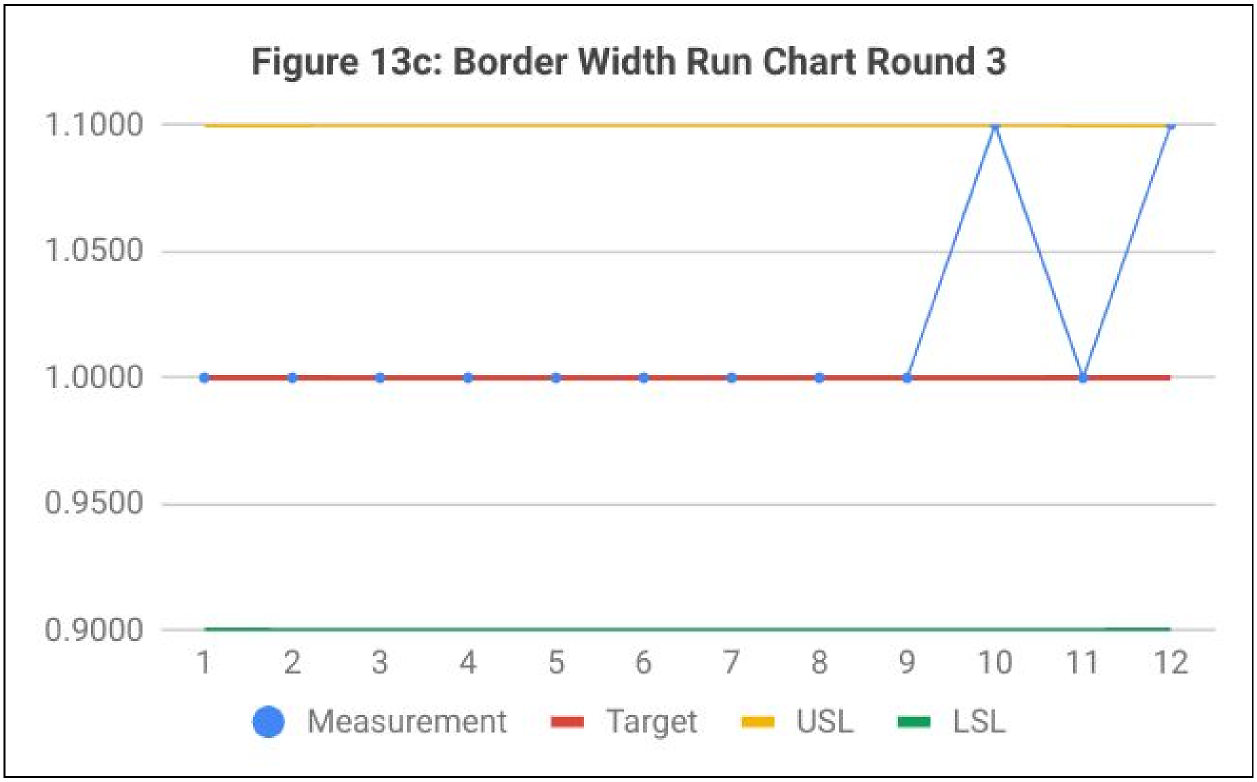


Figure 13c: Border Width Run Chart Round 3
1.1000
1.0500
1.0000
0.9500
0.9000
1 2 3 4 5 6 7 8 9 10 11 12
Measurement
Target
USL
LSL

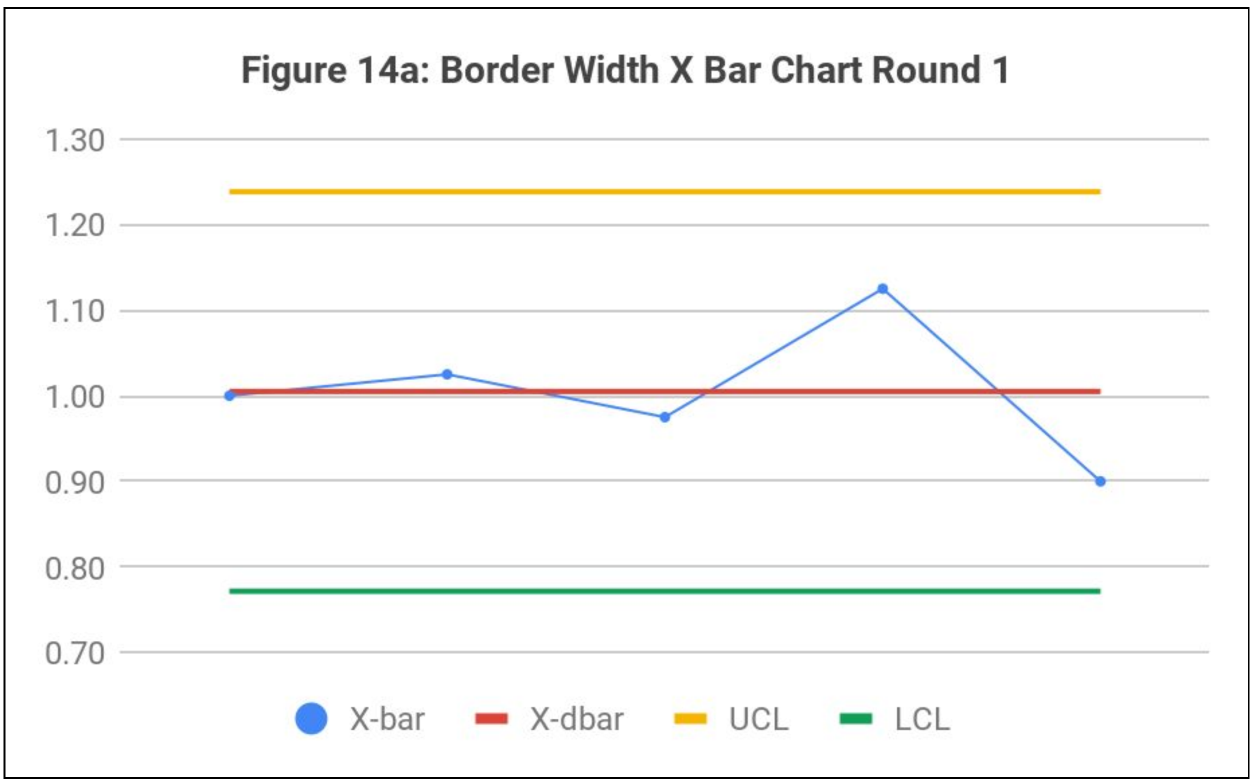


Figure 14a: Border Width X Bar Chart Round 1
1.30
1.20
1.10
1.00
0.90
0.80
0.70
X-bar
X-dbar
UCL
LCL

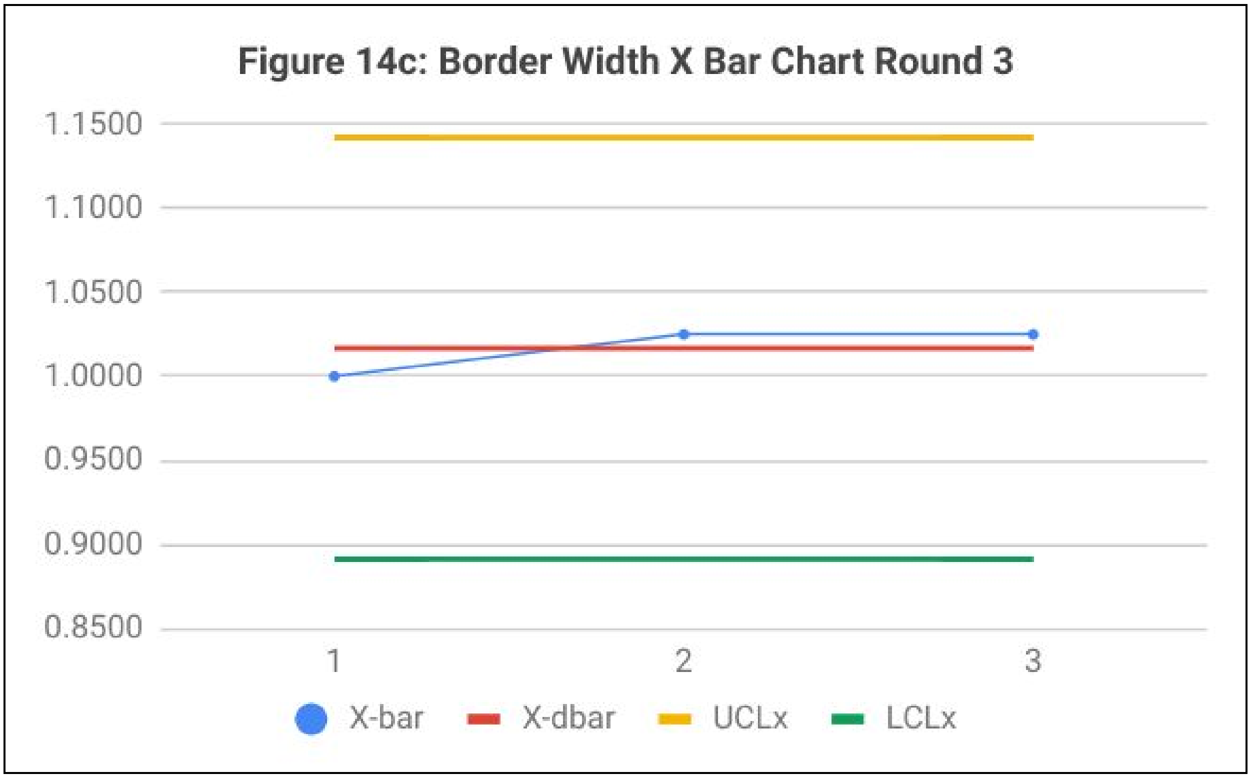


Figure 14c: Border Width X Bar Chart Round 3
1.1500
1.1000
1.0500
1.0000
0.9500
0.9000
0.8500
1
2
3
X-bar
X-dbar
UCLx
LCLx

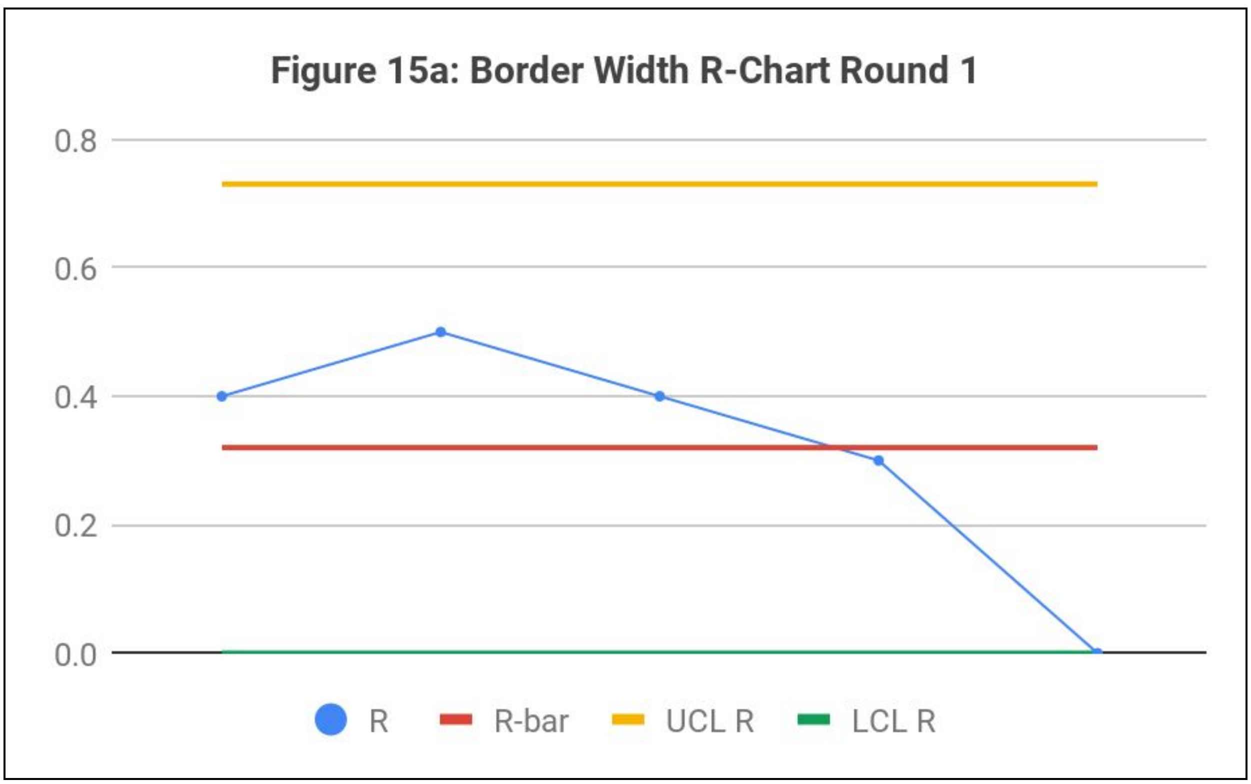


Figure 15a: Border Width R-Chart Round 1
0.8
0.6
0.4
0.2
0.0
R
R-bar
UCL R
LCL R

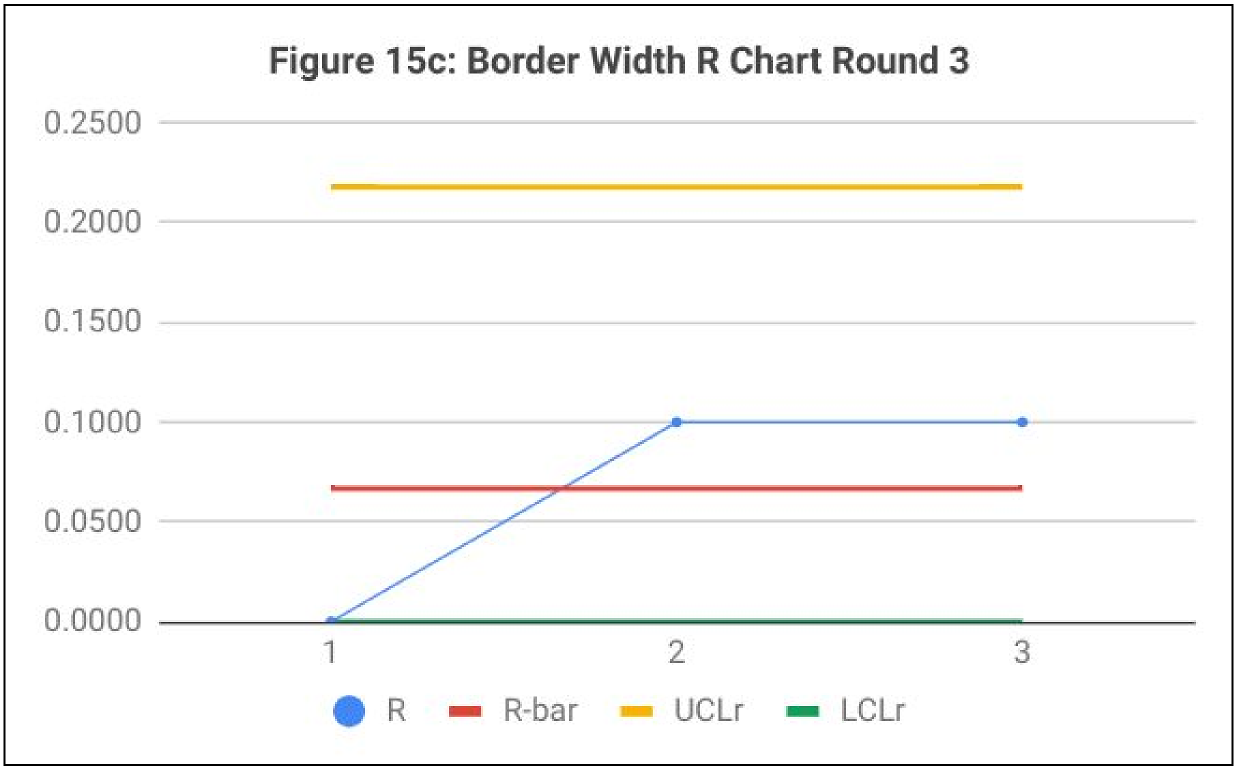


Figure 15c: Border Width R Chart Round 3
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
1
2
3
R
R-bar
UCLr
LCLr

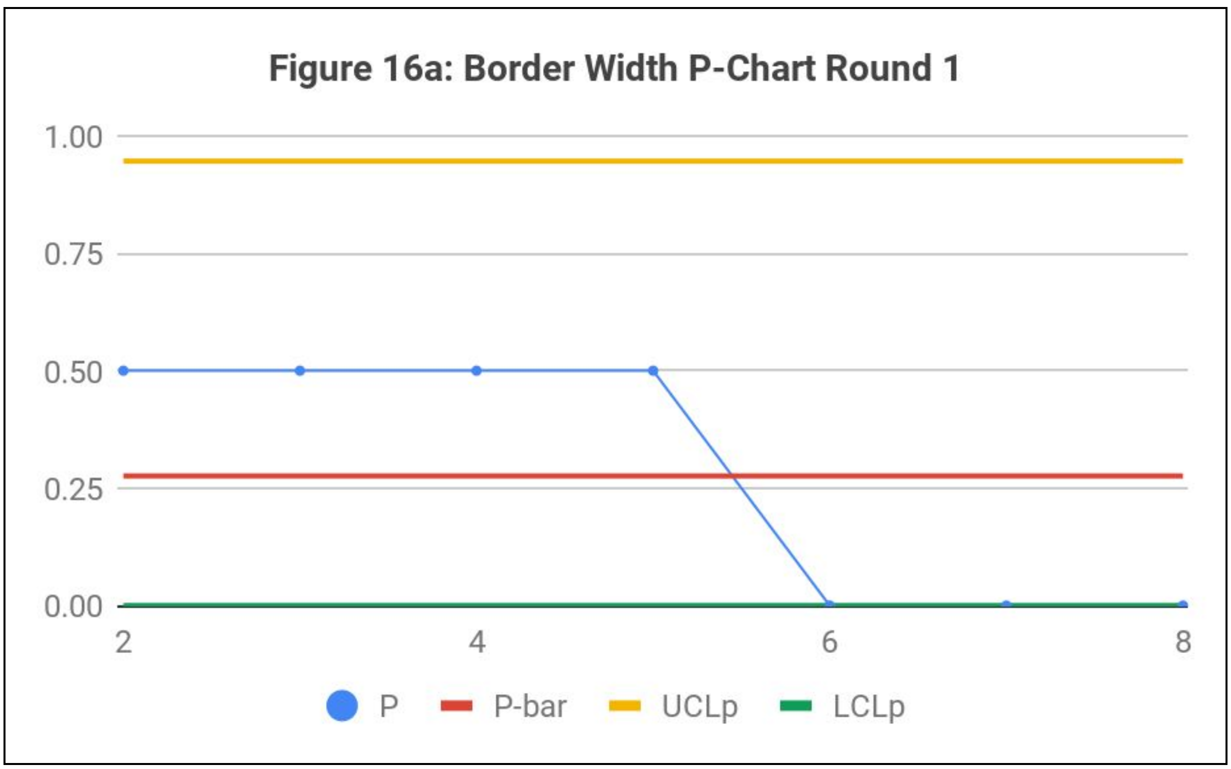


Figure 16a: Border Width P-Chart Round 1
1.00
0.75
0.50
0.25
0.00
2
4
6
8
P
P-bar
UCLp
LCLp

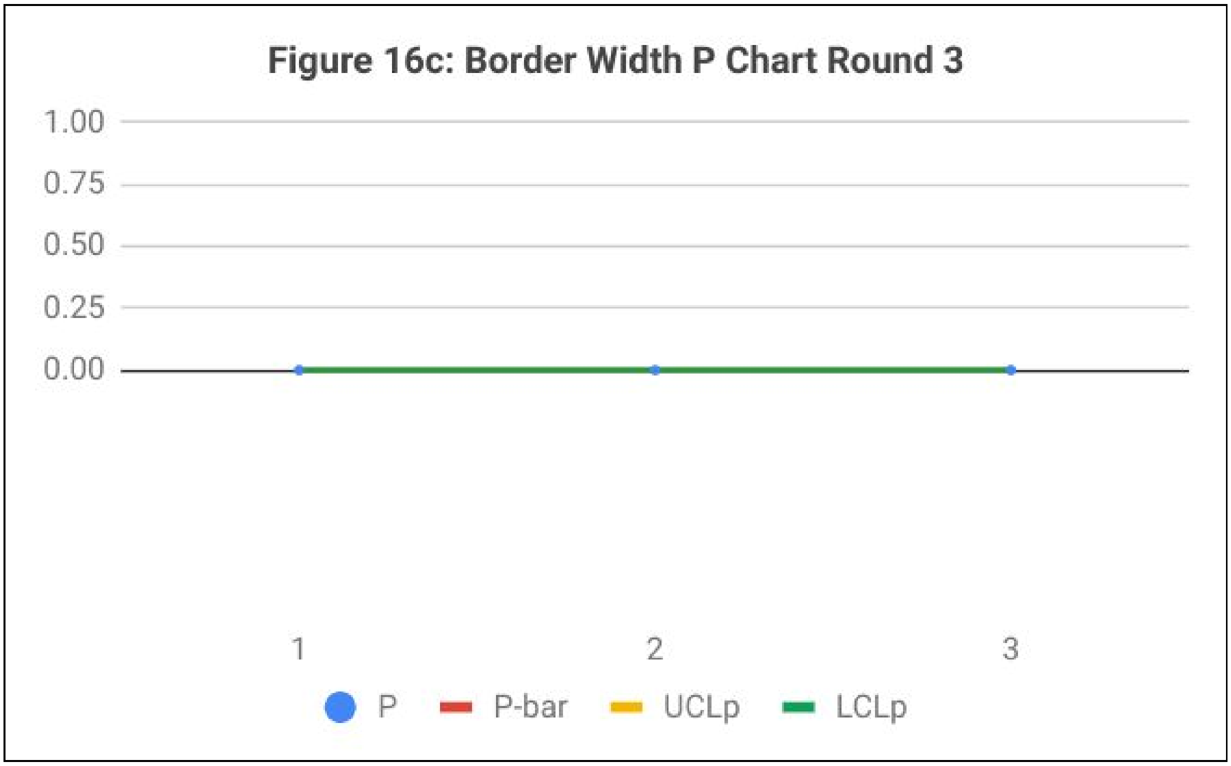
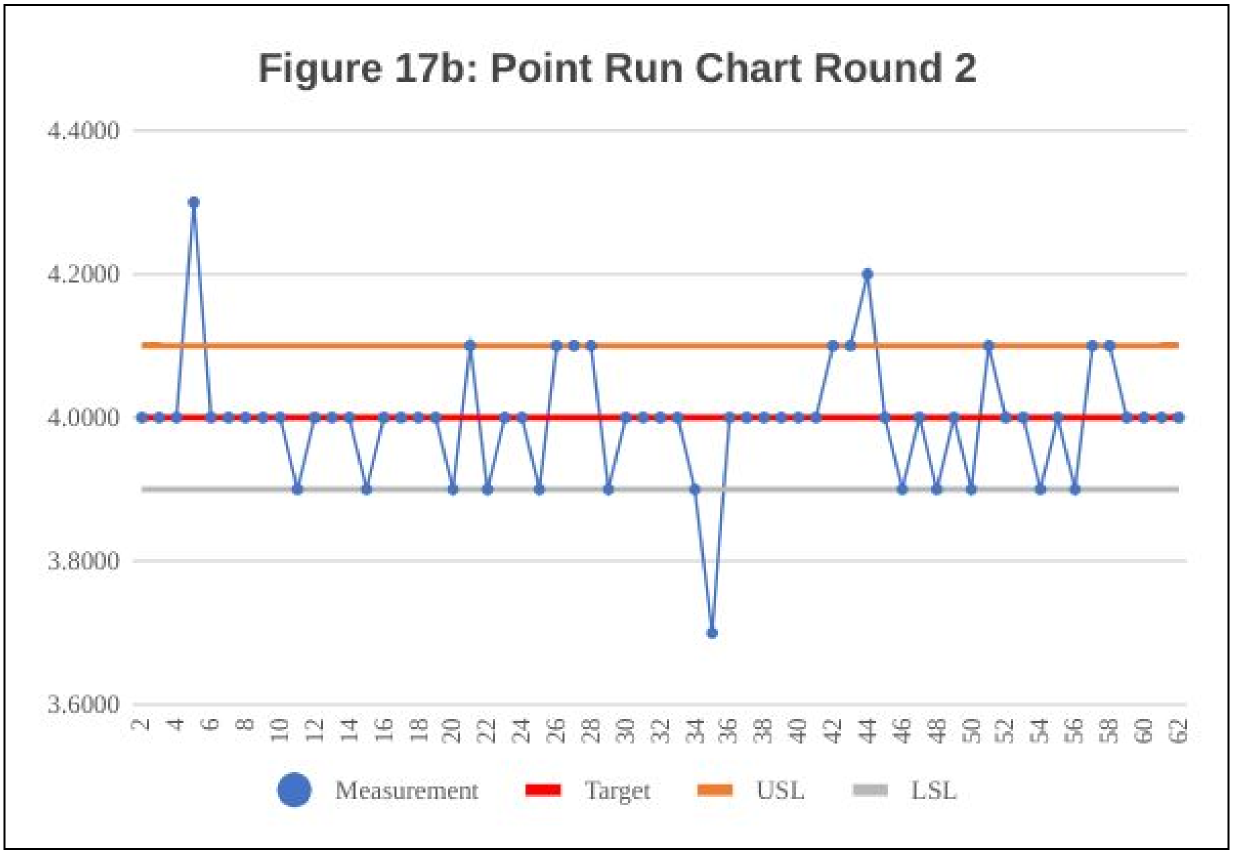


Figure 16c: Border Width P Chart Round 3
1.00
0.75
0.50
0.25
0.00
1
2
3
P
P-bar
UCLp
LCLp

Section 7: Assembly - Point - Run Charts and Control Charts

Summary	We see very similar patterns between Round 2 and Round 3 for this metric, but with slightly better quality (at least with one fewer defects).
Recommendation	Defects within this metric are closely related to cutting accuracy and center pin placement precision. Defects in one of those other metrics frequently resulted in corners being out-of-square, and thus failing the measurement test by QC. Therefore the recommendation is to focus on quality in these other areas, and advising the cutter to try to maintain the 90 degree corners.



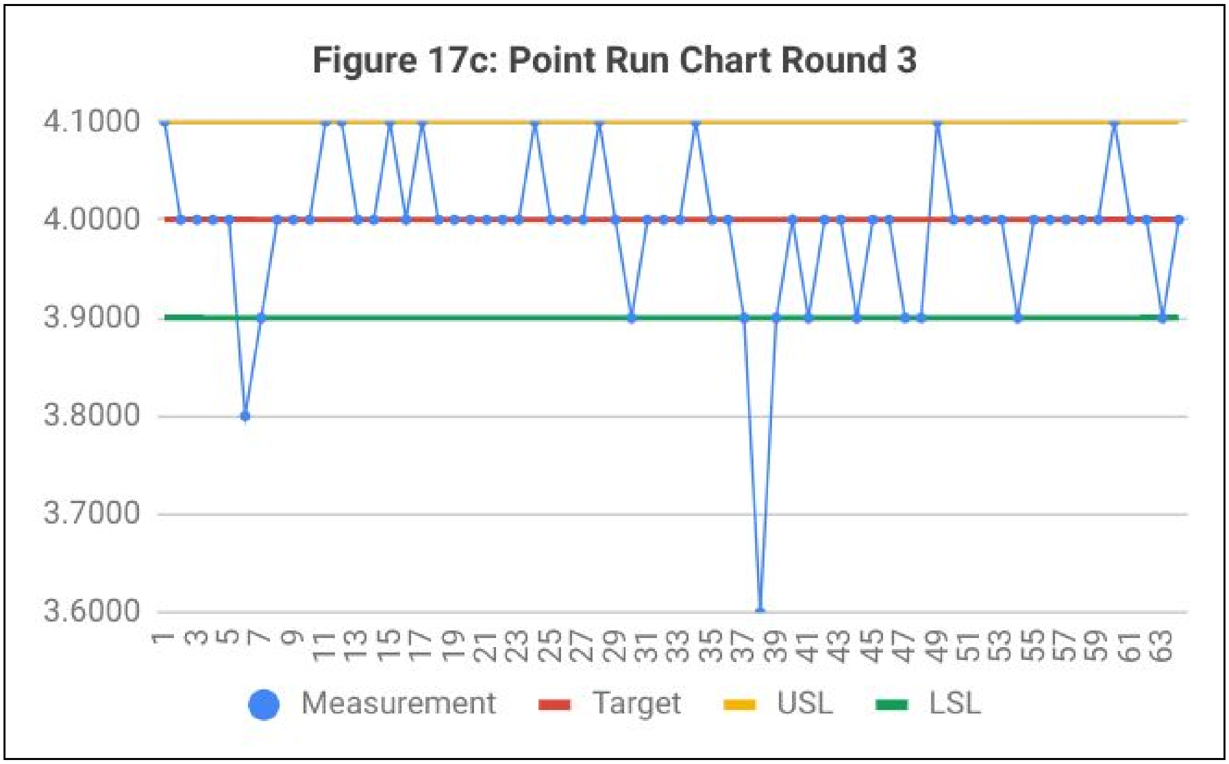


Figure 17c: Point Run Chart Round 3
4.1000
4.0000
3.9000
3.8000
3.7000
3.6000
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63
Measurement
Target
USL
LSL

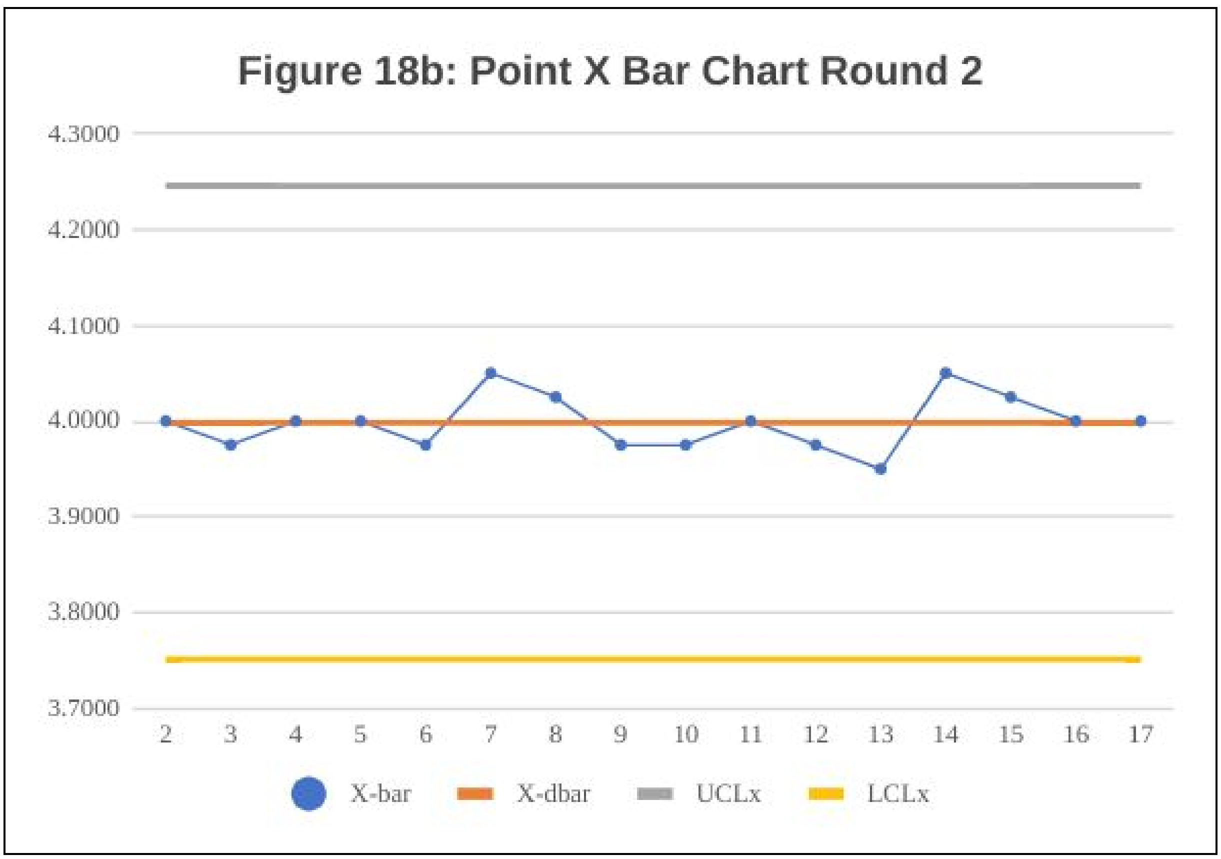


Figure 18b: Point X Bar Chart Round 2
4.3000
4.2000
4.1000
4.0000
3.9000
3.8000
3.7000
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17
X-bar
X-dbar
UCLx
LCLx

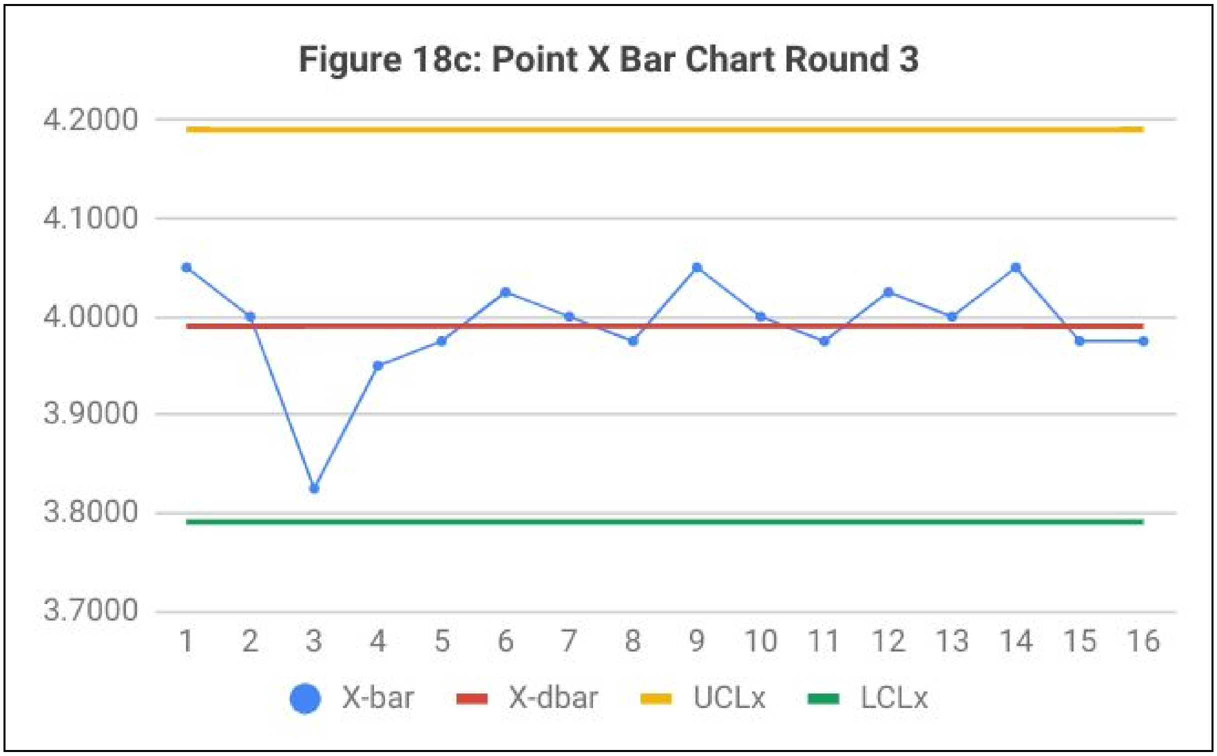


Figure 18c: Point X Bar Chart Round 3
4.2000
4.1000
4.0000
3.9000
3.8000
3.7000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
X-bar
X-dbar
UCLx
LCLx

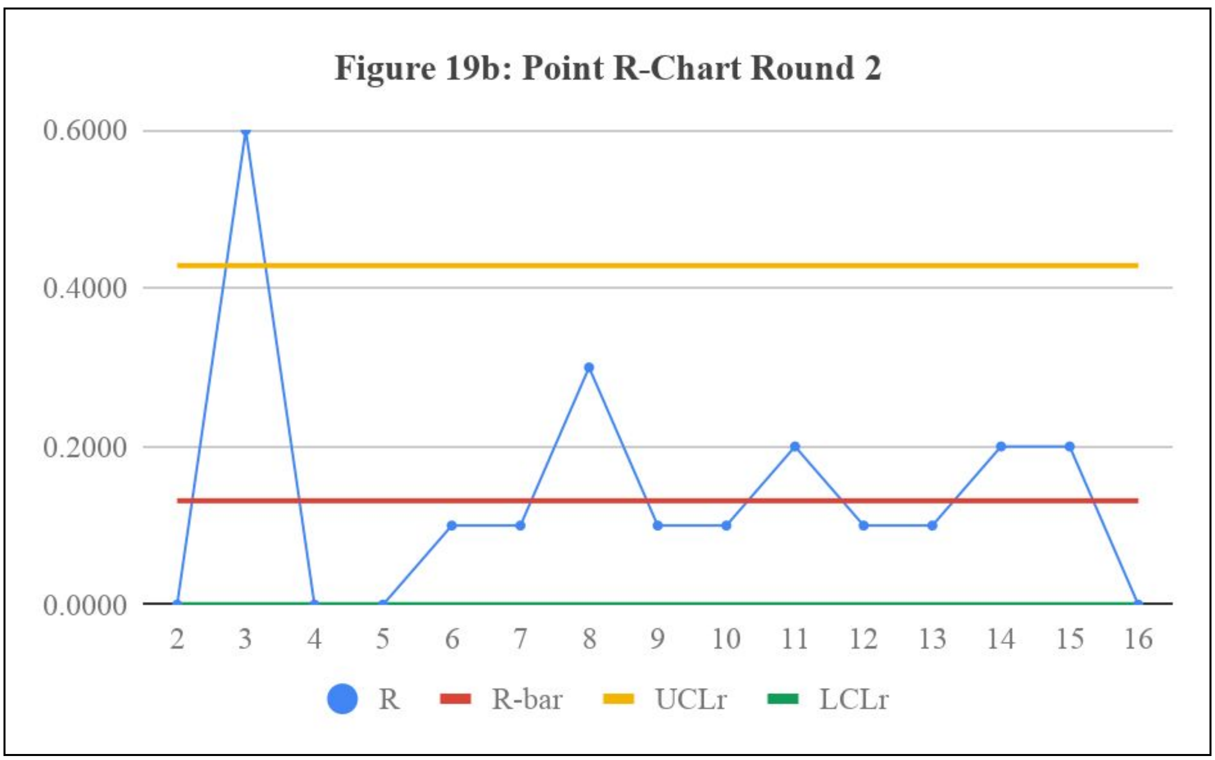


Figure 19b: Point R-Chart Round 2
0.6000
0.4000
0.2000
0.0000
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
R
R-bar
UCLr
LCLr

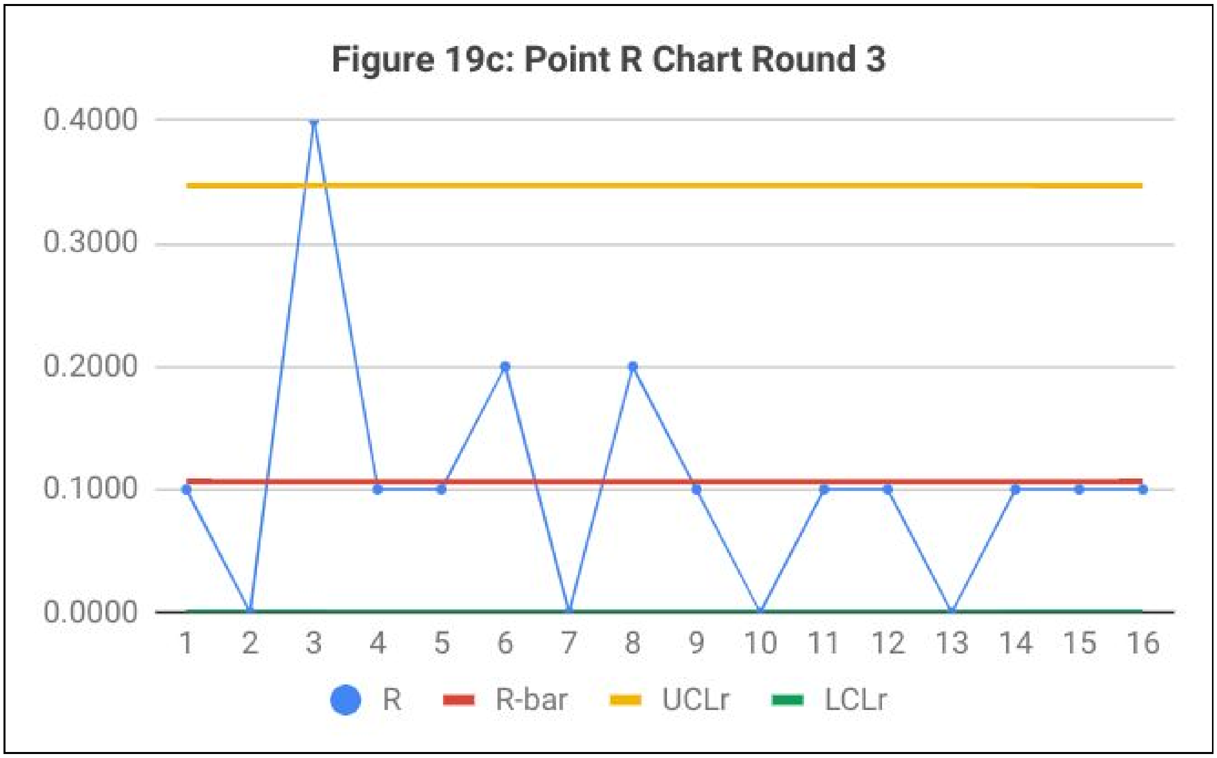


Figure 19c: Point R Chart Round 3
0.4000
0.3000
0.2000
0.1000
0.0000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
R
R-bar
UCLr
LCLr

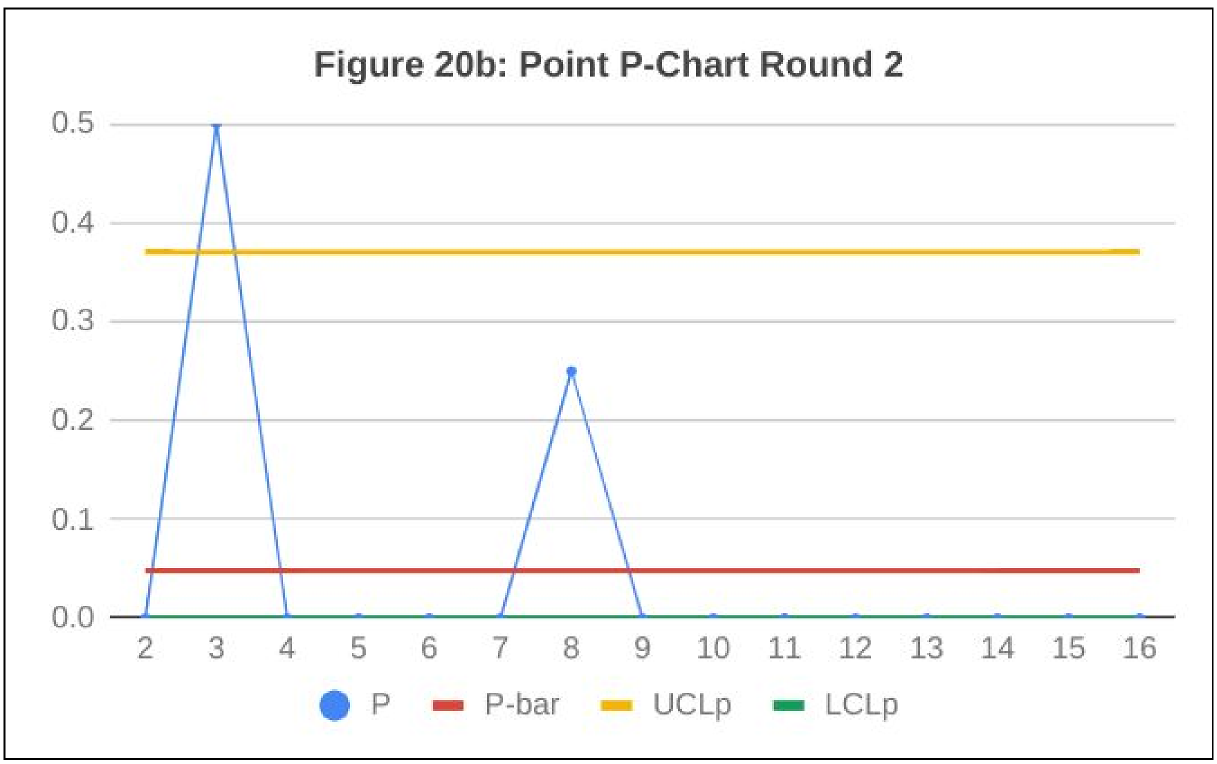


Figure 20b: Point P-Chart Round 2
0.5
0.4
0.3
0.2
0.1
0.0
2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
P
P-bar
UCLp
LCLp

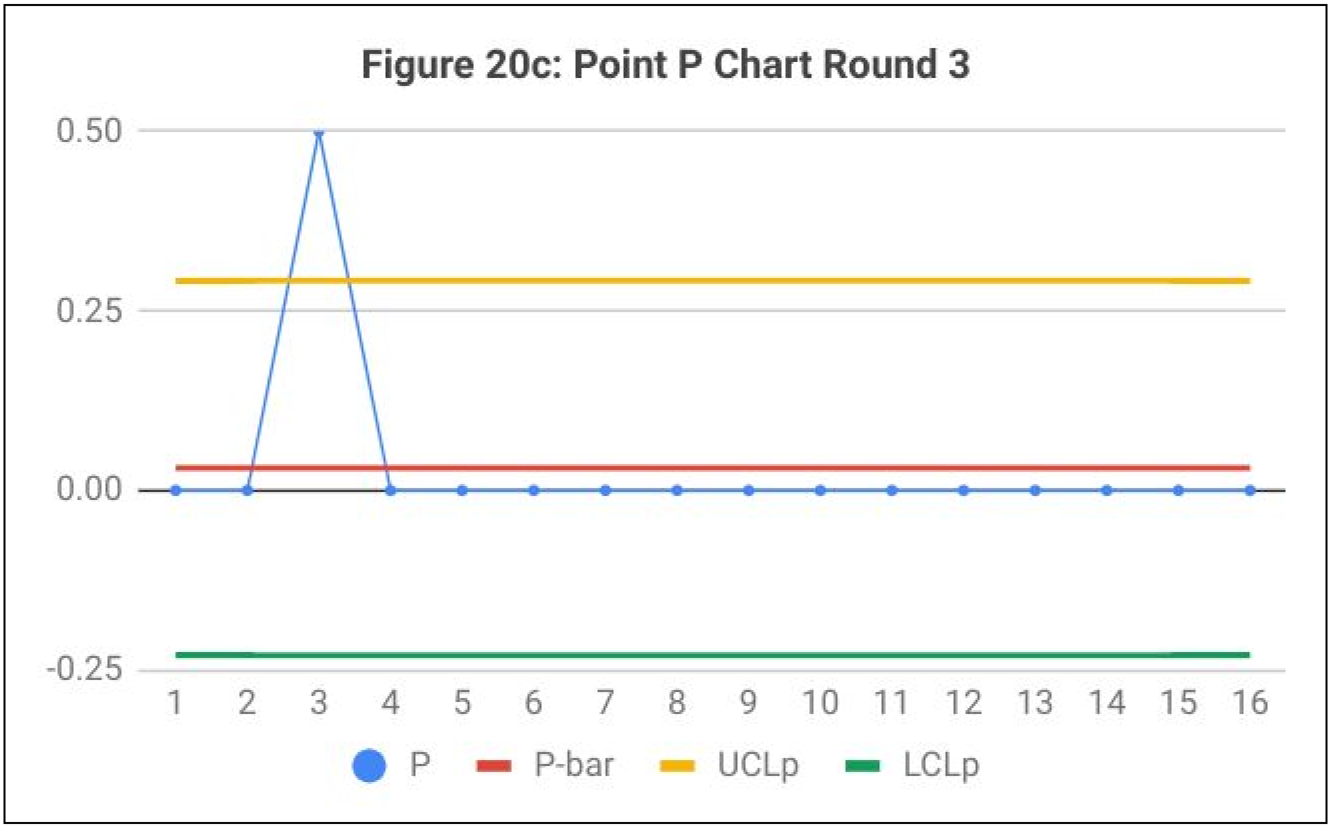
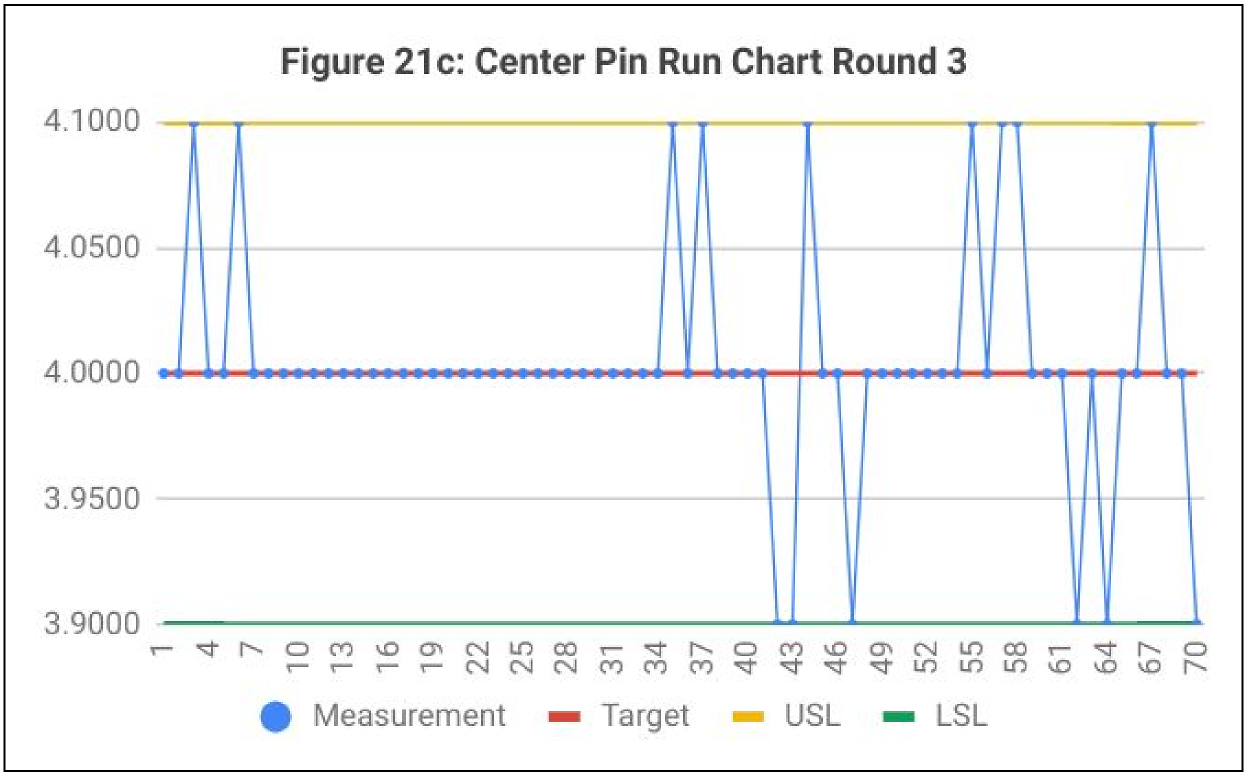


Figure 20c: Point P Chart Round 3
0.50
0.25
0.00
-0.25
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
P
P-bar
UCLp
LCLp

Section 8: Assembly - Center Pin - Run Charts and Control Charts

Summary	We only have this metric for Round 3, but it is useful in explaining the cause of the point defects above. The placement of the center pin can cause one or more points of the inner square to deviate significantly from the specifications.
Recommendation	A method of finding the center for both the inner and outer squares was developed by folding the papers. However, when switching from an SS series product to an SD series, sometimes the papers were folded incorrectly and thus confused the assembler of where to place the center pin. Therefore this process would also benefit from better visual cues regarding which product is being assembled at the time.



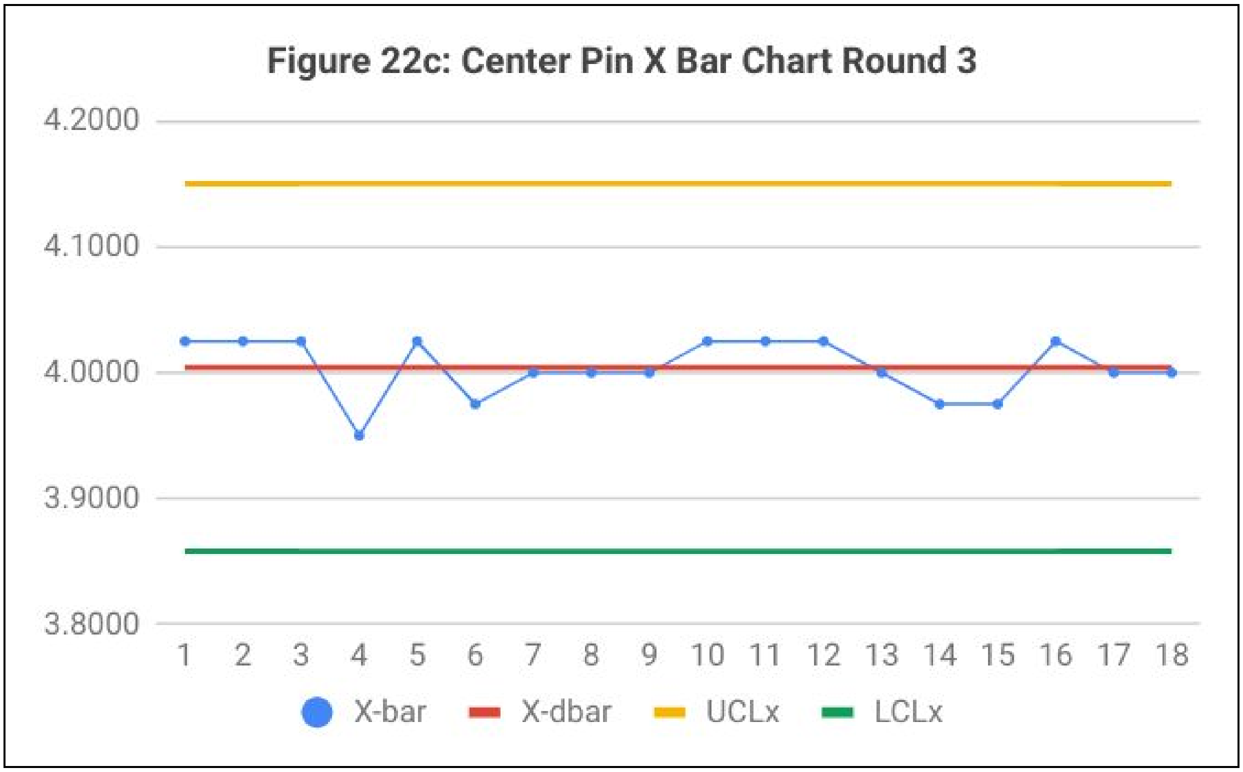


Figure 22c: Center Pin X Bar Chart Round 3
4.2000
4.1000
4.0000
3.9000
3.8000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
X-bar
X-dbar
UCLx
LCLx

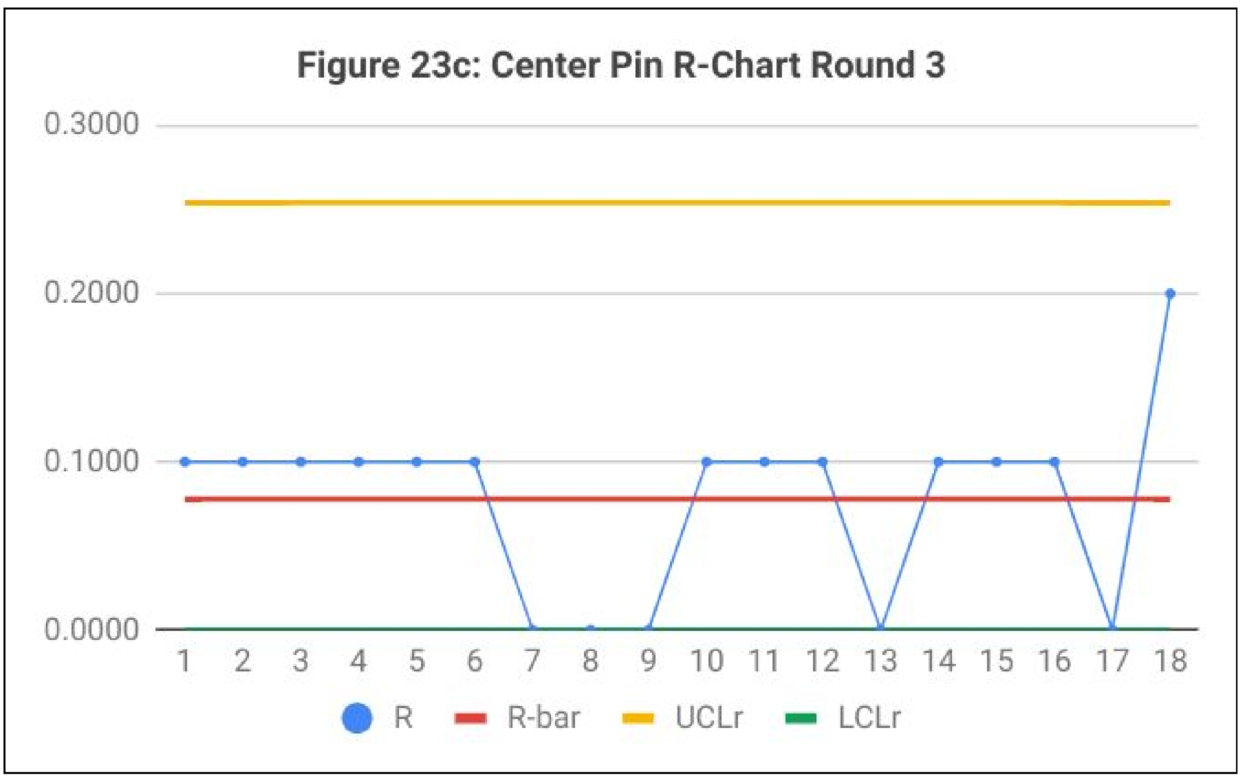


Figure 23c: Center Pin R-Chart Round 3
0.3000
0.2000
0.1000
0.0000
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
R
R-bar
UCLr
LCLr

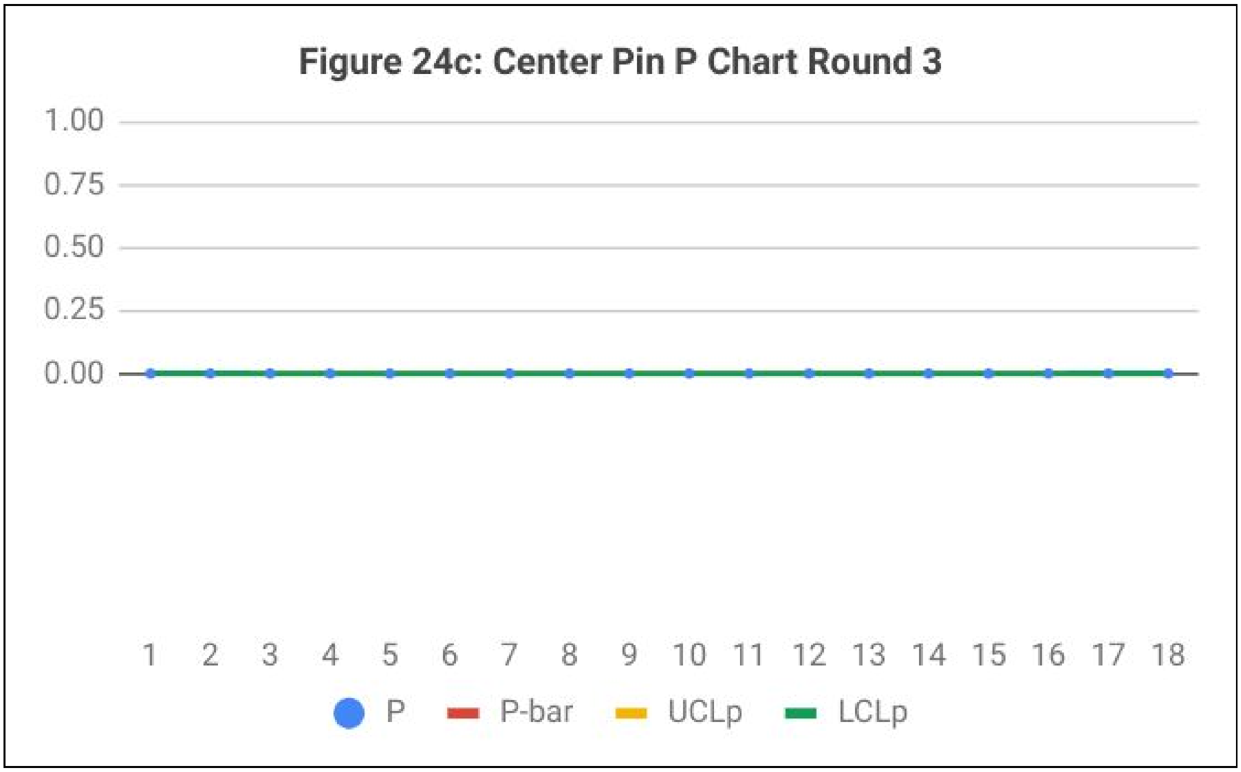


Figure 24c: Center Pin P Chart Round 3
1.00
0.75
0.50
0.25
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18
P
P-bar
UCLp
LCLp

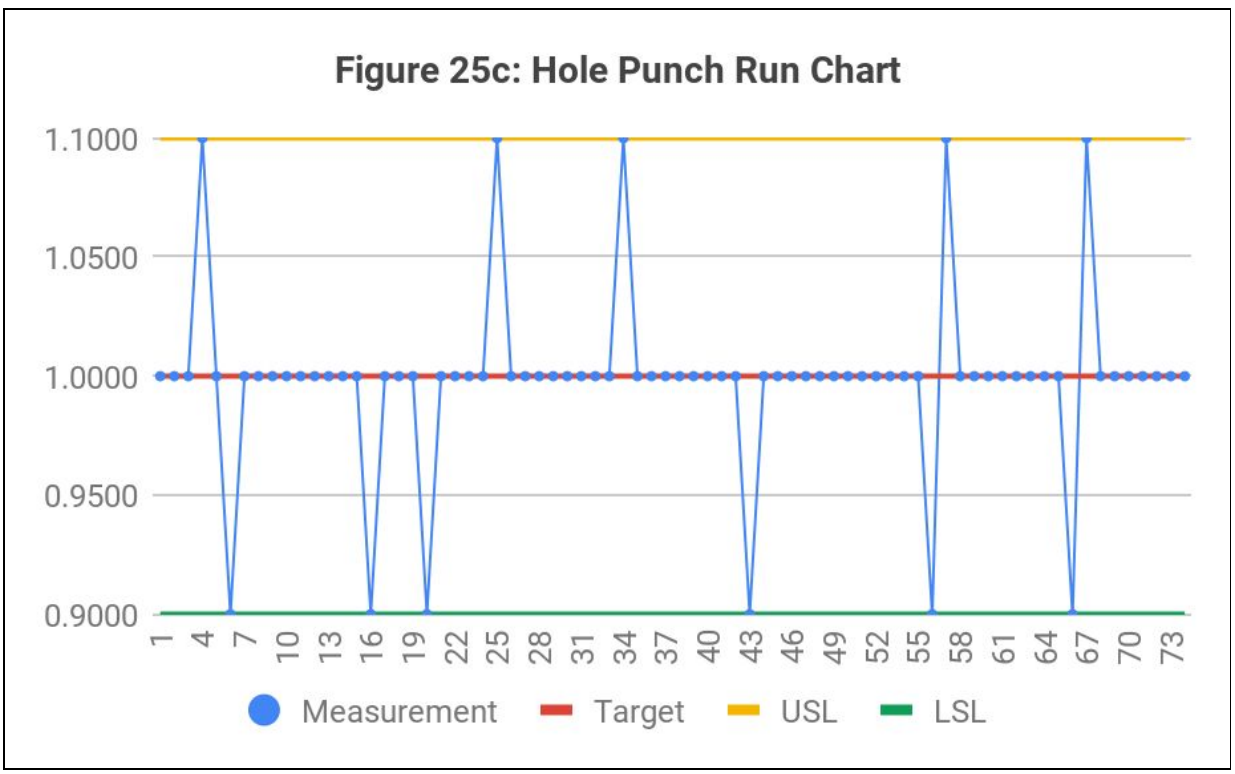


Figure 25c: Hole Punch Run Chart
1.1000
1.0500
1.0000
0.9500
0.9000
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64 67 70 73
Measurement
Target
USL
LSL

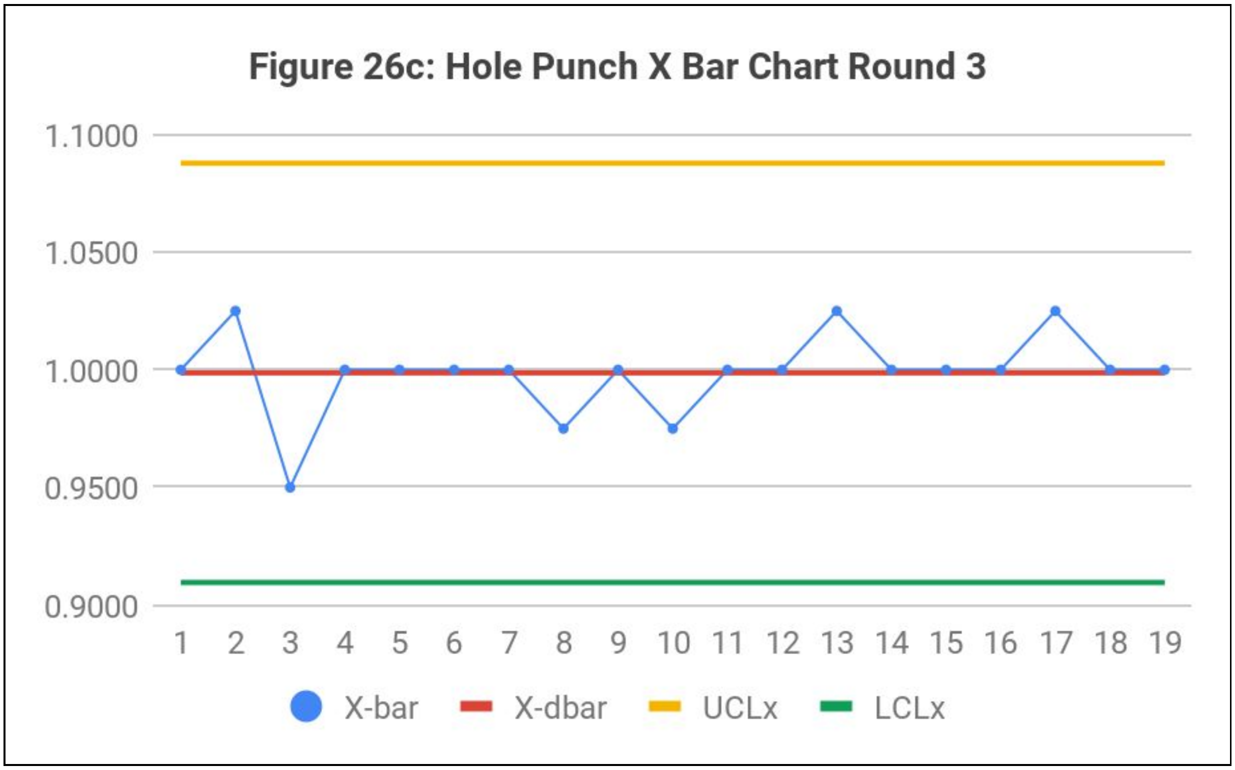


Figure 26c: Hole Punch X Bar Chart Round 3
1.1000
1.0500
1.0000
0.9500
0.9000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
X-bar
X-dbar
UCLx
LCLx

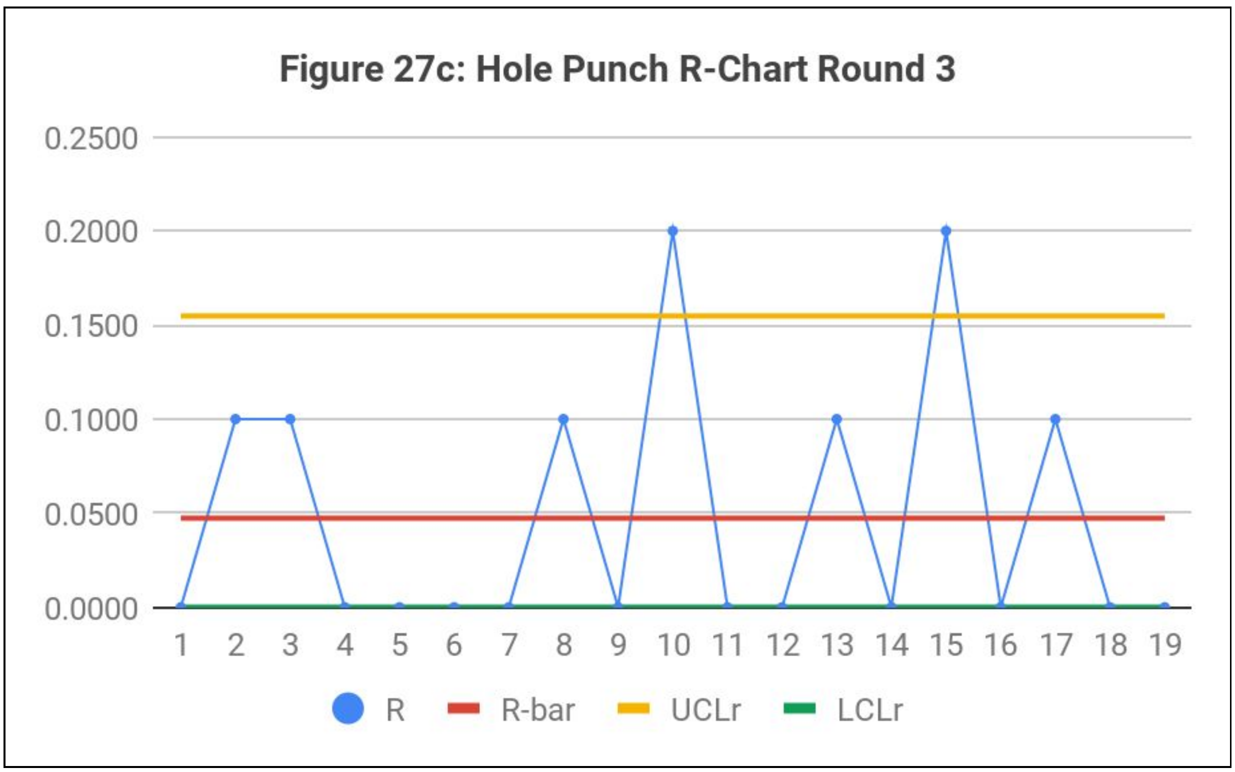
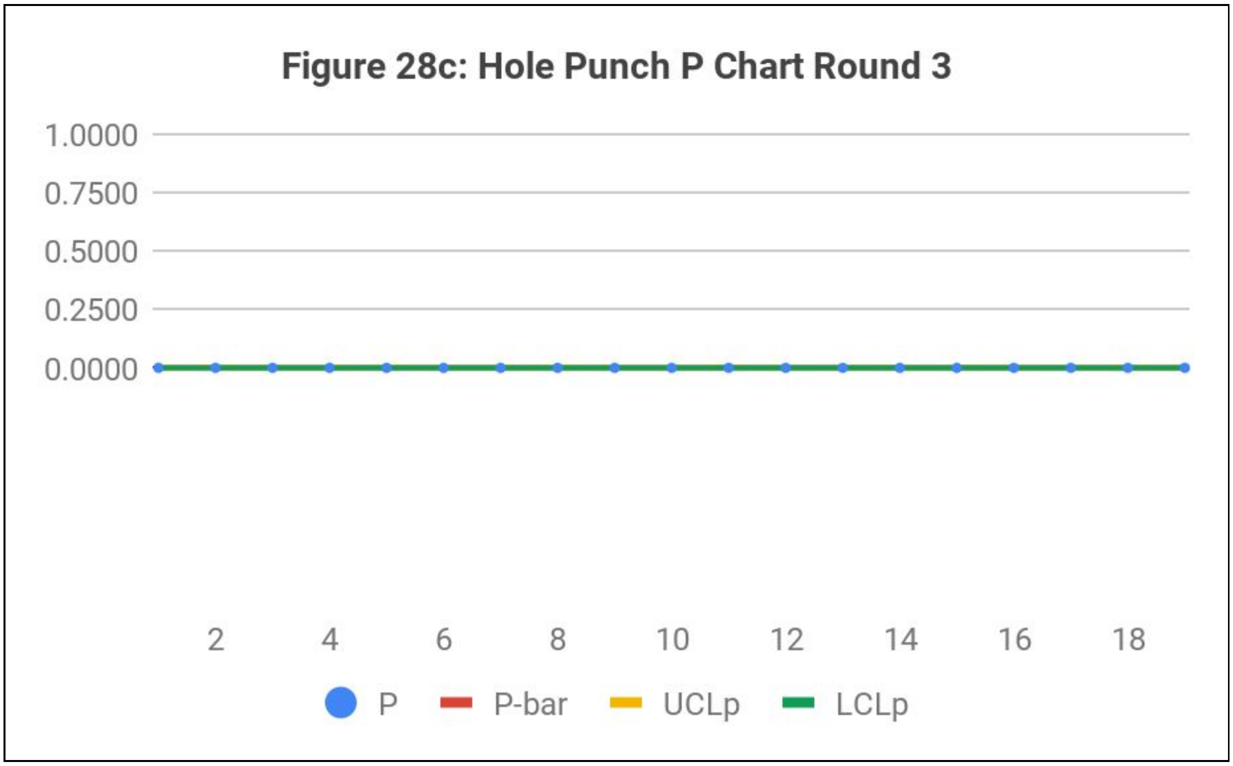
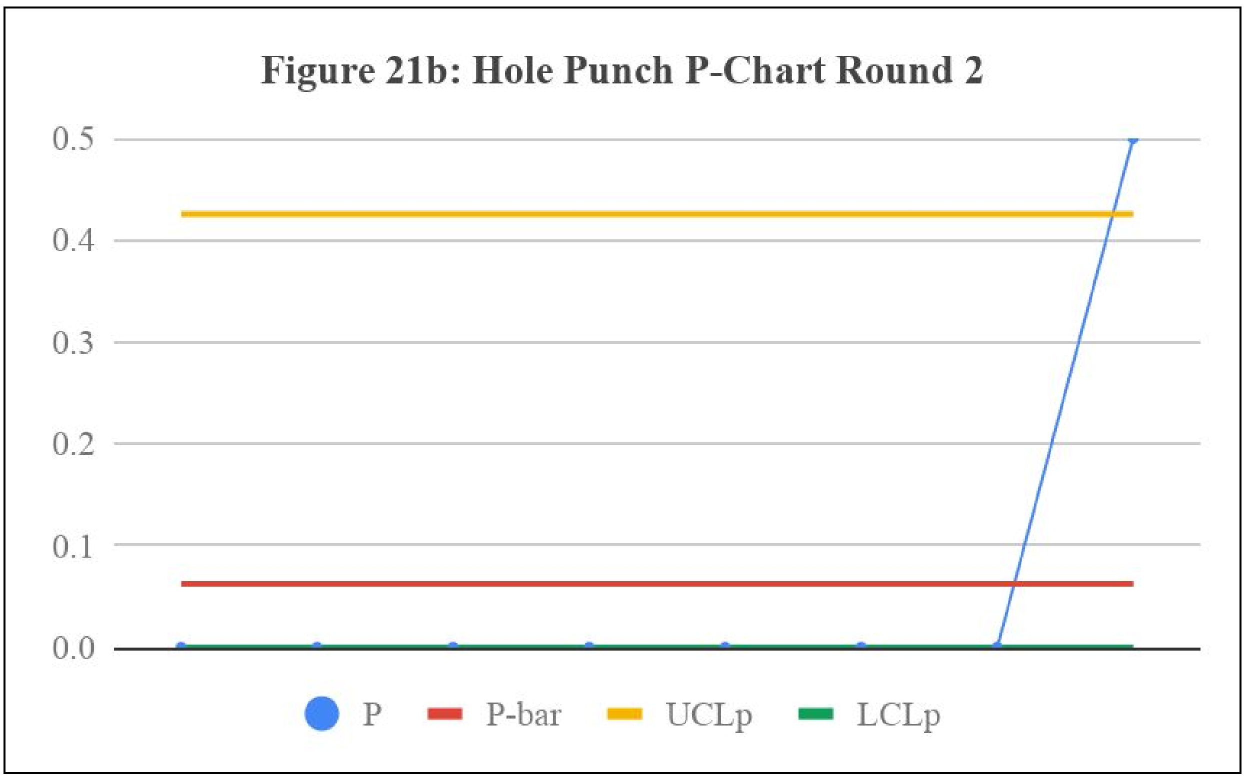


Figure 27c: Hole Punch R-Chart Round 3
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
R
R-bar
UCLr
LCLr





* Note: No Hole Punch data provided for Round 1

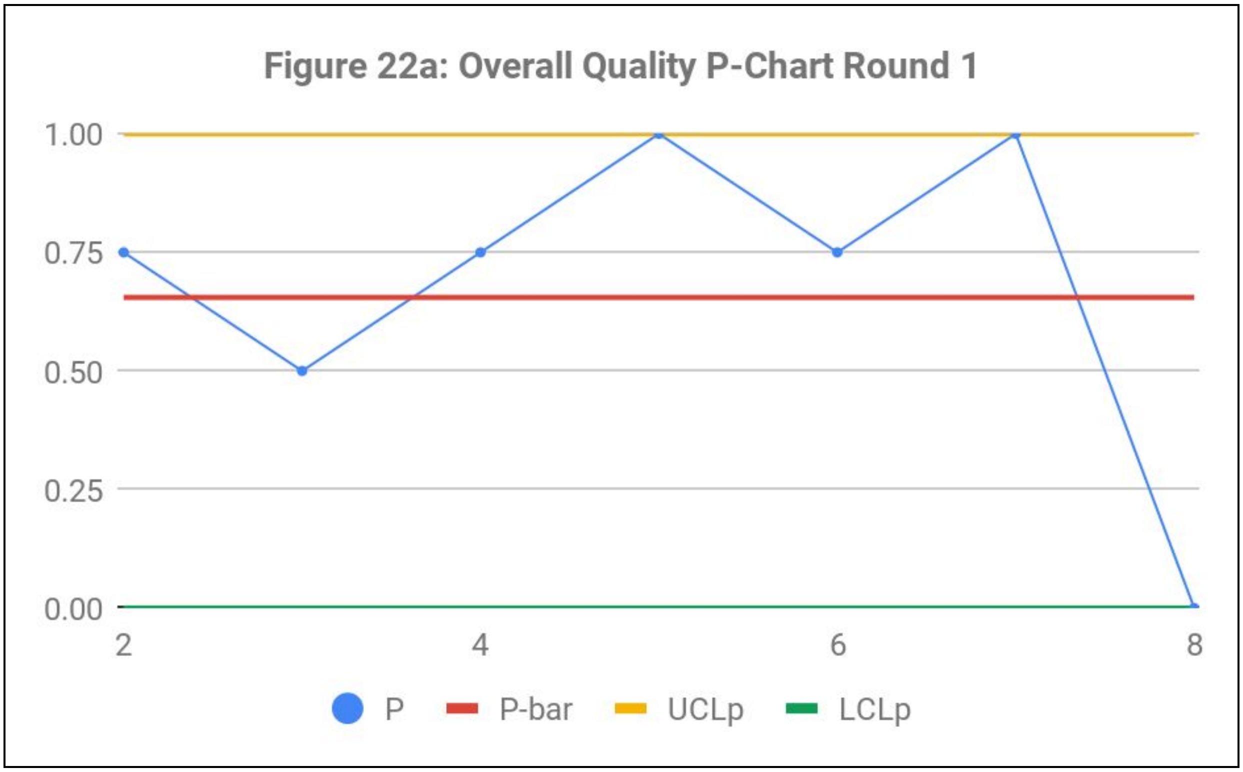


Figure 22a: Overall Quality P-Chart Round 1
1.00
0.75
0.50
0.25
0.00
2
4
6
8
P
P-bar
UCLp
LCLp

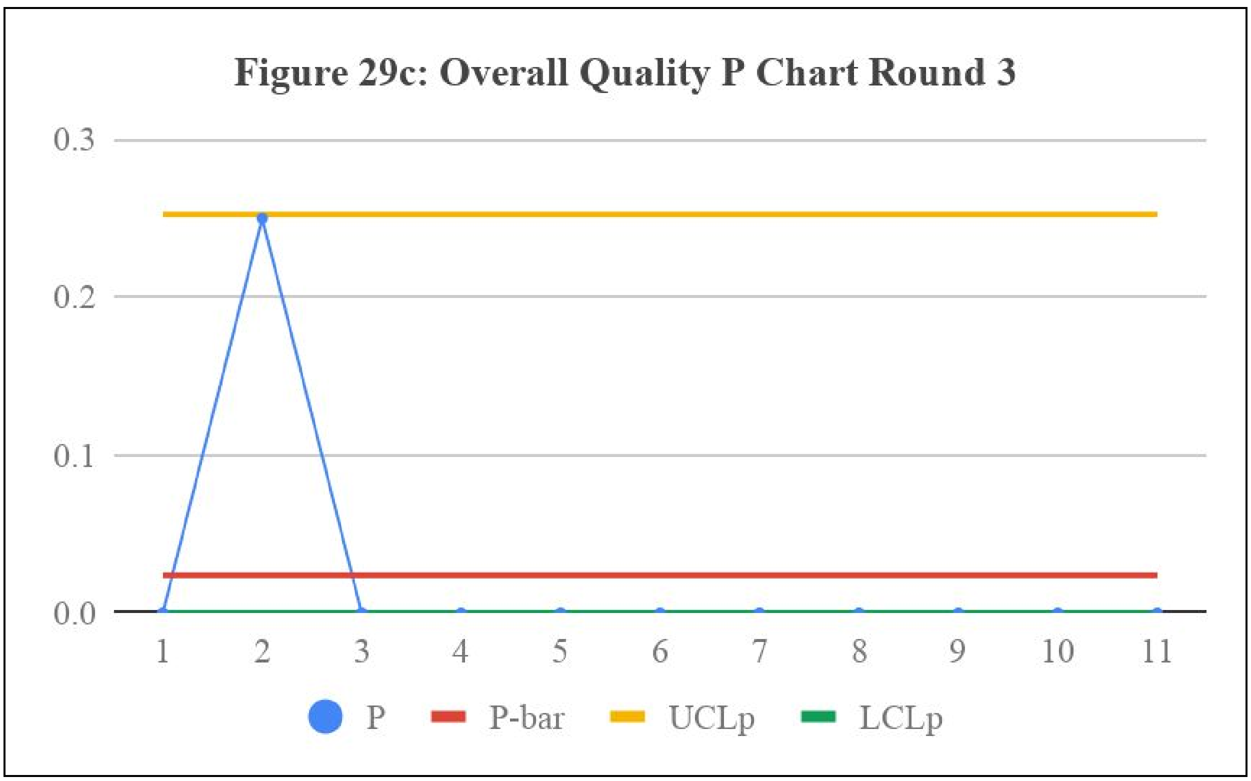


Figure 29c: Overall Quality P Chart Round 3
0.3
0.2
0.1
0.0
1
2
3
4
5
6
7
8
9
10
11
P
P-bar
UCLp
LCLp

Quality Report Round 3 GSCM 469

Whoever was in charge of revenue data hasn't shared it with the rest of the team. These calculations thus are left over from Round 2 as a placeholder. If still highlighted, then I wasn't able to get the information before the assignment was due.

Revenue

Product	Number produced	unit price	subtotal
ss-1	6	$10.00	$60.00
ss-2	3	$15.00	$45.00
sd-1	8	$12.00	$96.00
sd-4	10	$32.00	$320.00
		Total Revenue	$521.00

Costs

Supplies	**Quantity**	**Price**	**Subtotal**
White Sheets	6	$5.00	$30.00
Pink Sheets	3	$3.00	$9.00
Fasteners	30	$0.25	$7.50
Tools Leased			
Scissors	1	$3.00	$3.00
Rulers	3	$2.00	$6.00
Hole Punch	2	$4.00	$8.00
Jigs	1	$3.00	$3.00
Overtime	19	$10	$190
		Total Costs	**$256.50**

Profit

Total Revenue	$521.00
Total Costs	- $256.50
Total Profits	$264.50

Quality Report Round 3 GSCM 469

The confusion from the switching of roles also caused little or no reliable data to be produced to calculate. The below data is from Round 2 as a placeholder.

Takt Time EC

Total available time per game:

	Shift 1	Shift 2	Overtime 1	Overtime 2	Total
Total available time per game	10	10	10	10	40 minutes/per game

Each team has to be able to produce at least one pulse which is 4 SS-1, 3 SS-2, 6 SD-1, and 2 SD-4 by the end of every shift including overtime.

The total number of parts per game: 15 parts per shift, which is 30 parts per game.

As a result, Takt Time = 40/30 = 1.33 minutes per part.

Round 3 revenue

Product	Number produced	Unit price	Subtotal
ss-1	2	10	$20
ss-2	3	15	$45
sd-2	6	12	$72
sd-4	22	32	$704
		Total revenue	**$841**

Costs

Supplies	Quantity	Unit costs	Subtotal
white sheets	8	$3	$24
Pink sheets	4	$5	$20
Fasteners	47	$0.25	$11.75
Tools leased	Quantity	Unit costs	

scissors	2	$3	$6
rulers	3	$2	$6
hole punch	1	$4	$4
jigs	1	$3	$3
# person Labor costs (Reg time)	13	$5	$75
# person Labor costs (overtime)	13	$10	$150
	Total costs		$269.75

We have 13 people in total in each factory and each one of them performs one regular shift and one overtime. That is why I have 13 in the number of person labor costs in regular time and in overtime.

Profit

Total revenue: $841

Total Costs -$269.75

Profit: $571.25