Almen Strip Comparison

by Jack Champaigne

An investigation was conducted to compare two different sources of Almen strips. A direct pressure air blast machine with a single nozzle aimed at a rotating table with 12 stations for Almen strips was used. The machine parameters were set to achieve a nominal intensity of 8A. Fifty strips of each type were measured and the data is shown in the histogram of Figure 1.

The histograms show Lower Spec Limit (LSL) at 7 and Upper Spec Limit (USL) at 9. Data in group B fall within the LSL and USL, noting the -3sp and +3sp (3 times sigma standard deviation). The Cp and Cpk were 2.09 and 2.01, respectively. Data in group C are shifted from the target and do not fall within the LSL. The Cp and Cpk were .91 and .44, respectively. This would result in an estimated out of tolerance of 9.6%.

Since the peening samples were conducted simultaneously, i.e. 4 each of groups A, B and Group C during one run, the differences in performance are to be attributed to Almen strip performance, not peening machine process parameters. (Results of group A are not reported here.)

The next step in the investigation was to plot the histograms of thickness, pre-peen flatness and strip hardness, shown in figures 2, 3 and 4. These attributes are deemed to be the dominant influence of Almen strip performance.

The shift in mean thickness between the groups, C thicker than B by .00027", would contribute to lower arc heights for C. Earlier estimates of the influence of thickness assigned a value of -0.05A shift for a thickness shift of +.00030.

The pre-peen flatness values for Cp and Cpk were slightly better for group B than group C. The significance of this difference is not clear since the post peen arc height was calculated using the pre-peen flatness as an offset. (Final value = Final reading-Initial reading).

The difference in hardness, 0.7 Hrc lower hardness of group C, would contribute to lower arc heights for C. Earlier work done at G. E. indicates that the arc height would change by -0.07A for a hardness decrease of Hrc 0.7.

The expected arc height change of -0.12A was much less than actual arc height change. Of -0.56A. Although the shift in arc height of -0.56A may seem to be insignificant, the estimated 9.6% of out of tolerance should be of concern. The fact that the -3sp point is less than the LSL lower spec limit is also of direct concern. (Fig 1.) Additional testing is planned since the three common attributes (thickness, flatness, hardness) do not appear to be causing the process shift. Stress profiles, using both X-Ray diffraction and Barkhausen noise, will be generated and the condition of the surface will be considered. Treatments such as vibratory finish after heat setting may be found to be detrimental.

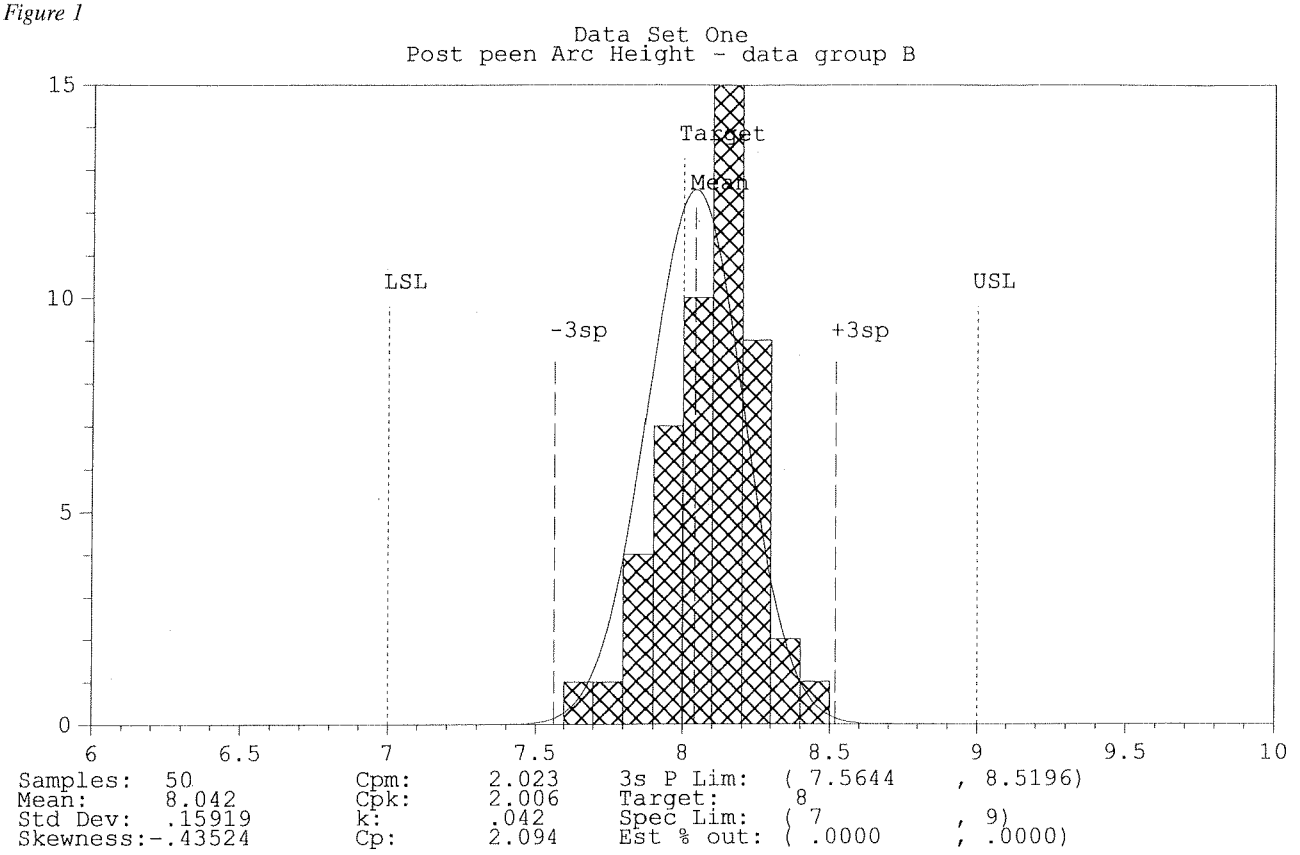
We may discover that the process will not tolerate any mechanical treatment after heat setting under pressure to draw the hardness back to the 44-50 HRc range. This would also preclude use of "final hardness" strip material that is straightened and sheared to length but not heat set under pressure.

	Group B	Group C	Difference	Expected Shift in Arc Height
Thickness	0.05078	0.05105	0.00027"	-0.05
Flatness	-0.000262	-0.000260	-0.000002"	N/A
Hardness	47.64	46.94	-0.70 HRc	-0.07
Arc Height	8.04A	7.48A	-0.56A	-0.12

Table 1

Graphs on pages 10 - 13

Figure 1


Data Set One
Post peen Arc Height - data group B
Target
Mean
LSL
USL
-3sp
+3sp
15
10
5
0
6
6.5
7
7.5
8
8.5
9
9.5
10
Samples: 50
Mean: 8.042
Std Dev: .15919
Skewness:-.43524
Cpm: 2.023
Cpk: 2.006
k: .042
Cp: 2.094
3s P Lim: (7.5644 , 8.5196)
Target: 8
Spec Lim: (7 , 9)
Est % out: (.0000 , .0000)

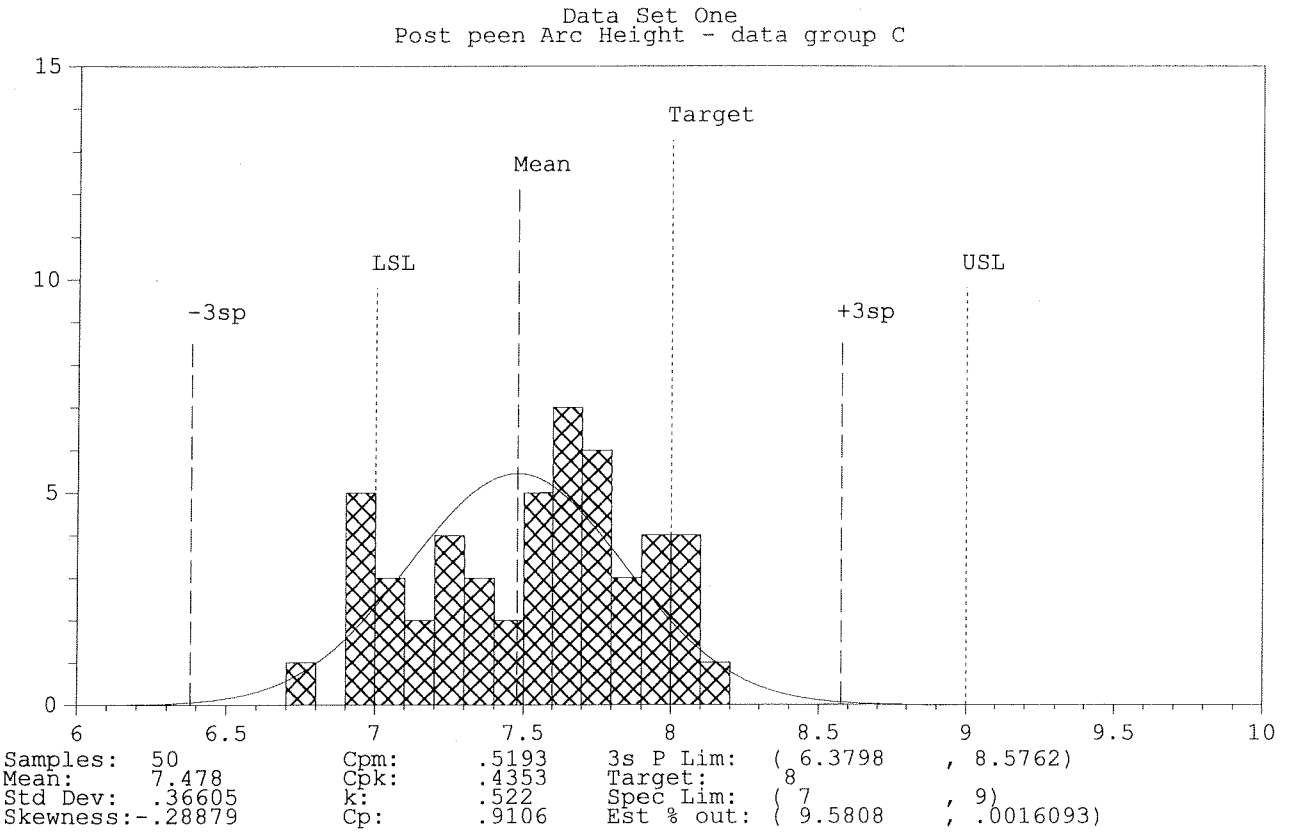
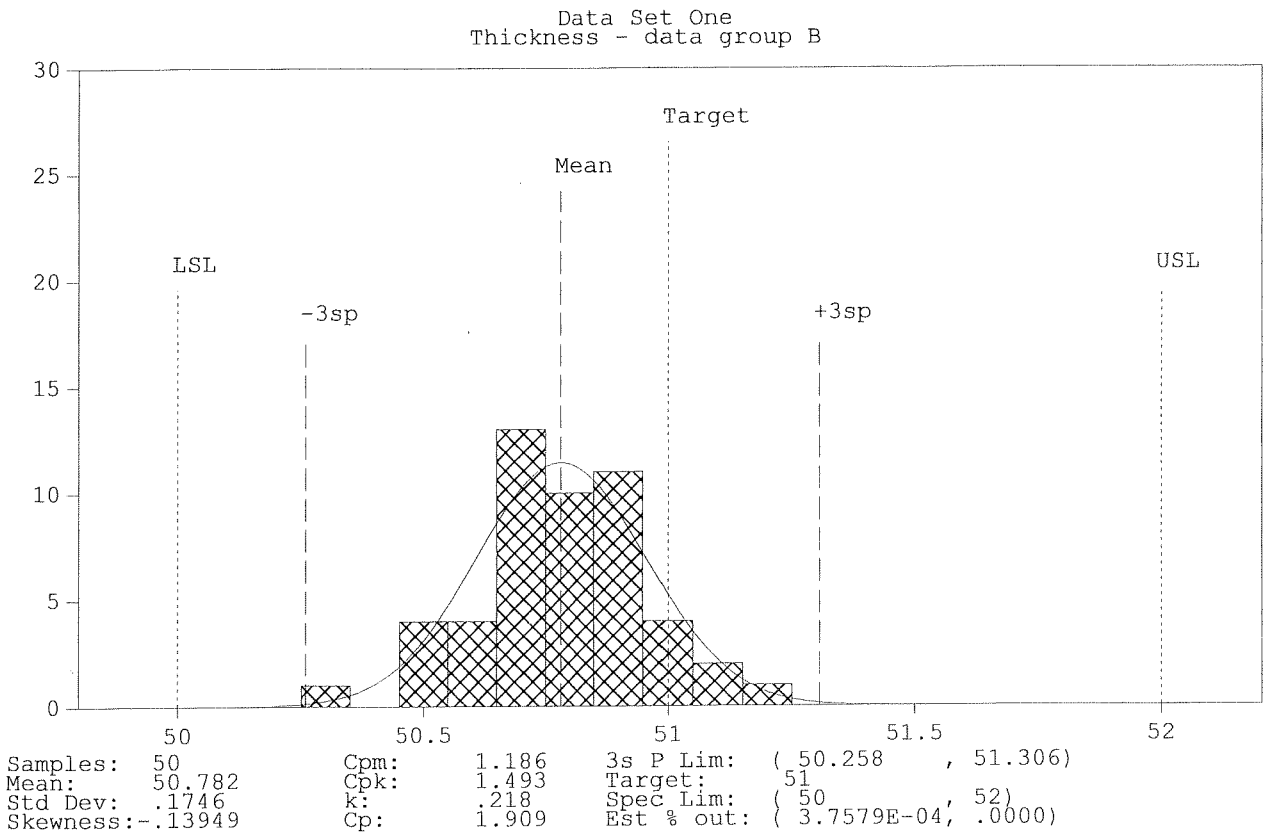
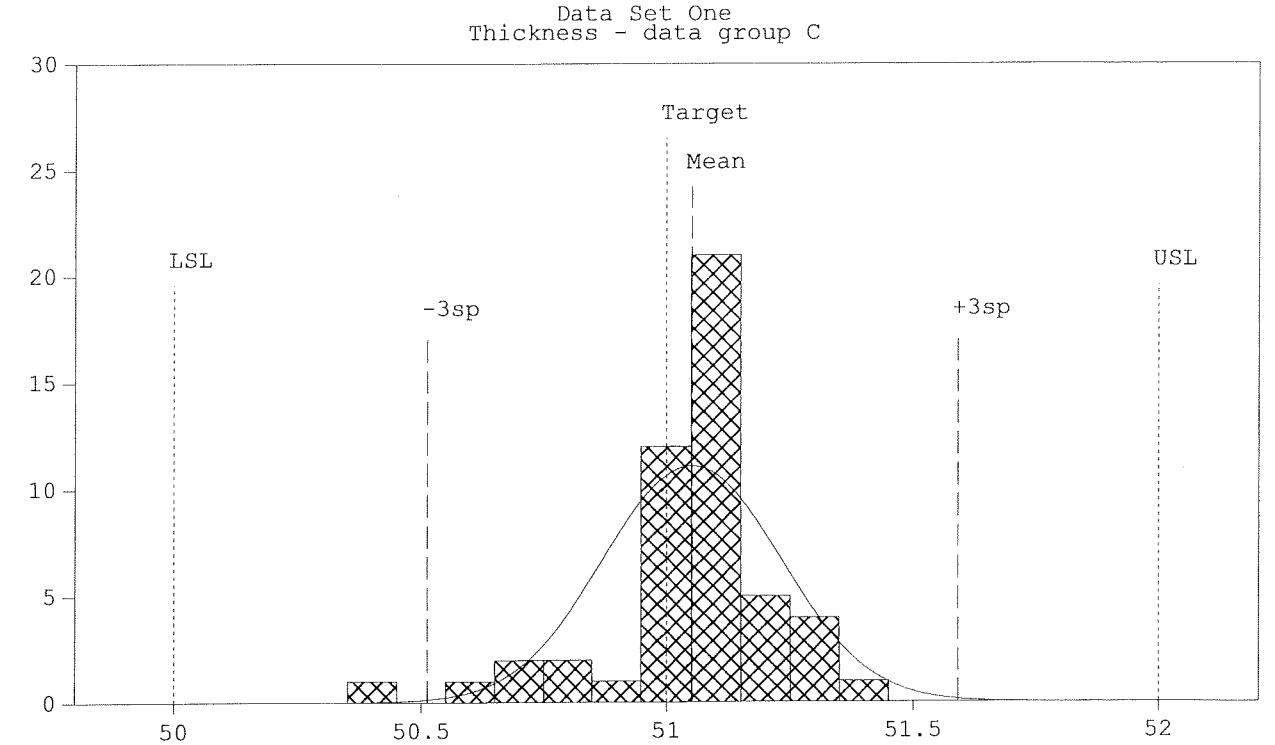

Data Set One
Post peen Arc Height - data group C
Target
Mean
LSL
USL
-3sp
+3sp
15
10
5
0
6
6.5
7
7.5
8
8.5
9
9.5
10
Samples: 50
Mean: 7.478
Std Dev: .36605
Skewness:-.28879
Cpm: .5193
Cpk: .4353
k: .522
Cp: .9106
3s P Lim: (6.3798 , 8.5762)
Target: 8
Spec Lim: (7 , 9)
Est % out: (9.5808 , .0016093)

Figure 2

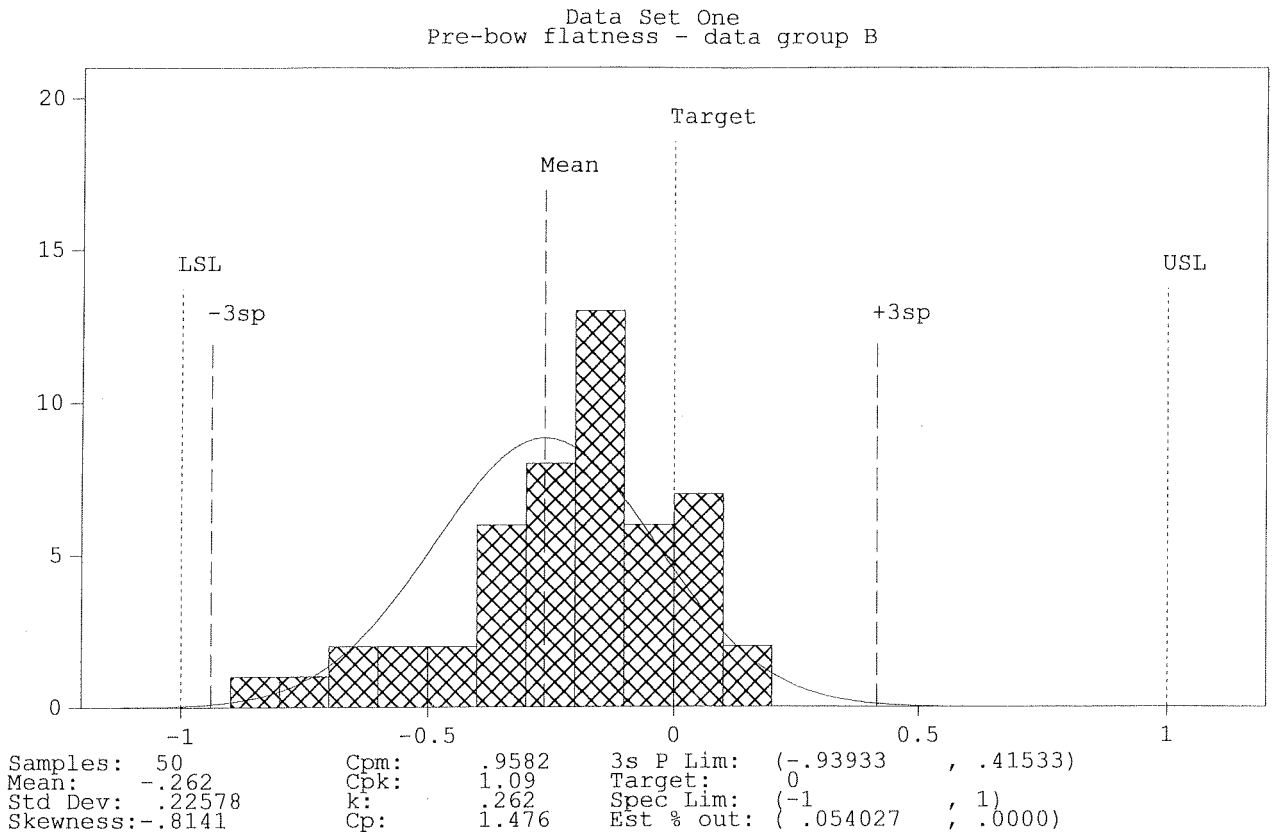


Samples:	50	Cpm:	1.186	3s P Lim:	(50.258 , 51.306)
Mean:	50.782	Cpk:	1.493	Target:	51
Std Dev:	.1746	k:	.218	Spec Lim:	(50 , 52)
Skewness:	-.13949	Cp:	1.909	Est % out:	(3.7579E-04, .0000)



Samples:	50	Cpm:	1.779	3s P Lim:	(50.512 , 51.592)
Mean:	51.052	Cpk:	1.757	Target:	51
Std Dev:	.17984	k:	.052	Spec Lim:	(50 , 52)
Skewness:	-1.3194	Cp:	1.853	Est % out:	(.0000 , .0000)

Figure 3


Data Set One
Pre-bow flatness - data group B
Target
Mean
LSL
-3sp
+3sp
USL
20
15
10
5
0
-1
-0.5
0
0.5
1
Samples: 50
Mean: -.262
Std Dev: .22578
Skewness:-.8141
Cpm: .9582
Cpk: 1.09
k: .262
Cp: 1.476
3s P Lim: (-.93933 , .41533)
Target: 0
Spec Lim: (-1 , 1)
Est % out: (.054027 , .0000)

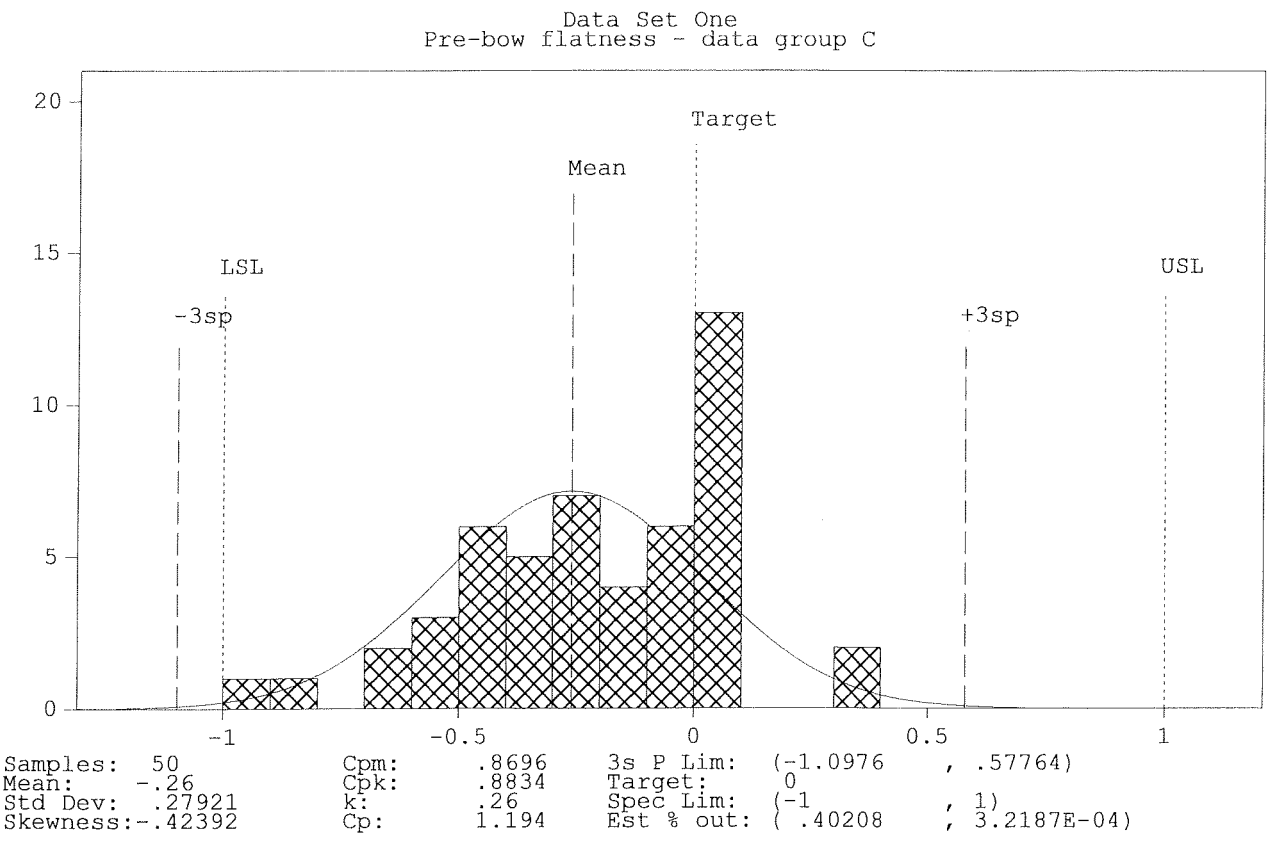
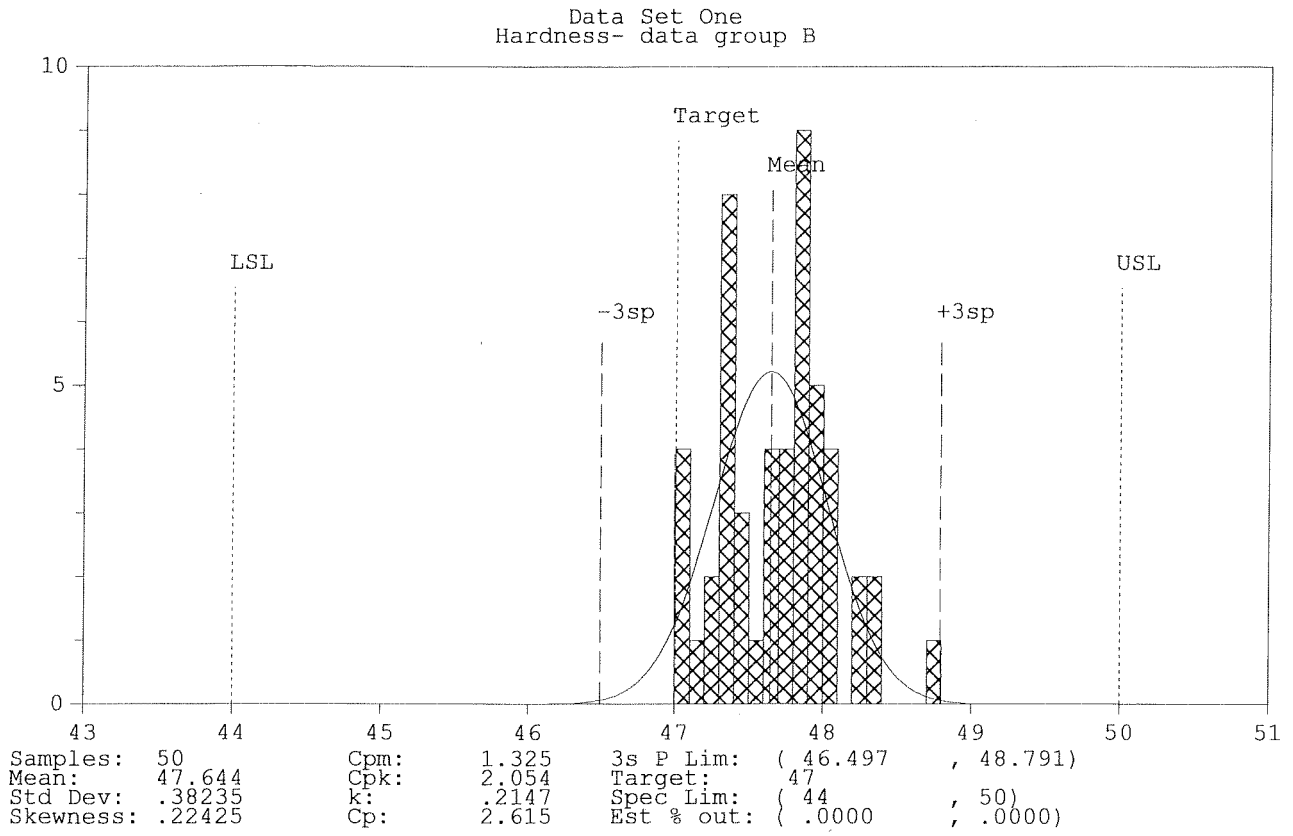
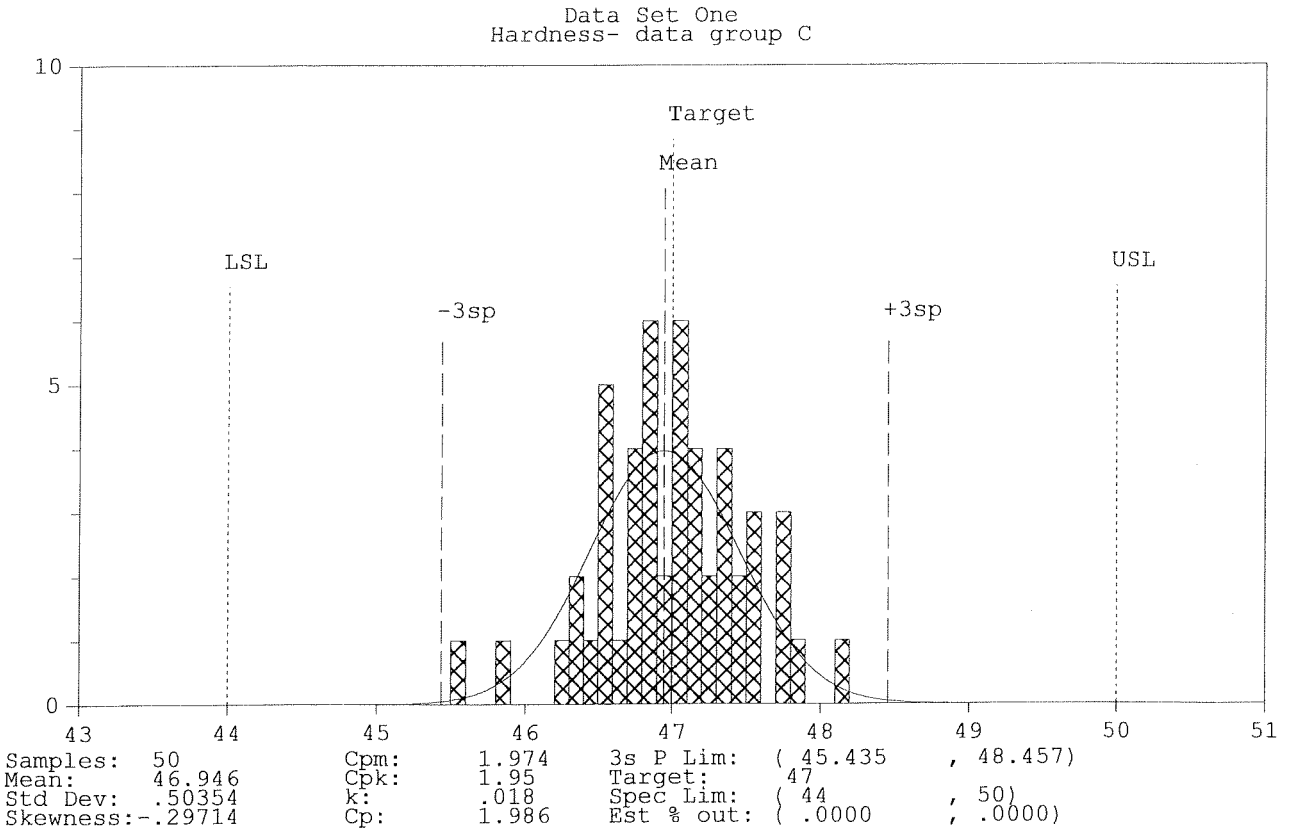

Data Set One
Pre-bow flatness - data group C
Target
Mean
LSL
-3sp
+3sp
USL
20
15
10
5
0
-1
-0.5
0
0.5
1
Samples: 50
Mean: -.26
Std Dev: .27921
Skewness:-.42392
Cpm: .8696
Cpk: .8834
k: .26
Cp: 1.194
3s P Lim: (-1.0976 , .57764)
Target: 0
Spec Lim: (-1 , 1)
Est % out: (.40208 , 3.2187E-04)

Figure 4


Data Set One
Hardness- data group B
10
5
0
Target
Mean
LSL
USL
-3sp
+3sp
43
44
45
46
47
48
49
50
51
Samples: 50
Mean: 47.644
Std Dev: .38235
Skewness: .22425
Cpm: 1.325
Cpk: 2.054
k: .2147
Cp: 2.615
3s P Lim: (46.497 , 48.791)
Target: 47
Spec Lim: (44 , 50)
Est % out: (.0000 , .0000)


Data Set One
Hardness- data group C
10
5
0
Target
Mean
LSL
USL
-3sp
+3sp
43
44
45
46
47
48
49
50
51
Samples: 50
Mean: 46.946
Std Dev: .50354
Skewness:-.29714
Cpm: 1.974
Cpk: 1.95
k: .018
Cp: 1.986
3s P Lim: (45.435 , 48.457)
Target: 47
Spec Lim: (44 , 50)
Est % out: (.0000 , .0000)