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Variation Management of Key Characteristics

Mo/Yr

Revisions			Rev:	
Letter	E.O. Number	Description	Date	
Used On	Contract#:	Your Company Name		
Prepared By:	Date			
Your Dept:	Date	YOUR PROGRAM		
Your Dept:	Date			
Your Dept:	Date	Your Procedure #		
Your Dept:	Date	Size: A	CAGE:	Form Rev: Orig 1 of 16

Your Company Logo

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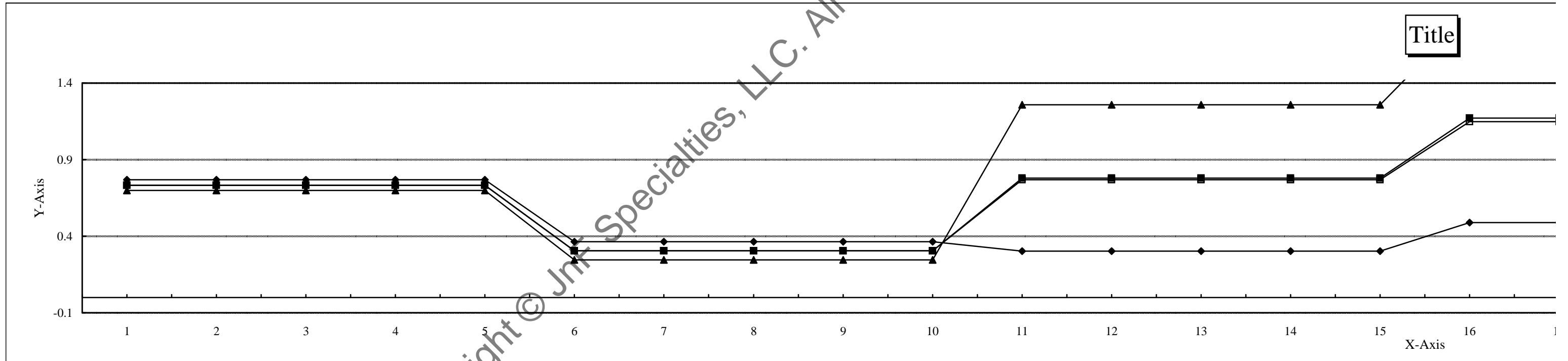
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Your Company Name	REV	CAGE	DOC#:	2 of 16
			Your Procedure #	

USL:	1.75	LSL: 1.55				Cpm Target: 1.65		Minimum Cpk, Cpm: 1.33							
Lot:	223	223	223	223	223	224	224	224	224	224	225	225	225	225	225
Comments:															
Date:															
1	1.72	1.65	1.62	1.64	1.59	1.59	1.61	1.65	1.71	1.68	1.70	1.71	1.68	1.62	1.64
2	1.68	1.65	1.63	1.68	1.67	1.00	1.60	1.65	1.68	1.70	1.68	1.74	1.71	1.60	1.70
3	1.61	1.63	1.63	1.64	1.64	1.57	1.63	1.63	1.55	1.64	1.73	1.69	1.73	1.73	1.68
4	1.65	1.60	1.65	1.66	1.68	1.61	1.60	1.72	1.58	1.65	1.81	1.74	1.74	1.75	1.72
5	1.61	1.66	1.64	1.69	1.74	1.70	1.65	1.60	1.72	1.65	1.75	1.77	1.68	1.68	1.72
6	1.53	1.66	1.64	1.69	1.75	1.67	1.67	1.60	1.66	1.69	1.75	1.72	1.69	1.73	1.80
7	1.62	1.59	1.73	1.60	1.61	1.71	1.66	1.64	1.66	1.68	1.68	1.72	1.76	1.66	1.73
8	1.65	1.61	1.70	1.58	1.59	1.65	1.67	1.59	1.63	1.68	1.71	1.68	1.75	1.66	1.71
Average:	1.63	1.63	1.66	1.65	1.66	1.56	1.64	1.64	1.65	1.67	1.73	1.72	1.72	1.68	1.71
Control ?:	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out

Cp: 0.7335425 0.7335425 0.7335425 0.7335425 0.7335425 0.3044561 0.3044561 0.3044561 0.3044561 0.3044561 0.780074 0.780074 0.780074 0.780074 0.780074
 CpkU: 0.7683858 0.7683858 0.7683858 0.7683858 0.7683858 0.3630639 0.3630639 0.3630639 0.3630639 0.3630639 0.3022787 0.3022787 0.3022787 0.3022787 0.3022787
 CpkL: 0.6986992 0.6986992 0.6986992 0.6986992 0.6986992 0.2458483 0.2458483 0.2458483 0.2458483 0.2458483 1.2578693 1.2578693 1.2578693 1.2578693 1.2578693
 Cpm: 0.7334818 0.7334818 0.7334818 0.7334818 0.7334818 0.3042844 0.3042844 0.3042844 0.3042844 0.3042844 0.7688242 0.7688242 0.7688242 0.7688242 0.7688242



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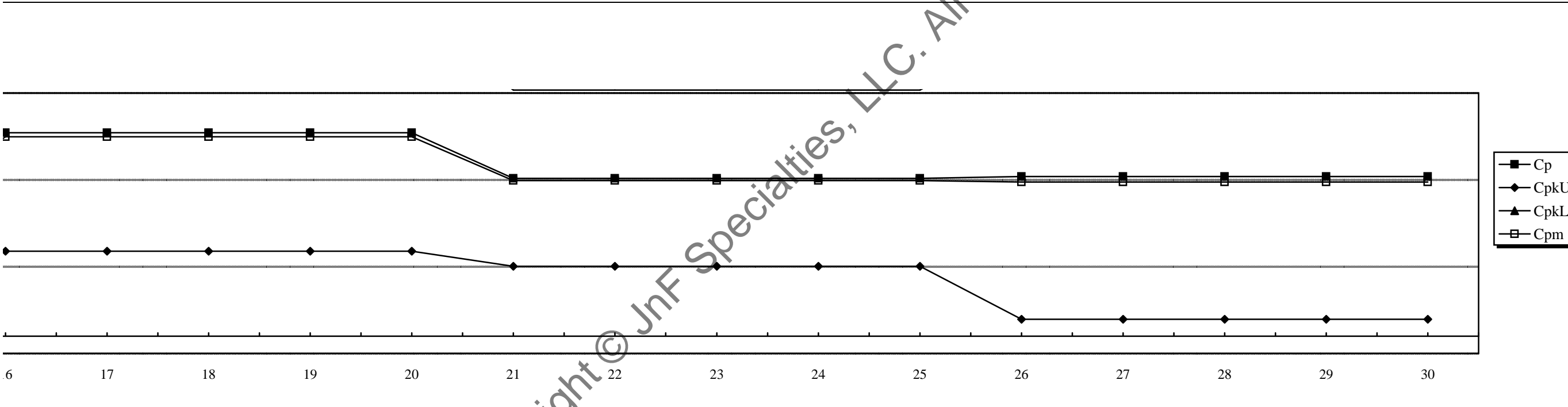
- Cpm measures the process mean relative to the target
- Cpk measures the process mean relative to the midpoint between specification limits
- Cp measures the spread of the data to the specification limits

Lot#:

StdDev:

Avg:

226	226	226	226	226	227	227	227	227	227	228	228	228	228	228
1.75	1.77	1.71	1.69	1.68	1.67	1.67	1.73	1.76	1.72	1.72	1.75	1.74	1.72	1.78
1.70	1.71	1.71	1.68	1.69	1.67	1.63	1.73	1.72	1.76	1.73	1.72	1.72	1.73	1.75
1.66	1.67	1.72	1.72	1.69	1.64	1.73	1.76	1.64	1.78	1.69	1.80	1.68	1.75	1.70
1.69	1.63	1.73	1.73	1.70	1.69	1.71	1.73	1.66	1.74	1.71	1.77	1.67	1.75	1.75
1.73	1.73	1.72	1.73	1.70	1.64	1.73	1.67	1.75	1.70	1.73	1.74	1.73	1.62	1.76
1.70	1.70	1.71	1.72	1.70	1.69	1.67	1.71	1.72	1.72	1.77	1.75	1.72	1.73	1.78
1.69	1.75	1.73	1.68	1.75	1.69	1.70	1.71	1.69	1.70	1.72	1.76	1.76	1.80	1.76
1.70	1.71	1.73	1.66	1.76	1.69	1.75	1.71	1.70	1.75	1.78	1.80	1.71	1.76	1.77
1.70	1.71	1.72	1.70	1.71	1.67	1.70	1.72	1.71	1.73	1.73	1.76	1.72	1.73	1.76
Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out	Out
1.1716208	1.1716208	1.1716208	1.1716208	1.1716208	0.9090933	0.9090933	0.9090933	0.9090933	0.9090933	0.9192998	0.9192998	0.9192998	0.9192998	0.9192998
0.4891517	0.4891517	0.4891517	0.4891517	0.4891517	0.4022738	0.4022738	0.4022738	0.4022738	0.4022738	0.0965265	0.0965265	0.0965265	0.0965265	0.0965265
1.85409	1.85409	1.85409	1.85409	1.85409	1.4159127	1.4159127	1.4159127	1.4159127	1.4159127	1.7420731	1.7420731	1.7420731	1.7420731	1.7420731
1.1487865	1.1487865	1.1487865	1.1487865	1.1487865	0.8964289	0.8964289	0.8964289	0.8964289	0.8964289	0.886654	0.886654	0.886654	0.886654	0.886654



REPEATABILITY AND REPRODUCIBILITY

GAGE TYPE: 6" Deep Throat Micrometer
 PART NAME: Gage Block
 PART NUMBER: 0.025000"
 PRODUCT SPEC: N/A

DATE: _____
 GAGE NUMBER: MI-30
 CHARACTERISTIC: Thickness
 TOLERANCE RANGE: 0.0030

COLUMN#:	1	2	3	4	5	6	7	8	9	10	11	12
OPERATOR:	A- Anne			B- Darrell			C- Mary Mc			D- Suzy		
SAMPLE#	1stTRIAL	2ndTRIAL	DIFF	1stTRIAL	2ndTRIAL	DIFF	1stTRIAL	2ndTRIAL	DIFF	1stTRIAL	2ndTRIAL	DIFF
1	0.0249	0.0250	0.0001	0.0250	0.0251	0.0001	0.0250	0.0250	0.0000	0.0250	0.0248	0.0002
2	0.0252	0.0249	0.0003	0.0251	0.0250	0.0001	0.0251	0.0250	0.0001	0.0253	0.0250	0.0003
3	0.0252	0.0248	0.0004	0.0251	0.0250	0.0001	0.0251	0.0250	0.0001	0.0248	0.0250	0.0002
4	0.0252	0.0250	0.0002	0.0250	0.0250	0.0000	0.0251	0.0250	0.0001	0.0250	0.0248	0.0002
5	0.0250	0.0249	0.0001	0.0251	0.0250	0.0001	0.0250	0.0250	0.0000	0.0250	0.0250	0.0000
6												
7												
8												
9												
10												
TOTALS	0.1255	0.1246	0.0011	0.1253	0.1251	0.0004	0.1253	0.1250	0.0003	0.1251	0.1246	0.0009
AVERAGES	0.0251	0.0249	0.0002	0.0251	0.0250	0.0001	0.0251	0.0250	0.0001	0.0250	0.0249	0.0002

Col1Avg:	0.0251	Col4Avg:	0.0251	Col7Avg:	0.0251	Col10Avg:	0.0250
SumCol1&2Avs:	0.0500	SumCol4&5Avs:	0.0501	SumCol7&8Avs:	0.0501	SumCol10&11Avs:	0.0499
Avg(OperatorA):	0.0250	Avg(OperatorB):	0.0250	Avg(OperatorC):	0.0250	Avg(OperatorD):	0.0250

RANGE VARIATION

AvgCol3	0.0002
AvgCol6	0.0001
AvgCol9	0.0001
AvgCol12	0.0002
SUM	0.0005

R₁ = GndAvg = 0.0001
 UCL = (D₄)x(R₁)
 D4 value: = (3.27)x 0.0001
 = 0.0004
 3.27=# of trials=D₄ Table

REPRODUCIBILITY = OPERATOR VARIATION

DIFFERENCE IN MEANS
 $X_{Diff} = (AvgOp_{Max}) - (AvgOp_{Min}) = 0.0001$
 Est. STANDARD DEVIATION of MEANS
 (SDM) = (1/d₂)x(X_{Diff}) = 0.0000
 (1/d₂) = 0.446
 1/d₂ = (0.446) = (n=4, k=1)
 n=# of appraisers
 k=# of GndAvg means
 VARIANCE = SDM² = 0.0000

REPEATABILITY = EQUIPMENT VARIATION

DIFFERENCE IN READINGS
 $R_1 = (Table D_4 Value) \times (Avg Range)$
 Est. STANDARD DEVIATION of READINGS
 (SDR) = (1/d₂) x (R₁) = 0.0001
 (1/d₂) = 0.885
 (1/d₂) = (.885) = (n=2, k=20)
 n=# of repeat trials
 k=(# of Operators)x(# of parts in 1st trial)
 VARIANCE = SDR² = 0.0000

Insert the actual D4 value above

#Trials:	2	3	4
D4	3.27	2.58	2.28

REPRODUCIBILITY AND REPEATABILITY (COMBINED)
 STANDARD DEVIATION (R&R) = SQRT of [SDM² + SDR²]

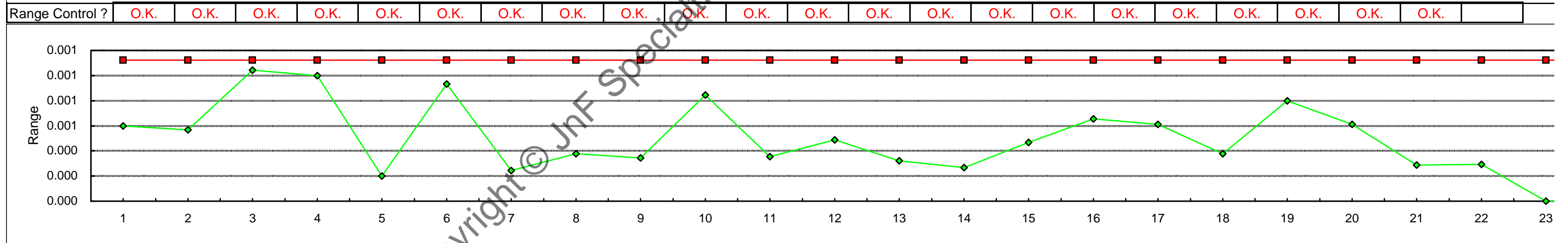
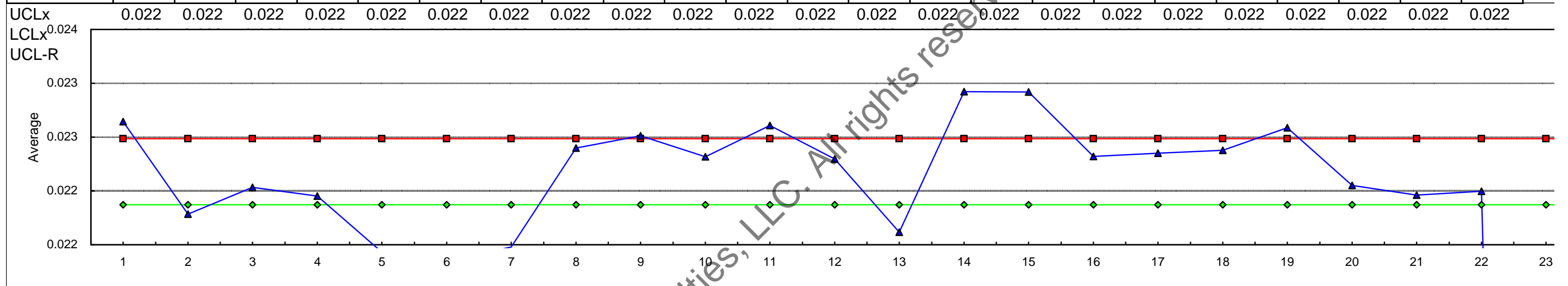
PERCENT TOLERANCE CONSUMED BY R&R
 P.T.C. = [(5.15) x (SDRR)]/TOLERANCE RANGE]*100

Tolerance Range must be inserted for P.T.C. to calculate SDRR = 0.0001

% = 21.2

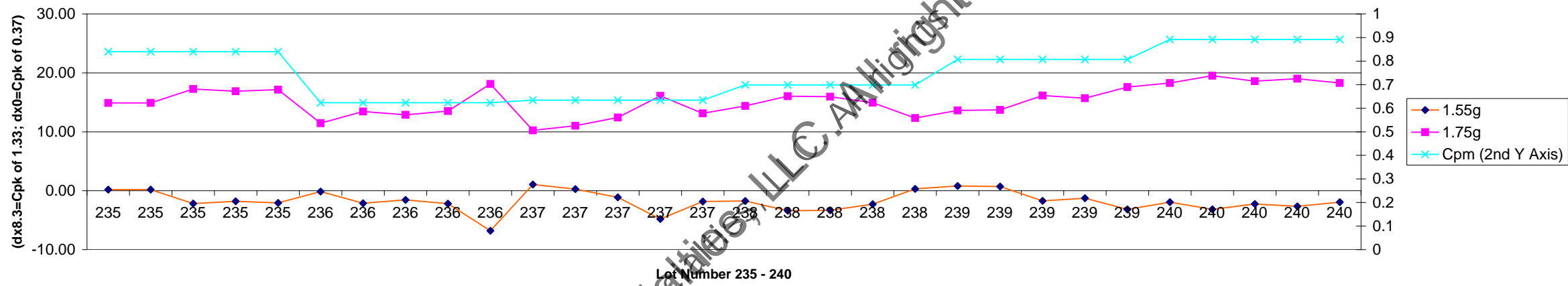
Insert (1/d₂) for SDM and SDR from Table; 0.446 and 0.885 are correct for 4 appraisers and at least 3 parts.

Sample #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	18	19	20	21	22
Comments:																							
Date:																							
Time:	11:19	11:35	11:51	12:07	12:30	01:30	03:30	06:09	06:58	07:46	08:34	09:22	10:11	10:59	11:47	12:35	01:24	01:24	02:12	04:44	05:33	06:21	
Operator:	YS	YS	YS	YS	RC	RC	RC	IS	IS	RC	DD	DD	IS	IS	RC	DD	YS	DD	DD	IS	IS	IS	
Sample 1	0.0229	0.0215	0.0218	0.0217	0.0214	0.0208	0.0216	0.0225	0.0225	0.0223	0.0226	0.0221	0.0214	0.0230	0.0226	0.0227	0.0222	0.0223	0.0230	0.0221	0.0220	0.0220	
Sample 2	0.0228	0.0220	0.0216	0.0224	0.0213	0.0216	0.0213	0.0223	0.0226	0.0224	0.0227	0.0225	0.0217	0.0228	0.0227	0.0220	0.0226	0.0224	0.0226	0.0219	0.0218	0.0218	
Sample 3	0.0223	0.0217	0.0226	0.0220	0.0215	0.0217	0.0216	0.0222	0.0224	0.0228	0.0224	0.0222	0.0217	0.0229	0.0231	0.0226	0.0221	0.0226	0.0222	0.0219	0.0219	0.0220	
Sample 4	0.0224	0.0218	0.0222	0.0214	0.0215	0.0212	0.0215	0.0224	0.0223	0.0219	0.0227	0.0221	0.0217	0.0229	0.0230	0.0222	0.0222	0.0224	0.0228	0.0219	0.0219	0.0220	
Sample 5	0.0227	0.0219	0.0220	0.0223	0.0215	0.0214	0.0215	0.0225	0.0227	0.0222	0.0226	0.0226	0.0217	0.0230	0.0231	0.0222	0.0227	0.0222	0.0223	0.0225	0.0221	0.0221	
Sum:	0.1132	0.1089	0.1102	0.1098	0.1072	0.1067	0.1074	0.1120	0.1126	0.1116	0.1130	0.1115	0.1081	0.1146	0.1146	0.1116	0.1118	0.1119	0.1129	0.1103	0.1098	0.1100	
Average: (x)	0.0226	0.0218	0.0220	0.0220	0.0214	0.0213	0.0215	0.0224	0.0225	0.0223	0.0226	0.0223	0.0216	0.0229	0.0229	0.0223	0.0224	0.0224	0.0226	0.0221	0.0220	0.0220	
Range - R	0.0006	0.0006	0.0010	0.0010	0.0002	0.0009	0.0002	0.0004	0.0003	0.0008	0.0004	0.0005	0.0003	0.0003	0.0005	0.0007	0.0006	0.0004	0.0008	0.0006	0.0003	0.0003	
Xbar Control ?	?	?	O.K.	O.K.	?	?	?	O.K.	?	O.K.	?	O.K.	?	?	?	O.K.	O.K.	O.K.	?	O.K.	O.K.	O.K.	



The upper and lower control limit calculations are located under the x-bar graph

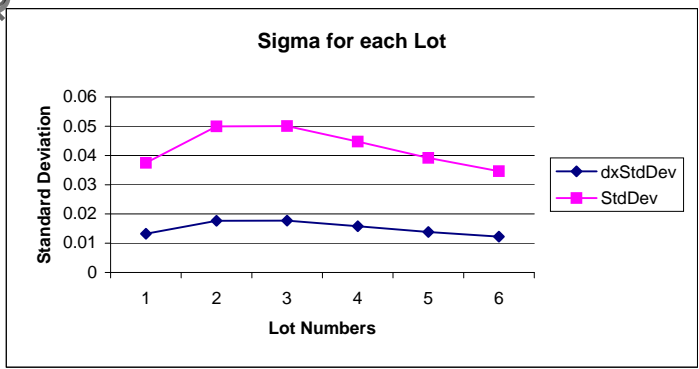
USL, g:	1.75		LSL, g:		1.55		Sample Process						Process Acceptance Chart								
Lot#:	235	235	235	235	235	236	236	236	236	236	237	237	237	237	237	238	238	238	238	238	239
Comment:																					
Date:																					
1	1.76	1.75	1.84	1.82	1.77	1.74	1.78	1.76	1.78	1.91	1.75	1.76	1.78	1.78	1.80	1.80	1.84	1.85	1.80	1.77	1.76
2	1.73	1.73	1.84	1.80	1.84	1.76	1.71	1.79	1.79	1.84	1.75	1.75	1.78	1.79	1.86	1.82	1.71	1.85	1.77	1.77	1.76
3	1.75	1.74	1.73	1.81	1.76	1.73	1.76	1.76	1.77	1.93	1.68	1.69	1.79	1.88	1.73	1.81	1.85	1.77	1.81	1.80	1.72
4	1.74	1.66	1.76	1.78	1.75	1.76	1.78	1.80	1.74	1.88	1.67	1.74	1.73	1.85	1.75	1.83	1.77	1.77	1.78	1.76	1.77
5	1.77	1.81	1.74	1.75	1.75	1.73	1.84	1.81	1.79	1.85	1.78	1.76	1.77	1.88	1.83	1.78	1.85	1.81	1.80	1.67	1.73
6	1.79	1.77	1.80	1.76	1.77	1.76	1.81	1.71	1.78	1.88	1.79	1.73	1.75	1.81	1.79	1.76	1.79	1.80	1.78	1.66	1.75
7	1.72	1.76	1.77	1.75	1.83	1.76	1.81	1.78	1.83	1.85	1.70	1.75	1.76	1.83	1.77	1.70	1.84	1.77	1.76	1.78	1.71
8	1.72	1.76	1.75	1.72	1.75	1.78	1.81	1.81	1.83	1.82	1.73	1.78	1.80	1.86	1.73	1.72	1.78	1.80	1.79	1.75	1.71
Average:	1.75	1.75	1.78	1.77	1.78	1.75	1.79	1.78	1.79	1.87	1.73	1.75	1.77	1.84	1.78	1.78	1.80	1.80	1.79	1.75	1.74



81
 .63
 K.
 113
 0716

$$dx = \frac{avg - LSL}{\sigma / \sqrt{n}} > 4 \sqrt{n} - 3$$

$$dx = \frac{USL - avg}{\sigma / \sqrt{n}} > 4 \sqrt{n} - 3$$



dx provides a means to answer the question: Are we making acceptable parts? -- instead of -- Are we in control?

The Cpm capability index depends on both variability and centering.

This is not a control chart

Acceptance is based on the Lower Acceptance Limit