

1. 體溫資料如下表整理。Sample 分組方式為：3/25 第一時段為 sample 1、第二時段為 sample 2、第三時段為 sample 3、3/26 第一時段為 sample 4.....以此類推。由於每個時段的量測為同一時間進行，因此透過這樣分組所篩選出來的 R chart 可以用來判斷每一次的量測是否有效。若單次的量測差距較大，則可以判定該次量測無效。

	3月25日	3月26日	3月27日	3月28日	3月29日	3月30日	3月31日	4月1日	4月2日	4月3日	4月4日	4月5日
時段1	36	36.1	36.5	36	35.7	35.8	35.2	36	36	35.9	35.6	36.1
	36	36.2	36.4	36.1	35.6	35.7	35.6	36.1	35.8	36.1	35.7	36.2
	36.1	36.2	36.4	35.9	35.5	35.7	35.6	36.2	35.8	36.1	35.8	36.1
	36.2	36.3	36.3	36	35.7	35.9	35.7	36.1	36	36.1	35.8	36
	36.2	36.3	36.4	36	35.6	36	35.8	36.2	35.8	36.1	35.8	36
時段2	35.9	35.6	36.3	35.9	35.5	35.8	36	36.1	35.8	36.1	36	35.8
	36.1	35.7	36.4	35.7	35.4	35.9	36	36.6	35.6	36.2	36.2	35.7
	36	35.6	36.4	35.9	36.1	36.2	36.1	36.5	35.6	36.2	36.2	35.6
	36.1	35.8	36.1	36	36.1	36.4	35.7	36.3	35.9	36.3	36.3	35.6
	36.1	36.1	36.2	36	36	36.5	36.2	36.3	35.6	36.4	36.2	35.7
時段3	36.2	35.9	35.8	36.1	35.6	36	36.1	36.1	35.8	35.7	36	36.1
	36.1	36.1	35.9	36.2	35.8	36.1	36	36.3	35.8	35.8	35.8	36
	36.2	36.2	35.8	36.3	35.9	36.2	36.1	36.3	35.7	36	35.9	36
	36.2	36.2	35.7	36.3	36.1	36.1	35.9	36.5	35.8	35.8	35.9	36.2
	36.1	36.3	35.9	36.3	36	36.2	36.2	36.5	35.8	35.9	36	36.1

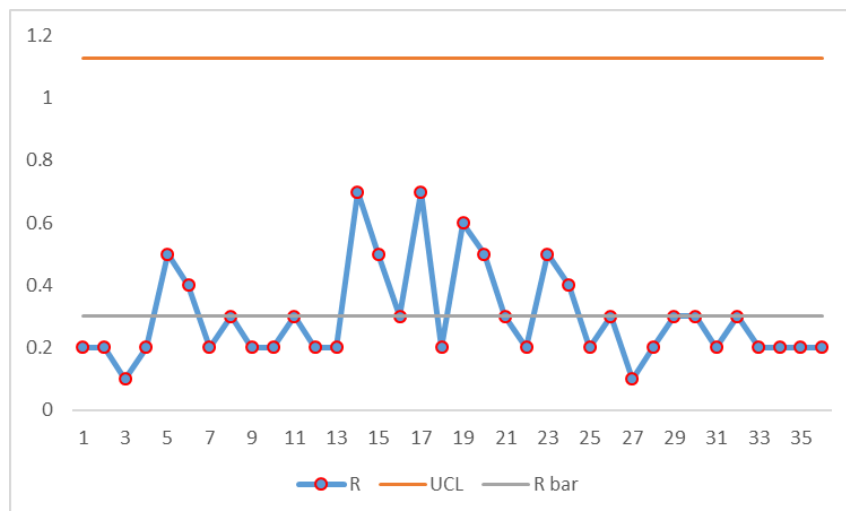
從數據中可整理出 $\bar{R} = 0.3$, $S_R = 0.27634$ 。因此可列出：

$$CL = \bar{R} = 0.3$$

$$UCL = \bar{R} + 3S_R = 1.129019$$

$$LCL = \max(\bar{R} - 3S_R, 0) = 0$$

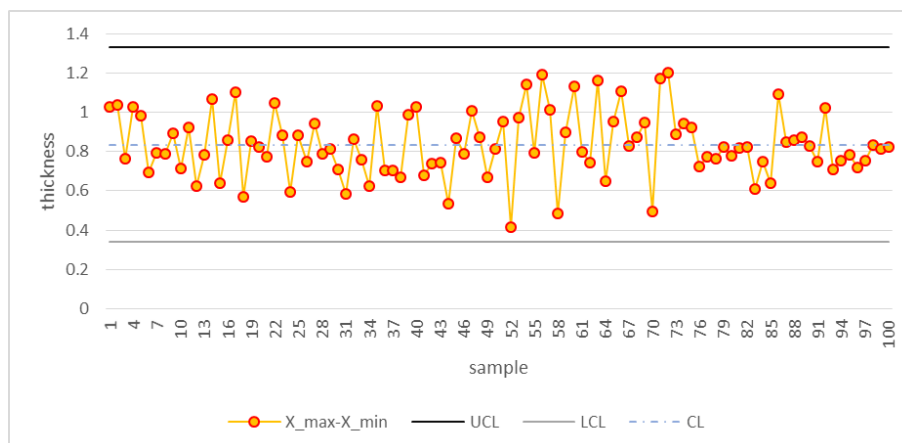
建立 R chart 如下圖：



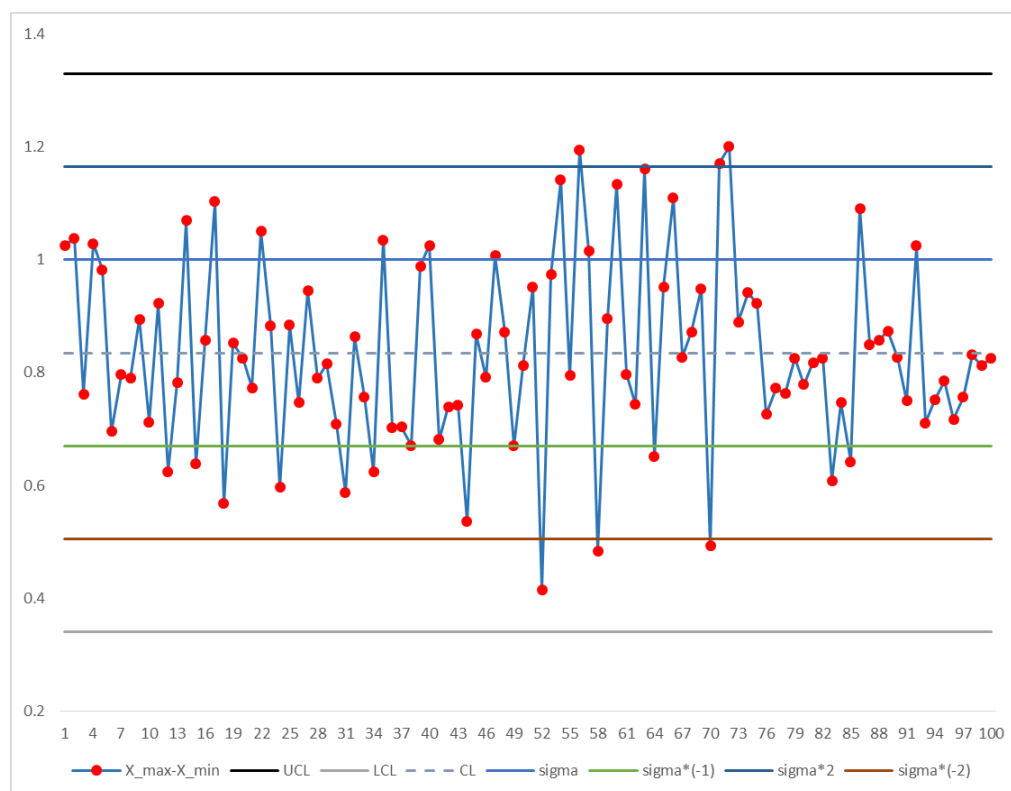
2.

- (i) R-chart 為用來 monitor Wafer 的外圍四個 CD_site 是否平整，因

此在產出 R chart 時將中心點的 CD_site 3 排除在外，僅使用 CD_site 1, 2, 4, 5 產出 R chart。在每一組 Wafer 中找出四個 CD_site 的最大與最小量測值的差做為 R，將 100 組 wafer 的 R 取出 \bar{R} 及 S_R ，並使 $CL = \bar{R}$, $UCL = \bar{R} + 3 \times S_R$, $LCL = \text{MAX}(0, \bar{R} - 3 \times S_R)$ ，並匯出 R chart 如下：

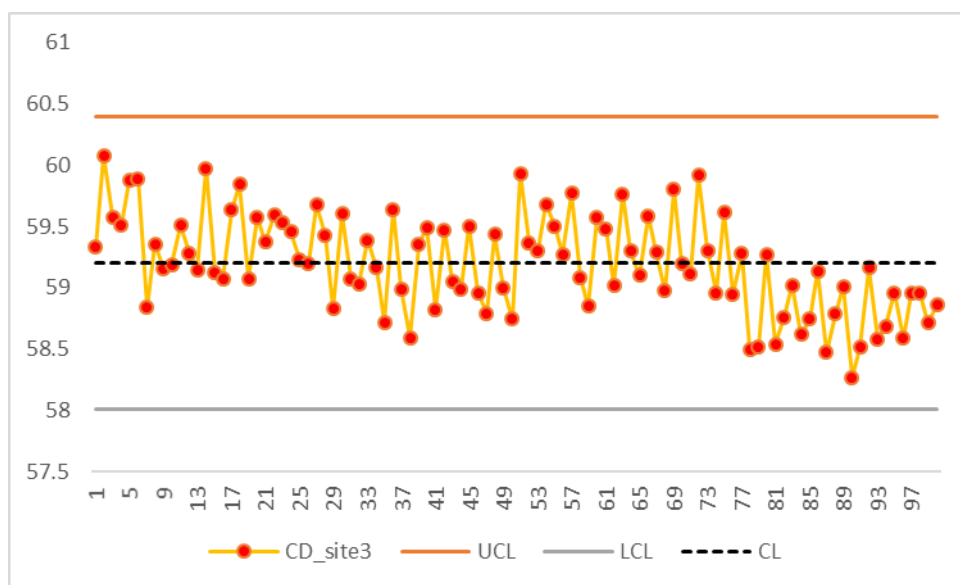


- (ii) 使用 runs rule 進行判斷時，則須加入 1 個標準差及 2 個標準差的界線做為判斷依據。修整後的 R chart 如下：



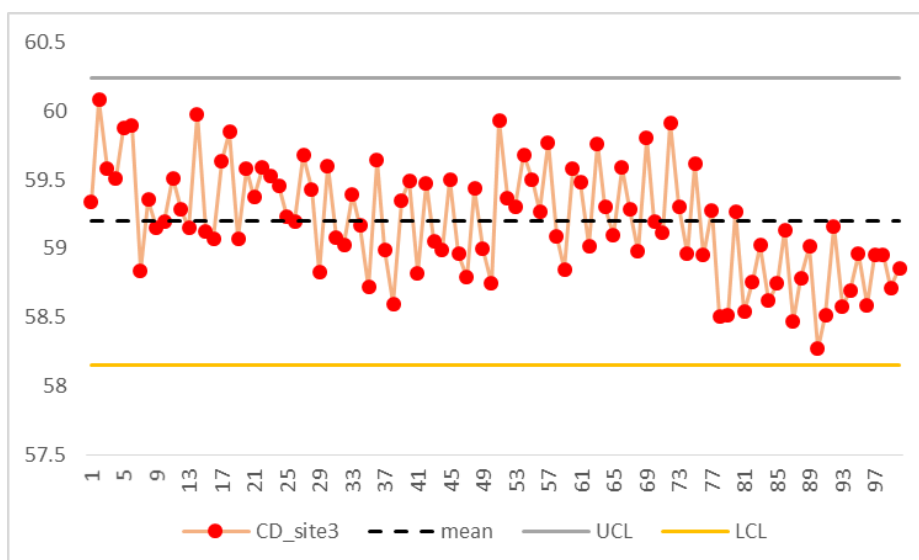
- a. Run rule 1: one point beyond the control limit—passed

- b. Run rule 2: two out of three point in zone 2-3 σ or beyond – failed at sample number 72
 - c. Run rule 3: four out of five points in zone 1-2 σ or beyond – passed
 - d. Run rule 4: eight points above or below the centerline – failed at 83, 100.
 - e. Run rule 5: six points show a continuing increase or decrease – passed.
 - f. Run rule 6: 14 points oscillate up and down – passed
 - g. Run rule 7: 8 points avoid 0-1 σ —passed
 - h. Run rule 8: 15 points fall in 0-1 σ only – passed.
- (iii) CD_site 3 的 control chart 分別以平均數作為 mean=59.1975，並將所有的 CD_site 3 取樣本標準差，進而得到 UCL=60.3882 與 LCL=58.0069，可畫出 control chart 如下：



- (iv) 對 Range=2 的 individual X chart 而言，將前後兩項的 CD_site 3 相減後平方再除以二，從資料中可以得到 $S_{p2} = \sqrt{\frac{\sum_{i=1}^{n-1} ms_i^2}{n-1}} = 0.347708$ ，其中 $n=99$ 。令 $CL=\bar{X} = 59.1975$ ， $UCL=\bar{X} + 3 \times S_{p2} = 60.2407$ ， $LCL=\bar{X} - 3 \times S_{p2} = 58.1544$ 。根據上下邊界可畫出

individual control chart 如下：



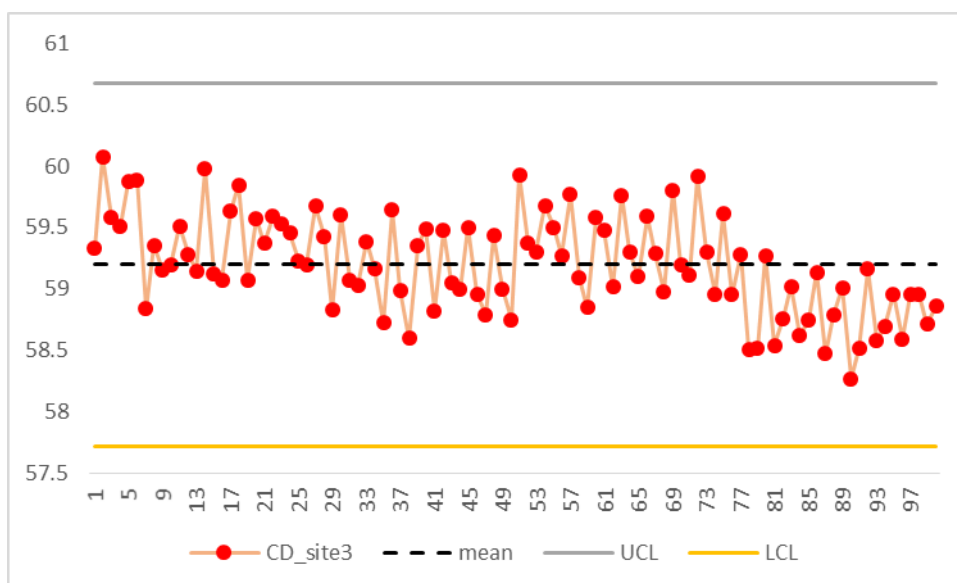
對 Range=5 的 individual X chart 而言，將前後兩項的 CD_site 3

相減後平方再除以二，從資料中可以得到 $S_{p2} = \sqrt{\frac{\sum_{i=1}^{n-1} ms_i^2}{n-1}} =$

0.492743，其中 $n=5$ 。令 $CL=\bar{X} = 59.1975$ ， $UCL=\bar{X} + 3 \times S_{p2} =$

60.67582， $LCL=\bar{X} - 3 \times S_{p2} = 57.71936$ 。根據上下邊界可畫出

individual control chart 如下：

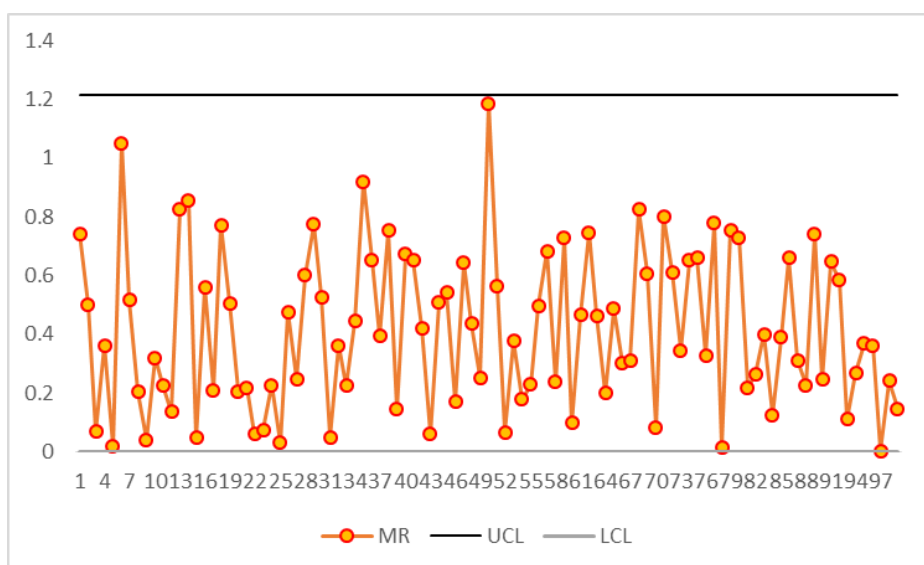


與(iii)圖比較，(iii)的上下界範圍較 range=2 的來的大，但又比

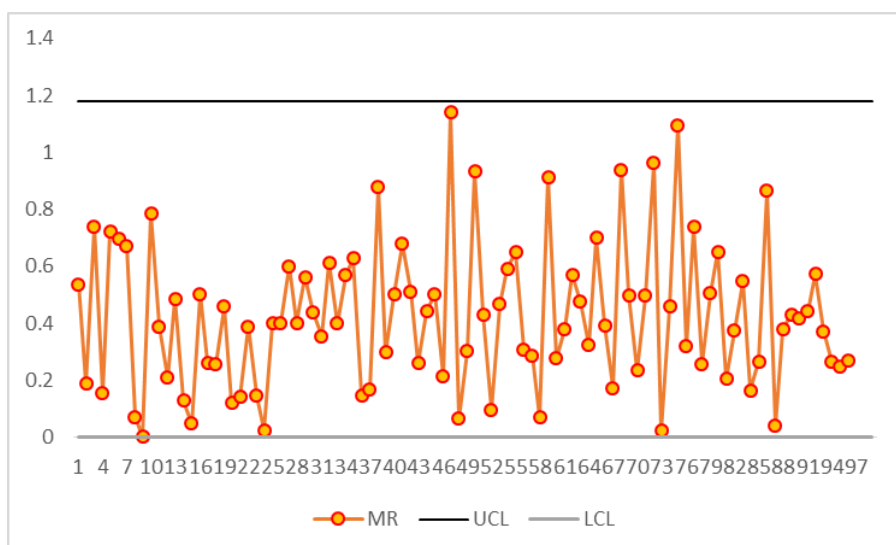
range=5 的來的小，比較三者的上下界大小為

$\text{range}=5 > (\text{iii}) > \text{range}=2$ 。因此可以解釋 $\text{range}=2$ 的敏感度較 $\text{range}=5$ 及 (iii) 都來的高。

- (v) 當 $\text{range}=2$ 時，取得每一組 $\text{MR} = |x_i - x_{i+1}|$ ，將 MR 取得平均後做為 CL；將 MR 的 sample variance 做為 S_{MR} ，可訂出上下界 $\text{UCL} = \overline{\text{MR}} + 3S_{\text{MR}} = 1.213414$ ， $\text{LCL} = \text{MAX}(0, \overline{\text{MR}} - 3S_{\text{MR}}) = 0$ ，可繪出 MR chart 如下：



當 $\text{range}=5$ 時，取得每一組 $\text{MR} = |x_i - x_{i+4}|$ ，將 MR 取得平均後做為 $\text{CL} = 0.492743$ ；將 MR 的 sample variance 做為 S_{MR} ，可訂出上下界 $\text{UCL} = \overline{\text{MR}} + 3S_{\text{MR}} = 1.18034$ ， $\text{LCL} = \text{MAX}(0, \overline{\text{MR}} - 3S_{\text{MR}}) = 0$ ，可繪出 MR chart 如下：

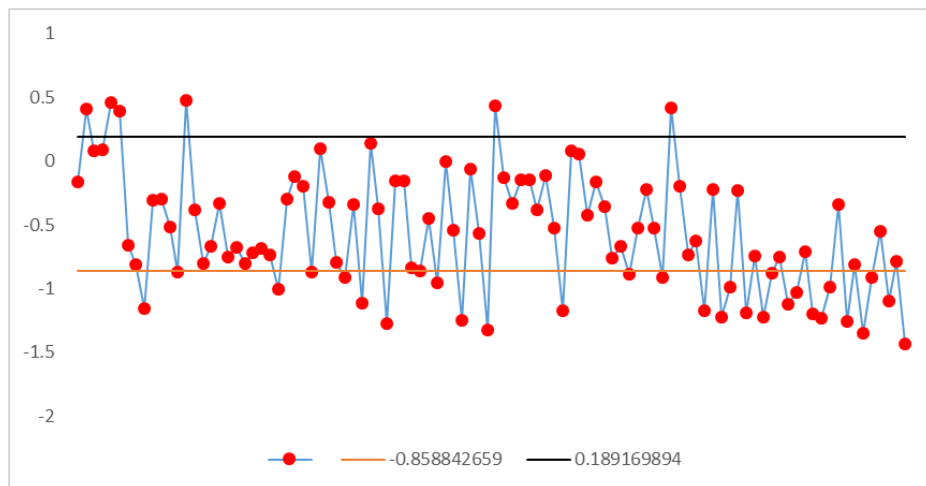


- (vi) 使用 sequential likelihood ratio 來檢定是否為 μ_0 或 μ_1 ，檢定標準為：

$$C_t \leq \frac{\sigma^2}{\delta} \ln\left(\frac{1-\beta}{\alpha}\right), \text{ 接受 } H_1$$

$$C_t \geq \frac{\sigma^2}{\delta} \ln\left(\frac{\beta}{1-\alpha}\right), \text{ 接受 } H_0$$

其中 $\delta = \mu_1 - \mu_0$ ， σ 為 CD_site 3 的樣本標準差，令 $\mu_1 = 59$ ， $\mu_0 = 60$ 。一旦 C value 累積到了有足夠證據接受 H_1 或 H_0 時，即將 C value 重新累積。檢定結果如下：



sample	cumulated value	accept H1	accept H0
1	-0.1647	0	0
2	0.413	0	accept H0
3	0.0779	0	0
4	0.0889	0	0
5	0.4613	0	accept H0
6	0.3892	0	accept H0
7	-0.6621	0	0
8	-0.8077	0	0
9	-1.1575	accept H1	0

10	-0.3093	0	0
11	-0.2989	0	0
12	-0.5157	0	0
13	-0.8687	accept H1	0
14	0.4744	0	accept H0
15	-0.3799	0	0
16	-0.8062	0	0
17	-0.672	0	0
18	-0.3274	0	0
19	-0.7555	0	0
20	-0.6788	0	0
21	-0.8067	0	0
22	-0.7176	0	0
23	-0.6875	0	0
24	-0.7325	0	0
25	-1.0029	accept H1	0
26	-0.3008	0	0
27	-0.1248	0	0
28	-0.1964	0	0
29	-0.8697	accept H1	0
30	0.1014	0	0
31	-0.3238	0	0
32	-0.7973	0	0
33	-0.909	accept H1	0
34	-0.3356	0	0
35	-1.1152	accept H1	0
36	0.1401	0	0
37	-0.3705	0	0
38	-1.2748	accept H1	0
39	-0.1508	0	0
40	-0.158	0	0
41	-0.8368	0	0
42	-0.8639	accept H1	0
43	-0.4482	0	0
44	-0.956	accept H1	0
45	0.0009	0	0
46	-0.5388	0	0

47	-1.2474	accept H1	0
48	-0.0661	0	0
49	-0.5685	0	0
50	-1.3221	accept H1	0
51	0.4318	0	accept H0
52	-0.1317	0	0
53	-0.3294	0	0
54	-0.1503	0	0
55	-0.1499	0	0
56	-0.3789	0	0
57	-0.11	0	0
58	-0.5236	0	0
59	-1.1734	accept H1	0
60	0.0783	0	0
61	0.0596	0	0
62	-0.4236	0	0
63	-0.1608	0	0
64	-0.3603	0	0
65	-0.7594	0	0
66	-0.6717	0	0
67	-0.8839	accept H1	0
68	-0.5237	0	0
69	-0.2221	0	0
70	-0.5283	0	0
71	-0.9141	accept H1	0
72	0.4152	0	accept H0
73	-0.1966	0	0
74	-0.737	0	0
75	-0.6253	0	0
76	-1.1745	accept H1	0
77	-0.2207	0	0
78	-1.2193	accept H1	0
79	-0.9846	accept H1	0
80	-0.2291	0	0
81	-1.188	accept H1	0
82	-0.7403	0	0
83	-1.2192	accept H1	0

84	-0.8797	accept H1	0
85	-0.7537	0	0
86	-1.119	accept H1	0
87	-1.0259	accept H1	0
88	-0.714	0	0
89	-1.2015	accept H1	0
90	-1.2295	accept H1	0
91	-0.9842	accept H1	0
92	-0.3363	0	0
93	-1.2563	accept H1	0
94	-0.8104	0	0
95	-1.3518	accept H1	0
96	-0.9102	accept H1	0
97	-0.5475	0	0
98	-1.0935	accept H1	0
99	-0.7883	0	0
100	-1.4297	accept H1	0

(vii) 設定 $\mu_0 = 59.5$, $(K, H) = (0.5\sigma, 5\sigma)$ 時，繪出 Tabular CUSUM chart。

其中， $C_i^+ = \max[0, x_i - (\mu_0 + K) + C_{i-1}^+]$ ， $C_i^- = \max[0, (\mu_0 - K) + x_i + C_{i-1}^-]$ 。分別計算 C^+ 與 C^- 後，紀錄 C^+ 及 C^- 不為 0 時的累進次數。結果如圖表所示：

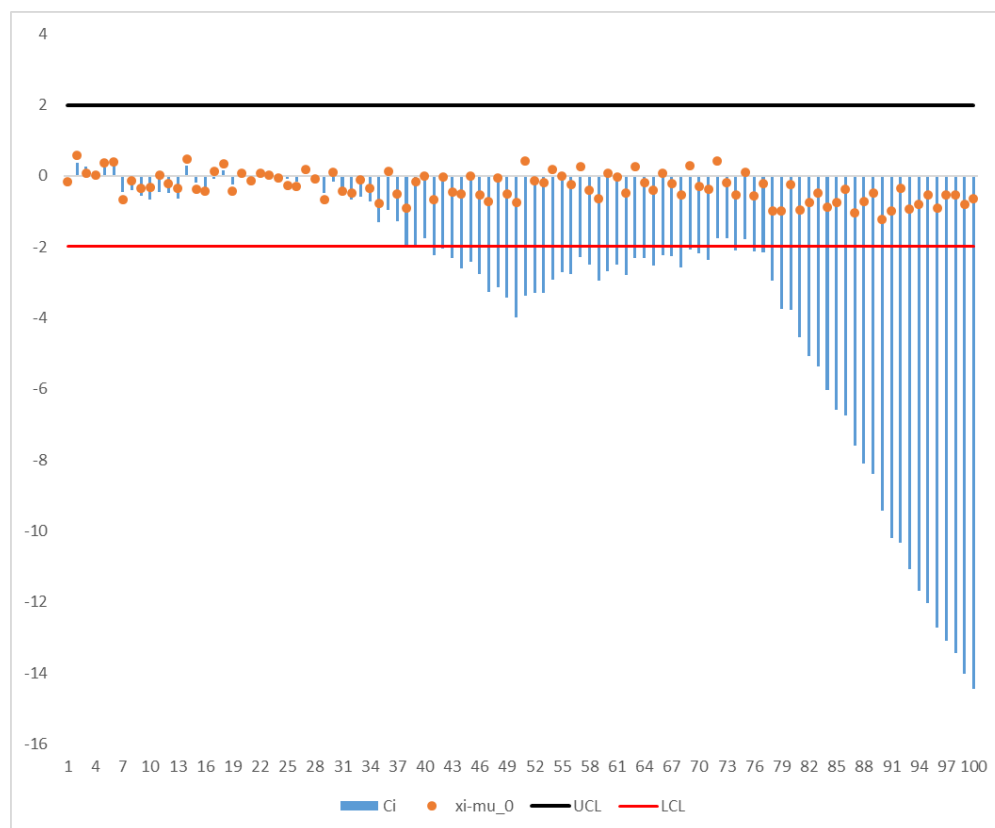
		a		b	
	CD_site3	$x - (\mu_0 + K)$	N+	$(\mu_0 - K) - x_i$	N-
1	59.3353	0	0	0	0
2	60.0777	0.379259532	1	0	0
3	59.5779	0.258719063	2	0	0
4	59.511	0.071278595	3	0	0
5	59.8724	0.245238126	4	0	0
6	59.8892	0.435997658	5	0	0
7	58.8379	0	0	0.46365953	1
8	59.3544	0	0	0.41081906	2
9	59.1502	0	0	0.56217859	3
10	59.1907	0	0	0.67303813	4
11	59.5104	0	0	0.46419766	5

12	59.2832	0	0	0.48255719	6
13	59.147	0	0	0.63711672	7
14	59.9744	0.275959532	1	0	0
15	59.1201	0	0	0.18145953	1
16	59.0737	0	0	0.40931906	2
17	59.6342	0	0	0.07667859	3
18	59.8446	0.146159532	1	0	0
19	59.0719	0	0	0.22965953	1
20	59.5767	0	0	0	0
21	59.3721	0	0	0	0
22	59.5891	0	0	0	0
23	59.5301	0	0	0	0
24	59.455	0	0	0	0
25	59.2296	0	0	0.07195953	1
26	59.1992	0	0	0.17431906	2
27	59.676	0	0	0	0
28	59.4284	0	0	0	0
29	58.8267	0	0	0.47485953	1
30	59.6014	0	0	0.17501906	2
31	59.0748	0	0	0.40177859	3
32	59.0265	0	0	0.67683813	4
33	59.3883	0	0	0.59009766	5
34	59.1644	0	0	0.72725719	6
35	58.7204	0	0	1.30841672	7
36	59.6401	0	0	0.96987625	8
37	58.9894	0	0	1.28203578	9
38	58.5957	0	0	1.98789532	10
39	59.3492	0	0	1.94025485	11
40	59.4928	0	0	1.74901438	12
41	58.8212	0	0	2.22937391	13
42	59.4729	0	0	2.05803344	14
43	59.0518	0	0	2.30779297	15
44	58.9922	0	0	2.6171525	16
45	59.5009	0	0	2.41781204	17
46	58.9603	0	0	2.75907157	18
47	58.7914	0	0	3.2692311	19
48	59.4339	0	0	3.13689063	20

49	58.9976	0	0	3.44085016	21
50	58.7464	0	0	3.99600969	22
51	59.9318	0.233359532	1	3.36576922	23
52	59.3683	0	0	3.29902876	24
53	59.3023	0	0	3.29828829	25
54	59.6791	0	0	2.92074782	26
55	59.5004	0	0	2.72190735	27
56	59.271	0	0	2.75246688	28
57	59.7689	0.070459532	1	2.28512641	29
58	59.0864	0	0	2.50028595	30
59	58.8502	0	0	2.95164548	31
60	59.5783	0	0	2.67490501	32
61	59.4813	0	0	2.49516454	33
62	59.0168	0	0	2.77992407	34
63	59.7628	0.064359532	1	2.3186836	35
64	59.3005	0	0	2.31974313	36
65	59.1009	0	0	2.52040267	37
66	59.5877	0	0	2.2342622	38
67	59.2878	0	0	2.24802173	39
68	58.9763	0	0	2.57328126	40
69	59.8016	0.103159532	1	2.07324079	41
70	59.1938	0	0	2.18100032	42
71	59.1142	0	0	2.36835985	43
72	59.9152	0.216759532	1	1.75471939	44
73	59.3034	0	0	1.75287892	45
74	58.9596	0	0	2.09483845	46
75	59.6117	0	0	1.78469798	47
76	58.9508	0	0	2.13545751	48
77	59.2793	0	0	2.15771704	49
78	58.5014	0	0	2.95787658	50
79	58.5154	0	0	3.74403611	51
80	59.2709	0	0	3.77469564	52
81	58.5411	0	0	4.53515517	53
82	58.7597	0	0	5.0770147	54
83	59.0211	0	0	5.35747423	55
84	58.6203	0	0	6.03873376	56
85	58.7463	0	0	6.5939933	57

86	59.1347	0	0	6.76085283	58
87	58.4741	0	0	7.58831236	59
88	58.786	0	0	8.10387189	60
89	59.0125	0	0	8.39293142	61
90	58.2705	0	0	9.42399095	62
91	58.5158	0	0	10.2097505	63
92	59.1637	0	0	10.34761	64
93	58.58	0	0	11.0691695	65
94	58.6896	0	0	11.6811291	66
95	58.9586	0	0	12.0240886	67
96	58.5898	0	0	12.7358481	68
97	58.9525	0	0	13.0849077	69
98	58.954	0	0	13.4324672	70
99	58.7117	0	0	14.0223267	71
100	58.8586	0	0	14.4652863	72

計算後得 $H=1.984405$ ，可繪出 control chart:



從圖中可以看到五個區段的平均數是在檢定範圍之外的，計算每組的

平均後可整理於下表：

start sample	end sample	new process mean
29	38	59.10277
29	41	59.13007
29	42	59.15456
29	43	59.14771
29	44	59.13799
29	45	59.15934
29	46	59.14828
29	47	59.12949
29	48	59.14472
29	49	59.13771
29	50	59.11992
29	51	59.15522
29	52	59.1641
29	53	59.16963
29	54	59.18922
29	55	59.20075
29	56	59.20326
29	57	59.22276
29	58	59.21822
29	59	59.20635
29	60	59.21797
29	61	59.22595
29	62	59.2198
29	63	59.23531
29	64	59.23712
29	65	59.23344
29	66	59.24276
29	67	59.24392
29	68	59.23723
29	69	59.25099
29	70	59.24963
29	71	59.24648
29	74	59.25602

29	76	59.25707
29	77	59.25752
29	78	59.2424
29	79	59.22815
29	80	59.22897
29	81	59.21599
29	82	59.20754
29	83	59.20415
29	84	59.19373
29	85	59.18588
29	86	59.18499
29	87	59.17294
29	88	59.1665
29	89	59.16397
29	90	59.14956
29	91	59.1395
29	92	59.13988
29	93	59.13126
29	94	59.12457
29	95	59.1221
29	96	59.11427
29	97	59.11192
29	98	59.10967
29	99	59.10406
29	100	59.10065

設定 $\mu_0 = 59.5$, $(K, H) = (0.25\sigma, 8\sigma)$ 時，繪出 Tabular CUSUM chart。

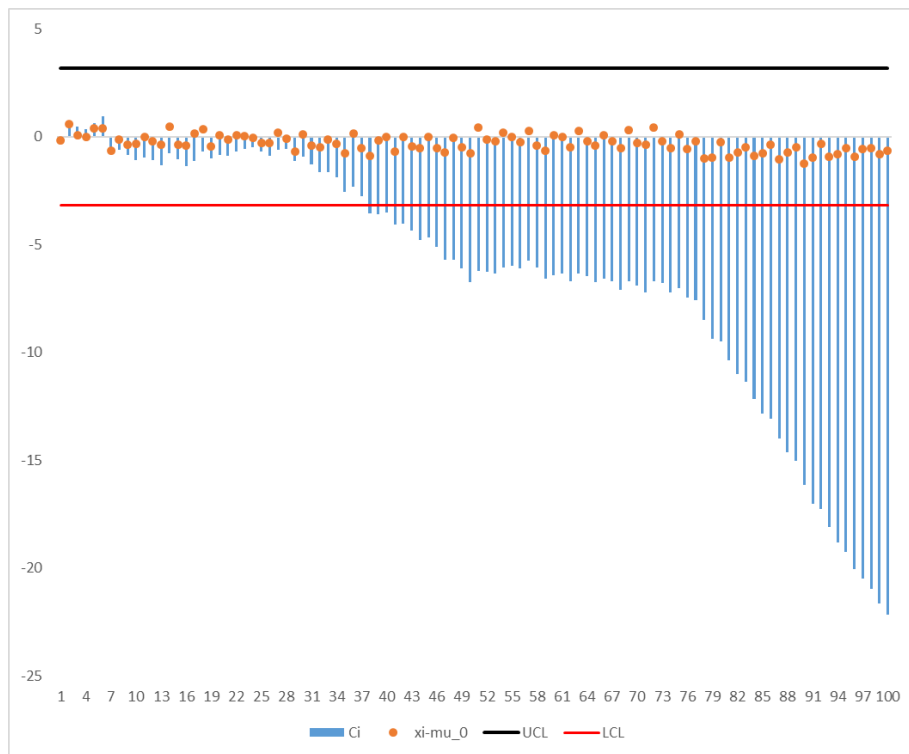
其中， $C_i^+ = \max[0, x_i - (\mu_0 + K) + C_{i-1}^+]$ ， $C_i^- = \max[0, (\mu_0 - K) + x_i + C_{i-1}^-]$ 。分別計算 C^+ 與 C^- 後，紀錄 C^+ 及 C^- 不為 0 時的累進次數。結果如圖表所示：

		a		b	
		$x - (\mu_0 + K)$	N+	$(\mu_0 - K) - x_i$	N-
1	59.3353	0	0	0.06547977	1

2	60.0777	0.478479766	1	0	0
3	59.5779	0.457159532	2	0	0
4	59.511	0.368939297	3	0	0
5	59.8724	0.642119063	4	0	0
6	59.8892	0.932098829	5	0	0
7	58.8379	0.170778595	6	0.56287977	1
8	59.3544	0	0	0.60925953	2
9	59.1502	0	0	0.8598393	3
10	59.1907	0	0	1.06991906	4
11	59.5104	0	0	0.96029883	5
12	59.2832	0	0	1.07787859	6
13	59.147	0	0	1.33165836	7
14	59.9744	0.375179766	1	0.75803813	8
15	59.1201	0	0	1.03871789	9
16	59.0737	0	0	1.36579766	10
17	59.6342	0.034979766	1	1.13237742	11
18	59.8446	0.280359532	2	0.68855719	12
19	59.0719	0	0	1.01743695	13
20	59.5767	0	0	0.84151672	14
21	59.3721	0	0	0.87019649	15
22	59.5891	0	0	0.68187625	16
23	59.5301	0	0	0.55255602	17
24	59.455	0	0	0.49833578	18
25	59.2296	0	0	0.66951555	19
26	59.1992	0	0	0.87109532	20
27	59.676	0.076779766	1	0.59587508	21
28	59.4284	0	0	0.56825485	22
29	58.8267	0	0	1.14233461	23
30	59.6014	0.002179766	1	0.94171438	24
31	59.0748	0	0	1.26769414	25
32	59.0265	0	0	1.64197391	26
33	59.3883	0	0	1.65445368	27
34	59.1644	0	0	1.89083344	28
35	58.7204	0	0	2.57121321	29
36	59.6401	0.040879766	1	2.33189297	30
37	58.9894	0	0	2.74327274	31
38	58.5957	0	0	3.5483525	32

39	59.3492	0	0	3.59993227	33
40	59.4928	0	0	3.50791204	34
41	58.8212	0	0	4.0874918	35
42	59.4729	0	0	4.01537157	36
43	59.0518	0	0	4.36435133	37
44	58.9922	0	0	4.7729311	38
45	59.5009	0	0	4.67281086	39
46	58.9603	0	0	5.11329063	40
47	58.7914	0	0	5.7226704	41
48	59.4339	0	0	5.68955016	42
49	58.9976	0	0	6.09272993	43
50	58.7464	0	0	6.74710969	44
51	59.9318	0.332579766	1	6.21608946	45
52	59.3683	0.101659532	2	6.24856922	46
53	59.3023	0	0	6.34704899	47
54	59.6791	0.079879766	1	6.06872876	48
55	59.5004	0	0	5.96910852	49
56	59.271	0	0	6.09888829	50
57	59.7689	0.169679766	1	5.73076805	51
58	59.0864	0	0	6.04514782	52
59	58.8502	0	0	6.59572758	53
60	59.5783	0	0	6.41820735	54
61	59.4813	0	0	6.33768712	55
62	59.0168	0	0	6.72166688	56
63	59.7628	0.163579766	1	6.35964665	57
64	59.3005	0	0	6.45992641	58
65	59.1009	0	0	6.75980618	59
66	59.5877	0	0	6.57288595	60
67	59.2878	0	0	6.68586571	61
68	58.9763	0	0	7.11034548	62
69	59.8016	0.202379766	1	6.70952524	63
70	59.1938	0	0	6.91650501	64
71	59.1142	0	0	7.20308477	65
72	59.9152	0.315979766	1	6.68866454	66
73	59.3034	0.020159532	2	6.78604431	67
74	58.9596	0	0	7.22722407	68
75	59.6117	0.012479766	1	7.01630384	69

76	58.9508	0	0	7.4662836	70
77	59.2793	0	0	7.58776337	71
78	58.5014	0	0	8.48714313	72
79	58.5154	0	0	9.3725229	73
80	59.2709	0	0	9.50240267	74
81	58.5411	0	0	10.3620824	75
82	58.7597	0	0	11.0031622	76
83	59.0211	0	0	11.382842	77
84	58.6203	0	0	12.1633217	78
85	58.7463	0	0	12.8178015	79
86	59.1347	0	0	13.0838813	80
87	58.4741	0	0	14.010561	81
88	58.786	0	0	14.6253408	82
89	59.0125	0	0	15.0136206	83
90	58.2705	0	0	16.1439003	84
91	58.5158	0	0	17.0288801	85
92	59.1637	0	0	17.2659599	86
93	58.58	0	0	18.0867396	87
94	58.6896	0	0	18.7979194	88
95	58.9586	0	0	19.2400992	89
96	58.5898	0	0	20.0510789	90
97	58.9525	0	0	20.4993587	91
98	58.954	0	0	20.9461384	92
99	58.7117	0	0	21.6352182	93
100	58.8586	0	0	22.177398	94



start sample	end sample	new process mean
7	41	59.28989
7	41	59.29169
7	41	59.29761
7	41	59.28399
7	42	59.28924
7	43	59.28282
7	44	59.27518
7	45	59.28096
7	46	59.27295
7	47	59.2612
7	48	59.26531
7	49	59.25909
7	50	59.24744
7	51	59.26264
7	52	59.26494
7	53	59.26574
7	54	59.27435

7	55	59.27896
7	56	59.2788
7	57	59.28841
7	58	59.28453
7	59	59.27633
7	60	59.28192
7	61	59.28555
7	62	59.28075
7	63	59.28921
7	64	59.2894
7	65	59.28621
7	66	59.29123
7	67	59.29118
7	68	59.2861
7	69	59.29428
7	70	59.29271
7	71	59.28996
7	72	59.29944
7	73	59.2995
7	74	59.2945
7	75	59.29909
7	76	59.29412
7	77	59.29391
7	78	59.2829
7	79	59.27239
7	80	59.27237
7	81	59.26262
7	82	59.256
7	83	59.25295
7	84	59.24484
7	85	59.23853
7	86	59.23723
7	87	59.22781
7	88	59.22242
7	89	59.21989
7	90	59.20859
7	91	59.20044

7	92	59.20001
7	93	59.19289
7	94	59.18717
7	95	59.1846
7	96	59.17799
7	97	59.17551
7	98	59.1731
7	99	59.16814
7	100	59.16485