Control Chart Examples

X -bar and R chart

The measurements represent the thickness of a certain part. The numbers recorded are the amount by which the part exceeded 0.300 inches.

	thicknesses					
subgroup	----------				averages	ranges
1	1	4	6	4	3.75	5
2	3	7	5	5	5	4
3	4	5	5	7	5.25	3
4	6	2	4	5	4.25	4
5	1	6	7	3	4.25	6
6	8	3	6	4	5.25	5
7	7	5	6	6	6	2
8	5	3	4	6	4.5	3
9	4	5	9	2	5	7
10	7	5	6	5	5.75	2
11	4	5	6	5	5	2
12	6	7	8	5	6.5	3
13	3	3	7	3	4	4
14	6	3	2	9	5	7
15	7	3	4	3	4.25	4
16	6	4	6	5	5.25	2
17	5	5	0	5	3.75	5
18	6	4	6	3	4.75	3
19	6	4	4	0	3.5	6
20	6	2	5	4	4.25	4
					4.7625	4.05

X-bar

UCL and UCL =

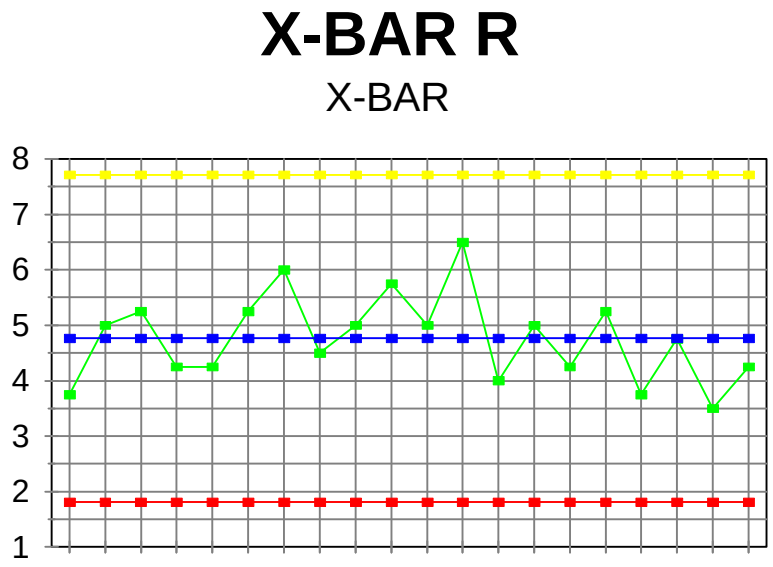
X-dbl bar +/- A_2 * R-bar

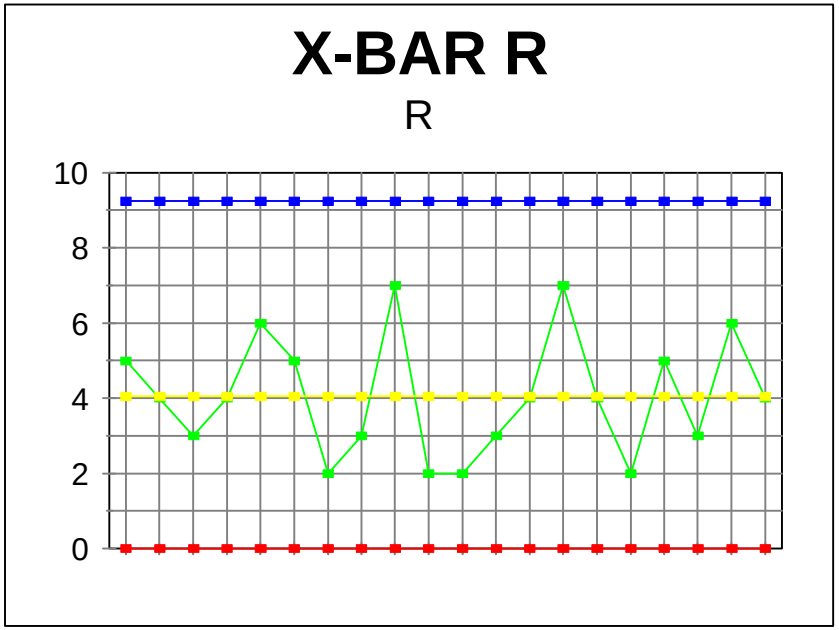
= 1.811 and 7.715

R chart

LCL = D_3 * R-bar = 0

UCL = D_4 * R-bar = 9.242





 Source: Understanding Statistical Process Control by Wheeler and Chambers

Individuals - Moving Range

The number of premium shipments:

One plant receives about 1000 shipments per month. Some of these shipments are handled as premium frieght, at a considerably greater expense.

The counts do not provide a fair comparison; therefore, percentages will be used.

number	percent
619	35.9
451	37.6
335	35.5
374	23.2
227	22.6
316	29.1
278	19.1
359	21.2
445	22.6
496	20.2
161	28.8
232	20.7
352	23.3
277	19.9
252	18.2
229	21.4
239	19.6
274	19.6
324	23.4
268	27.7
361	25.3
487	24.7
290	26.5
535	29.3
654	32.2
506	36.4
588	30.2
714	30.7
480	34.3

table 10.1	I-MR CHART		
premium	shipments		
number	percent	MR	
619	35.9		
451	37.6	1.7	
335	35.5	2.1	
374	23.2	12.3	
227	22.6	0.6	
316	29.1	6.5	
278	19.1	10	
359	21.2	2.1	
445	22.6	1.4	
496	20.2	2.4	
161	28.8	8.6	
232	20.7	8.1	
352	23.3	2.6	
277	19.9	3.4	
252	18.2	1.7	
229	21.4	3.2	
239	19.6	1.8	
274	19.6	0	
324	23.4	3.8	
268	27.7	4.3	
361	25.3	2.4	
487	24.7	0.6	
290	26.5	1.8	
535	29.3	2.8	
654	32.2	2.9	
506	36.4	4.2	
588	30.2	6.2	
714	30.7	0.5	
480	34.3	3.6	
	26.179	3.629	<-AVG
		3.216819	<-STDD

Average MR / d_2 = std dev
= 3.63/1.128 = 3.22

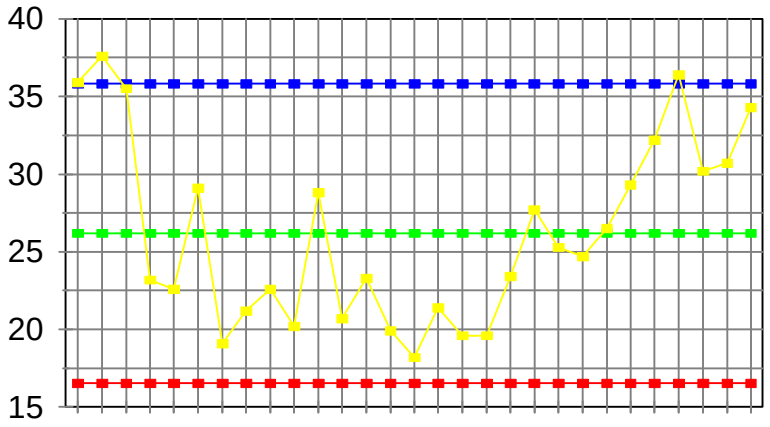
Average of percentages = 26.18

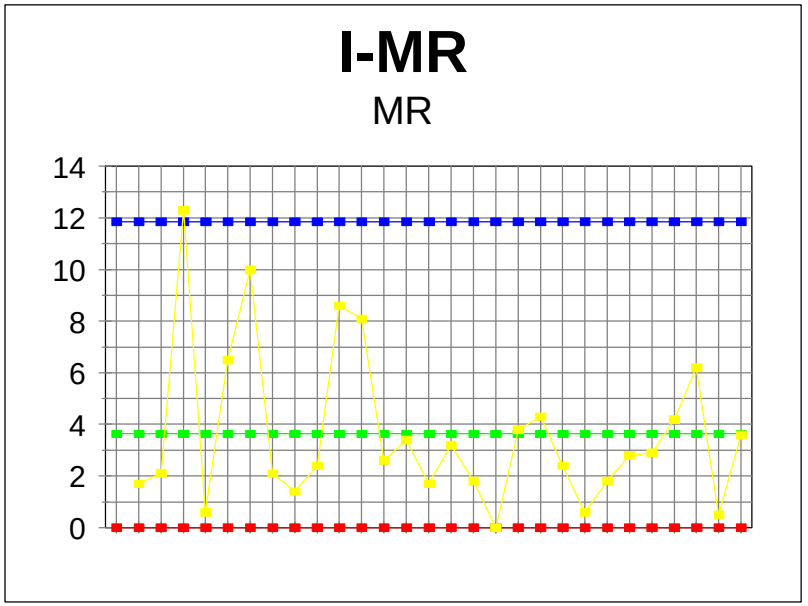
Individual limits =
Average +/- 3* std dev
26.18 +/- 9.66 = 16.52 to 35.84

Moving ranges
UCL = Avg MR * D_4 = 11.86

INDIVIDUALS

I-MR





 Source: Understanding Statistical Process Control by Wheeler and Chambers

Charts based on binomial counts

Conditions:

- The area of opportunity for count Y must consist of n distinct items.
- Each of the n items must be classified as either possessing or not possessing some attribute.
- The count is the number of items possessing the attribute.
- The occurences are independent.

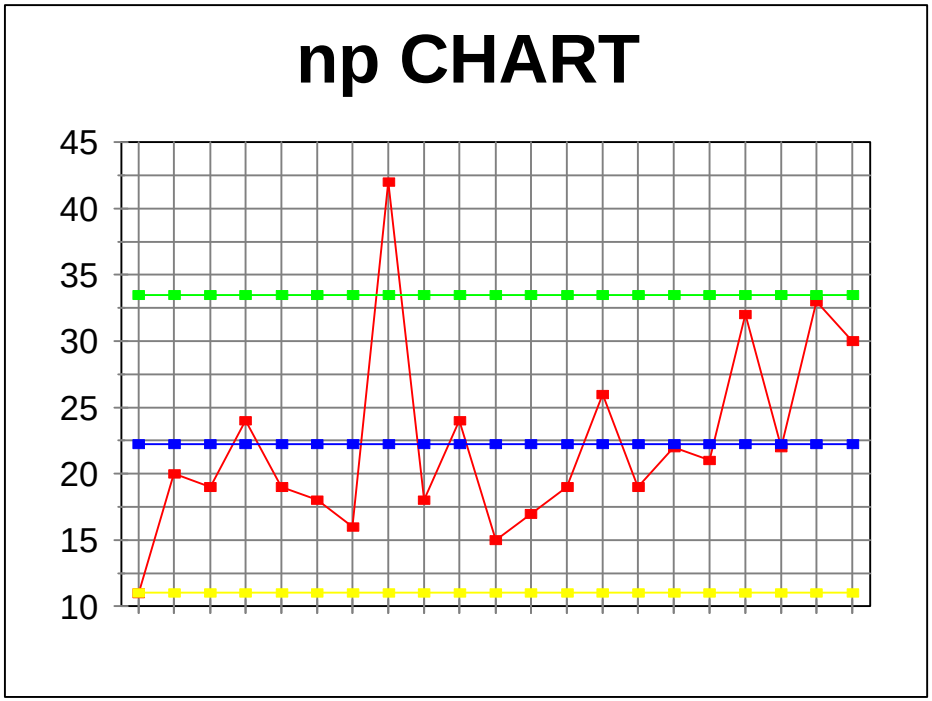
np-Chart

The number of rejected parts per basket:

At one inspect and pack operation an np chart was kept as follows. Twice each shift a clerk came by the station. the clerk watched while sixty consecutive parts came to the operator. Each time the operator placed a part on the rework line the reason was called out. The sixty pieces constitute a subgroup. The number rejected is the count.

Data for rejected parts subgroups

subgroup	count
1	11
2	20
3	19
4	24
5	19
6	18
7	16
8	42
9	18
10	24
11	15
12	17
13	19
14	26
15	19
16	22
17	21
18	32
19	22
20	33
21	30
SUM	467
P BAR	0.3706
NP	22.24



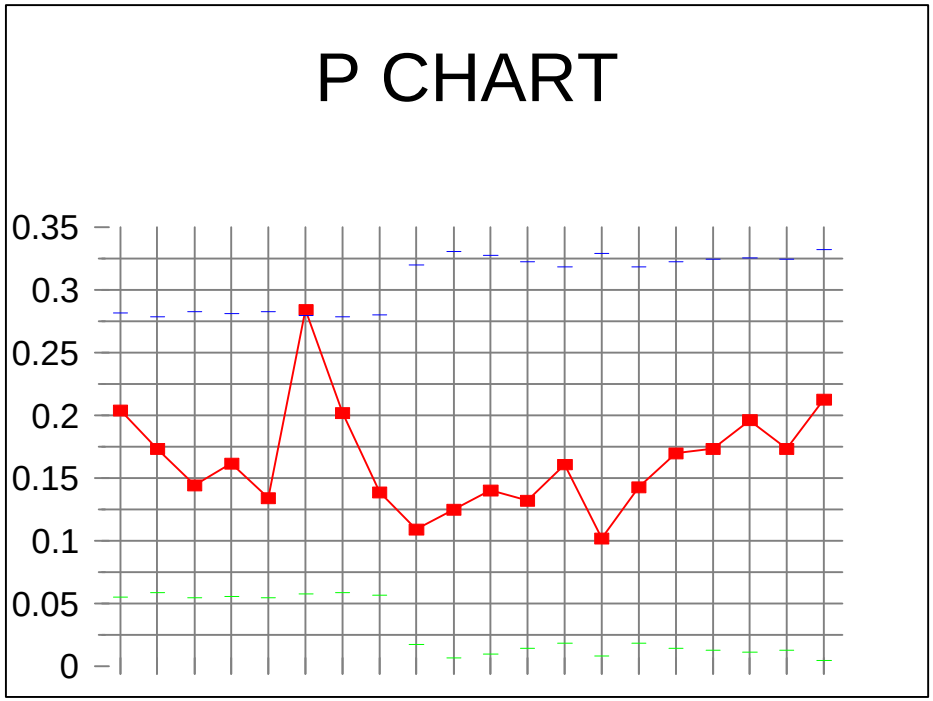
Limits are: n p-bar +/- 3 * sqrt [n p-bar (1 - p-bar)]

p-Chart

Incomplete invoices:

Invoices entered into a computerized system must have all information included on the invoice. An invoice without everything was assigned to an incomplete file. Since an unequal number arrive each day, one must compare rates rather than counts.

date	num_incompl	total num	Pi
09/27	20	98	0.204
09/28	18	104	0.173
09/29	14	97	0.144
09/30	16	99	0.162
10/01	13	97	0.134
10/04	29	102	0.284
10/05	21	104	0.202
10/06	14	101	0.139
10/07	6	55	0.109
10/08	6	48	0.125
10/11	7	50	0.140
10/12	7	53	0.132
10/13	9	56	0.161
10/14	5	49	0.102
10/15	8	56	0.143
10/18	9	53	0.170
10/19	9	52	0.173
10/20	10	51	0.196
10/21	9	52	0.173
10/22	10	47	0.213
SUM	240	1424	
P-BAR	0.168539326		



Limits = p-bar +/- 3 * sqrt [(p-bar * 1- p-bar) / n_i]

 Source: Understanding Statistical Process Control by Wheeler and Chambers

Charts for data based on Poisson counts

Conditions:

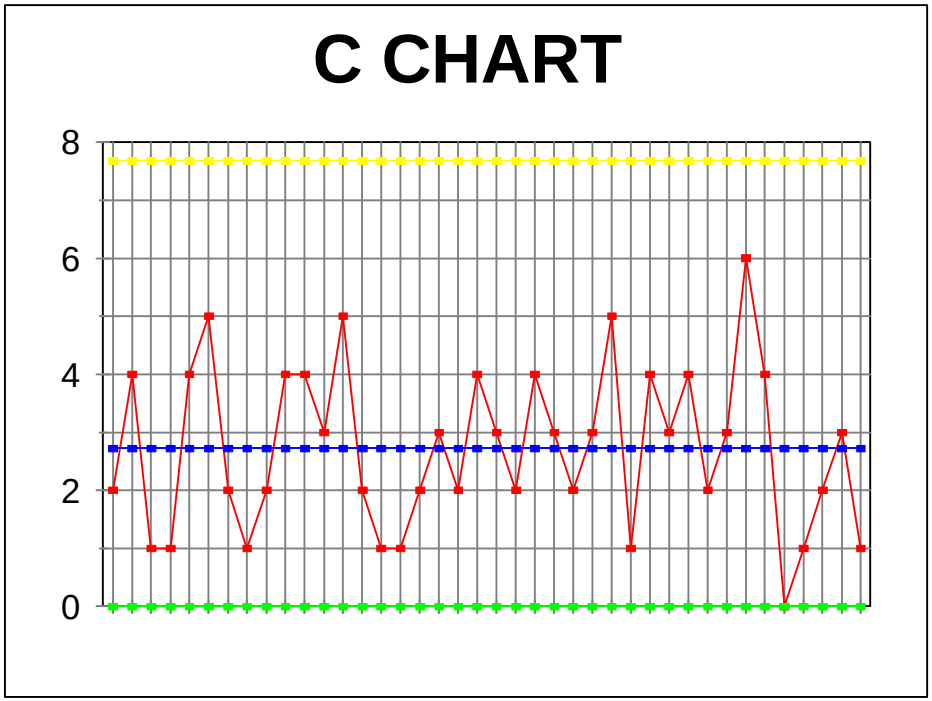
- The counts enumerate discrete events.
- The discrete events occur within some well-defined finite region of space, time or product. This is the area of opportunity for the count.
- The events occur independently of each other.
- The events are rare (compared to what might be).

c Chart

Blemishes per sample:

A certain process produced a sheet of vinyl 30 inches wide. A two-yard sample from the end of each roll was examined for blemishes, and the results recorded.

piece num	counts
1	2
2	4
3	1
4	1
5	4
6	5
7	2
8	1
9	2
10	4
11	4
12	3
13	5
14	2
15	1
16	1
17	2
18	3
19	2
20	4
21	3
22	2
23	4
24	3
25	2
26	3
27	5
28	1
29	4
30	3
31	4
32	2
33	3
34	6
35	4
36	0
37	1
38	2
39	3
40	1
SUM	109
C-BAR	2.725



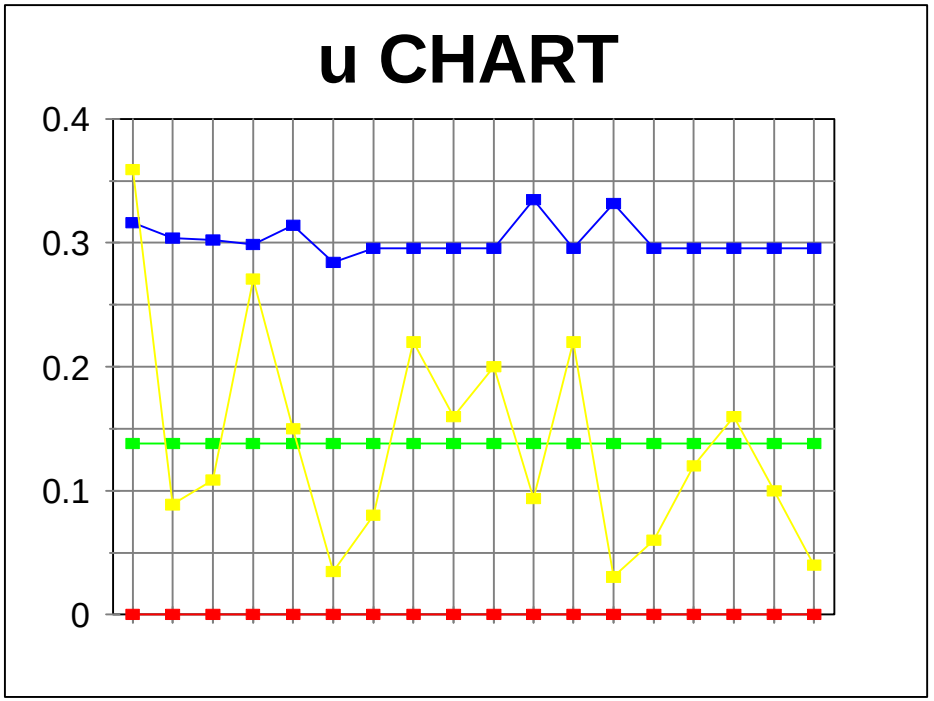
Limits = c-bar +/- 3 * sqrt (c-bar)

u Chart

Radiator leaks:

The following data was recorded for the number of outlet leaks found when two portions of an automobile radiator are assembled together for the first time.

date	leaks	num rad	rate
03-Jun	14	39	0.36
04-Jun	4	45	0.09
05-Jun	5	46	0.11
06-Jun	13	48	0.27
09-Jun	6	40	0.15
10-Jun	2	58	0.03
11-Jun	4	50	0.08
12-Jun	11	50	0.22
13-Jun	8	50	0.16
16-Jun	10	50	0.20
17-Jun	3	32	0.09
18-Jun	11	50	0.22
19-Jun	1	33	0.03
20-Jun	3	50	0.06
23-Jun	6	50	0.12
24-Jun	8	50	0.16
25-Jun	5	50	0.10
26-Jun	2	50	0.04
SUM	116	841	
U BAR	0.138		



Limits = u-bar +/- 3 * sqrt [u-bar / area of opportunity $_i$]

 Source: Understanding Statistical Process Control by Wheeler and Chambers