

# ass.R

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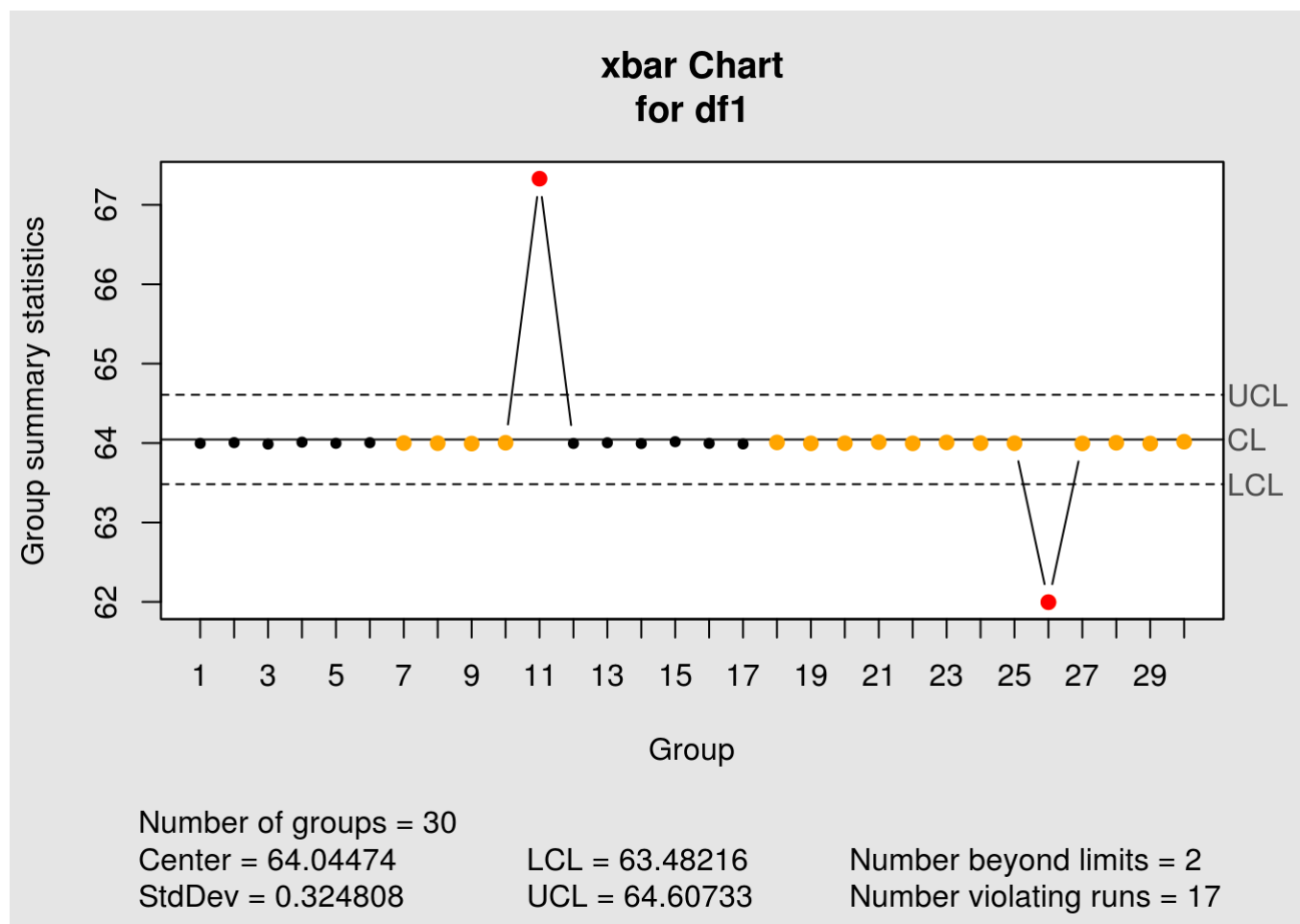
```
library(readxl)
df1=read_excel("Assignment.xlsx", sheet=1)
df2=read_excel("Assignment.xlsx", sheet=2)
df3=read_excel("Assignment.xlsx", sheet=3)
```

```
library(qcc)
```

```
## Package 'qcc', version 2.6
```

```
## Type 'citation("qcc")' for citing this R package in publications.
```

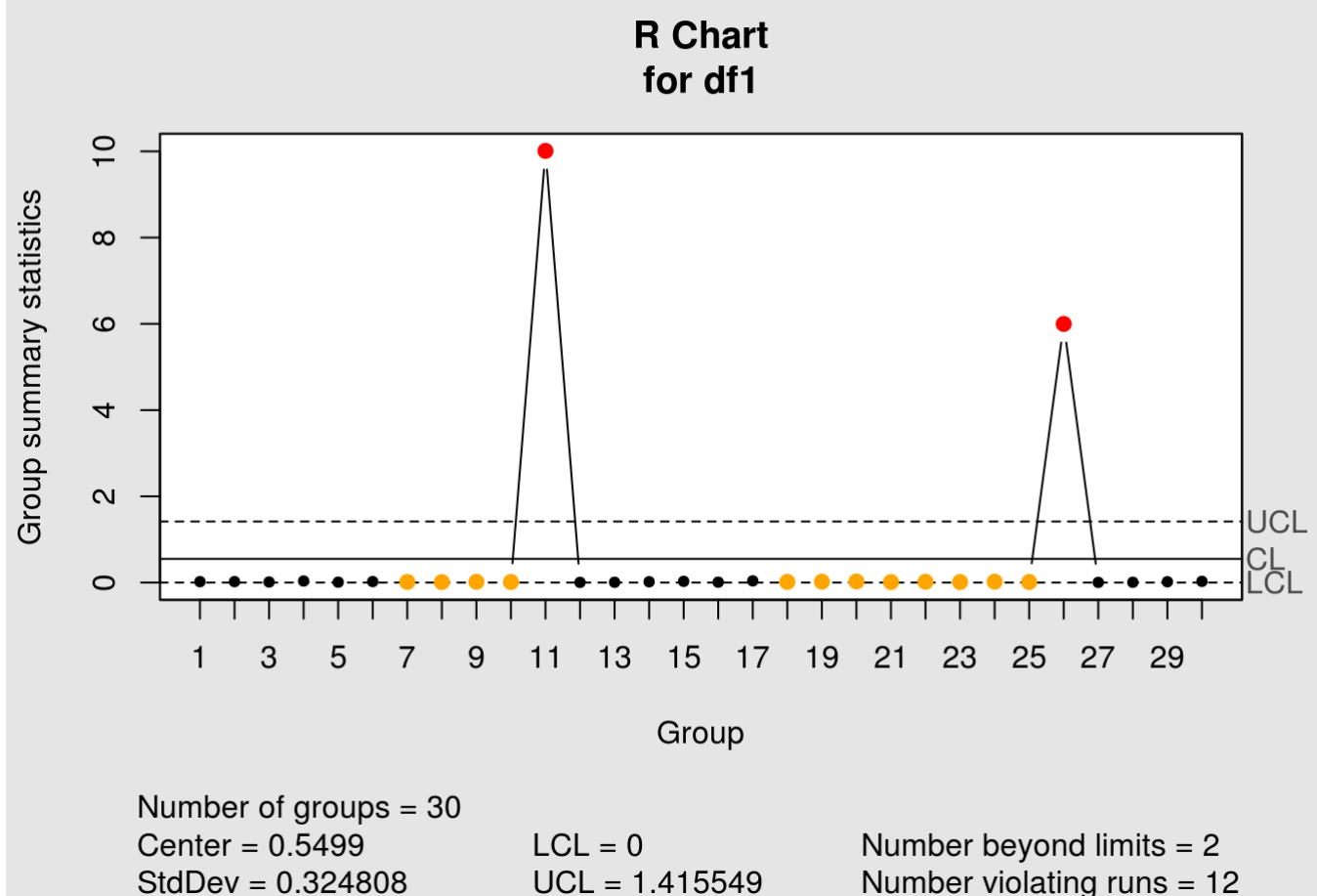
```
### Question1
# Control limits and control charts
obj1 <- qcc(df1, type = "xbar")
```



```
summary(obj1)
```

```
##
## Call:
## qcc(data = df1, type = "xbar")
##
## xbar chart for df1
##
## Summary of group statistics:
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 62.00   64.00   64.00   64.04   64.01   67.33
##
## Group sample size: 3
## Number of groups: 30
## Center of group statistics: 64.04474
## Standard deviation: 0.324808
##
## Control limits:
##      LCL      UCL
## 63.48216 64.60733
```

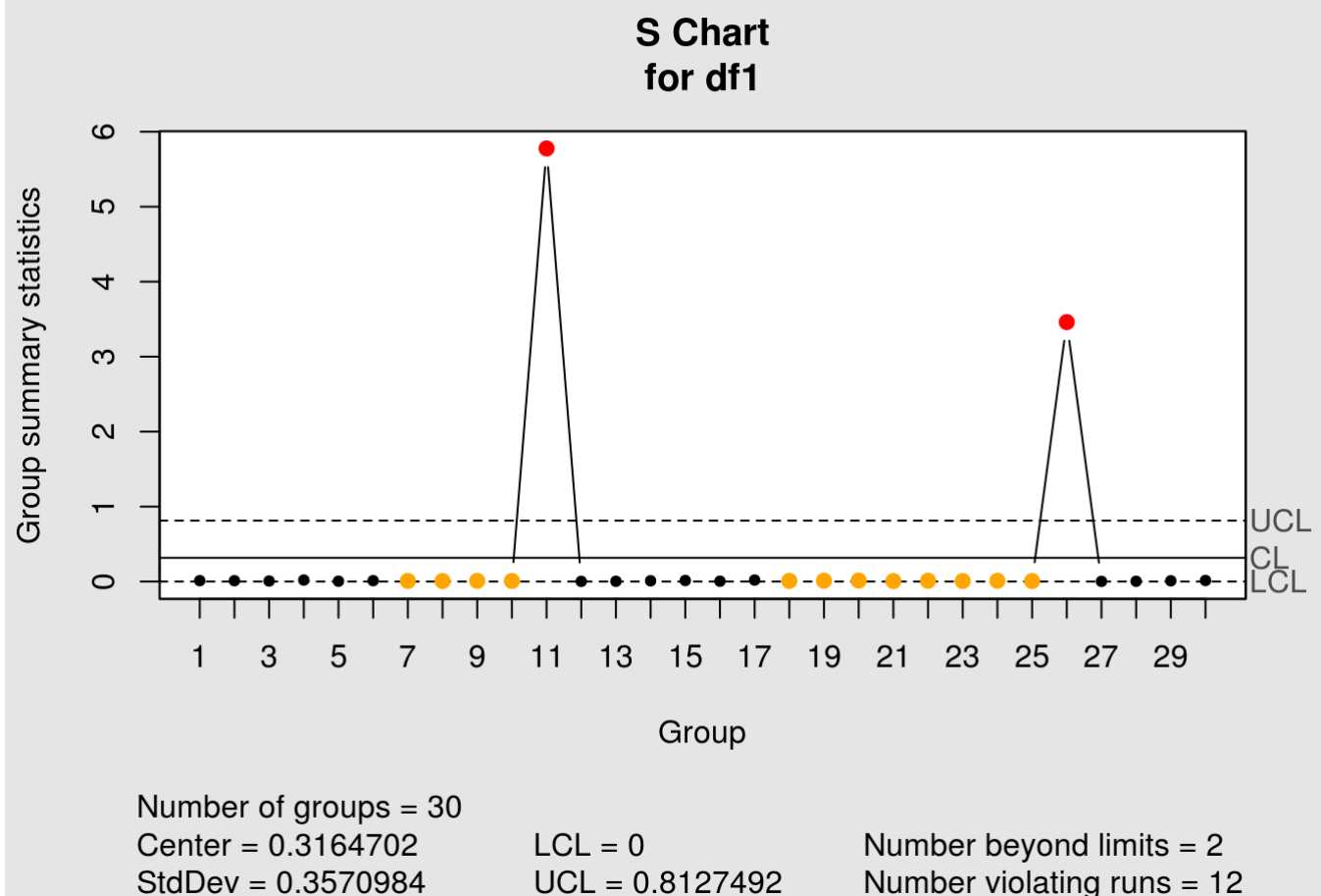
```
obj2 <- qcc(df1, type = "R")
```



```
summary(obj2)
```

```
##
## Call:
## qcc(data = df1, type = "R")
##
## R chart for df1
##
## Summary of group statistics:
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.00400 0.01225 0.01850 0.54990 0.02275 10.01000
##
## Group sample size: 3
## Number of groups: 30
## Center of group statistics: 0.5499
## Standard deviation: 0.324808
##
## Control limits:
## LCL      UCL
## 0 1.415549
```

```
obj3 <- qcc(df1, type = "S")
```

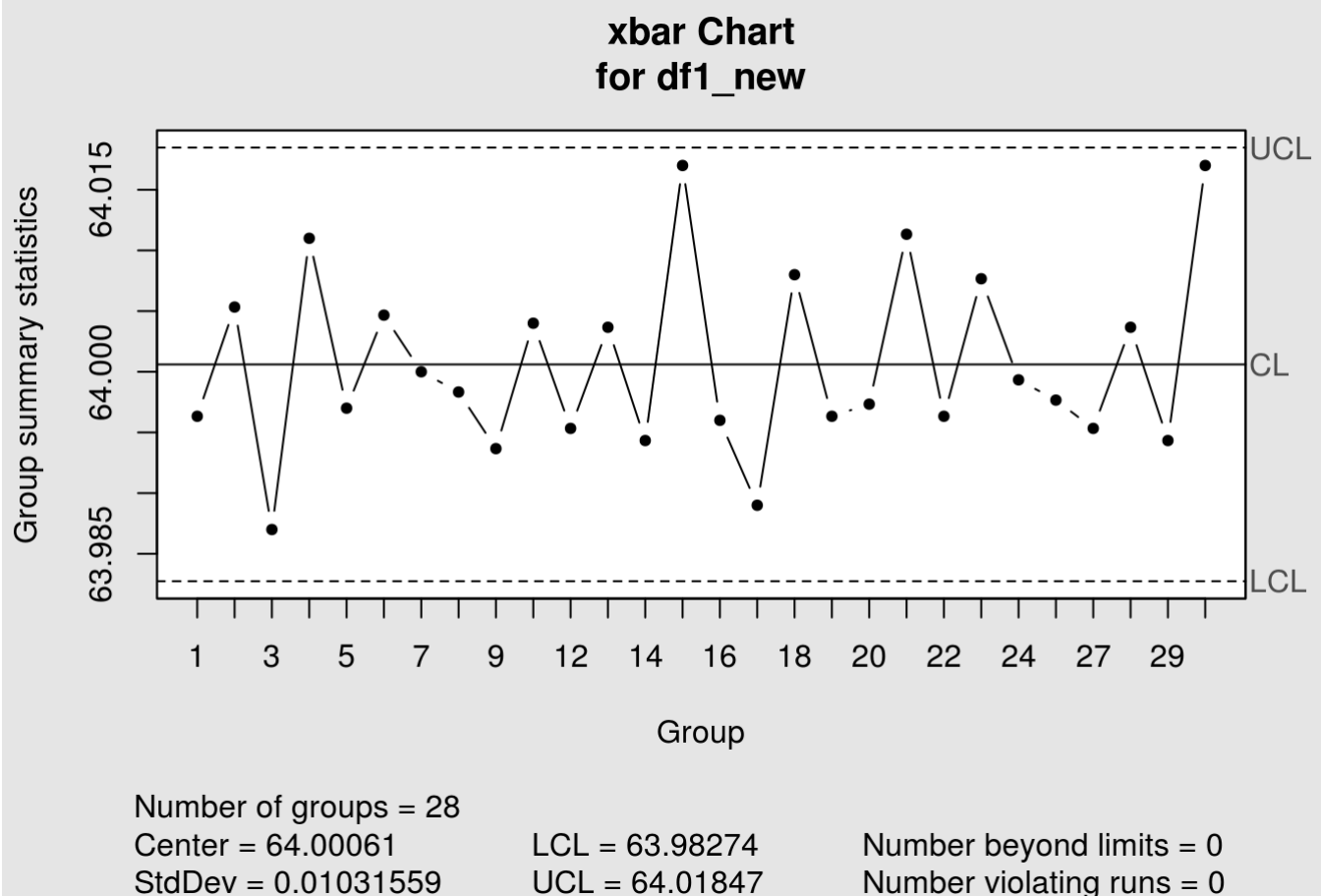


```
summary(obj3)
```

```
##
## Call:
## qcc(data = df1, type = "S")
##
## S chart for df1
##
## Summary of group statistics:
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.002309 0.006695 0.009518 0.316500 0.011800 5.777000
##
## Group sample size: 3
## Number of groups: 30
## Center of group statistics: 0.3164702
## Standard deviation: 0.3570984
##
## Control limits:
##  LCL      UCL
##    0 0.8127492
```

```
# No, the process is not under control.
# Out of control subgroups are 11 and 26.
# Elimination of control points:
df1_new=df1[-c(11,26),]

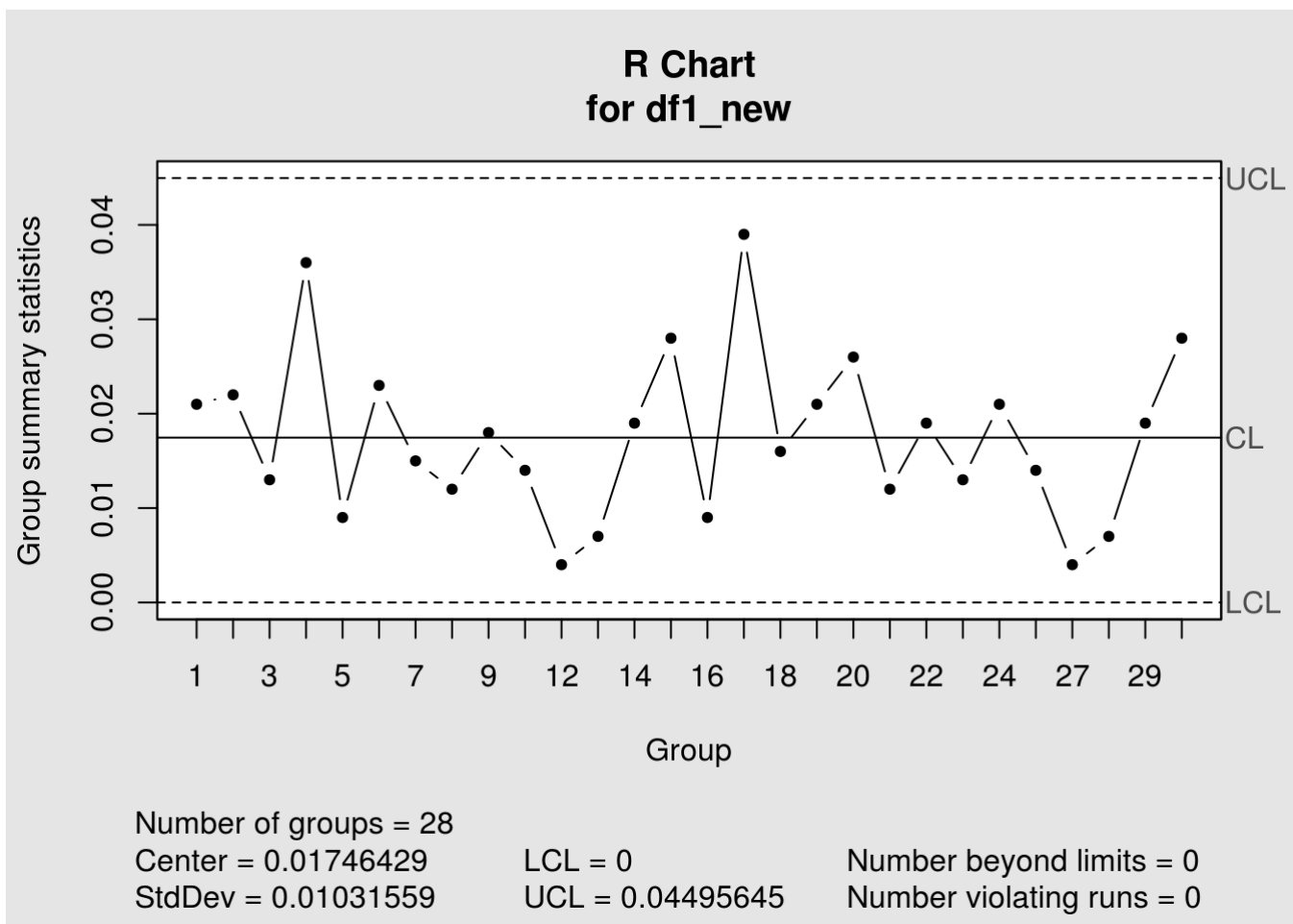
# Revised control limits and control charts
obj4 <-qcc(df1_new,type ="xbar")
```



```
summary(obj4)
```

```
##
## Call:
## qcc(data = df1_new, type = "xbar")
##
## xbar chart for df1_new
##
## Summary of group statistics:
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 63.99   64.00   64.00   64.00   64.00   64.02
##
## Group sample size: 3
## Number of groups: 28
## Center of group statistics: 64.00061
## Standard deviation: 0.01031559
##
## Control limits:
##      LCL      UCL
## 63.98274 64.01847
```

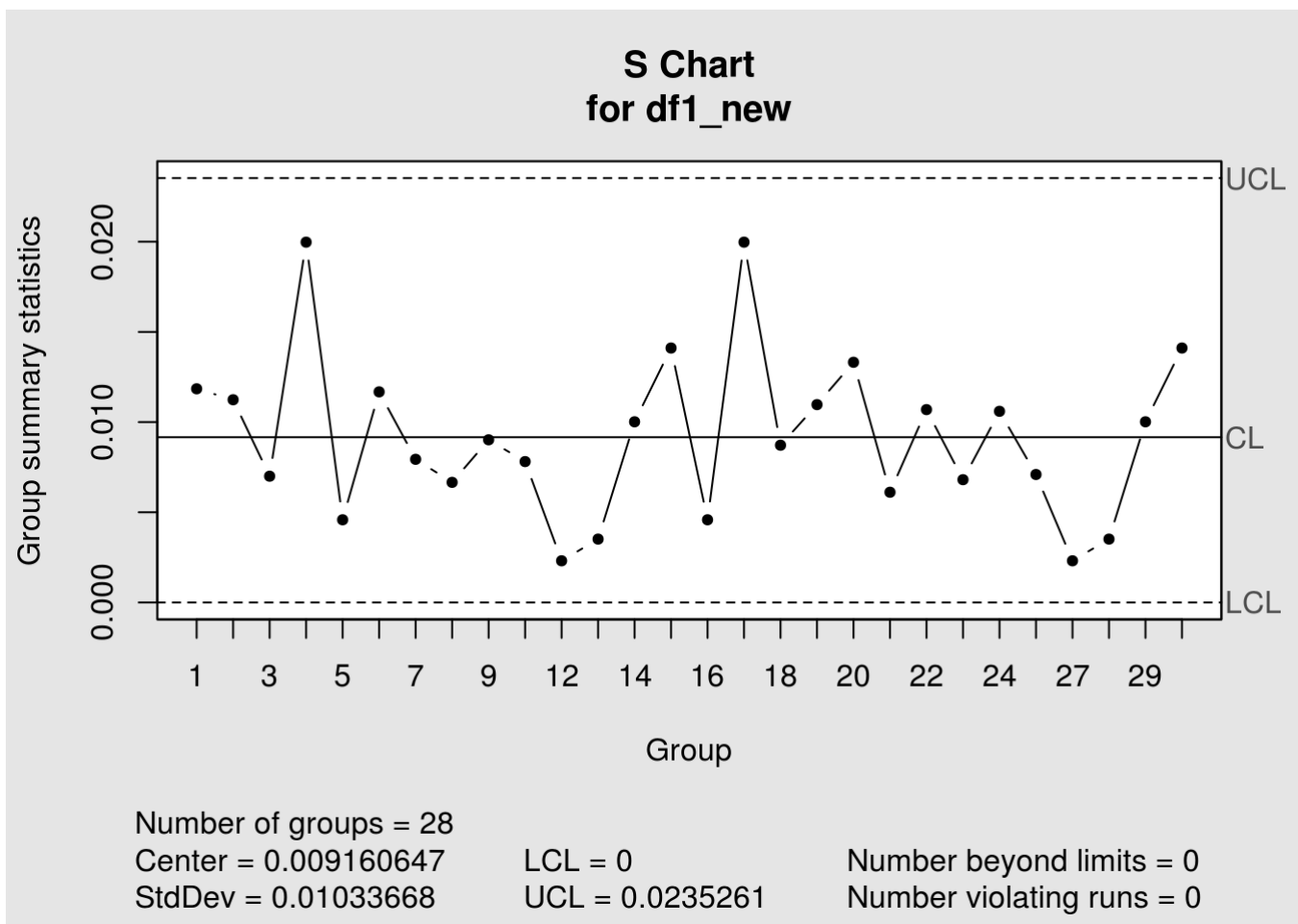
```
obj5 <- qcc(df1_new, type = "R")
```



```
summary(obj5)
```

```
##
## Call:
## qcc(data = df1_new, type = "R")
##
## R chart for df1_new
##
## Summary of group statistics:
##   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.00400 0.01200 0.01700 0.01746 0.02125 0.03900
##
## Group sample size: 3
## Number of groups: 28
## Center of group statistics: 0.01746429
## Standard deviation: 0.01031559
##
## Control limits:
##   LCL          UCL
##   0 0.04495645
```

```
obj6 <- qcc(df1_new, type = "S")
```



```
summary(obj6)
```

```
##
## Call:
## qcc(data = dfl_new, type = "S")
##
## S chart for dfl_new
##
## Summary of group statistics:
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
## 0.002309 0.006521 0.008868 0.009161 0.011350 0.019970
##
## Group sample size: 3
## Number of groups: 28
## Center of group statistics: 0.009160647
## Standard deviation: 0.01033668
##
## Control limits:
##  LCL      UCL
##    0 0.0235261
```

```
# Estimation of mu and sigma
xbar=rowMeans(dfl_new)
n=3
mu=mean(xbar)
mu
```

```
## [1] 64.00061
```

```
sigma=var(xbar)*n
sigma
```

```
## [1] 0.0001724458
```

```
# Before removing out of control subgroups
xbar=rowMeans(dfl)
n=3
mu=mean(xbar)
mu
```

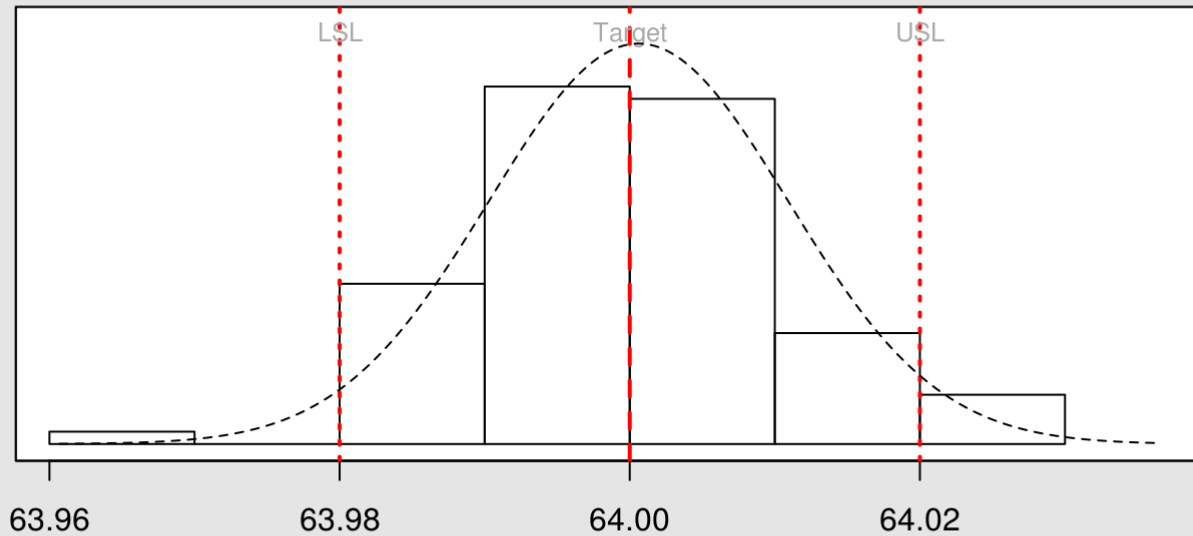
```
## [1] 64.04474
```

```
sigma=var(xbar)*n
sigma
```

```
## [1] 1.556067
```

```
# Process capability analysis
lsl=64-0.02
usl=64+0.02
process.capability(obj4,spec.limits=c(lsl,usl))
```

## Process Capability Analysis for df1\_new



Number of obs = 84	Target = 64	Cp = 0.646	Exp<LSL 2.3%
Center = 64.00061	LSL = 63.98	Cp_l = 0.666	Exp>USL 3%
StdDev = 0.01031559	USL = 64.02	Cp_u = 0.627	Obs<LSL 1.2%
		Cp_k = 0.627	Obs>USL 4.8%
		Cpm = 0.645	

```
##
## Process Capability Analysis
##
## Call:
## process.capability(object = obj4, spec.limits = c(lsl, usl))
##
## Number of obs = 84          Target = 64
##      Center = 64          LSL = 63.98
##      StdDev = 0.01032      USL = 64.02
##
## Capability indices:
##
##      Value      2.5%    97.5%
## Cp      0.6463  0.5481  0.7443
## Cp_l    0.6659  0.5619  0.7698
## Cp_u    0.6267  0.5268  0.7265
## Cp_k    0.6267  0.5076  0.7457
## Cpm     0.6452  0.5475  0.7426
##
## Exp<LSL 2.3%  Obs<LSL 1.2%
## Exp>USL 3%   Obs>USL 4.8%
```

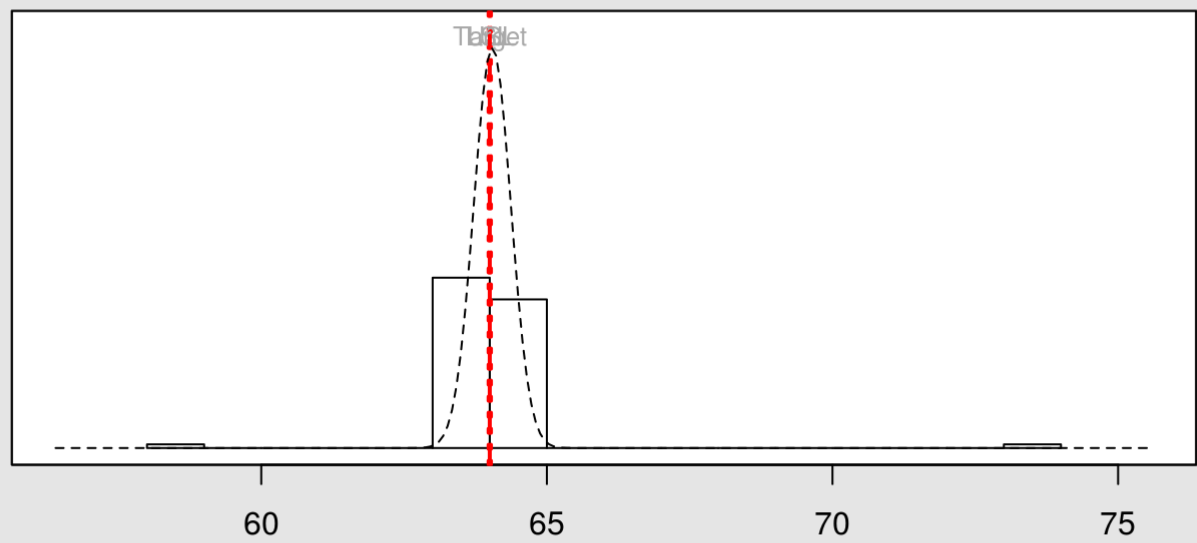
*# From graph, we note that Cp=0.646 and Cp\_k=0.627 after removing out of control subgroups.*

*# Hence the process is bound to produce rejections even when the mean is set on target.*

*# Before removing out of control subgroups*  
 process.capability(obj1,spec.limits=c(lsl,usl))



Process Capability Analysis  
for df1



Number of obs = 90	Target = 64	Cp = 0.0205	Exp<LSL 42%
Center = 64.04474	LSL = 63.98	Cp_l = 0.0664	Exp>USL 53%
StdDev = 0.324808	USL = 64.02	Cp_u = -0.0254	Obs<LSL 2.2%
		Cp_k = -0.0254	Obs>USL 5.6%
		Cpm = 0.0203	

```
##
## Process Capability Analysis
##
## Call:
## process.capability(object = obj1, spec.limits = c(lsl, usl))
##
## Number of obs = 90          Target = 64
##      Center = 64.04          LSL = 63.98
##      StdDev = 0.3248          USL = 64.02
##
## Capability indices:
##
##      Value      2.5%      97.5%
## Cp      0.02052  0.017513  0.02353
## Cp_l     0.06644  0.008072  0.12482
## Cp_u    -0.02539  0.032485 -0.08327
## Cp_k    -0.02539  0.043573 -0.09436
## Cpm      0.02033  0.017338  0.02332
##
## Exp<LSL 42%   Obs<LSL 2.2%
## Exp>USL 53%   Obs>USL 5.6%
```

```
# Cp=0.0205 and Cp_k=-0.0254
```

```
### Question2
```

```
# (a) x-bar control chart is good for such type of data.
```

```
# (b) Control limits and control charts
```

```
xbar=mean(df2$Q2)
```

```
xbar
```

```
## [1] 4.7
```

```
movingRange=vector("list", length=19)
```

```
for(i in 2:20){
```

```
  movingRange[i-1]=abs(df2$Q2[i]-df2$Q2[i-1])
```

```
}
```

```
movingRange=as.numeric(movingRange)
```

```
mrbar=mean(movingRange)
```

```
mrbar
```

```
## [1] 3.684211
```

```
d2=1.128
```

```
# Control chart for individuals
```

```
ucl=xbar + (3*mrbar)/d2
```

```
lcl=xbar - (3*mrbar)/d2
```

```
ucl
```

```
## [1] 14.49843
```

```
lcl
```

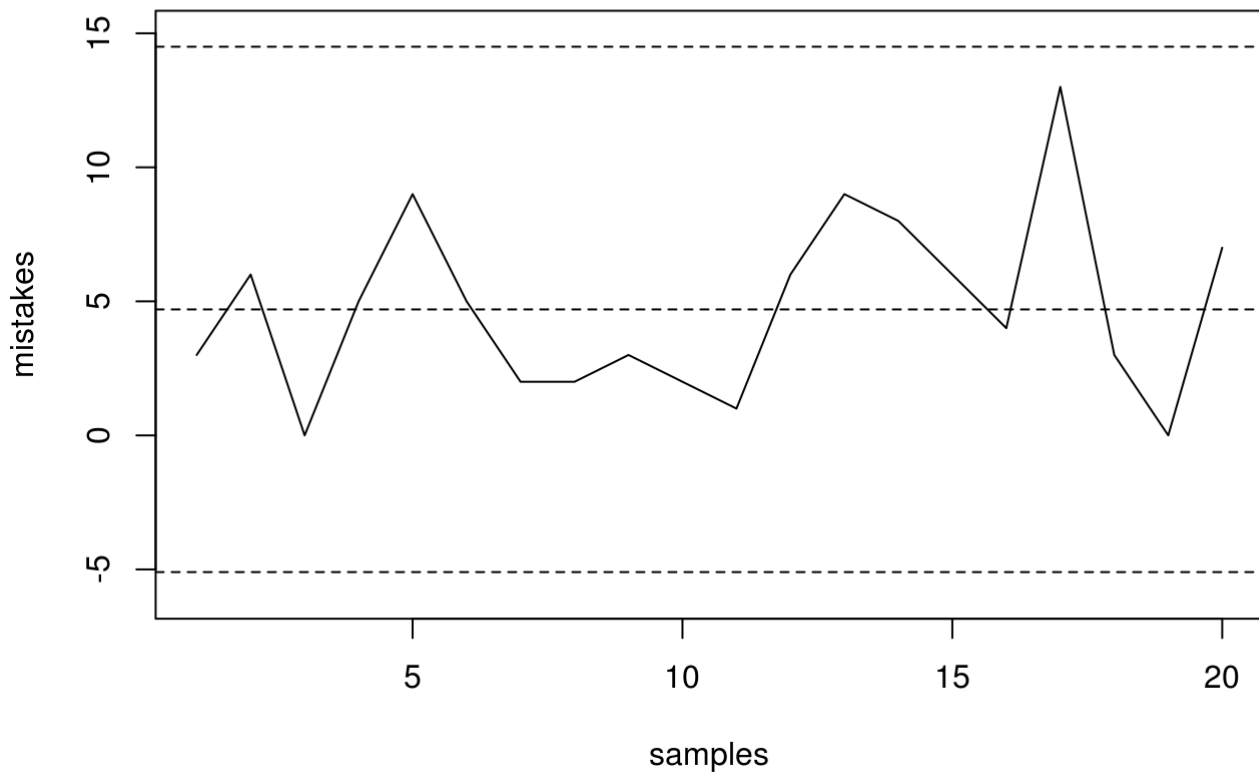
```
## [1] -5.098432
```

```
plot(df2$Q2,main="xbar control plot",xlab="samples",ylab="mistakes",type='l',
```

```
ylim=c(-6,15))
```

```
abline(h=c(xbar,lcl,ucl), lty=2)
```

## xbar control plot



```
# Control chart for moving ranges  
ucl=3.267*mrbar  
lcl=0  
ucl
```

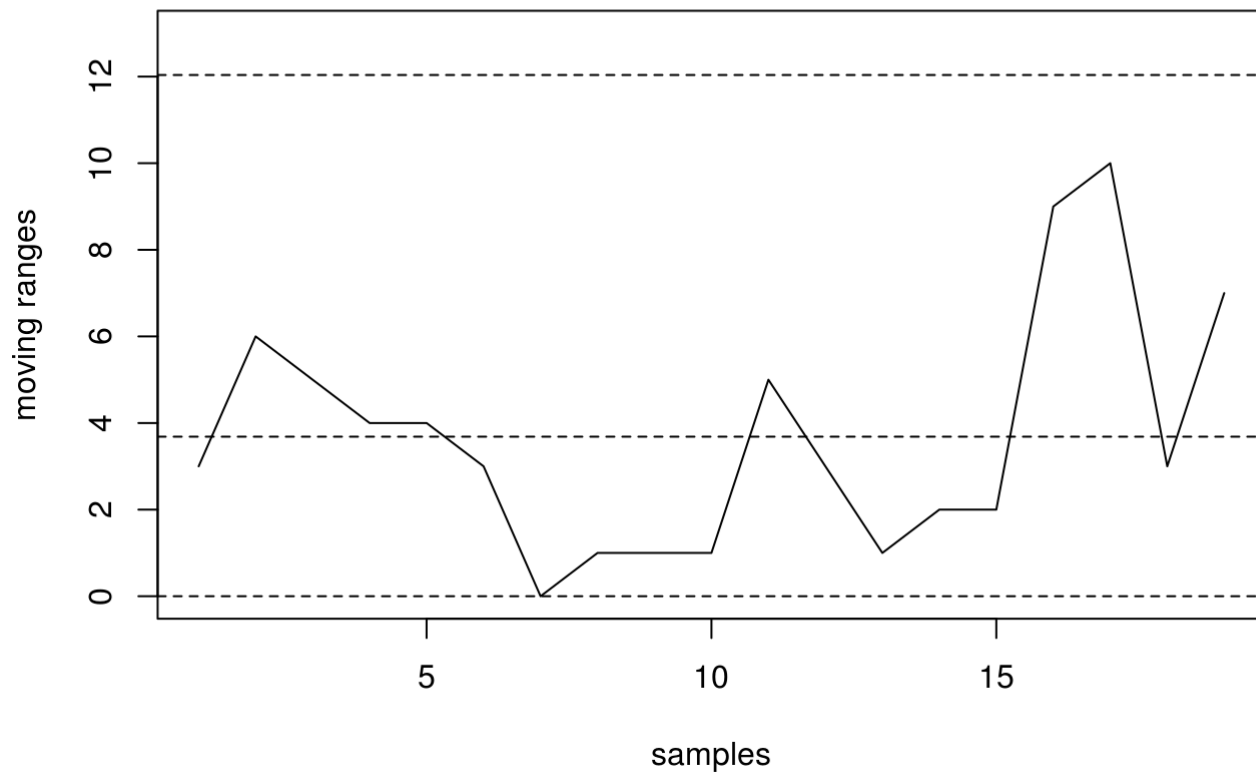
```
## [1] 12.03632
```

```
lcl
```

```
## [1] 0
```

```
plot(movingRange,main="moving ranges control plot",xlab="samples",ylab="moving range  
s",type='l', ylim=c(0,13))  
abline(h=c(mrbar,lcl,ucl), lty=2)
```

## moving ranges control plot



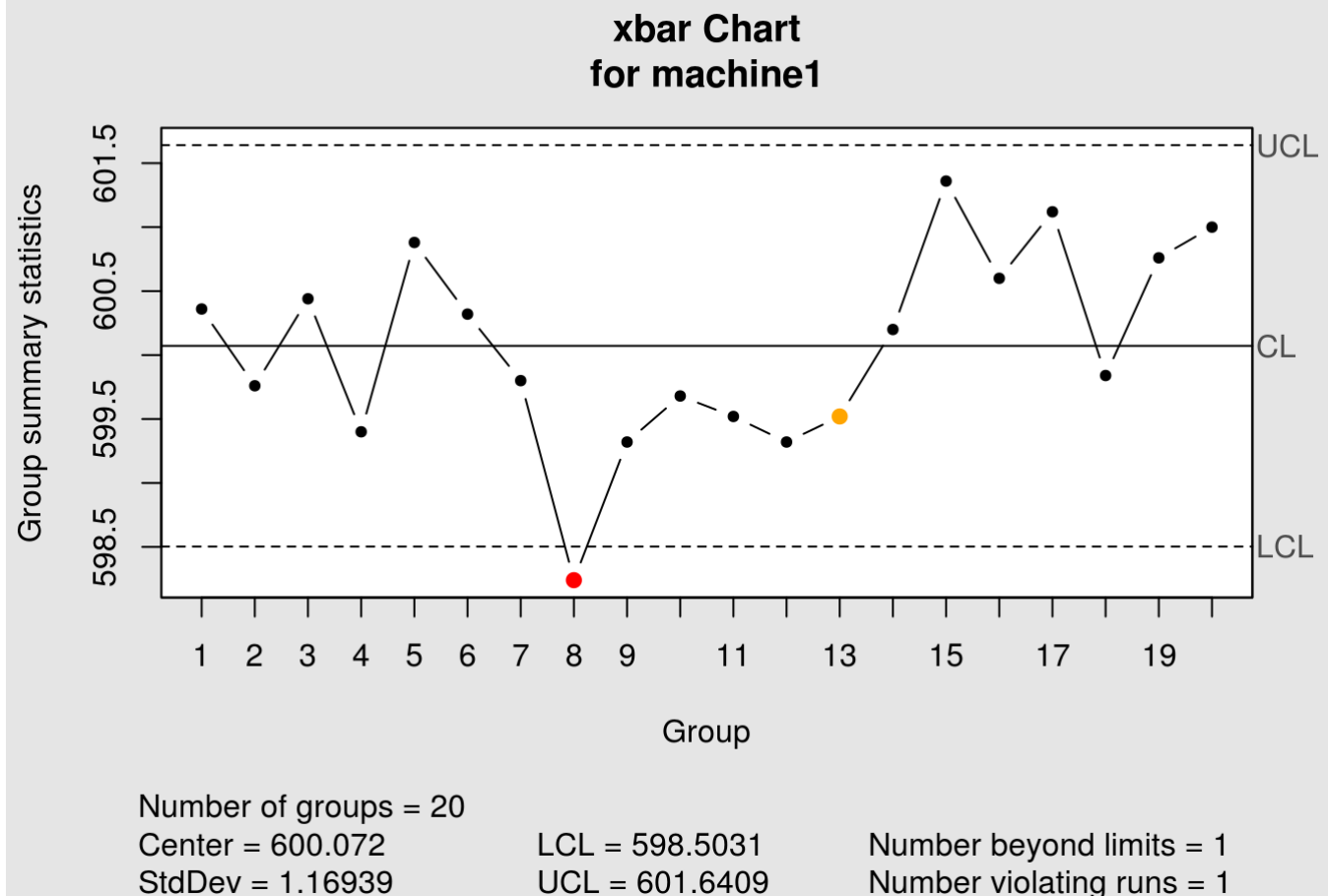
*# hence, the entire process is under control. There are no out of control points.*

### Question3

*# Control charts for machine1*

```
machine1<-qcc.groups(df3[,1],df3[,4])
```

```
obj1 <-qcc(machine1,type ="xbar")
```

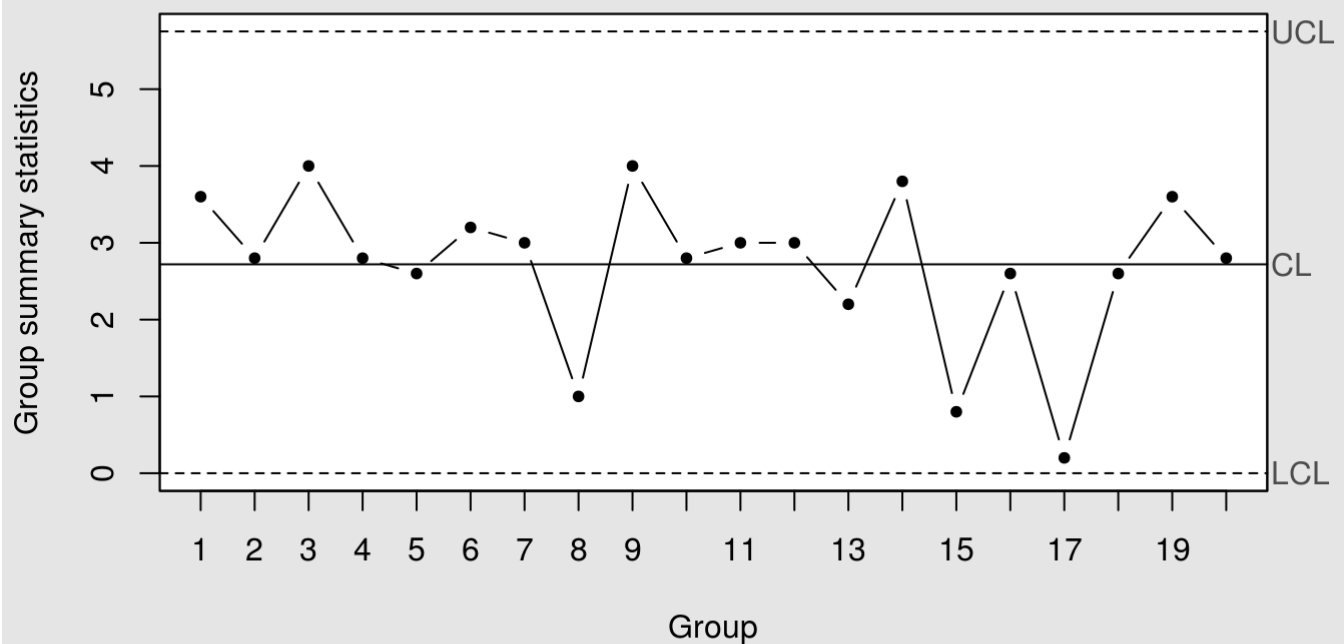


```
summary(obj1)
```

```
##
## Call:
## qcc(data = machine1, type = "xbar")
##
## xbar chart for machine1
##
## Summary of group statistics:
##   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   598.2  599.5   600.0   600.1   600.6   601.4
##
## Group sample size: 5
## Number of groups: 20
## Center of group statistics: 600.072
## Standard deviation: 1.16939
##
## Control limits:
##      LCL      UCL
## 598.5031 601.6409
```

```
obj2 <- qcc(machine1, type = "R")
```

## R Chart for machine1



Number of groups = 20

Center = 2.72

StdDev = 1.16939

LCL = 0

UCL = 5.751358

Number beyond limits = 0

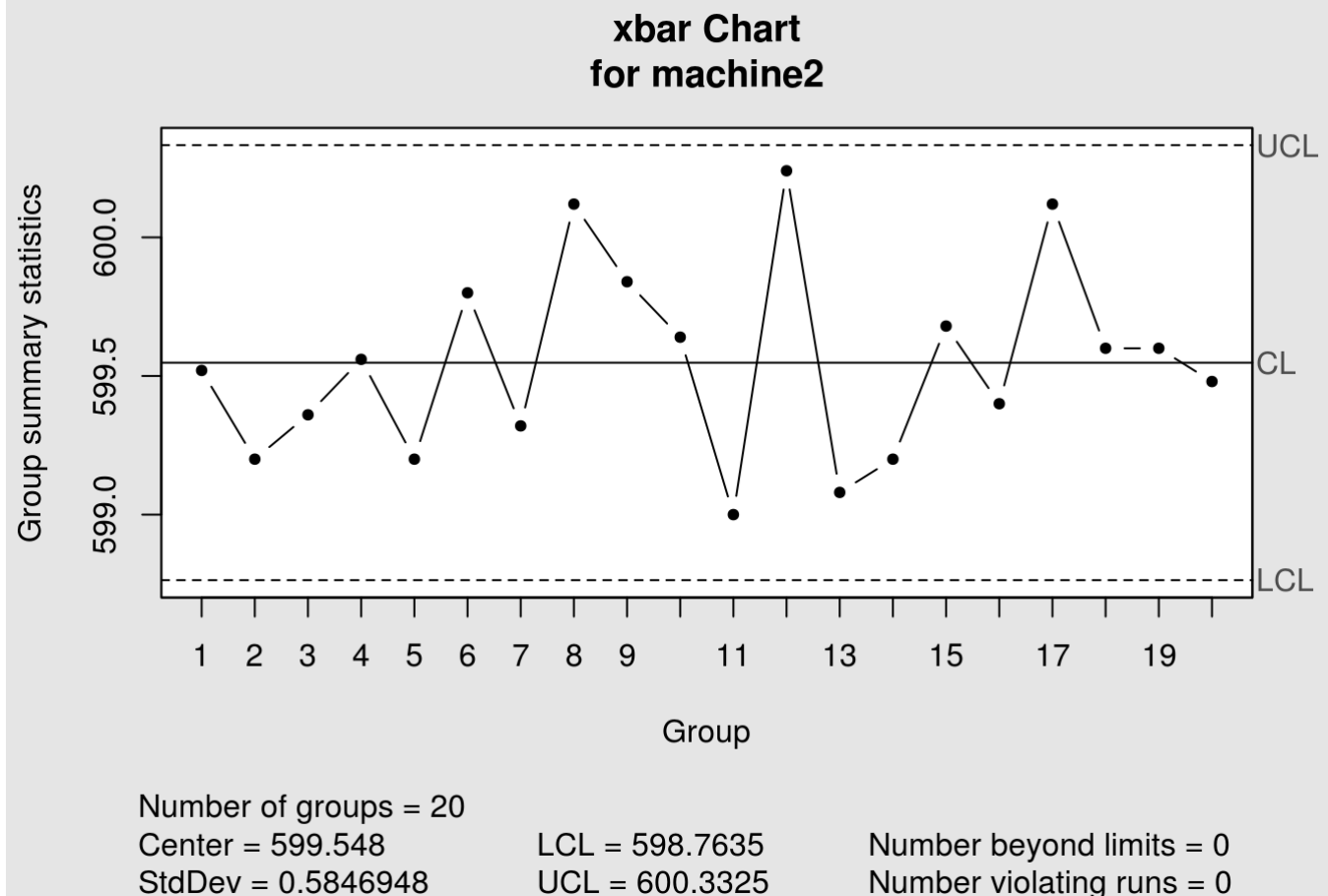
Number violating runs = 0

```
summary(obj2)
```

```
##
## Call:
## qcc(data = machine1, type = "R")
##
## R chart for machine1
##
## Summary of group statistics:
##      Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##      0.20   2.60   2.80   2.72   3.30   4.00
##
## Group sample size: 5
## Number of groups: 20
## Center of group statistics: 2.72
## Standard deviation: 1.16939
##
## Control limits:
##      LCL      UCL
##      0 5.751358
```

```
# Subgroup 8 is out of the control on the xbar chart. Hence, process variation is in control but mean is not in control for subgroup-8.
```

```
# Control charts for machine2
machine2<-qcc.groups(df3[,2],df3[,4])
obj1 <-qcc(machine2,type ="xbar")
```

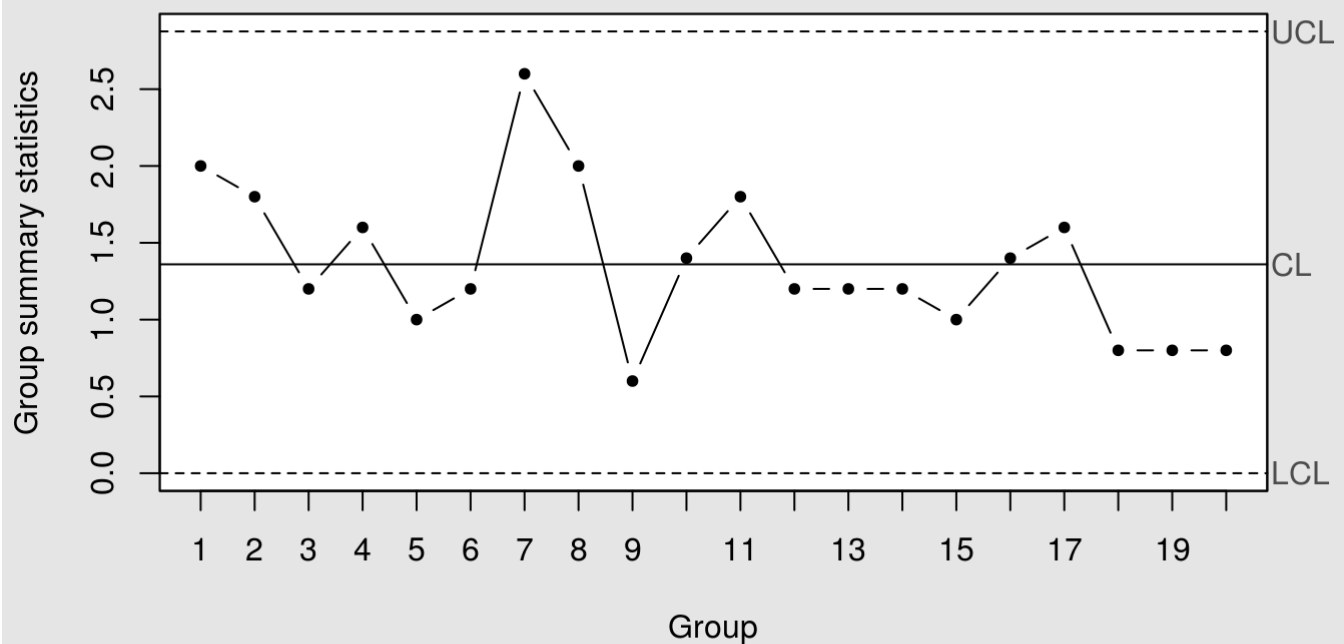


```
summary(obj1)
```

```
##
## Call:
## qcc(data = machine2, type = "xbar")
##
## xbar chart for machine2
##
## Summary of group statistics:
##   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##  599.0   599.3   599.5   599.5   599.7   600.2
##
## Group sample size: 5
## Number of groups: 20
## Center of group statistics: 599.548
## Standard deviation: 0.5846948
##
## Control limits:
##      LCL      UCL
## 598.7635 600.3325
```

```
obj2 <- qcc(machine2, type = "R")
```

## R Chart for machine2



Number of groups = 20

Center = 1.36

StdDev = 0.5846948

LCL = 0

UCL = 2.875679

Number beyond limits = 0

Number violating runs = 0

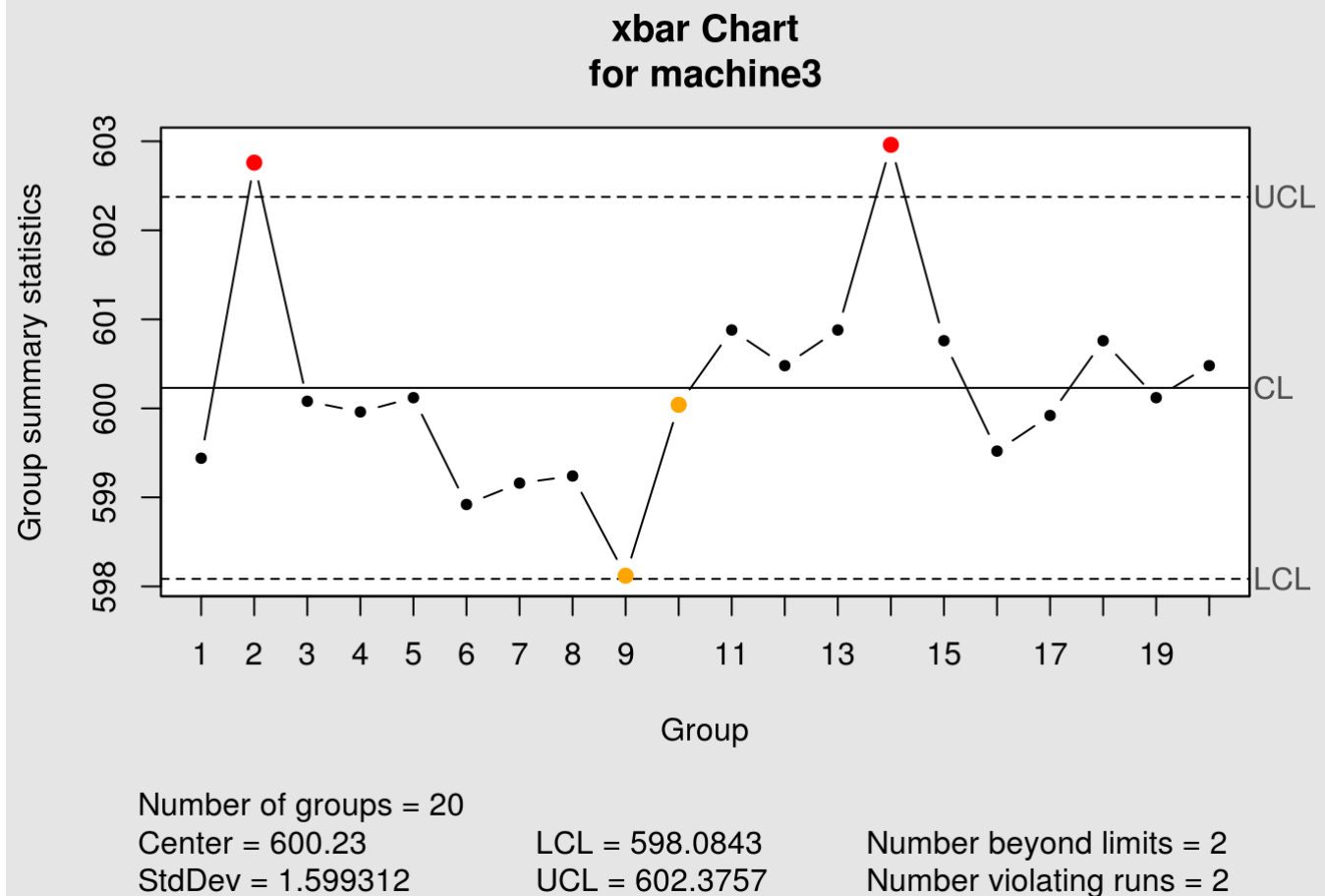
```
summary(obj2)
```

```
##
## Call:
## qcc(data = machine2, type = "R")
##
## R chart for machine2
##
## Summary of group statistics:
##   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   0.60   1.00   1.20   1.36   1.65   2.60
##
## Group sample size: 5
## Number of groups: 20
## Center of group statistics: 1.36
## Standard deviation: 0.5846948
##
## Control limits:
##   LCL      UCL
##   0 2.875679
```

```
# All subgroups of machine2 are in control. Hence, entire process is in control.
```

```
# Control charts for machine3
machine3<-qcc.groups(df3[,3],df3[,4])
obj1 <-qcc(machine3,type ="xbar")
```

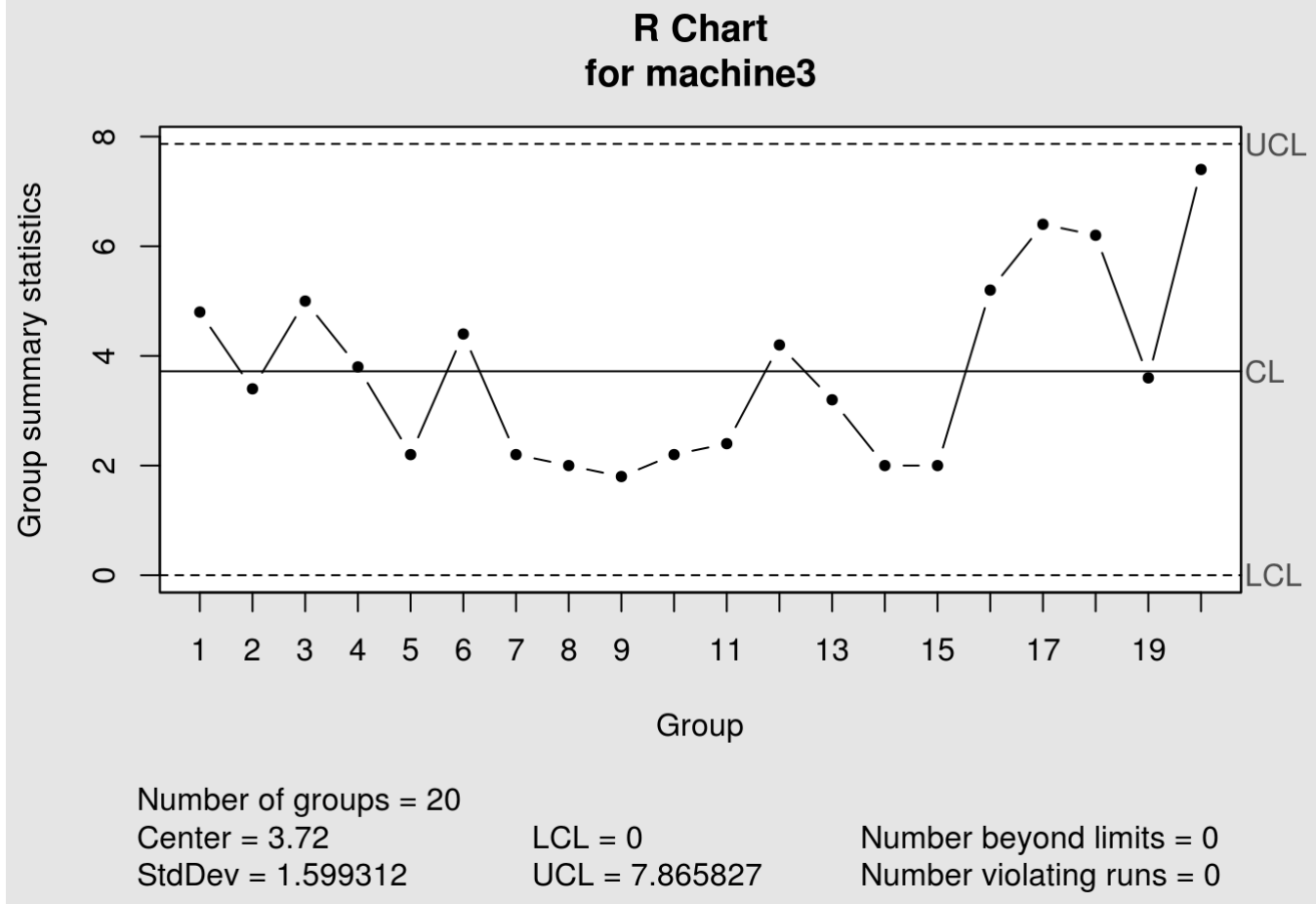




```
summary(obj1)
```

```
##
## Call:
## qcc(data = machine3, type = "xbar")
##
## xbar chart for machine3
##
## Summary of group statistics:
##   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   598.1  599.5   600.1   600.2   600.8   603.0
##
## Group sample size: 5
## Number of groups: 20
## Center of group statistics: 600.23
## Standard deviation: 1.599312
##
## Control limits:
##      LCL      UCL
## 598.0843 602.3757
```

```
obj2 <- qcc(machine3, type = "R")
```



```
summary(obj2)
```

```
##
## Call:
## qcc(data = machine3, type = "R")
##
## R chart for machine3
##
## Summary of group statistics:
##   Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
##   1.80   2.20   3.50   3.72   4.85   7.40
##
## Group sample size: 5
## Number of groups: 20
## Center of group statistics: 3.72
## Standard deviation: 1.599312
##
## Control limits:
##   LCL      UCL
##   0 7.865827
```

*# Subgroups 2 and 14 are out of the control on the xbar chart. Hence, process variability is in control but mean is not in control for subgroups-2 and 14.*