Data Collection Sheet

k	X_1	X_2	X_3	X_4	$\overline{X}$	*R*	*Comments*
1.							
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Notes

INDIVIDUAL VALUES AND MOVING RANGE (X,mR): ☐ Variables Data ☐ Attribute Data

Product/Service	Data Collector	Unit of Measure	Prepared by
Measurement Description		Time period covered	Date

Individual Values (X)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Date																									
Time																									
x																									
mR																									

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

Range

Calculations for mR Chart

Center Line: $m\overline{R} = \dfrac{\sum mR}{k-1} = \_\_\_\_\_$

$UCL_{mR} = 3.268\, m\overline{R} = (3.268)\,(\_\_\_\_\_\_\_) = \_\_\_\_\_\_\_$

(Formulas are based on a two-point moving range)

Calculations for X Chart:

Center line: $\overline{X} = \dfrac{\sum X}{k} = \_\_\_\_\_$

$\boldsymbol{UNPL_X} = \overline{\boldsymbol{X}} + 2.660\, \boldsymbol{m\overline{R}} = \overline{\boldsymbol{X}} + (2.660)\,(\_\_\_\_\_\_) = \_\_\_\_\_\_\_$

$\boldsymbol{LNPL_X} = \overline{\boldsymbol{X}} - 2.660\, \boldsymbol{m\overline{R}} = \overline{\boldsymbol{X}} - (2.660)\,(\_\_\_\_\_\_) = \_\_\_\_\_\_\_$

Rules for Defining Special Cause Signals

1. **Any point outside of the control limits (X and mR Charts).**
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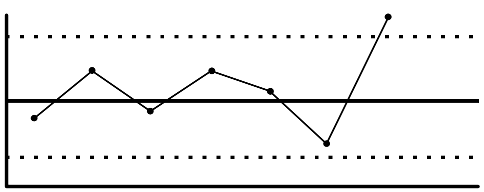
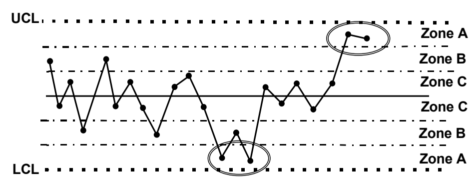
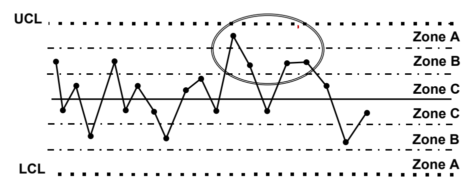
Rule 1



Rule 2



Rule 3



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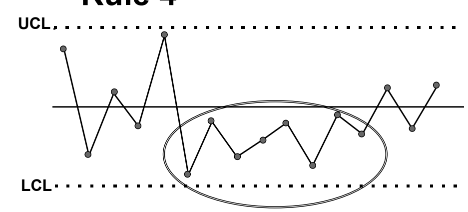

Notes: Date/Time	

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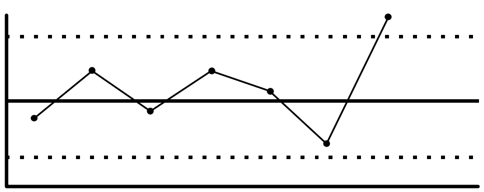

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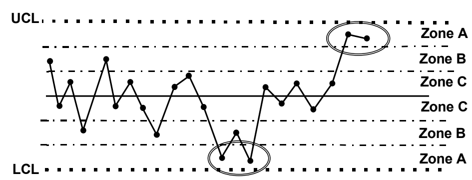

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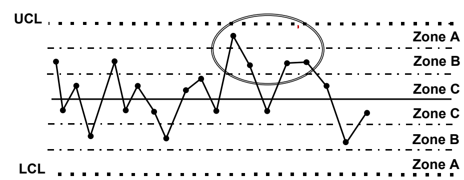

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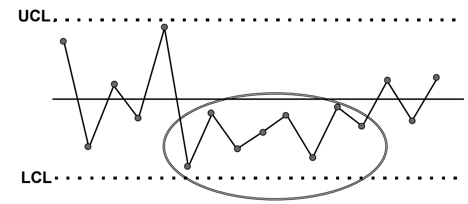

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(Formulas are based on a two-point moving range)

Calculations for X Chart:

Center line: $\overline{X} = \dfrac{\sum X}{k} = \underline{\qquad}$

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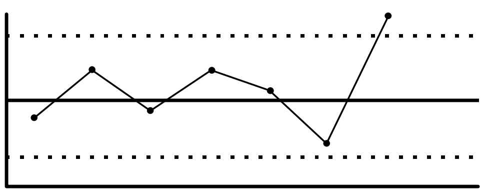
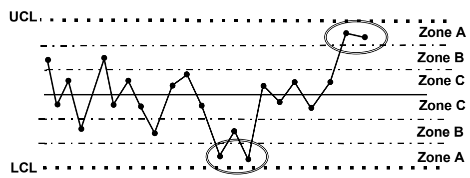
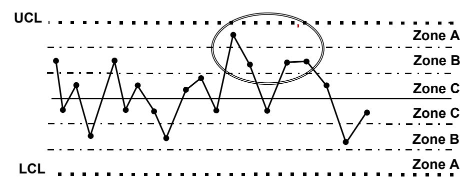


Rule 2



Rule 3



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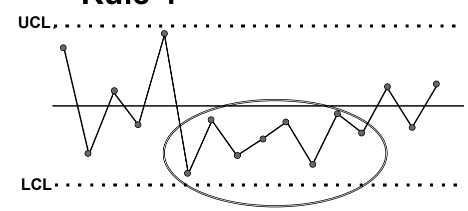

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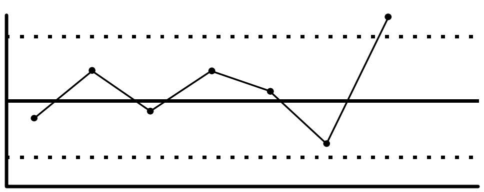
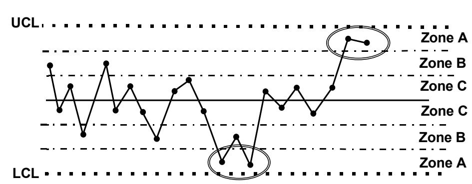
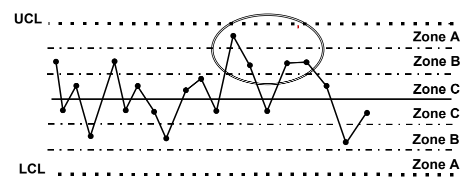


Rule 2



Rule 3



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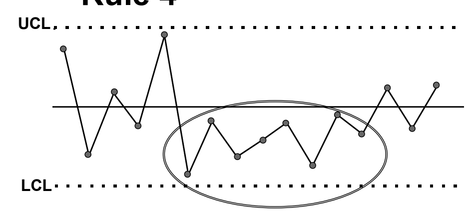

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k	X_1	X_2	X_3	X_4	$\bar{X}$	R	Comments
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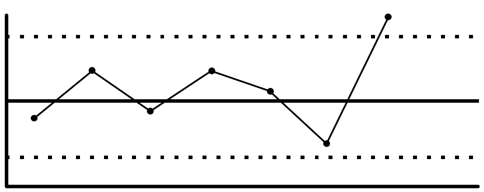
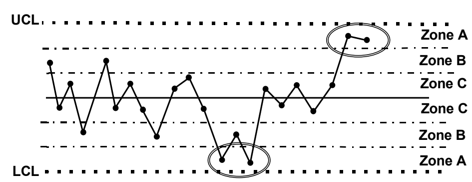


Rule 2



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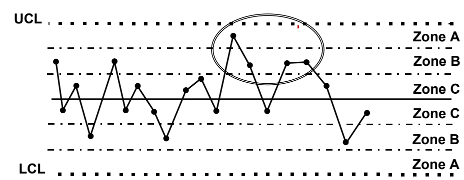

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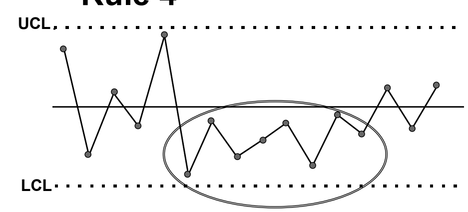

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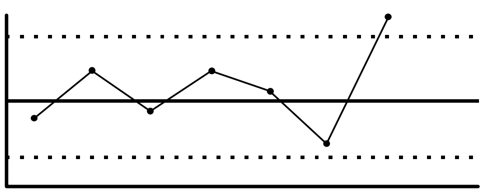

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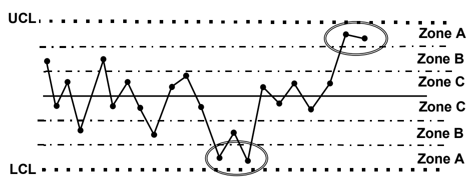

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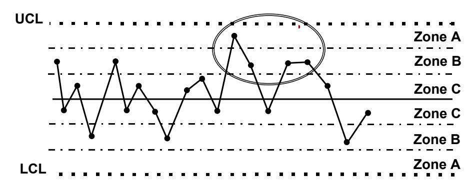

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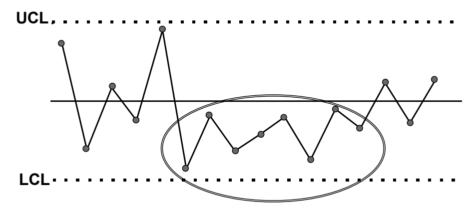

Notes: Date/Time	

HISTOGRAM

Product	Upper Spec	Unit of Measure	Prepared by
Measurement	Lower Spec	Time period covered	Date

SCALE FOR: FREQUENCY ☐ PERCENTAGE ☐

Histogram Construction

1. Collect and Record the appropriate Data
2. Summarize the data in a frequency distribution
   a. How many different values do you have (n)? n = ______
   b. What is your largest value (x_{max})? x_{max} = ______
   c. What is your smallest value (x_{min})? x_{min} = ______
3. Group the data into intervals
   a. Compute the range: $R = x_{max} - x_{min}$ = ______
   b. Determine the number of intervals (k):
      for $n < 50$, use 5-7 intervals k = ______
      for n = 50-100, use 6-10 intervals
      for n = 101-250, use 7-12 intervals (Rule of thumb: $k = \sqrt{n}$)
      for $n > 250$, use 10-20 intervals
   c. Determine the width (W) of the intervals: $W = R \div k$ ______
      (1.) Divide the range by the number of intervals; round to the nearest convenient unit.
   d. Determine the interval boundaries (ib):)
      (1.) Set the initial class boundary equal to or smaller than the smallest value (ib_1)
      (2.) Add the interval width to ib_1 to get the first interval. $ib_1 + W$ = ______
      (3.) Continue adding W to succeeding boundaries until all intervals are covered.

(Note: these interval widths are set so that: $ib_i \le X < ib_{i+1}$)

4. Plot the histogram.
5. Add the specification limits to the histogram USL = ______ LSL = ______
6. Find $\bar{R}$ for the process: $\bar{R} =$ ______
7. Find d_2 for the process (n = number in subgroup): d_2 = ______ (From Table of constants)
8. Find sigma$_{(x)}$ for the process: $sigma_{(x)} = \frac{\bar{R}}{d_2}$ = ________ units/sigma
9. Find specifications in sigma units: $\frac{USL - LSL}{sigma_{(x)}}$ = ________ sigma units

Table of Constants

n	d_2
2	1.128
3	1.693
4	2.059
5	2.326

If the specifications expressed in sigma units (from line 9) are greater than 6 and the distance from the process average to the nearest specification is greater than 3, a stable process may be said to be capable.

HISTOGRAM

Product	Upper Spec	Unit of Measure	Prepared by
Measurement	Lower Spec	Time period covered	Date

SCALE FOR: FREQUENCY ☐ PERCENTAGE ☐

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7. Find d_2 for the process (n = number in subgroup): d_2 = ______ (From Table of constants)
8. Find sigma$_{(x)}$ for the process: $sigma_{(x)} = \dfrac{\overline{R}}{d_2}$ = ________ units/sigma
9. Find specifications in sigma units: $\dfrac{USL - LSL}{sigma_{(x)}}$ = ________ sigma units

Table of Constants

n	d_2
2	1.128
3	1.693
4	2.059
5	2.326

If the specifications expressed in sigma units (from line 9) are greater than 6 and the distance from the process average to the nearest specification is greater than 3, a stable process may be said to be capable.

HISTOGRAM

Product	Upper Spec	Unit of Measure	Prepared by
Measurement	Lower Spec	Time period covered	Date

SCALE FOR: FREQUENCY ☐ PERCENTAGE ☐

Histogram Construction

1. Collect and Record the appropriate Data
2. Summarize the data in a frequency distribution
   a. How many different values do you have (n)? n = ______
   b. What is your largest value (x_{max})? x_{max} = ______
   c. What is your smallest value (x_{min})? x_{min} = ______
3. Group the data into intervals
   a. Compute the range: $R = x_{max} - x_{min}$ = ______
   b. Determine the number of intervals (k):
      for n < 50, use 5-7 intervals — k = ______
      for n = 50-100, use 6-10 intervals
      for n = 101-250, use 7-12 intervals (Rule of thumb: $k = \sqrt{n}$)
      for n > 250, use 10-20 intervals
   c. Determine the width (W) of the intervals: $W = R \div k$ ______
      (1.) Divide the range by the number of intervals; round to the nearest convenient unit.
   d. Determine the interval boundaries (ib):)
      (1.) Set the initial class boundary equal to or smaller than the smallest value (ib_1)
      (2.) Add the interval width to ib_1 to get the first interval. $ib_1 + W$ = ______
      (3.) Continue adding W to succeeding boundaries until all intervals are covered.

(Note: these interval widths are set so that: $ib_i \le X < ib_{i+1}$)

4. Plot the histogram.
5. Add the specification limits to the histogram — *USL* = ______ *LSL* = ______
6. Find R for the process: $\overline{R} =$ ______
7. Find d_2 for the process (n = number in subgroup): d_2 = ______ (From Table of constants)
8. Find sigma$_{(x)}$ for the process: $sigma_{(x)} = \dfrac{\overline{R}}{d_2}$ = ________ units/sigma
9. Find specifications in sigma units: $\dfrac{USL - LSL}{sigma_{(x)}}$ = ________ sigma units

Table of Constants

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      for n = 50-100, use 6-10 intervals
      for n = 101-250, use 7-12 intervals (Rule of thumb: $k = \sqrt{n}$)
      for $n > 250$, use 10-20 intervals
   c. Determine the width (W) of the intervals: $W = R \div k$ ______
      (1.) Divide the range by the number of intervals; round to the nearest convenient unit.
   d. Determine the interval boundaries (*ib*):)
      (1.) Set the initial class boundary equal to or smaller than the smallest value (ib_1)
      (2.) Add the interval width to ib_1 to get the first interval. $ib_1 + W$ = ______
      (3.) Continue adding W to succeeding boundaries until all intervals are covered.

(Note: these interval widths are set so that: $ib_i \leq X < ib_{i+1}$)

4. Plot the histogram.
5. Add the specification limits to the histogram USL = ______ LSL = ______
6. Find $\overline{R}$ for the process: $\overline{R}$ = ______
7. Find d_2 for the process (n = number in subgroup): d_2 = ______ (From Table of constants)
8. Find sigma$_{(x)}$ for the process: $sigma_{(x)} = \dfrac{\overline{R}}{d_2}$ = ________ units/sigma
9. Find specifications in sigma units: $\dfrac{USL - LSL}{sigma_{(x)}}$ = ________ sigma units

Table of Constants

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	Calculations	Answers
1. Figuring out the ***constant*** for the loss formula: Note: The term "constant" is usually referred to by the letter K in mathematical notation, and just means the result of some calculation which does not change in value . It is often used to complete some part of a more extensive mathematical computation later...	**Calculations** $= \frac{C_{scrap}}{(X_{scrap} - t)^2} = K$	**Answers**
Estimate the cost of complete miss and enter it here. Note: Deming says that there are "unknown and unknowable" costs. This is your best concrete estimate of how much it will cost you to "do it over again" ("LOSS" or "SCRAP") based on whatever criteria your team thinks is most likely to be useful in determining an answer...	$= C_{scrap}$	(A)
Find the Target Value for your process and enter it here.	$= t$	(B)
Subtract the value for the Target from the Upper Specification Limit (X_{scrap}) Note: This is the distance from the target at which total or maximum loss occurs, ie it's now "scrap".	$= X_{scrap} - t$	(C)
Square the value in (C) and enter it here.	$= (X_{scrap} - t)^2$	(D)
Divide answer (D) into answer (A) and enter it here. Note: This answer now represents the "scale" against which we will measure the loss as we get farther and farther away from the target value.	$= \frac{C_{scrap}}{(X_{scrap} - t)^2} = K$	(E)
2. Figuring out how much your process is wandering about the desired target value Note: Here we are looking for the difference between what you wanted and what you actually got.	**Calculations** **= MSD(t)**	**Answers**
Find the actual "Mean" value for your process and enter it here.	$= \bar{\bar{X}}$	(F)
Find the difference between answers (B) and (F) and enter it here.	$= \bar{\bar{X}} - t$	(G)
Square the value in (G) and enter it here.	$= (\bar{\bar{X}} - t)^2$	(H)
Put the value of Sigma(X) for the process here. Note: see Wheeler 1992, Table A-1	$= \bar{R} / d_2 = \text{Sigma}(X)$	(I)
Square the value in (I) and enter it here.	$= (\text{Sigma}(X))^2$	(J)
Add the answers from (H) and (J) together and enter it here. Note: This is know as the "Mean Squared Deviations about Target", and will be used to estimate how fast loss occurs as we deviate from target...	$(Sigma(X))^2 + (\bar{\bar{X}} - t)^2$ $= MSD_{(t)}$	(K)
3. Figuring out the loss in units (man-hours, dollars, etc.) for your process: Note: This is known as the "Average Loss per Unit of Production" for your process now and in the future if it is not constantly improved... It answers the question, "But when do we reach the point of diminishing returns?"	**Calculations** = K*MSD(t)	**Answers**
Multiply the answers from **(E)** and **(K)** together; enter the result here.	= K*MSD(t)	(L)

Notes

1. Figuring out the ***constant*** for the loss formula: Note: The term “constant” is usually referred to by the letter K in mathematical notation, and just means the result of some calculation which does not change in value . It is often used to complete some part of a more extensive mathematical computation later...	**Calculations** $= \frac{C_{scrap}}{(X_{scrap} - t)^2} = K$	**Answers**
Estimate the cost of complete miss and enter it here. Note: Deming says that there are “unknown and unknowable” costs. This is your best concrete estimate of how much it will cost you to “do it over again” (“LOSS” or “SCRAP”) based on whatever criteria your team thinks is most likely to be useful in determining an answer...	$= C_{scrap}$	(A)
Find the Target Value for your process and enter it here.	$= t$	(B)
Subtract the value for the Target from the Upper Specification Limit (X_{scrap}) Note: This is the distance from the target at which total or maximum loss occurs, ie it’s now “scrap”.	$= X_{scrap} - t$	(C)
Square the value in (C) and enter it here.	$= (X_{scrap} - t)^2$	(D)
Divide answer (D) into answer (A) and enter it here. Note: This answer now represents the “scale” against which we will measure the loss as we get farther and farther away from the target value.	$= \frac{C_{scrap}}{(X_{scrap} - t)^2} = K$	(E)
2. Figuring out how much your process is wandering about the desired target value Note: Here we are looking for the difference between what you wanted and what you actually got.	**Calculations** **= MSD(t)**	**Answers**
Find the actual “Mean” value for your process and enter it here.	$= \bar{\bar{X}}$	(F)
Find the difference between answers (B) and (F) and enter it here.	$= \bar{\bar{X}} - t$	(G)
Square the value in (G) and enter it here.	$= (\bar{\bar{X}} - t)^2$	(H)
Put the value of Sigma(X) for the process here. Note: see Wheeler 1992, Table A-1	$= \bar{R} / d_2 = \text{Sigma}(X)$	(I)
Square the value in (I) and enter it here.	$= (\text{Sigma}(X))^2$	(J)
Add the answers from (H) and (*J)* together and enter it here. Note: This is know as the “Mean Squared Deviations about Target”, and will be used to estimate how fast loss occurs as we deviate from target...	$(Sigma(X))^2 + (\bar{\bar{X}} - t)^2$ $= MSD_{(t)}$	(K)
3. Figuring out the loss in units (man-hours, dollars, etc.) for your process: Note: This is known as the “Average Loss per Unit of Production” for your process now and in the future if it is not constantly improved... It answers the question, “But when do we reach the point of diminishing returns?”	**Calculations** = K*MSD(t)	**Answers**
Multiply the answers from **(E)** and **(K)** together; enter the result here.	= K*MSD(t)	(L)

Notes

Measurements From Your Extended System

Data Collection Questions	Measurement A	Measurement B
Why do you want the data? (What do you hope to learn? What theory are you testing? How will this improve the extended system?)		
What types of data will be collected? **(Attribute? Variables?)**		
How will you gather the data?		
Who will collect the data?		
Where will the data be collected?		
How often and how much data will be collected? (Is it regular control chart data or periodically collected data?)		
What will you do with the data? Why? (Xbar & R charts XmR charts Other Uses)		