

STAT 495, Fall 2008

Homework Assignment #3

1. In the production of a household appliance a critical step occurs in the powder-coat room. Powder-coating is done to produce a durable decorative appearance and to enhance wear resistance. Coating thickness is measured with a digital coating thickness gage. Readings at the top have a target of 1.7 mils and those at the bottom should be between 3 and 5 mils. Below are data on 40 units.

Unit	Top	Bottom	Shift	Unit	Top	Bottom	Shift
1	3.9	4.4	1	21	3.1	4.0	2
2	3.4	4.2	1	22	2.5	3.3	2
3	2.5	4.0	2	23	3.1	3.3	2
4	2.8	4.2	2	24	3.6	4.3	1
5	2.9	4.3	2	25	3.6	3.8	1
6	4.6	4.5	1	26	3.9	3.6	1
7	4.2	4.0	1	27	2.7	3.3	2
8	3.8	3.8	1	28	2.3	3.3	2
9	3.0	3.9	2	29	2.4	3.8	2
10	2.7	3.9	2	30	3.7	4.6	1
11	3.1	3.6	2	31	4.0	4.2	1
12	3.8	4.5	1	32	2.7	4.0	2
13	3.6	4.3	1	33	3.1	4.0	2
14	3.3	4.6	1	34	2.6	4.3	2
15	2.8	4.1	2	35	4.1	4.9	1
16	2.5	3.6	2	36	3.6	3.7	1
17	2.5	4.0	2	37	3.7	3.4	1
18	3.6	3.9	1	38	2.9	3.7	2
19	3.6	3.4	1	39	2.8	4.1	2
20	4.1	4.1	1	40	2.7	4.1	2

- a) Construct a stem-and-leaf display for the top thickness measurement.
- b) Construct a frequency table for the 40 top thickness measurements. Include relative frequency and percent columns. Use classes; $1.0 \leq Y < 1.5$, $1.5 \leq Y < 2.0$, $2.0 \leq Y < 2.5$, etc.
- c) Construct a histogram from the frequency table in b).
- d) Describe the shape of the histogram in c). What does this shape indicate about the top thickness measurements?
- e) Plot top measurement vs. bottom measurement for the 40 units. Describe the general relationship between top and bottom measurements.
- f) Stratification is an important tool for understanding a process. Use stratification by shift and repeat parts a) through e) above. That is:
 - i. Construct a back-to-back stem-and-leaf display for the top thickness measurement.

- ii. Construct frequency tables for the top thickness measurements, by shifts. Include relative frequency and percent columns. Use classes; $1.0 \leq Y < 1.5$, $1.5 \leq Y < 2.0$, $2.0 \leq Y < 2.5$, etc.
 - iii. Construct histograms, by shift, from the frequency tables in ii).
 - iv. Describe the shape of the histograms in iii). What do these shapes indicate about the top thickness measurements, by shift?
 - v. Plot top measurement vs. bottom measurement for the 40 units using a different plotting symbol for each shift. Describe the general relationship between top and bottom measurements for each shift.
2. Before the measurements in problem #1 were taken, a gauge R&R study was performed. Three different operators measured the thickness of paint, in mils, for ten units. Each measurement was repeated three times. Below are the data.

Part	Operator A	Operator B	Operator C
1	4.9, 4.8, 4.7	4.5, 4.5, 4.7	5.2, 5.6, 4.6
2	5.2, 4.9, 4.9	4.6, 4.7, 4.7	5.0, 4.8, 5.1
3	5.0, 4.8, 4.7	4.9, 4.9, 5.0	5.2, 5.0, 5.0
4	5.5, 5.4, 5.5	5.4, 5.4, 5.5	5.9, 5.4, 5.6
5	4.6, 4.6, 4.6	4.3, 4.4, 4.6	5.4, 4.5, 5.0
6	5.6, 5.1, 5.2	5.0, 5.1, 5.1	5.3, 5.6, 5.7
7	5.3, 5.1, 4.9	5.0, 4.9, 4.9	5.7, 5.3, 5.2
8	4.9, 4.7, 5.0	5.1, 5.2, 5.0	5.0, 5.8, 5.2
9	5.2, 5.0, 5.1	5.0, 4.8, 4.9	5.0, 5.5, 5.1
10	4.9, 4.5, 4.5	4.8, 4.9, 4.8	5.7, 5.4, 4.9

Display the data graphically and comment on what appears to be the significant source of variability. Using the method presented in lecture/tape 8, compute the estimate of σ_{Repeat} and the estimate of σ_{Reprod} . Give the percentage of variation due to the gauge and that due to the operator. Where should improvement efforts be focused – training the operators or purchasing new gauges?