A TiW layer is deposited on a substrate using a sputtering tool. The following table presents data, in Angstroms, from 20 subgroups of n = 4. (a) Plot an x-bar and R control chart for this process. Performs runs tests to Western Electric rules 1 through 5 in Table 5.1, p. 197 of the textbook. Is the process in control? Revise the control limits as necessary. (b) Estimate the mean and standard deviation of the revised process. (c) Is the layer thickness of the revised process normally distributed? (d) If the specifications are 450 30 Angstroms, estimate the process capability.

Western Electric Rules 1-5

1. One or more points outside of the control limits.

2. Two of three consecutive points outside the two-sigma warning limits but still inside the control limits.

3. Four of five consecutive points beyond the one-sigma limits.

4. A run of eight consecutive points on one side of the center line.

5. Six points in a row steadily increasing or decreasing.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Subgroup | x1 | x2 | x3 | x4 |
| 1 | 458 | 448 | 434 | 449 |
| 2 | 442 | 439 | 441 | 441 |
| 3 | 458 | 445 | 450 | 445 |
| 4 | 468 | 462 | 452 | 437 |
| 5 | 442 | 456 | 444 | 453 |
| 6 | 444 | 456 | 456 | 457 |
| 7 | 444 | 448 | 449 | 444 |
| 8 | 461 | 462 | 456 | 463 |
| 9 | 461 | 469 | 474 | 457 |
| 10 | 427 | 463 | 468 | 443 |
| 11 | 446 | 453 | 454 | 439 |
| 12 | 457 | 458 | 447 | 458 |
| 13 | 459 | 445 | 441 | 447 |
| 14 | 442 | 466 | 449 | 451 |
| 15 | 460 | 453 | 457 | 438 |
| 16 | 453 | 444 | 451 | 435 |
| 17 | 450 | 459 | 449 | 456 |
| 18 | 446 | 455 | 449 | 452 |
| 19 | 444 | 446 | 448 | 467 |
| 20 | 450 | 450 | 454 | 454 |