

# Measurement System Analysis

## Measuring Success

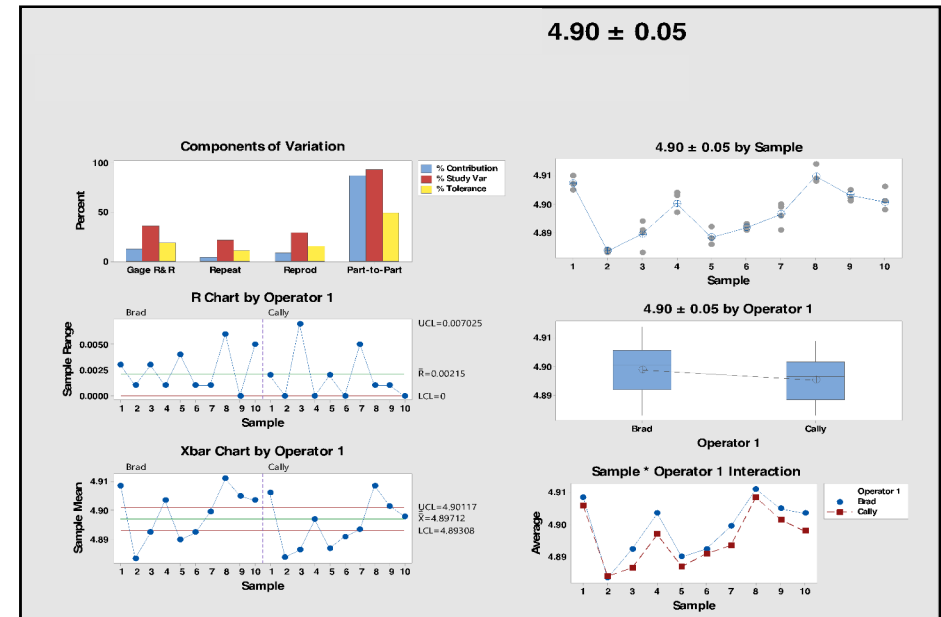
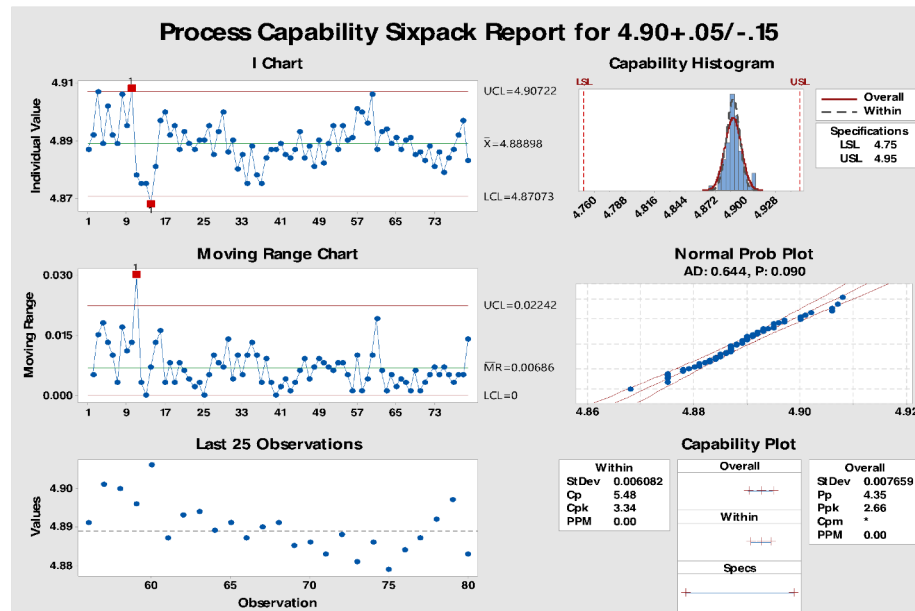
# Example 1

| Source          | VarComp   | %Contribution<br>(of VarComp) |
|-----------------|-----------|-------------------------------|
| Total Gage R&R  | 0.0000100 | 13.02                         |
| Repeatability   | 0.0000035 | 4.59                          |
| Reproducibility | 0.0000065 | 8.43                          |
| Part-To-Part    | 0.0000669 | 86.98                         |
| Total Variation | 0.0000769 | 100.00                        |

Process tolerance = 0.1

| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0031646   | 0.0189875             | 36.09               | 18.99                    |
| Repeatability   | 0.0018788   | 0.0112726             | 21.42               | 11.27                    |
| Reproducibility | 0.0025465   | 0.0152792             | 29.04               | 15.28                    |
| Part-To-Part    | 0.0081785   | 0.0490713             | 93.26               | 49.07                    |
| Total Variation | 0.0087694   | 0.0526167             | 100.00              | 52.62                    |

Number of Distinct Categories = 3



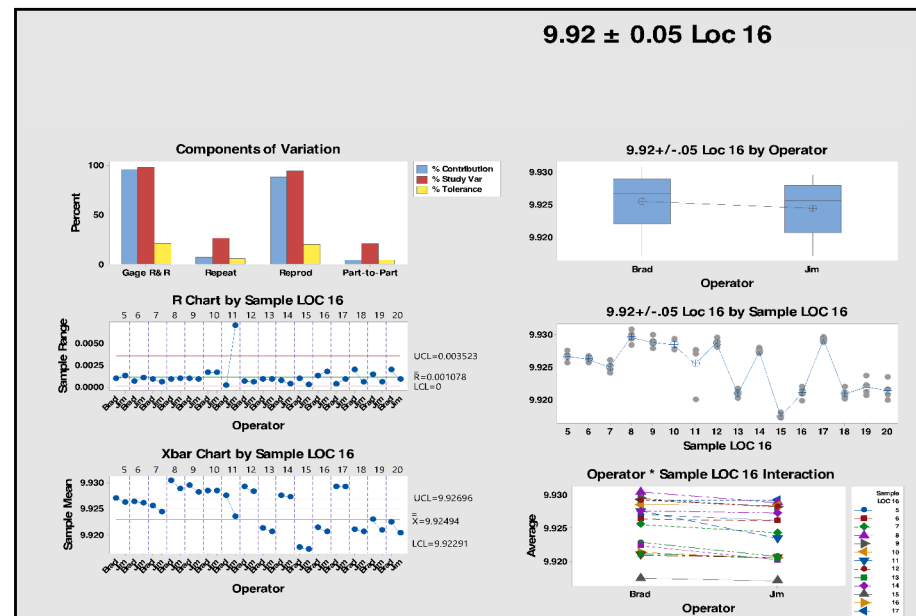
# Example 2

| Source          | VarComp   | %Contribution<br>(of VarComp) |
|-----------------|-----------|-------------------------------|
| Total Gage R&R  | 0.0000122 | 95.55                         |
| Repeatability   | 0.0000009 | 7.15                          |
| Reproducibility | 0.0000113 | 88.40                         |
| Part-To-Part    | 0.0000006 | 4.45                          |
| Total Variation | 0.0000128 | 100.00                        |

Process tolerance = 0.1

| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0034921   | 0.0209528             | 97.75               | 20.95                    |
| Repeatability   | 0.0009555   | 0.0057328             | 26.74               | 5.73                     |
| Reproducibility | 0.0033589   | 0.0201533             | 94.02               | 20.15                    |
| Part-To-Part    | 0.0007535   | 0.0045211             | 21.09               | 4.52                     |
| Total Variation | 0.0035725   | 0.0214350             | 100.00              | 21.44                    |

Number of Distinct Categories = 1



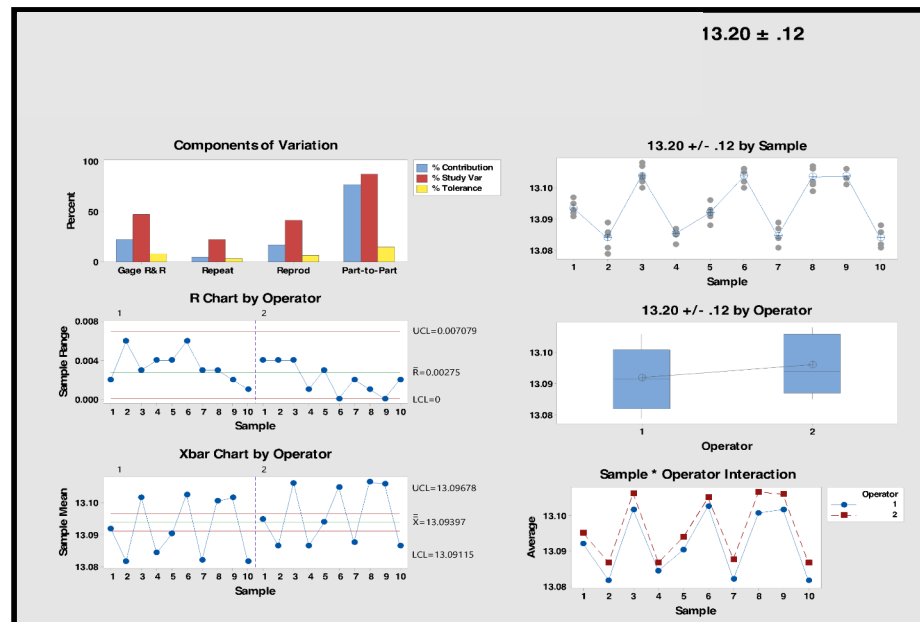
# Example 3

| Source          | VarComp   | %Contribution<br>(of VarComp) |
|-----------------|-----------|-------------------------------|
| Total Gage R&R  | 0.0000113 | 22.56                         |
| Repeatability   | 0.0000026 | 5.18                          |
| Reproducibility | 0.0000087 | 17.38                         |
| Part-To-Part    | 0.0000389 | 77.44                         |
| Total Variation | 0.0000503 | 100.00                        |

Process tolerance = 0.24

| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0033671   | 0.0202024             | 47.49               | 8.42                     |
| Repeatability   | 0.0016137   | 0.0096820             | 22.76               | 4.03                     |
| Reproducibility | 0.0029552   | 0.0177312             | 41.68               | 7.39                     |
| Part-To-Part    | 0.0062388   | 0.0374326             | 88.00               | 15.60                    |
| Total Variation | 0.0070894   | 0.0425363             | 100.00              | 17.72                    |

Number of Distinct Categories = 2



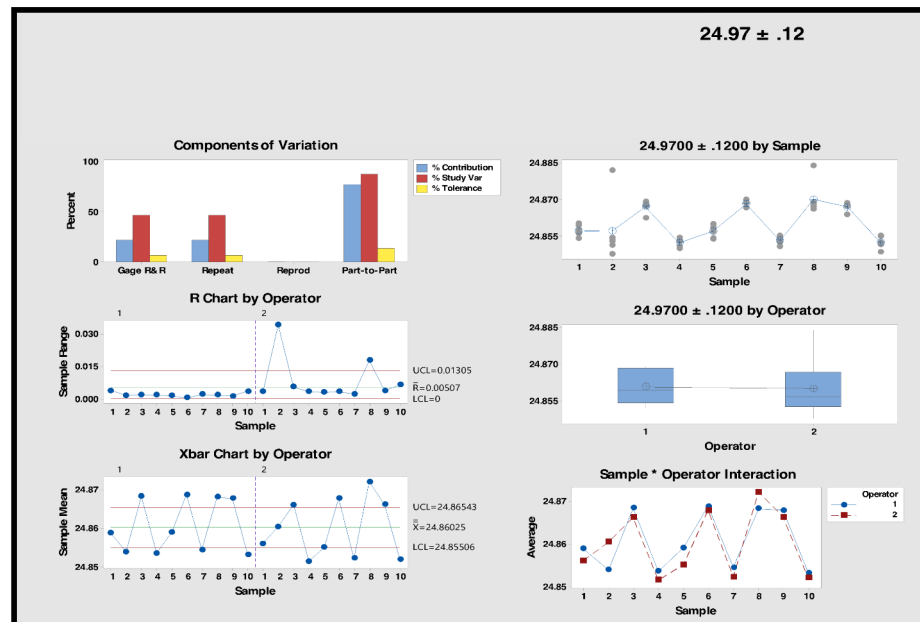
# Example 4

| Source          | VarComp   | %Contribution<br>(of VarComp) |
|-----------------|-----------|-------------------------------|
| Total Gage R&R  | 0.0000089 | 22.34                         |
| Repeatability   | 0.0000089 | 22.34                         |
| Reproducibility | 0.0000000 | 0.00                          |
| Part-To-Part    | 0.0000308 | 77.66                         |
| Total Variation | 0.0000396 | 100.00                        |

Process tolerance = 0.24

| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0029750   | 0.0178501             | 47.27               | 7.44                     |
| Repeatability   | 0.0029750   | 0.0178501             | 47.27               | 7.44                     |
| Reproducibility | 0.0000000   | 0.0000000             | 0.00                | 0.00                     |
| Part-To-Part    | 0.0055467   | 0.0332804             | 88.12               | 13.87                    |
| Total Variation | 0.0062942   | 0.0377652             | 100.00              | 15.74                    |

Number of Distinct Categories = 2



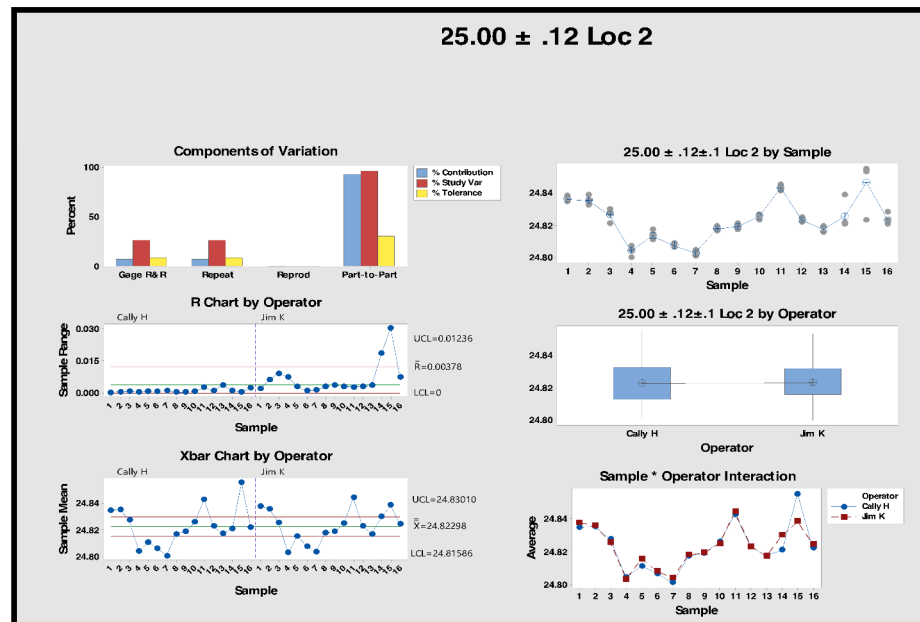
# Example 5

| Source          | VarComp   | %Contribution<br>(of VarComp) |
|-----------------|-----------|-------------------------------|
| Total Gage R&R  | 0.0000112 | 7.00                          |
| Repeatability   | 0.0000112 | 7.00                          |
| Reproducibility | 0.0000000 | 0.00                          |
| Part-To-Part    | 0.0001495 | 93.00                         |
| Total Variation | 0.0001608 | 100.00                        |

Process tolerance = 0.24

| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0033538   | 0.0201229             | 26.45               | 8.38                     |
| Repeatability   | 0.0033538   | 0.0201229             | 26.45               | 8.38                     |
| Reproducibility | 0.0000000   | 0.0000000             | 0.00                | 0.00                     |
| Part-To-Part    | 0.0122275   | 0.0733651             | 96.44               | 30.57                    |
| Total Variation | 0.0126791   | 0.0760747             | 100.00              | 31.70                    |

Number of Distinct Categories = 5



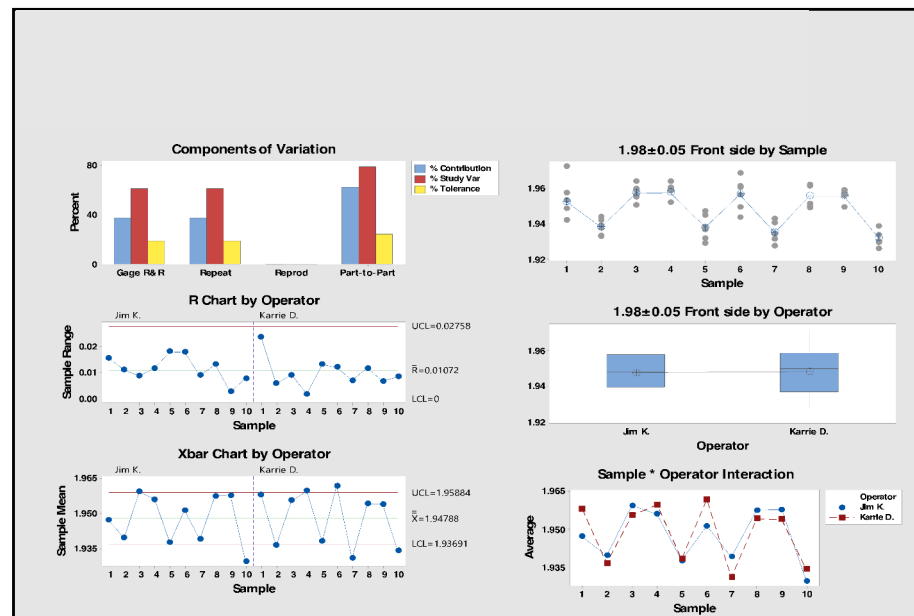
# Example 6

| Source          | VarComp   | %Contribution<br>(of VarComp) |
|-----------------|-----------|-------------------------------|
| Total Gage R&R  | 0.0000395 | 37.51                         |
| Repeatability   | 0.0000395 | 37.51                         |
| Reproducibility | 0.0000000 | 0.00                          |
| Part-To-Part    | 0.0000659 | 62.49                         |
| Total Variation | 0.0001054 | 100.00                        |

Process tolerance = 0.2

| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0062874   | 0.0377247             | 61.24               | 18.86                    |
| Repeatability   | 0.0062874   | 0.0377247             | 61.24               | 18.86                    |
| Reproducibility | 0.0000000   | 0.0000000             | 0.00                | 0.00                     |
| Part-To-Part    | 0.0081156   | 0.0486938             | 79.05               | 24.35                    |
| Total Variation | 0.0102662   | 0.0615974             | 100.00              | 30.80                    |

Number of Distinct Categories = 1



# Example 7

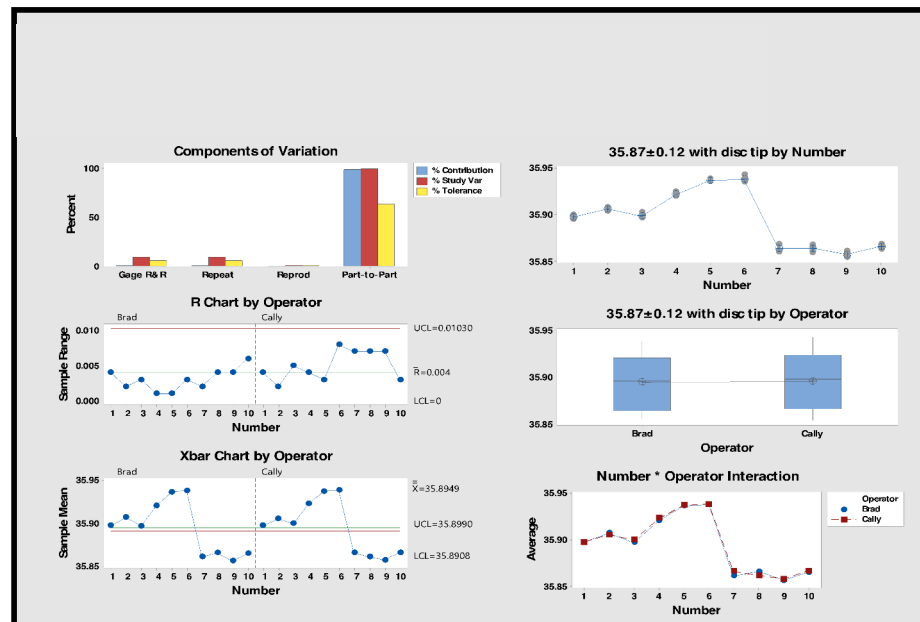
## Gage R&R Study - XBar/R Method

| Source          | VarComp   | %Contribution<br>(of VarComp) |
|-----------------|-----------|-------------------------------|
| Total Gage R&R  | 0.0000056 | 0.87                          |
| Repeatability   | 0.0000055 | 0.85                          |
| Reproducibility | 0.0000001 | 0.02                          |
| Part-To-Part    | 0.0006412 | 99.13                         |
| Total Variation | 0.0006468 | 100.00                        |

Process tolerance = 0.24

| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0023705   | 0.014223              | 9.32                | 5.93                     |
| Repeatability   | 0.0023472   | 0.014083              | 9.23                | 5.87                     |
| Reproducibility | 0.0003320   | 0.001992              | 1.31                | 0.83                     |
| Part-To-Part    | 0.0253220   | 0.151932              | 99.56               | 63.31                    |
| Total Variation | 0.0254327   | 0.152596              | 100.00              | 63.58                    |

Number of Distinct Categories = 15



# Example 8

## Variance Components

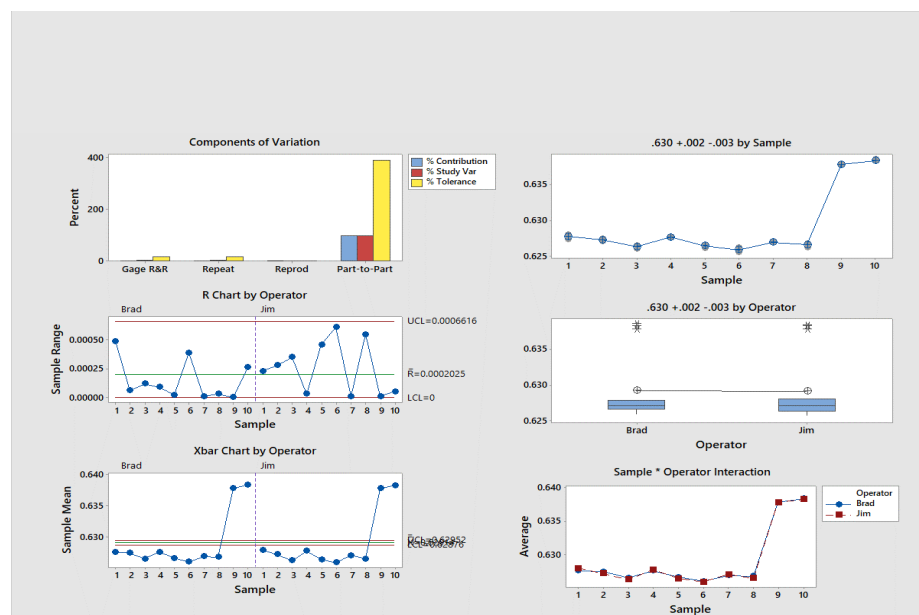
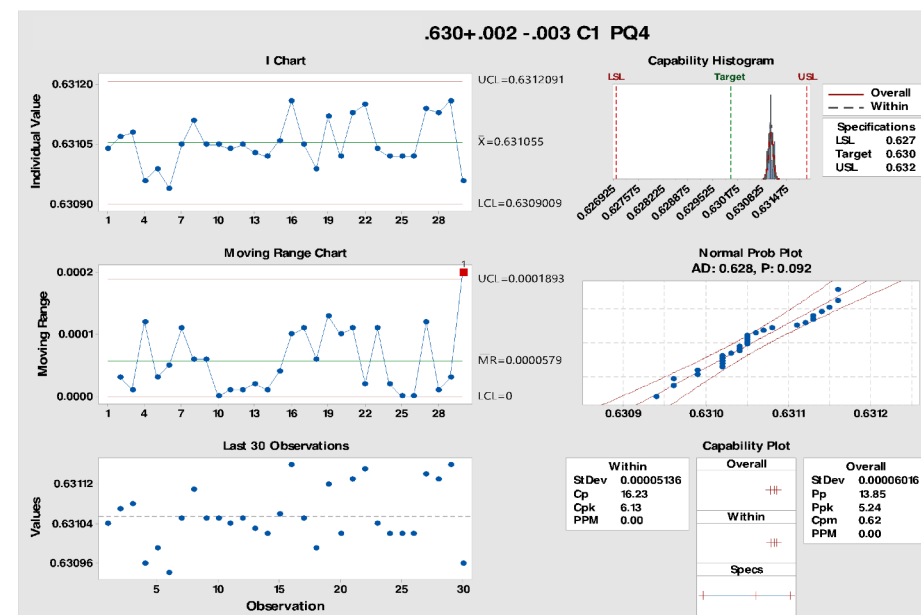
| Source          | VarComp   | %Contribution<br>(of VarComp) |
|-----------------|-----------|-------------------------------|
| Total Gage R&R  | 0.0000000 | 0.21                          |
| Repeatability   | 0.0000000 | 0.21                          |
| Reproducibility | 0.0000000 | 0.00                          |
| Part-To-Part    | 0.0000152 | 99.79                         |
| Total Variation | 0.0000152 | 100.00                        |

Process tolerance = 0.006

## Gage Evaluation

| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0001770   | 0.0010617             | 4.54                | 17.70                    |
| Repeatability   | 0.0001770   | 0.0010617             | 4.54                | 17.70                    |
| Reproducibility | 0.0000000   | 0.0000000             | 0.00                | 0.00                     |
| Part-To-Part    | 0.0038950   | 0.0233702             | 99.90               | 389.50                   |
| Total Variation | 0.0038990   | 0.0233943             | 100.00              | 389.90                   |

Number of Distinct Categories = 31

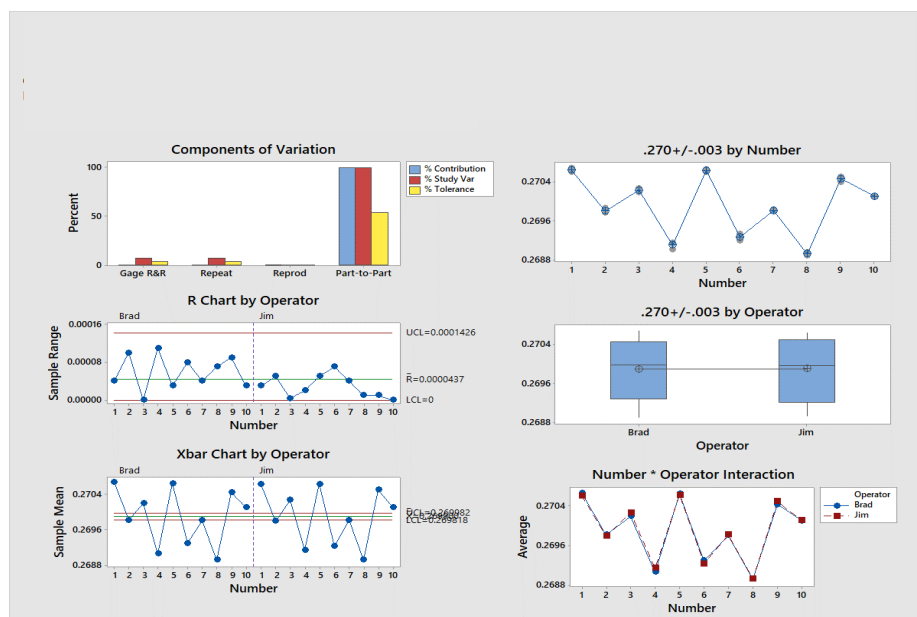
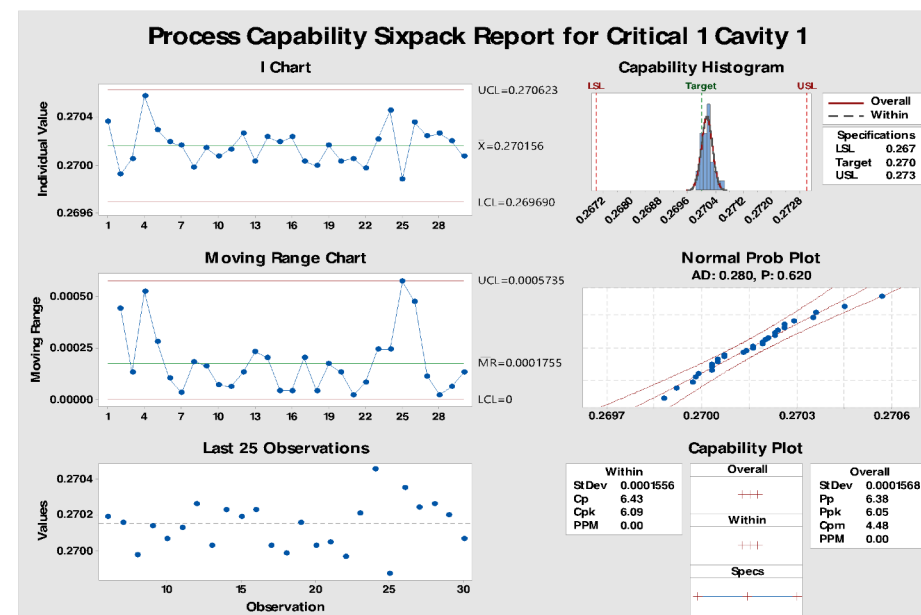


# Example 9

## Gage Evaluation

| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0000381   | 0.0002289             | 7.04                | 3.81                     |
| Repeatability   | 0.0000381   | 0.0002289             | 7.04                | 3.81                     |
| Reproducibility | 0.0000000   | 0.0000000             | 0.00                | 0.00                     |
| Part-To-Part    | 0.0005403   | 0.0032415             | 99.75               | 54.03                    |
| Total Variation | 0.0005416   | 0.0032496             | 100.00              | 54.16                    |

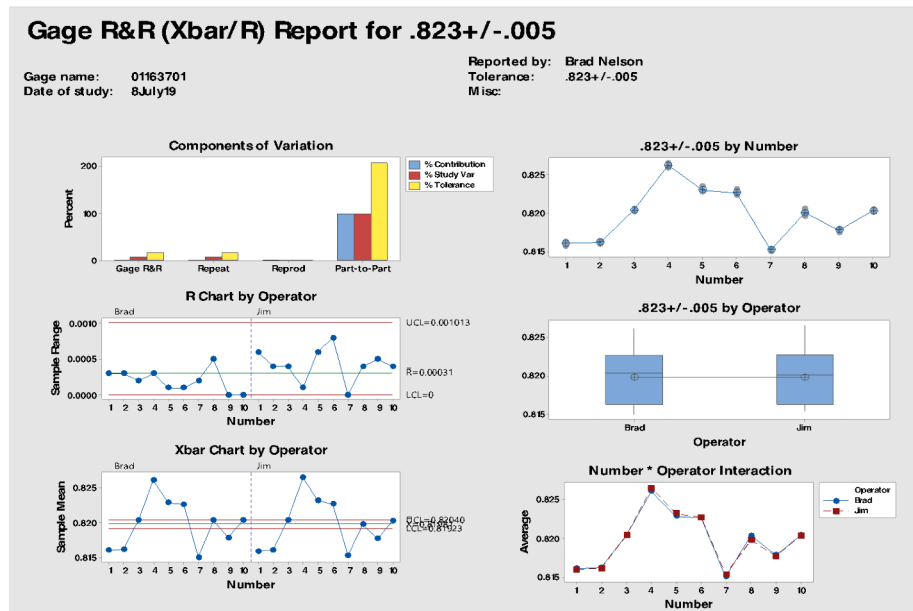
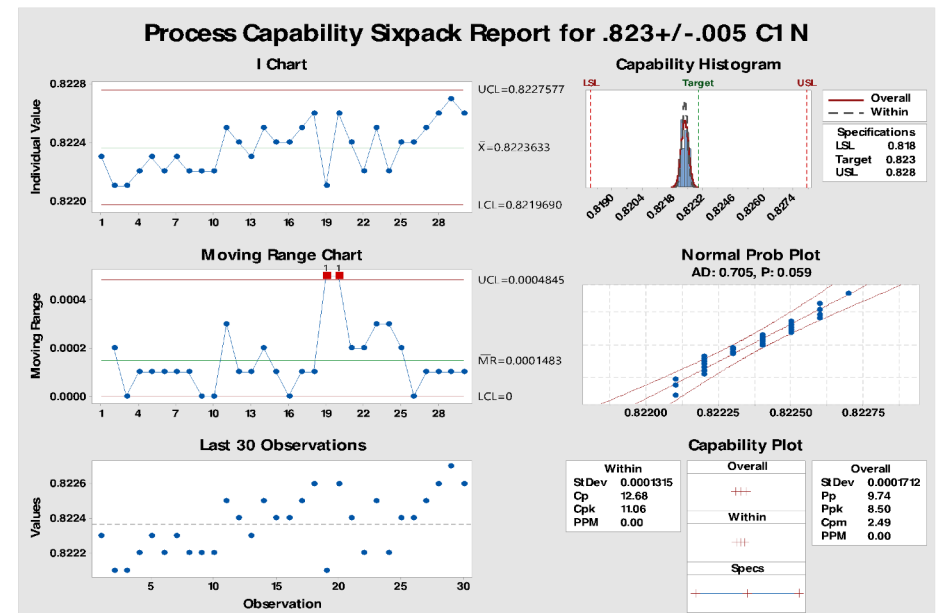
Number of Distinct Categories = 19



# Example 10

| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0002709   | 0.0016253             | 7.81                | 16.25                    |
| Repeatability   | 0.0002709   | 0.0016253             | 7.81                | 16.25                    |
| Reproducibility | 0.0000000   | 0.0000000             | 0.00                | 0.00                     |
| Part-To-Part    | 0.0034602   | 0.0207609             | 99.69               | 207.61                   |
| Total Variation | 0.0034707   | 0.0208244             | 100.00              | 208.24                   |

Number of Distinct Categories = 18



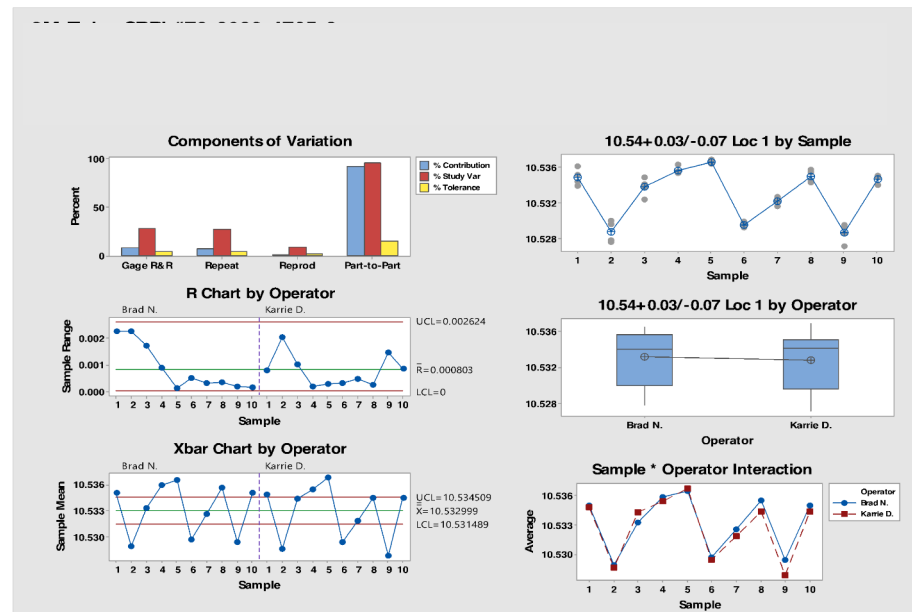
# Example 11

| Source          | VarComp   | %Contribution<br>(of VarComp) |
|-----------------|-----------|-------------------------------|
| Total Gage R&R  | 0.0000003 | 5.70                          |
| Repeatability   | 0.0000003 | 5.55                          |
| Reproducibility | 0.0000000 | 0.15                          |
| Part-To-Part    | 0.0000050 | 94.30                         |
| Total Variation | 0.0000053 | 100.00                        |

Process tolerance = 0.1

| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0005499   | 0.0032997             | 23.88               | 3.30                     |
| Repeatability   | 0.0005427   | 0.0032559             | 23.56               | 3.26                     |
| Reproducibility | 0.0000892   | 0.0005353             | 3.87                | 0.54                     |
| Part-To-Part    | 0.0022365   | 0.0134191             | 97.11               | 13.42                    |
| Total Variation | 0.0023031   | 0.0138188             | 100.00              | 13.82                    |

Number of Distinct Categories = 5



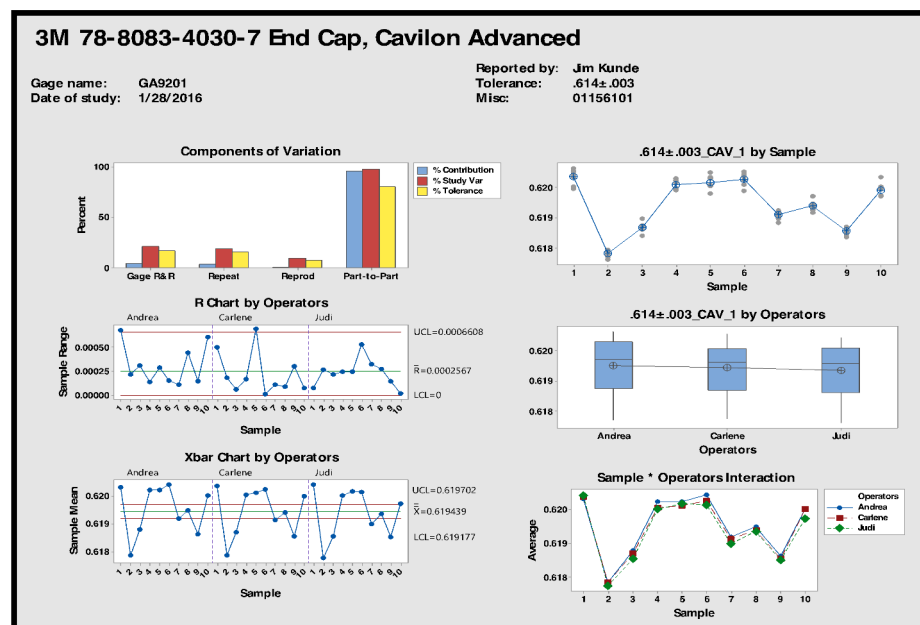
# Example 12

| Source          | VarComp   | %Contribution<br>(of VarComp) |
|-----------------|-----------|-------------------------------|
| Total Gage R&R  | 0.0000000 | 4.32                          |
| Repeatability   | 0.0000000 | 3.45                          |
| Reproducibility | 0.0000000 | 0.86                          |
| Part-To-Part    | 0.0000006 | 95.68                         |
| Total Variation | 0.0000007 | 100.00                        |

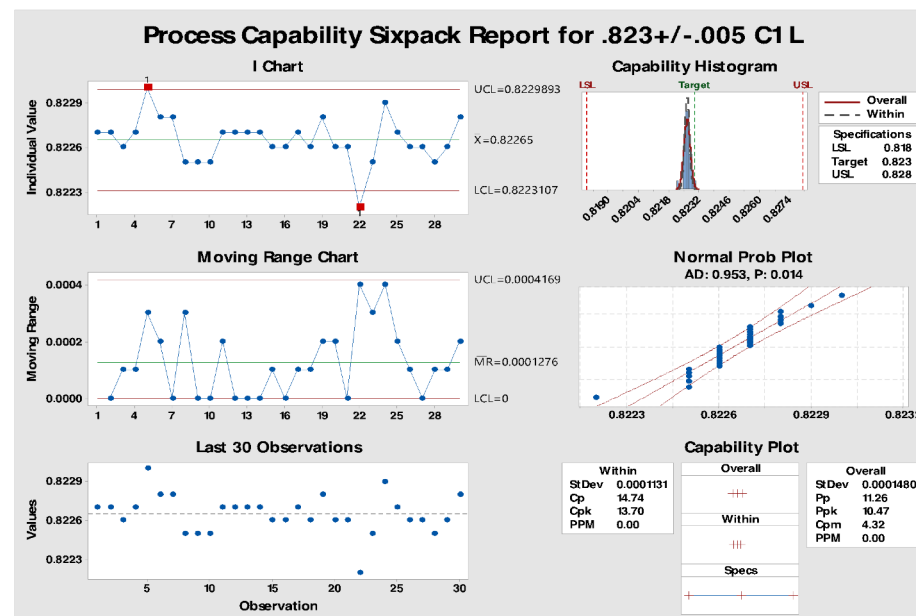
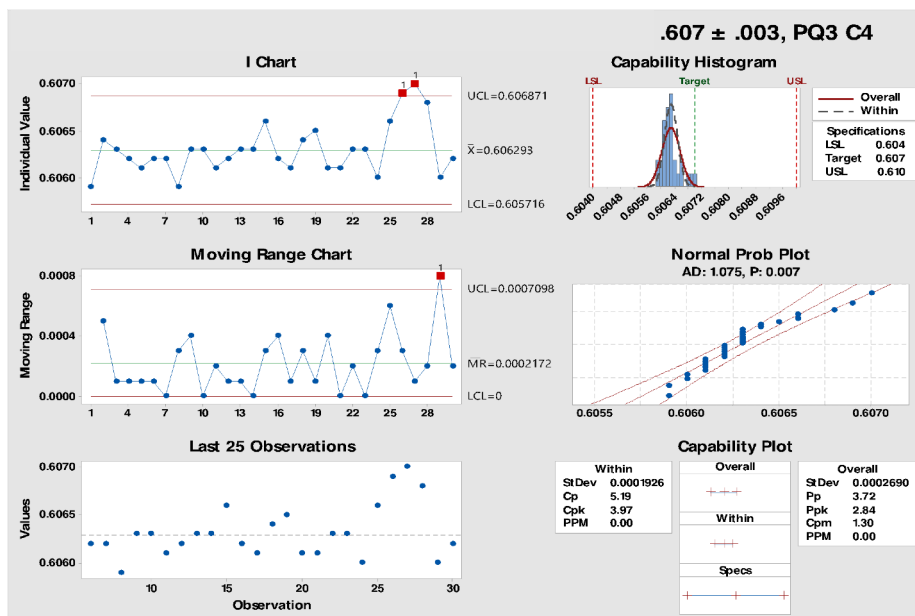
Process tolerance = 0.006

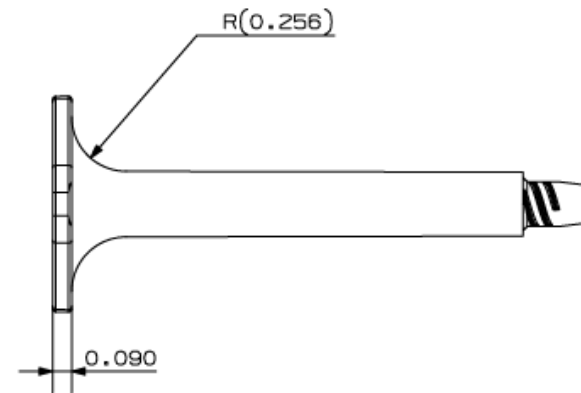
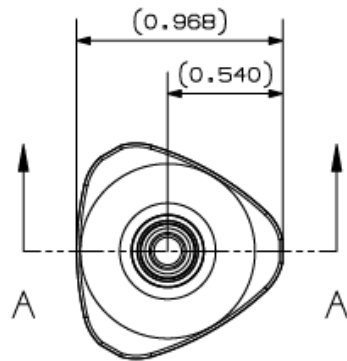
| Source          | StdDev (SD) | Study Var<br>(6 × SD) | %Study Var<br>(%SV) | %Tolerance<br>(SV/Toler) |
|-----------------|-------------|-----------------------|---------------------|--------------------------|
| Total Gage R&R  | 0.0001696   | 0.0010176             | 20.78               | 16.96                    |
| Repeatability   | 0.0001517   | 0.0009100             | 18.58               | 15.17                    |
| Reproducibility | 0.0000759   | 0.0004554             | 9.30                | 7.59                     |
| Part-To-Part    | 0.0007984   | 0.0047901             | 97.82               | 79.84                    |
| Total Variation | 0.0008162   | 0.0048970             | 100.00              | 81.62                    |

Number of Distinct Categories = 6



# Example 13





SEE NOTE #7

0.254  $\pm 0.001$  TOP

0.250  $\pm 0.001$  BOTTOM

