Individual Assignment 2

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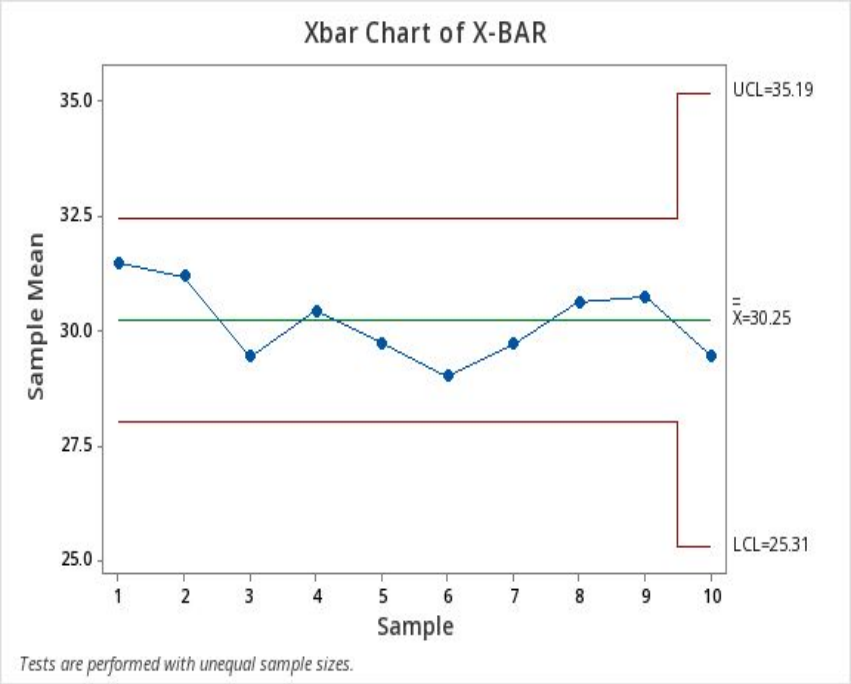
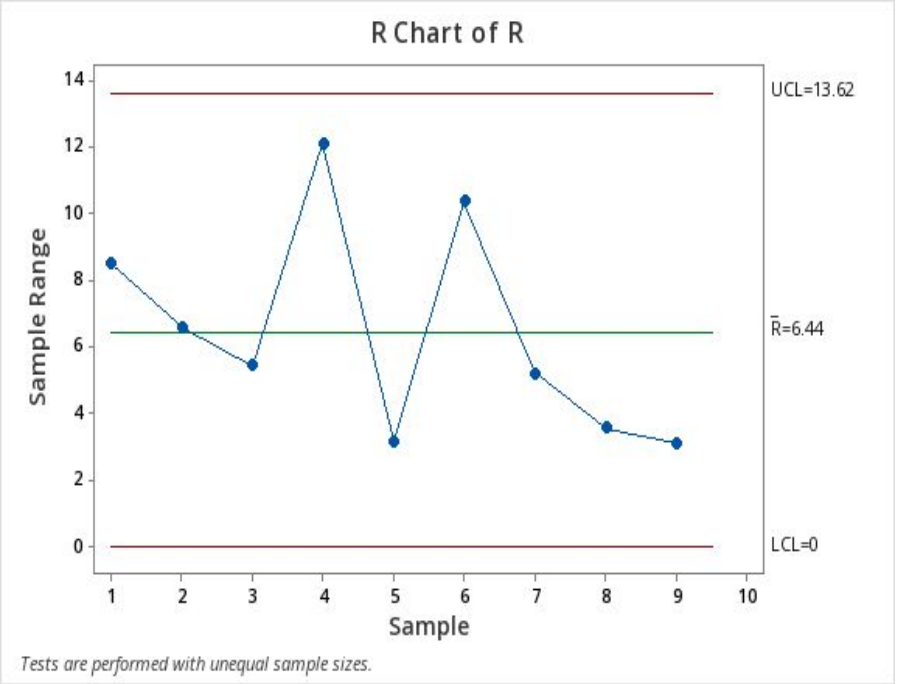
PJM 6135 Quality for Project Management Fall 2024

Instructor:- Dr. Jim ODonnell
Date: October 23, 2024

Challenge 1





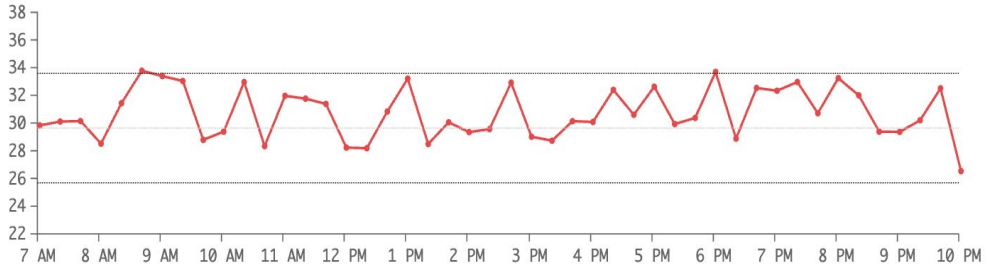
Control limits for the X-bar	Control limits for the R Graphs
UCL = 35.19	UCL = 13.62
LCL = 25.31	LCL = 0

CHALLENGE 2

Keeping the Process in Control While Minimizing Costs

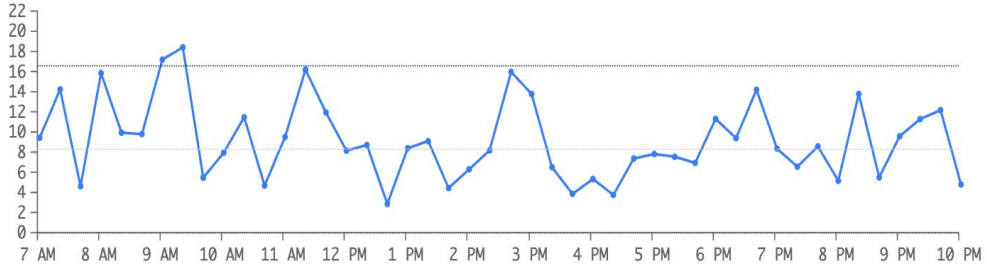
4 internal defects × $3.20	$12.80	Number of Recalibrations	4	Number of Labor Changes	5
286 external defects × $4.50	$1,287.00	Cost per Recalibration	$75	Cost per Labor Change	$100
Total Defect Costs	**$1,299.80**	**Total Recalibration Costs**	**$300**	**Total Labor Change Costs**	**$500**

X-bar Chart



Freq.

R Chart



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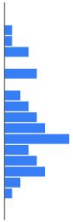


Shift Over

This process produced 290 total defects and was out of control 4 times

Defects discovered

4

Defects shipped

286

Effective Yield

99%

Total Cost

$2,182.30

RESET

COPY DATA

Formulas used for Challenge 3

Process Capability

1. Use visual inspection to determine whether the process mean is centered between the specification limits.
2. Calculate the process capability index.
   a. Use $\hat{C}_p$ if the process mean is centered between the specification limits.

$$\hat{C}_p = \frac{USL - LSL}{6\hat{\sigma}}$$

   b. Use $\hat{C}_{pk}$ if the process mean is *not* centered between the specification limits.

$$\hat{C}_{pk} = \min\left[\frac{USL - \hat{\mu}}{3\hat{\sigma}}, \frac{\hat{\mu} - LSL}{3\hat{\sigma}}\right]$$

USL = Upper specification limit

LSL = Lower specification limit

$\hat{\mu}$ = Process mean, which is the centerline between the UCL and LCL. This can be calculated by adding the UCL and LCL, then dividing by 2.

$\hat{\sigma}$ = Process standard deviation, which can be calculated from the control limits, as follows. Calculate the process standard error as the difference between either of the control limits and the process mean, divided by 3. Then, calculate the process standard deviation by multiplying the process standard error by $\sqrt{n}$.

3. Higher values of $\hat{C}_p$ and $\hat{C}_{pk}$ indicate a more capable process. Experts recommend a process capability index of at least 1.33 for a two-sided specification. For a one-sided specification that consists of an upper limit only (for example, concentration) or a lower limit only (for example, for strength), the process is considered capable if the process capability index > 1.25.

For example for Company A under Challenge 3 :-

- **Upper Specification Limit (USL): 1.62 oz**
- **Lower Specification Limit (LSL): 1.50 oz**
- **Upper Control Limit (UCL): 1.5691 oz**
- **Lower Control Limit (LCL): 1.5535 oz**
- **Subgroup Size (n): 30**

- ❖ **Process Mean (UCL+LCL)/2 = (1.5691+1.5535)/2 = 1.5613 oz**
- ❖ **Process Standard Error (UCL−Process Mean)/3 = (1.5691 −1.5613)/3 = 0.0026 oz**
- ❖ **Process Standard Deviation σ = Standard Error × √n = 0.0026 × √30 ≈ 0.0142 oz**
- ❖ **Process Capability Index (Cp) Cp = (USL−LSL)/(6×σ) = (1.62−1.50)/(6×0.0142) ≈ 1.404 selected.**

CHALLENGE 3 - Company A

PREPARE CHALLENGES: 1 2 3 COMPANY: A B C D 4

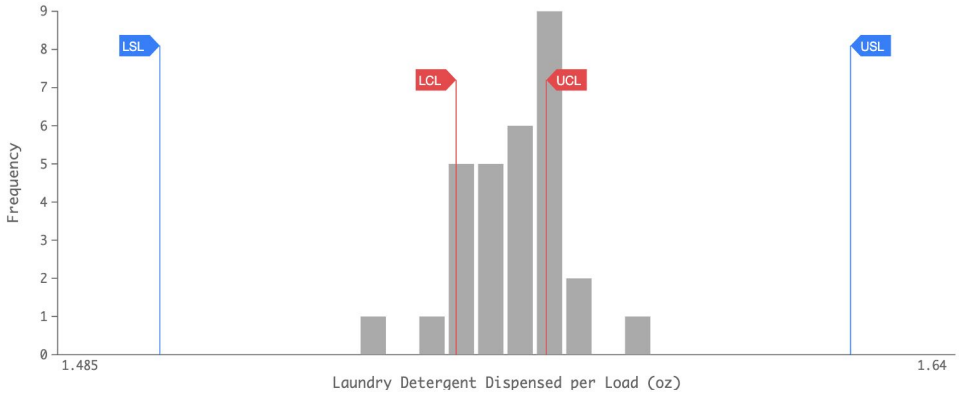
Determine whether each process is capable of producing to specifications

Hospital Laundry

The laundry department of a large hospital contains energy efficient industrial washing machines for laundering sheets and towels. High energy (HE) laundry detergent is automatically dispensed at the start of each load. If an insufficient amount of detergent is dispensed, the laundry will not be completely cleaned, while too much is unnecessarily costly and can damage the machine's bearings.

Spec Limits
Lower 1.5 Upper 1.62

Control Limits
Lower 1.5535 Upper 1.5691



What is Hospital Laundry's process capability index?

1.40

Is this process capable?

YES

NO

```python
# Given data
USL = 1.62  # Upper Specification Limit in oz
LSL = 1.50  # Lower Specification Limit in oz
UCL = 1.5691  # Upper Control Limit in oz
LCL = 1.5535  # Lower Control Limit in oz
subgroup_size = 30  # Size of the subgroup

# Calculate the process mean
process_mean = (UCL + LCL) / 2

# Calculate the process standard error
process_standard_error = (UCL - process_mean) / 3

# Calculate the process standard deviation (σ)
process_standard_deviation = process_standard_error * math.sqrt(subgroup_size)

# Calculate Cp
Cp = (USL - LSL) / (6 * process_standard_deviation)

# Print the results
print(f"Process Mean: {process_mean:.4f} oz")
print(f"Process Standard Error: {process_standard_error:.4f} oz")
print(f"Process Standard Deviation (σ): {process_standard_deviation:.4f} oz")
print(f"Process Capability Index (Cp): {Cp:.2f}")
```

```
Process Mean: 1.5613 oz
Process Standard Error: 0.0026 oz
Process Standard Deviation (σ): 0.0142 oz
Process Capability Index (Cp): 1.404
```

Explanation of the Code:

1. **Define Specifications**: The upper and lower specification limits and control limits are defined.
2. **Calculate Process Mean**: The mean is calculated using the upper and lower control limits.
3. **Calculate Process Standard Error**: The standard error is calculated based on the difference between the upper control limit and the mean.
4. **Calculate Process Standard Deviation (σ)**: The standard deviation is derived from the standard error adjusted for the size of the subgroup.
5. **Calculate Cp**: The capability index Cp is calculated using the formula provided.
6. **Print Results**: Outputs the process mean, standard error, standard deviation, and Cp.

CHALLENGE 3 - Company B

PREPARE CHALLENGES: 1 2 3 COMPANY: A B C D 4

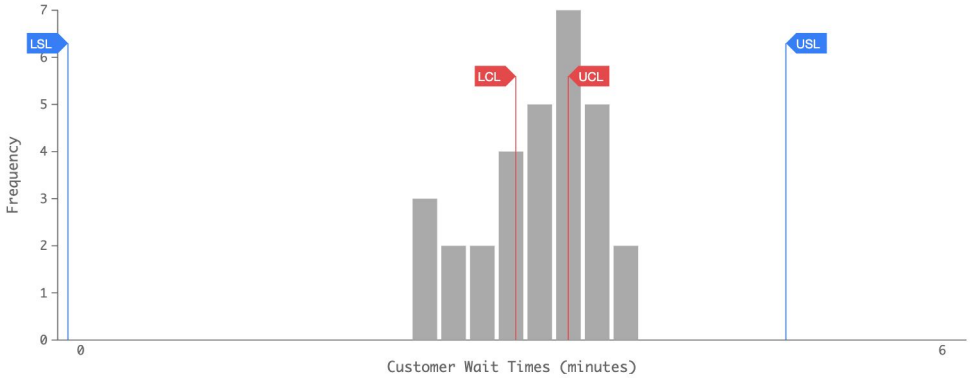
Determine whether each process is capable of producing to specifications

Tea Shop

Herb's Tea Garden is a small tea shop specializing in blended loose leaf hot tea. Customers select from a variety of fine loose tea leaves, dried flowers and dried fruits to create their own unique tea blend. Because of the popularity of the tea shop, combined with the custom blending process, waiting times can sometimes be excessive; most customers would prefer to wait less than five minutes.

Spec Limits
Lower Upper
0 5

Control Limits
Lower Upper
2.8665 3.3051



What is Tea Shop's process capability index?

2.08

Is this process capable?

YES

NO

```
# Given data for the tea shop
USL = 5.0  # Upper Specification Limit in minutes
LSL = 0.0  # Lower Specification Limit in minutes
UCL = 3.3051  # Upper Control Limit in minutes
LCL = 2.8665  # Lower Control Limit in minutes
subgroup_size = 30  # Size of the subgroup

# Calculate the process mean
process_mean = (UCL + LCL) / 2

# Calculate the process standard error
process_standard_error = (UCL - process_mean) / 3

# Calculate the process standard deviation (σ)
process_standard_deviation = process_standard_error * math.sqrt(subgroup_size)

# Calculate Cp
Cp = (USL - LSL) / (6 * process_standard_deviation)
```

```
Process Mean: 3.0858 minutes
Process Standard Error: 0.0731 minutes
Process Standard Deviation (σ): 0.4004 minutes
Process Capability Index (Cp): 2.08
```

CHALLENGE 3 - Company C

PREPARE CHALLENGES: 1 2 3 COMPANY: A B C D 4

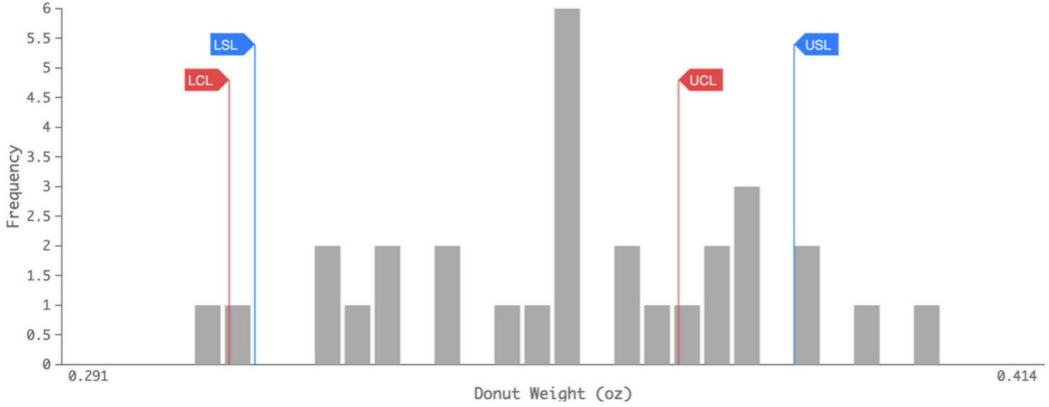
Determine whether each process is capable of producing to specifications

Filled Donuts

Bob's Bakery carries a wide variety of pastries, including his famous filled donuts. Each donut is injected with a flavored jelly or cream. The customers complain if they feel that there isn't a sufficient amount of filling in their donuts. Overfilled donuts are messy and waste costly filling.

Spec Limits
Lower 0.32 Upper 0.38

Control Limits
Lower 0.315 Upper 0.365



What is Filled Donuts's process capability index?

0.22

Is this process capable?

YES

NO

```
# Given data for Bob's Bakery
USL = 0.38  # Upper Specification Limit in oz
LSL = 0.32  # Lower Specification Limit in oz
UCL = 0.365  # Upper Control Limit in oz
LCL = 0.315  # Lower Control Limit in oz
subgroup_size = 30  # Size of the subgroup

# Calculate the process mean
process_mean = (UCL + LCL) / 2

# Calculate the process standard error
process_standard_error = (UCL - process_mean) / 3

# Calculate the process standard deviation (σ)
process_standard_deviation = process_standard_error * math.sqrt(subgroup_size)

# Calculate Cp
Cp = (USL - LSL) / (6 * process_standard_deviation)
```

```
Process Mean: 0.3400 oz
Process Standard Error: 0.0083 oz
Process Standard Deviation (σ): 0.0456 oz
Process Capability Index (Cp): 0.22
```

CHALLENGE 3 - Company D

PREPARE CHALLENGES: 1 2 3 COMPANY: A B C D 4

Determine whether each process is capable of producing to specifications

Tire Pressure

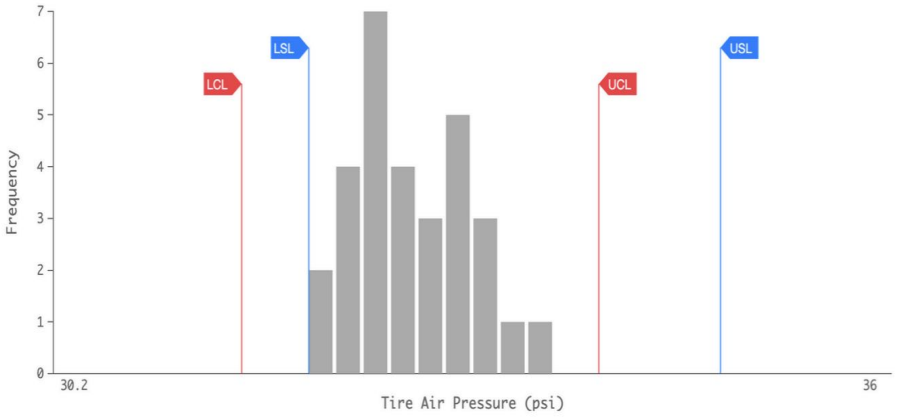
One of the tasks on the turnaround list for a rental car agency is to check and adjust tire pressure. When a tire is over-inflated, it can cause a bouncy ride and poor handling. If it is under-inflated, it can cause premature wear due to increased friction.

Spec Limits

Lower	Upper
32	35

Control Limits

Lower	Upper
31.2763	33.8737



What is Tire Pressure's process capability index?

0.21

Is this process capable?

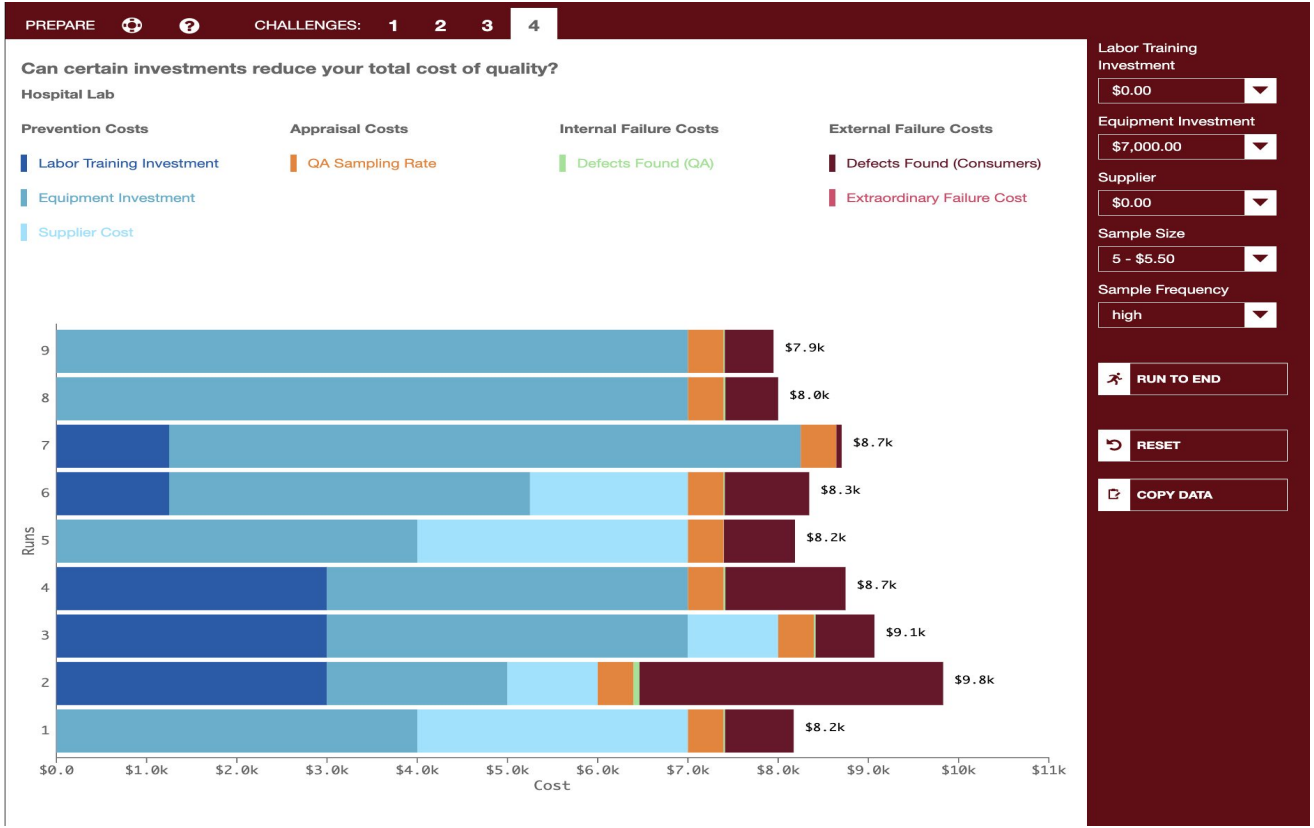
YES

NO

```
# Given data for Tire Pressure
USL = 35.0  # Upper Specification Limit in psi
LSL = 32.0  # Lower Specification Limit in psi
UCL = 33.8737  # Upper Control Limit in psi
LCL = 31.2763  # Lower Control Limit in psi
subgroup_size = 30  # Size of the subgroup

# Calculate the process mean
process_mean = (UCL + LCL) / 2

# Calculate the process standard error
process_standard_error = (UCL - process_mean) / 3

# Calculate the process standard deviation (σ)
process_standard_deviation = process_standard_error * math.sqrt(subgroup_size)

# Calculate Cp
Cp = (USL - LSL) / (6 * process_standard_deviation)
```

```
Process Mean: 32.5750 psi
Process Standard Error: 0.4329 psi
Process Standard Deviation (σ): 2.3711 psi
Process Capability Index (Cp): 0.21
```

CHALLENGE 4 - Total Cost of Quality achieved $7.9k



For **Challenge 3**, given the following Cp values:

- A = 1.404
- B = 2.08
- C = 0.22
- D = 0.21

The **Cp** values suggest that **Company B** has the highest process capability (Cpk = 2.08), indicating its process is the most capable of consistently meeting specification limits, while **Company C** and **Company D** have significantly lower capabilities (Cpk < 1), indicating issues with their processes.

Thank-You

Reference:

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