

**Lever 3000 (Load class 2000 Nm)  
Missing Teeth Segment**

**20 March 2019**

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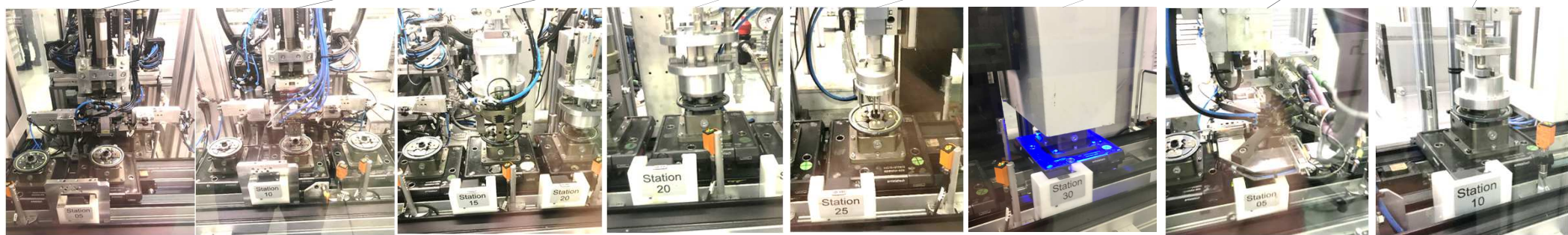
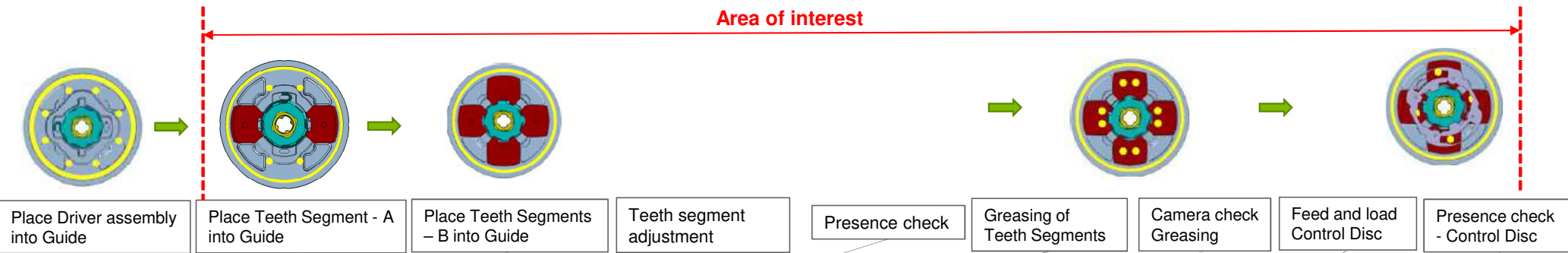
**Improving the experience of a world in motion**

# Lever 3000 Recliner – Process Flow & Controls – Lever II

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## Assembly Steps



## Process flow & Controls



# Lever 3000

## Recliner – Why made?

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### Why? Missing front Toothed Segment B

- > **Why?** Toothed Segment B fell out of guide before assembly of control disc due to collision between Work piece carriers
- > **Why?** Toothed Segment B was not properly placed into guide slot during assembly process (Placed in tilted condition)
- > **Why?** Gripper of pick and place Toothed Segments B not properly adjusted

Correct placement

Incorrect placement

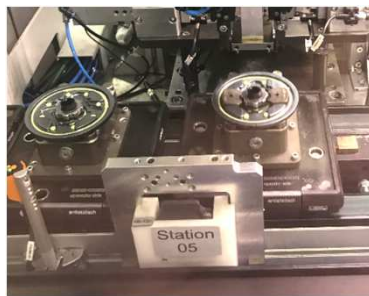
Teeth Segment - B

Teeth Segment - B

Guide

Guide

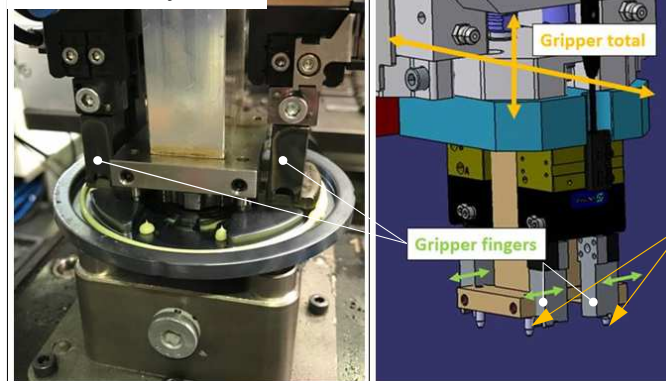
Hit to next Work Piece carrier could make the Teeth segment to fall-off



### PCA

- Optimization of grippers for pick and place of toothed segments B to reduce chance of misplacement. implemented on 8 Feb 2019

Previous system



Locator to Guide on Base Plate  
**Fixed unit** without any adjustments to compensate variation

**Additional Units in updated system for accurate positioning with additional DoF**  
1) **AFAG Module**

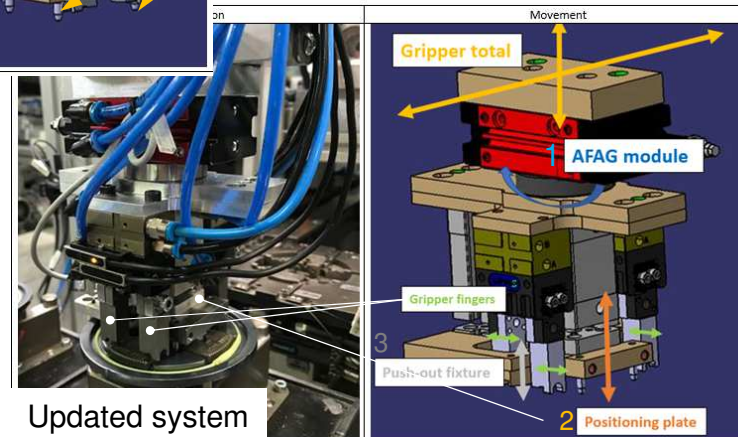
Additional rotary freedom for proper lead in

2) **Positioning Plate**

Additional vertical flexibility for Locator to touch Guide before Gripper

3) **Push-out Fixture**

To slide Teeth Segments directly into the slot and push down by compressing Grease



Updated system

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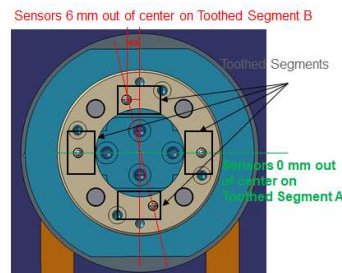
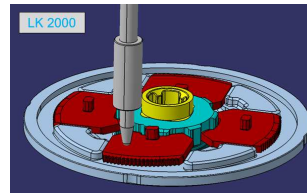
**Why? Missing front Toothed Segment B**

- > **Why?** 100% online detection of front Toothed Segment B failed
- > **Why?** Sensor for detection of presence of front Toothed Segment B not adjusted to detect sloped Toothed Segment B (sloped Toothed Segments B can fall out of sub-assembly before next process step / assembly of control disc)
- > **Why?** Failure of sloped Toothed Segments B not considered in PFMEA



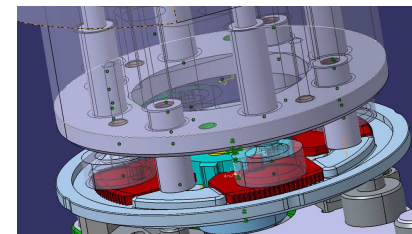
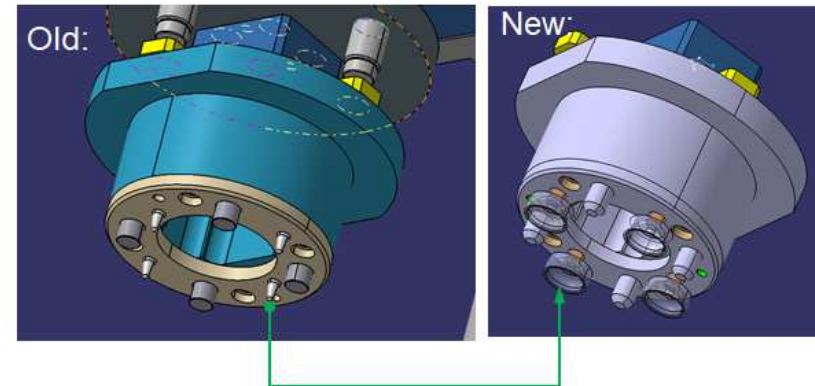
Segment A Sensor Placement – Difference in height is significant to be detected

Segment B Sensor Placement – Difference in height is insignificant to be detected in case of tilted teeth segment



**PCA**

- Optimization of sensing device for detection of presence and position of toothed segments B
  - a) Diameter of pins enlarged
  - b) Position of pins optimized to be at the middle
- implemented on 21 Jan 2019



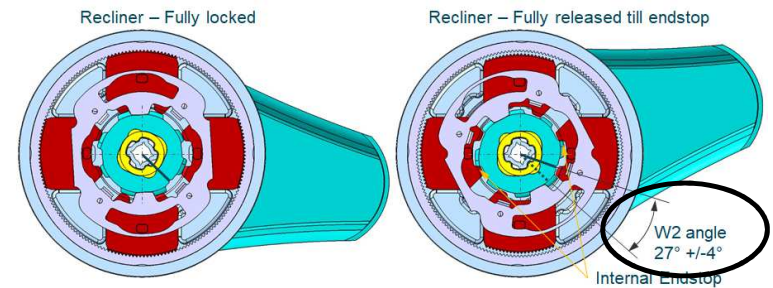
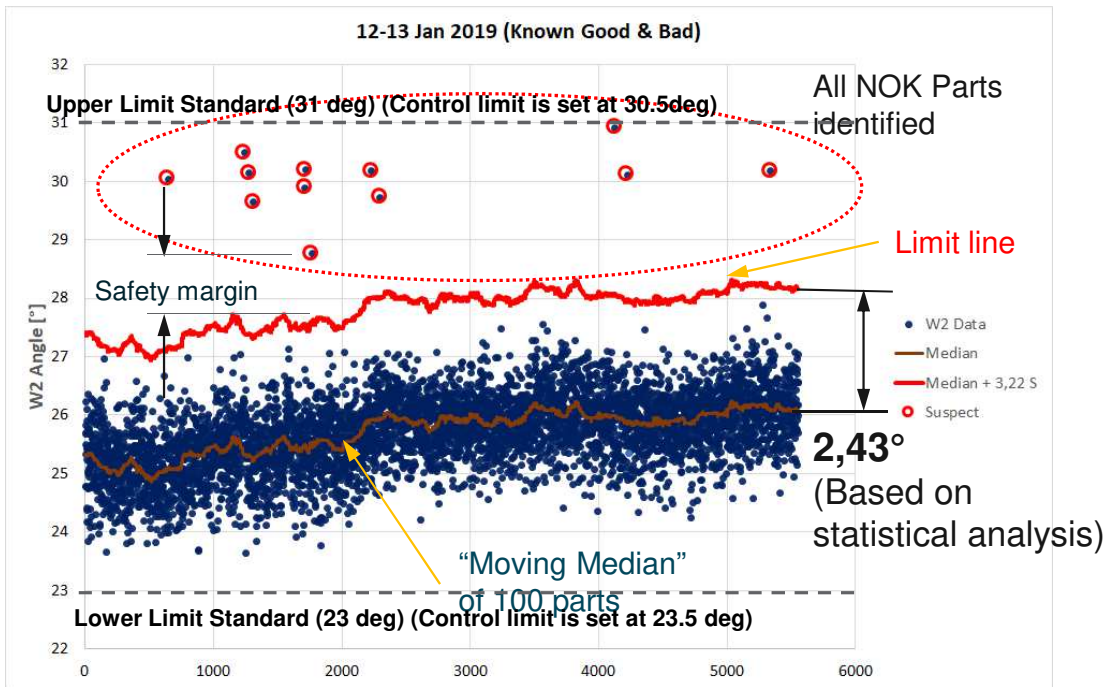
# Lever 3000 Recliner – Detection method $\Delta W2$

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Principle : Use increase in W2 angle to rest of the population to identify Outliers as Suspect



### Algorithm:

If  $W2 > \text{Moving Median of 100 data} + 2,43^\circ$

=> Suspect

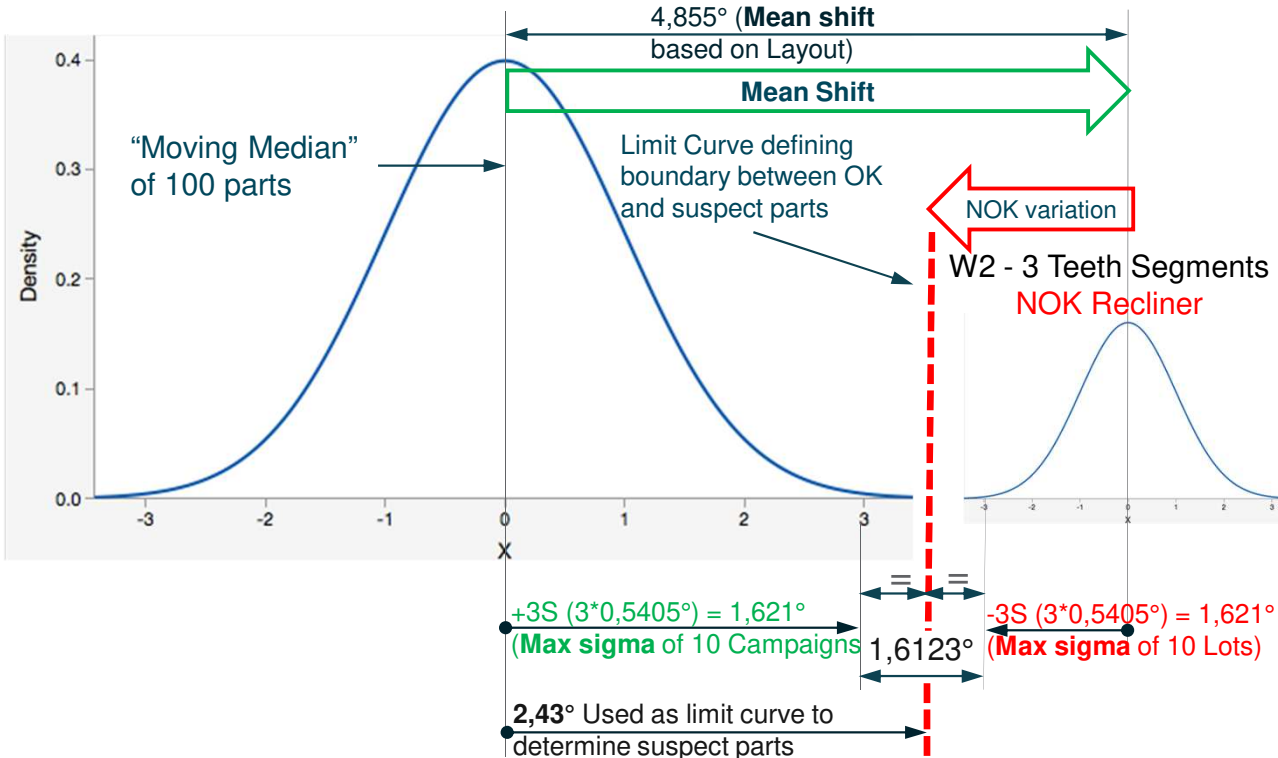
=> Otherwise, OK

1. All parts identified for NOK W2 angle increase were opened and found to have missing segment.
2. Mean shift in W2 angle was able to identify recliners with 3 segments vs 4 segments. W2 is 100% monitored and recorded

Detection method – Explanation

Principle : Use increase in W2 angle to rest of the population to identify Outliers as Suspect

W2 - 4 Teeth Segments – OK Recliner

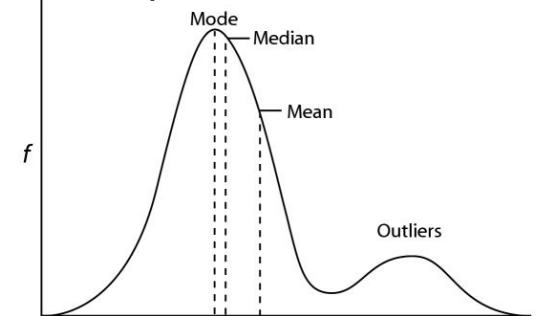


Sorting Procedure:

For each lot,

- Sigma = 0,5405°
- Calculate „Moving Median“ for each data point based on next 100 data
  - Median is chosen over Average to improve stability against Outliers
- Moving Median curve is the Base line
- Offset by 2,43° to define the Limit curve (Offset Factor = 4,5 \* Sigma)
- Any data point lying above the limit curve is declared as Suspect

Explanation – Mean Vs Median



# Lever 3000

## Recliner – Detection method $\Delta W2$

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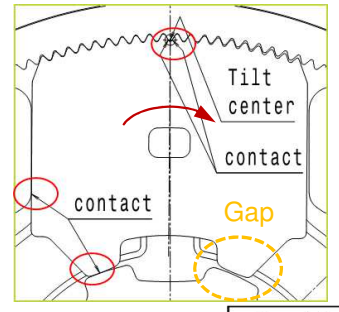
### Derivation of Mean Shift in W2

#### Functional principle

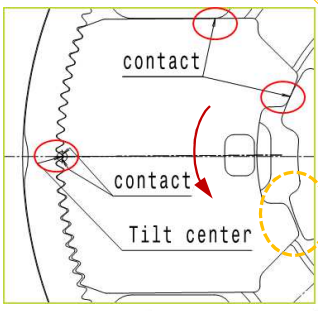
#### 4x Contacts between Excenter to Teeth segment

Excenter is allowed to float to support all 4 Teeth segments at the same time

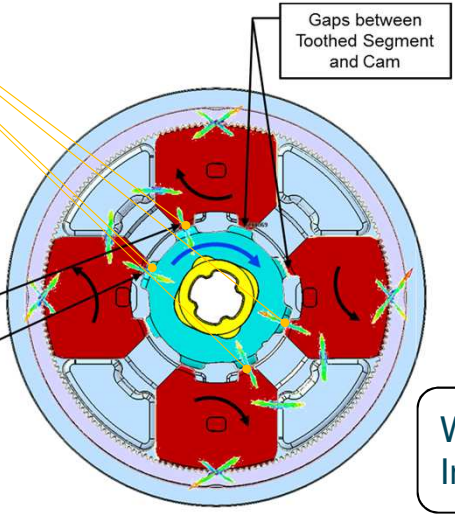
Upper and Lower Toothed Segment (shown = Upper; Lower is 180° rotated)



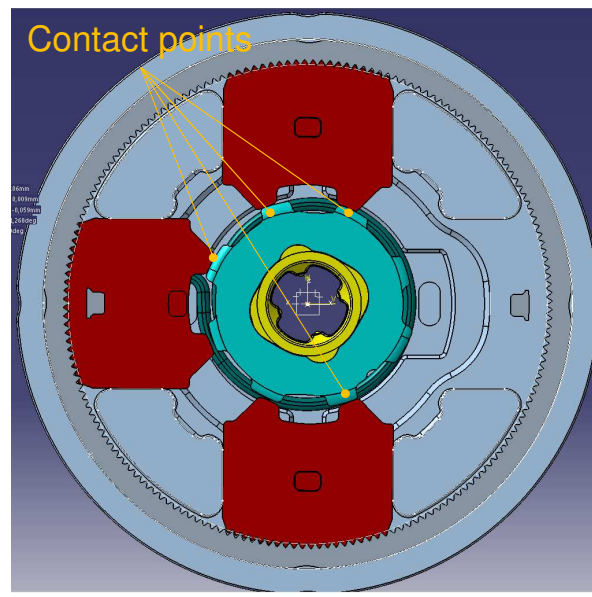
Left and Right Toothed Segment (shown = Left; Right is 180° rotated)



Contact between Toothed Segment and Cam



With missing Teeth segment - B, Excenter loses support at one of four contact points and has to turn more to find the next possible support



W2 angle depends on,

- Variation in functional geometry of all components in recliner
- Variations are relatively constant for particular batch of production; but, changes over time with mixup of batches

When all other conditions remain the same, Increase  $\Delta W2$ : +4.855° (Based on CAD study on Nominal geometry)

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# Lever 3000 Recliner – Detection method $\Delta W2$

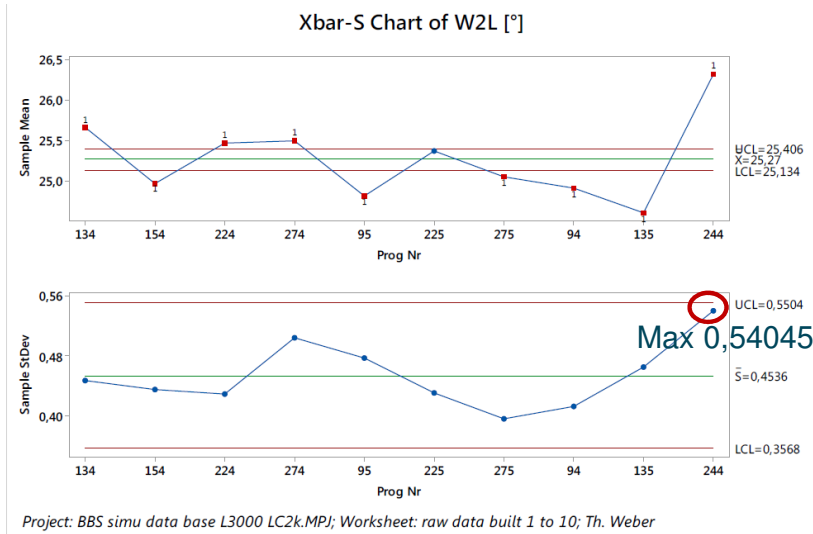
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## Derivation of standard deviation in W2

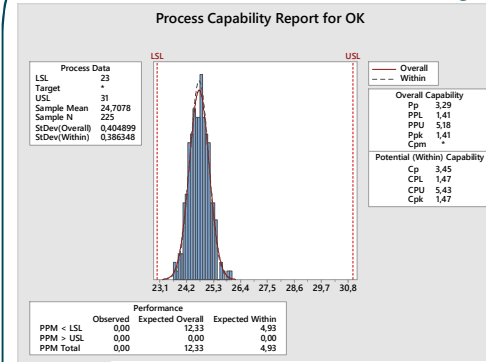
10 randomly chosen serial built campaigns LC 2000 in timeframe Oct '18 till Feb '19 show lower standard deviation than mixture between the two load classes.



Max Standard deviation 0,5405° is chosen to set the sorting criteria

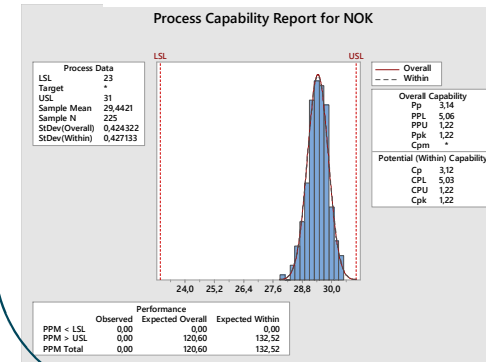
## CONTROL BUILD for verification

### W2 – Recliner with 4 Segments - OK



Mean : 24,71°  
Sigma : 0,405°  
N : 225

### W2 – Recliner with 3 Segments - NOK



Mean : 29,442°  
Sigma : 0,427°  
N : 225

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