HEXAGON

Q-DAS qs-STAT

Comparison C- and P-values

A case study to output the Capabilities like required from the AIAG

CAS
21 February 2024
Created with Version V14

HxGN
Quality Assurance

Information about this document

Parts of this document may be automatically translated.

Document History

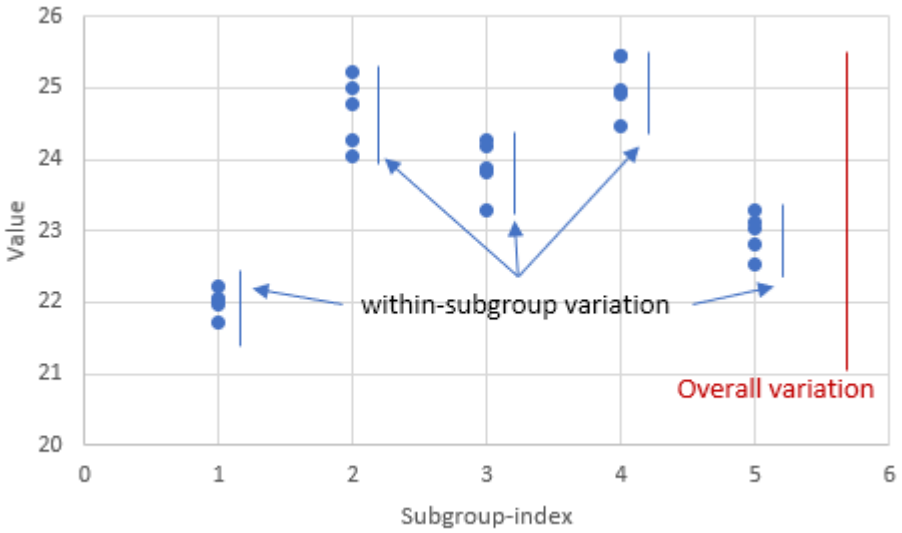
Version	Date	Author(s)	Modifications / Remarks
	13.06.2023	RA/SJ	Initial release
v-0.7	21.08.2023	LG	New template

CONTENTS

1 Task – C-value comparison report

The evaluation product qs-STAT can output various process capability and process performance indices, like C_p/C_{pk} and P_p/P_{pk}. In this document the focus is on capability indices, which are defined in the SPC-Manual of the Automotive Industry Action Group (AIAG).

The **AIAG SPC-Manual** distinguishes between:



- **Process Capability indices C_p and C_{pk}** are calculated based on the inherent *within-subgroup variation* only. The process capability considers only a *fraction* of the overall process variation.

  Within the Q-DAS software products the AIAG-specific indices C_p and C_{pk} have been renamed to C_{pi} and C_{pki} to indicate to the user that these indices only take into account the *inherent* within-subgroup variation.

- **Process Performance indices P_p and P_{pk}** are calculated based on the *overall process variation*. The *overall process variation* takes into account not only the *within-subgroup variation* but also the *between-subgroup variation*. An internal or external customer is typically more concerned with the process performance indices.

The actual naming of the various capability and performance indices as well as the “letters” used, such as “Cm”, “Pm”, “Tp”, are described in the separate document “Naming of the C-values”.

The task of this case study is to create a single report that contains both process performance indices and process capability indices. This enables the user to compare the results. Special causes are responsible for the difference between Cpi/Cpki and Pp/Ppk. Therefore, the difference shows the theoretical process improvement potential.

Overall evaluation

Model distribution			Mixed distribution (EM)
Calculation method		$M_{2,1}$ Percentile (0,135%-50%-99,865%)	
Potential Performance index	P_p	1.98 ≤ **2.05** ≤ 2.12	0 — 1.67
Critical performance index	P_{pk}	1.84 ≤ **1.91** ≤ 1.98	0 — 1.67
The requirements were met (P_p,P_{pk},LV)			
Demand Potential Performance index		$P_{p\,target}$	1.67
Demand Critical performance index		$P_{pk\,target}$	1.67
⌀ CAS_0401_Comparison_C-and-P-Values_AIAG			

Calculation of inner variation

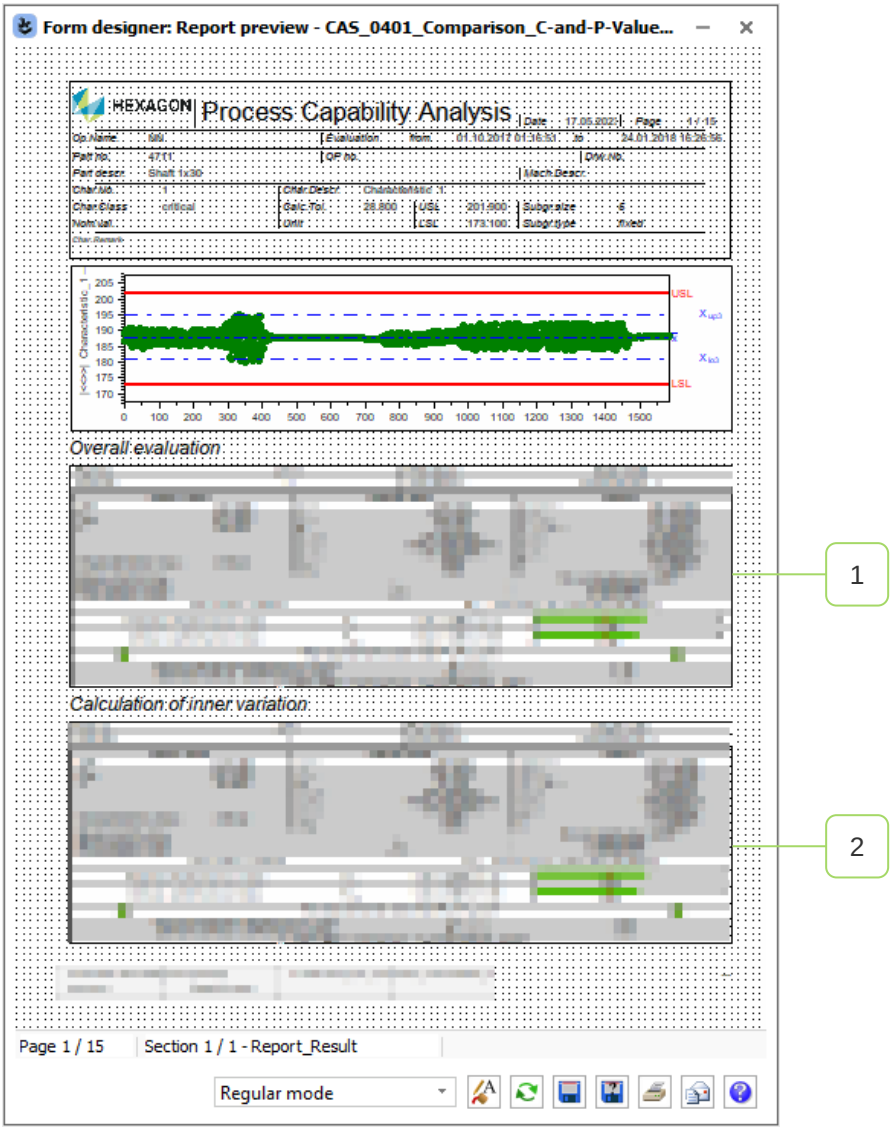
Potential Performance index	C_{pi}	3.21	0 — 2
Critical performance index	C_{pki}	3.13	0 — 2
The requirements were met (P_p,P_{pk},LV)			
Demand Potential Performance index		$C_{pi\,target}$	2.00
Demand Critical performance index		$C_{pki\,target}$	2.00
⌀ CAS_0401_Comparison_C-and-P-Values_AIAG			

2 Approach to the solution

The first step is to ensure that the calculation methods and requirements have been defined in the evaluation strategy.

The loaded data pool is automatically evaluated in the Q-DAS applications according to the defined evaluation strategy. The information from the data pool and the results calculated during the evaluation are available in the application as output points. In order to be able to output the C-values in the reports, it is necessary to know how to handle the output points.

The reports are created and customized using the “Form designer”. In this case study the graphic “Form sheet - Design 3” is used to display the C-values. The graphic is included twice in the report. The first one is configured with the output points for the “Overall evaluation” (Process Performance indices Pp/Ppk). The second one with the output points for the “Calculation of inner variation” (Process Capability indices Cpi/Cpki).



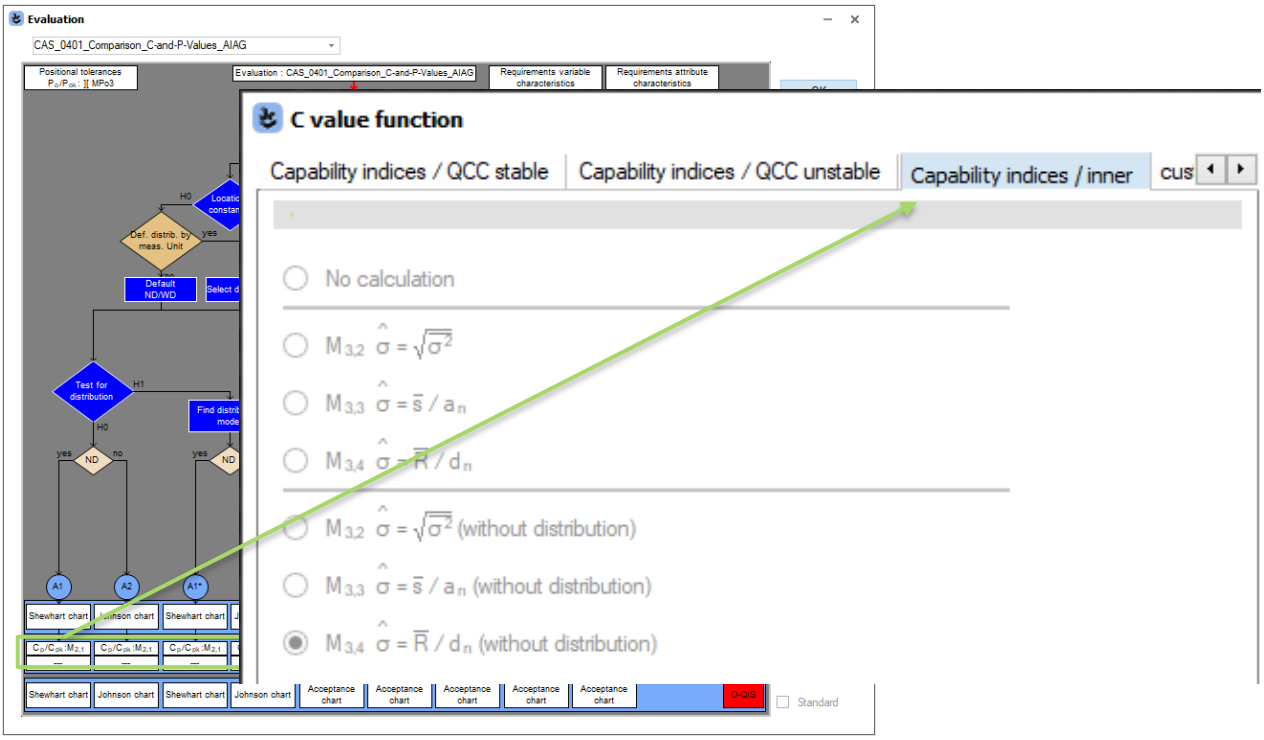
2.1 C-values configuration in the evaluation strategy

With the statement "C and P values at the same time", most customers ask for a report according to the AIAG. The designations of the capability indices differ from ISO.

- The P-value is the calculated process performance based on the estimator of the overall variation.
- The C-value is the calculated process capability based on the estimator of the inherent within-subgroup variation.

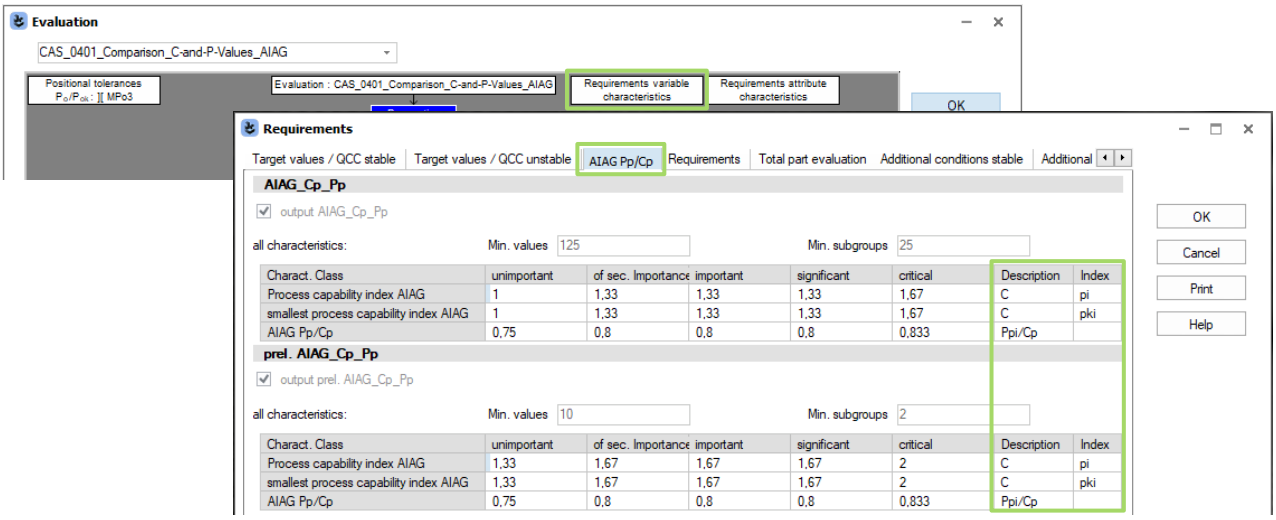
Calculation method

In the evaluation strategy, it is possible to specify in each path the calculation method of the inherent within-subgroup variation of the process capability index Cpi/Cpki.



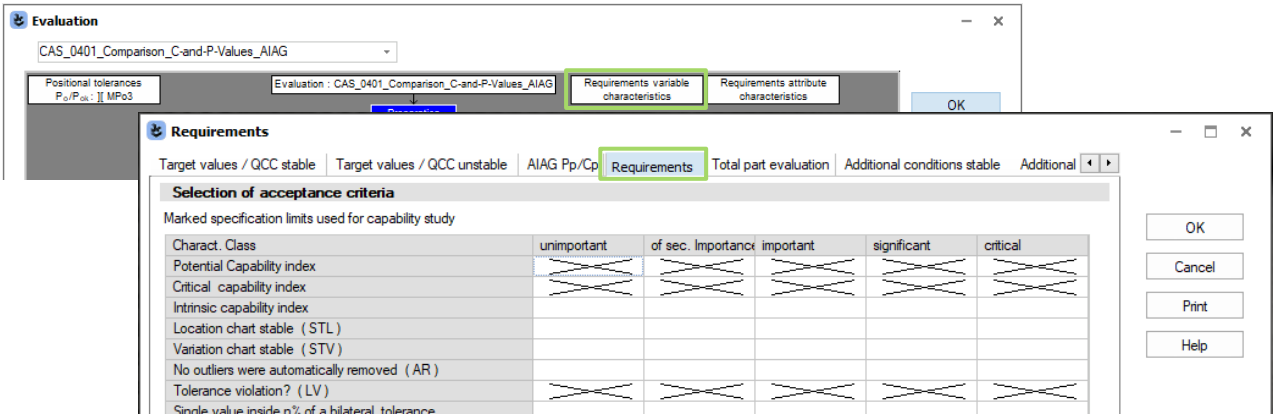
C-values naming

In the window “Requirements”, tab “AIAG Pp/Cp”, we use the index “i” to mark the AIAG-specific process capability indices, which are based on the inherent within-subgroup variation only.

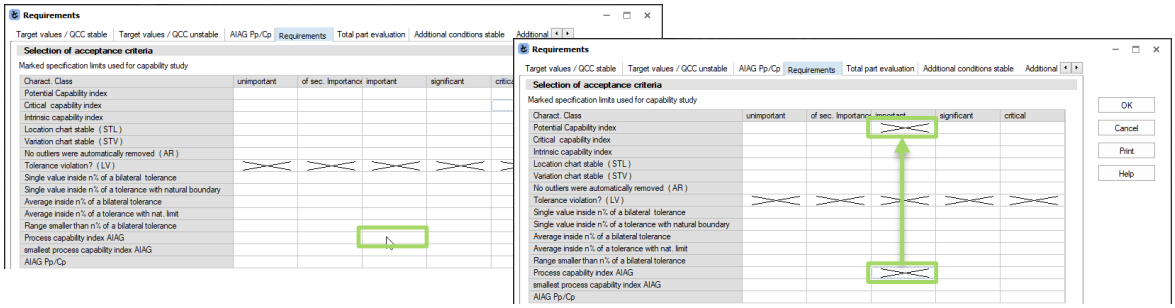


Requirements

In tab “Requirements” we can check, which requirements are active. Active requirements are marked with an “X” and will be used for the overall evaluation provided in output point 15000 | 0.



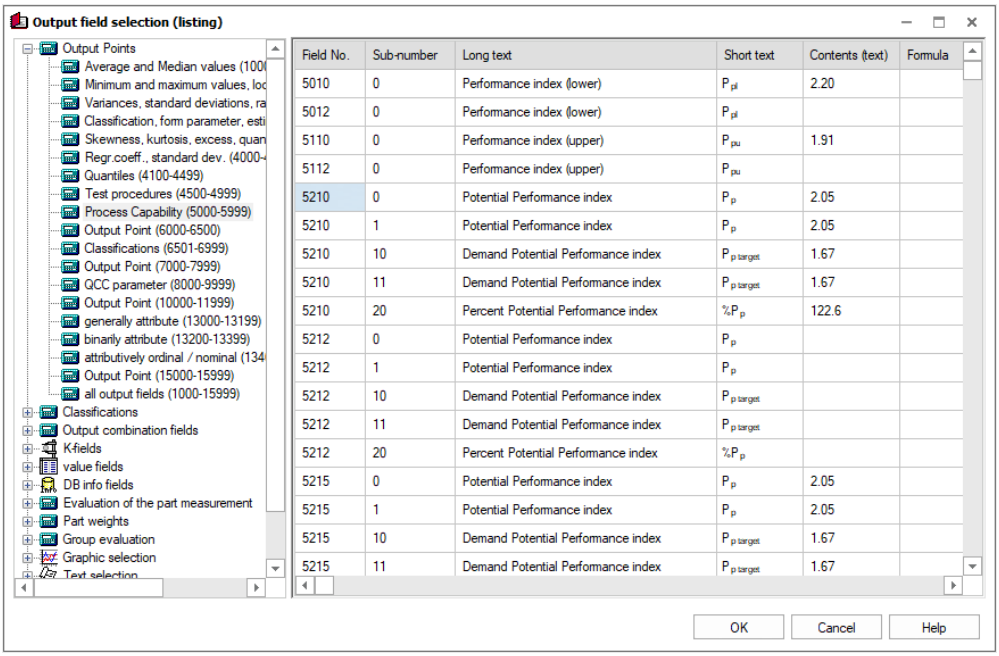
Some requirements have dependencies. For example, "Potential Capability Index" and “Process Capability Index AIAG”. Selecting “Process Capability Index AIAG” automatically selects "Potential Capability Index" as a requirement.



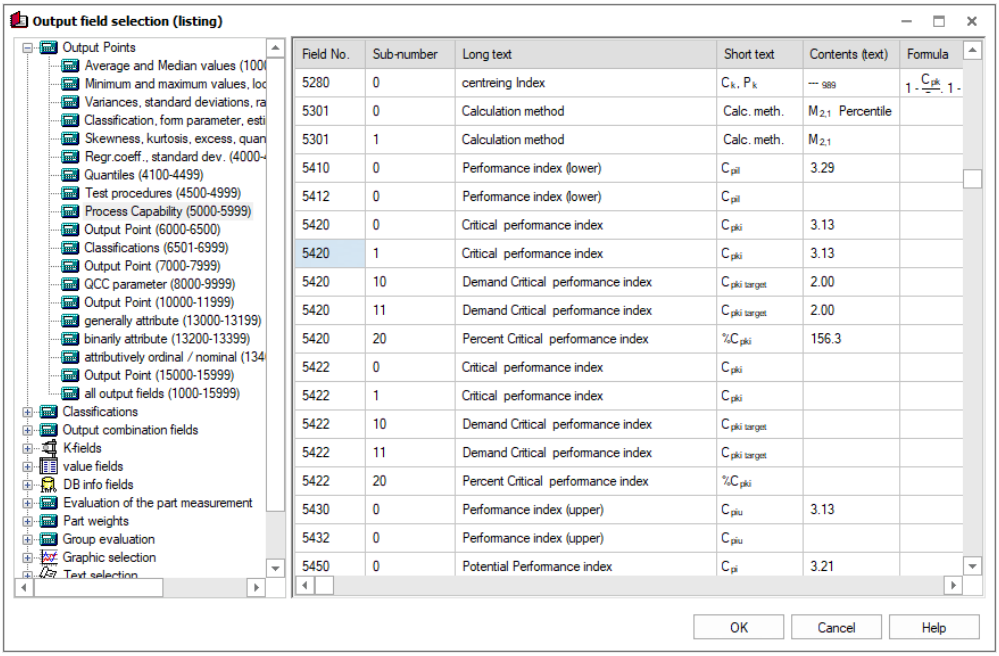
2.2 C-value output points

The output points are selected using the "Output field selection (listing)" dialogue. Depending on the selected graphic and its purpose, different output points are available for selection. The C-value output points can be found in the "Process Capability" group.

The “Output field selection (listing)" dialogue with the C-values, which are calculated based on the overall variation (Field No. 52XX; Pp/Ppk):

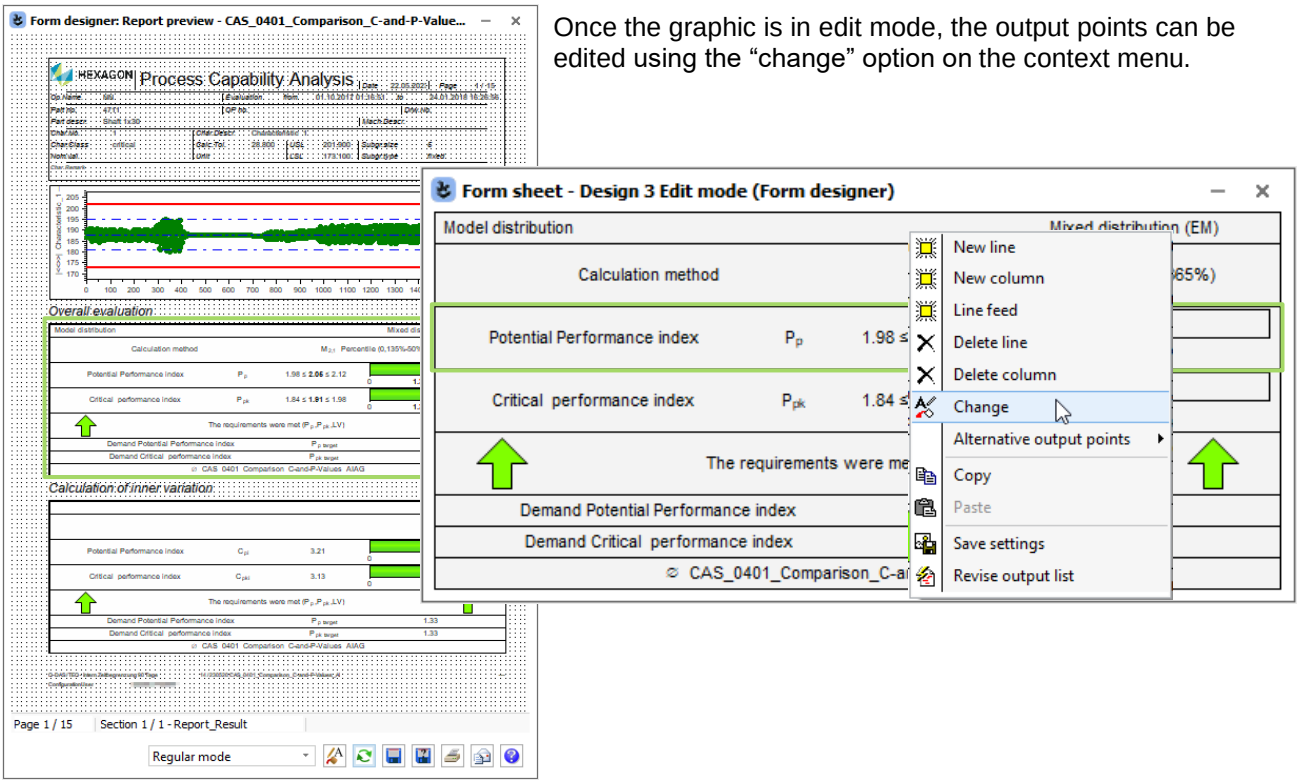


The “Output field selection (listing)" dialogue with the AIAG-specific C-values, which are calculated based on the inherent within-subgroup variation (Field No. 54XX; Cpi/Cpki):



2.3 Output points in the graphic

The following explains the configuration of the output points with the example of the graphic “Form sheet – Design 3” and the C-value “Potential Performance Index”.

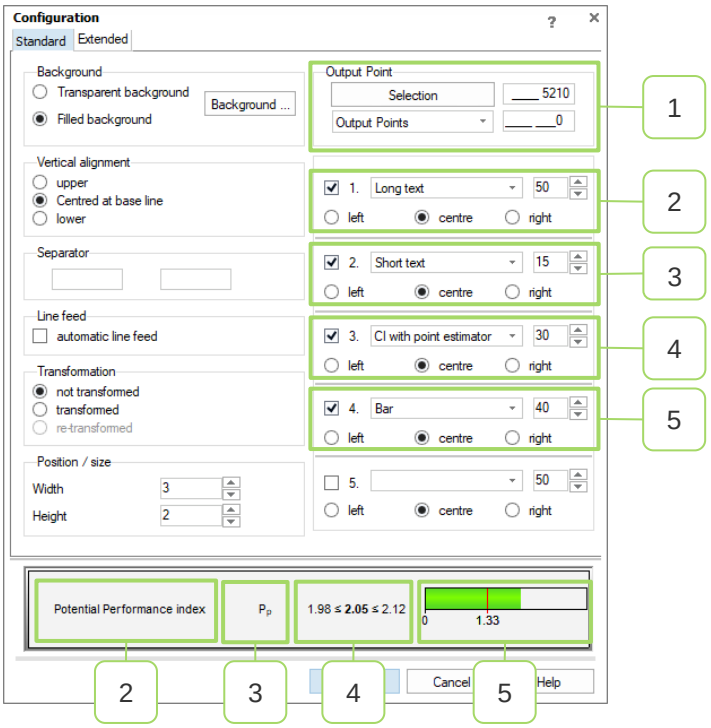


Once the graphic is in edit mode, the output points can be edited using the “change” option on the context menu.

For the selected line, the output point 5210 is configured with the sub-number 0 (1).

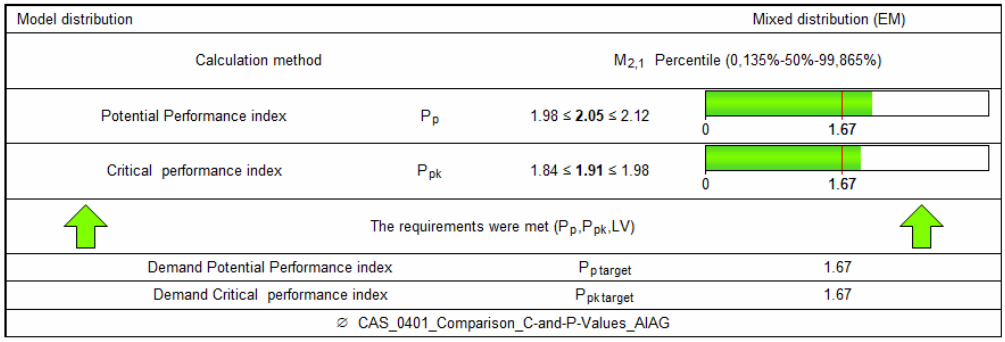
As you can see, the line can contain up to five field-sections.

Four different field-sections have been configured here to design the display of the output point (2 - 5).



Overview of the output point in the "Form sheet - Design 3" graphic for displaying the overall evaluation.

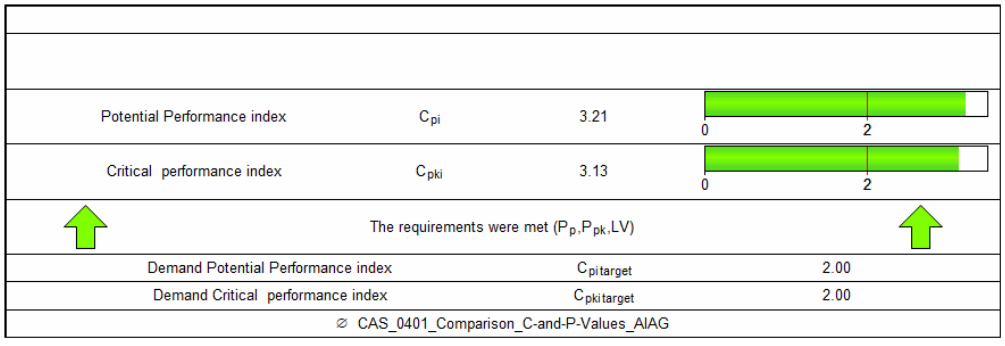
Overall evaluation



Line	Output point	Sub no.	Description	Output forms
1	6000	0	Model distribution	Long text; Empty field; Contents
2	5301	0	Calculation method	Long text; contents
3	5210	0	Potential Performance index	Long text; Short text; CI with point estimator; Bar
4	5220	0	Critical Performance index	Long text; Short text; CI with point estimator; Bar
5	15000	0	Requirements (Overall evaluation result)	Arrow; Contents; Arrow
6	5210	10	Potential Performance index	Long text; Short text; Contents
7	5220	10	Critical Performance index	Long text; Short text; Contents
8	6040	1	Evaluation strategy name	Contents

Overview of the output points in the "Form sheet - Design 3" graphic for displaying the calculation of inner variation.

Calculation of inner variation

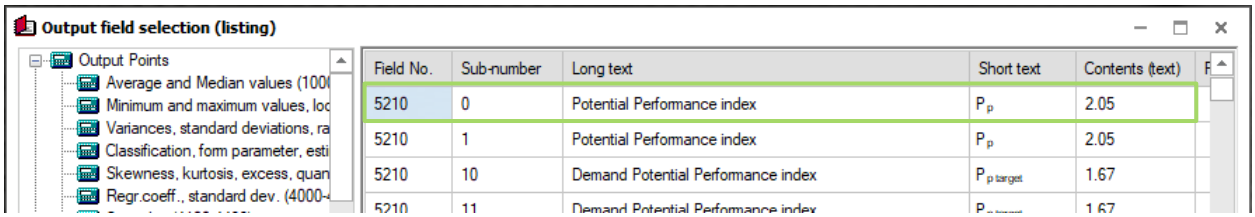


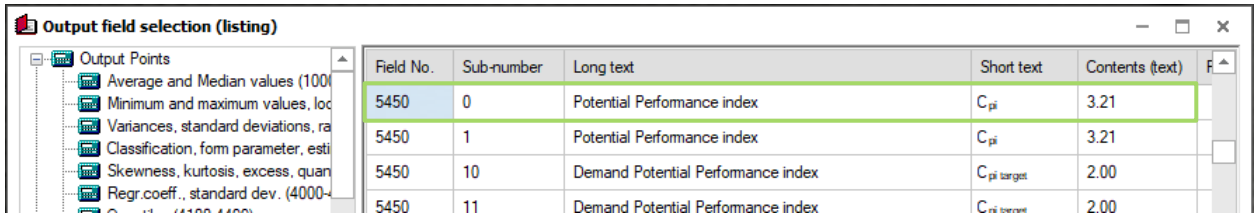
Line	Output point	Sub no.	Description	Output forms
1				
2				
3	5450	0	Potential Performance index	Long text; Short text; CI with point estimator; Bar
4	5420	0	Critical Performance index	Long text; Short text; CI with point estimator; Bar
5	15000	0	Requirements (Overall evaluation result)	Arrow; Contents; Arrow
6	5450	10	Demand Potential Performance index	Long text; Short text; Contents
7	5420	10	Demand Critical Performance index	Long text; Short text; Contents
8	6040	1	Evaluation strategy name	Contents

3 Notes on handling output points

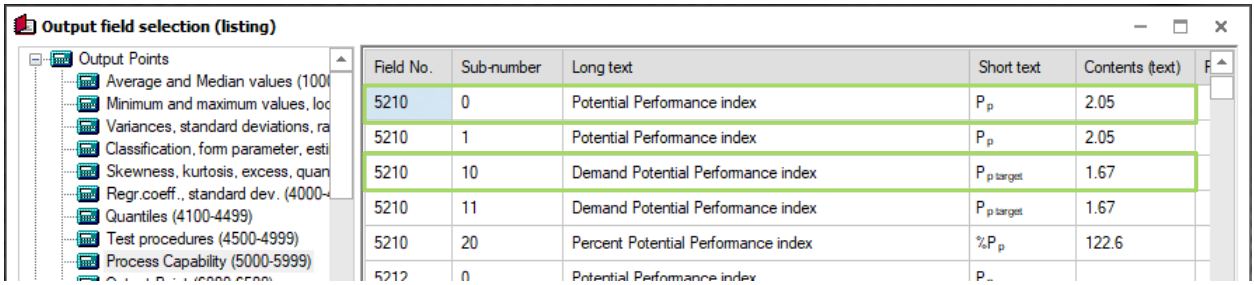
Selecting the correct output point and sub-number is very important.

For example, the output points 5210 | 0 and 5450 | 0 have the same long text (name) but different contents.



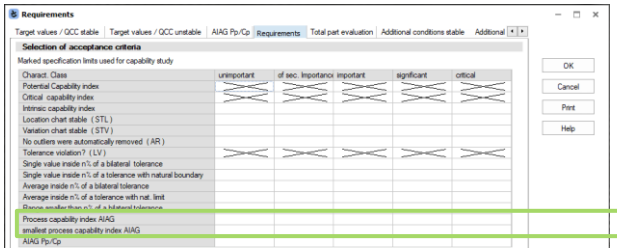


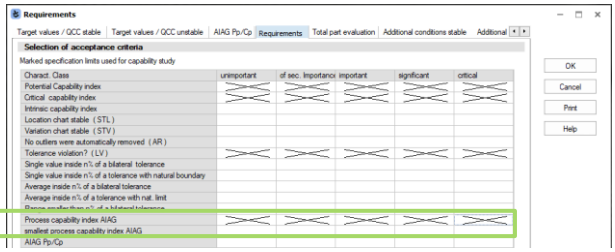
The sub-numbers “0” and “10” for output point 5210 differ in content.



The content of an output point is affected by the configuration of the evaluation strategy.

The contents of output point 15000 | 0 are requirements of the evaluation strategy. On the left, the C-values “Process capability index AIAG” are not activated.





The requirements were met (P_p,P_{pk},LV)

The requirements were met (P_p,P_{pk},LV,C_{pi})

4 Output points of common capability figures

The *short text* and the *content* of the output points is typically bound to settings within the evaluation strategy that is in use. In other words: The *short text* and the *content* will normally change when the user choses a different evaluation strategy.

Output point	Longtext	Short text
5301 | 0	Calculation method	Calc. meth.
5210 | 0	Potential Capability Index	P_p
5210 | 10	Demand potential capability index	$P_{p\ target}$
5110 | 0	Capability Index (upper)	P_{pu}
5010 | 0	Capability Index (lower)	P_{pl}
5220 | 0	Critical capability index	P_{pk}
5220 | 10	Demand critical capability index	$P_{pk\ target}$
5240 | 0	Intrinsic Capability index	P_{pi}
5230 | 0	Non-critical Capability Index	C_{pl}
5535 | 0	Expected proportion outside	$p_{>T<}$
5636 | 0	Sigma short term	z_{rst}
5637 | 0	Sigma long term = Sigma short term – 1.5	z_{lt}

5 Output points of AIAG specific C-figures

The *short text* and the *content* of the output points is typically bound to settings within the evaluation strategy used. In other words: The *short text* and the *content* will normally change when the user choses a different evaluation strategy.

Output point	Longtext	Short text
5450 | 0	Potential Capability Index	C_{pi}
5450 | 10	Demand Potential Capability Index	$C_{pi\ target}$
5430 | 0	Capability index (upper)	C_{pui}
5410 | 0	Capability index (lower)	C_{pli}
5420 | 0	Critical capability index	C_{pki}
5420 | 10	Demand Critical capability index	$C_{pki\ target}$
5460 | 0	AIAG Pp/Cpi	$AIAG\ P_p/C_{pi}$
5460 | 10	Demand AIAG Pp/Cpi	$AIAG\ P_p/C_{pi\ target}$
5470 | 1	Relevant proportion outside specification for z-score	p_{LSL}
5471 | 0	Z-score	z_c
5472 | 0	AIAG z-score	P_{pk}

The numerical examples for process capability indices Cpi and Cpki inside the AIAG SPC-manual are typically based on the within-subgroup variation sigma estimator $\hat{\sigma} = \frac{\bar{R}}{d_2}$. To get the same evaluation results that fit the example values of the AIAG SPC-Manual the estimator calculation method should be set to $M_{3,4}$.