MSA capability studies for electronics tester qualification

Contents

Scope 2
1. General Information 2
2. Applicability 3
3. Software – supported analysis 3
4. MSA type 1 capability study 3
   a. Precondition for MSA type 1 study 3
   b. Accuracy of the measurement devices 4
   c. Procedure of MSA type 1 4
   d. Calculation of the capability indices Cg and Cgk 6
5. MSA type 2 capability study 7
   a. Precondition for the MSA type 2 capability study 7
   b. Procedure of MSA 2 7
6. MSA type 3 capability study 9
   a. Precondition for the MSA type 3 capability study 9
   b. Procedure of MSA 3 9
7. Gage R&R result classification for MSA type 2 and 3 11
   a. Results ≤ 10% 11
   b. Investigation on 10% < GRR ≤ 30% 11
   c. Investigation on GRR > 30% 12
8. Impact of MSA 1, MSA 2 and MSA 3 on production status 12

Scope

This requirement shall be used for all:

- Electronics
- Electronic components as PCB
- Assemblies, which host electronics

manufactured and/or developed for Hilti.

1. General Information

As part of the production lines on which electronics or electronic components are manufactured, testers of multiple functional principles are used. These testers shall be capable of delivering reliable results regarding:

- Resolution
- Reproducibility
- Repeatability

That these characteristics meet the demands given in this document shall be verified by the supplier by means of MSA capability studies.

The performance of MSA analyses is largely standardized by different literature sources. Nevertheless, there are differences, even if very minor, in the calculation rules of key figures. Beyond the MSA, other statistical tools enable the evaluation of processes within the production lines. The illustration of all possible boundary conditions, initial situations as well as limitations concerning an MSA analysis is not the aim of this document. Rather, individual aspects of MSA´s are to be highlighted and standardized within this document and thus, represents the minimum scope of requirements Hilti demands for the execution of an MSA.

The aim of this document is that Hilti, as the addressee of MSA analyses, receives them as far as possible unified and standardized and thus receives a clear statement about the capability of measurement processes.

Deviations, Exceptions shall be agreed upon by Hilti Quality. All deviations from general requirements shall be released by Hilti Quality.

2. Applicability

MSA-studies 1, 2 and 3 are applicable to all types of measurement units inside a production line like

- ICT
- Functional testers
- High Voltage testers

which generate electrical quantizable measurement results.

3. Software – supported analysis

MSA-studies 1, 2 and 3 require the execution of mathematical calculations. These can either be done manually or automatically by means of software-supported analysis tools, which additionally offer the possibility to present the measurement results graphically.

The representation of the measured values within a diagram simplifies the investigation on root causes for capability indices, which lie outside of the specified range such as:

- A too low long-term stability of the measurement system or the device under test
- A drift of the measurement results due to temperature for instance
- Single measurement outliers / extreme values

4. MSA type 1 capability study

a. Precondition for MSA type 1 study

The MSA type 1 study shall verify the capability of a measurement process to be repeatable. The study requires product characteristics with two-sided specification limits. The tolerance T is the difference between these two limits.

If only one specification limit exists for either the upper or the lower side in addition with a natural limit, the tolerance T is the difference between these two limits as well.

Product characteristics, which are only limited to one side, either the upper or the lower, the parameters Cg and Cgk cannot be calculated. Instead, acceptance criteria shall be defined to judge the capability of the measurement process.

The reference values x_m of the product characteristics are ideally located in the center of the tolerance range.

b. Accuracy of the measurement devices

The resolution RE of the measurement devices shall be checked prior to the measurements and shall be:

$$RE \leq 5\% \cdot T$$

The Tolerance T stands for the complete tolerance width.

Example:

When Resistor R = 250Ω ± 10% shall be measured, where the 10% equals 25Ω, the resolution shall be ≤ 0,05 · 50Ω = 2,5Ω.

c. Procedure of MSA type 1

MSA type 1 is carried out using a measurement standard, that is measured 50 times by a single operator. The measurements shall be done including all actions, which will also be executed in the series production. Does an ICT for instance require the production personnel to place a pcb inside a fixture and remove it afterwards, these actions shall be done for each of the 50 measurement steps. From the results of the measurements the capability indices Cg and Cgk shall be calculated.

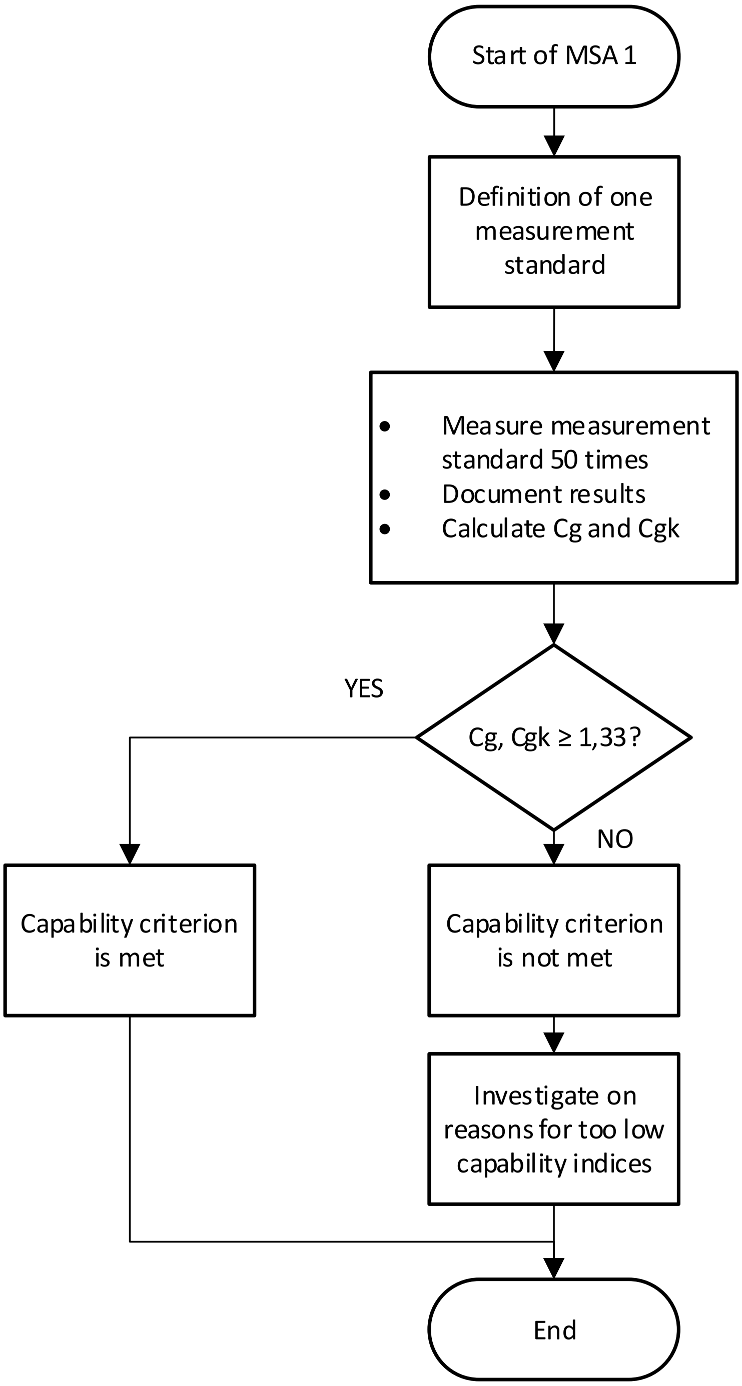

Figure 1: Flow chart of MSA type 1

d. Calculation of the capability indices Cg and Cgk

For the calculation of the potential capability and the critical capability indices, the following formulas shall be used.

Data type	Index / formula	Note
Tolerance of characteristic	T = USL – LSL	USL: Upper tolerance limit LSL: Lower tolerance limit
Reference value	x_m	Reference value of the measurement standard
Potential capability index	$Cg = \frac{0{,}2 \cdot T}{6 \cdot s}$	s: standard deviation of measured values
Critical capability index	$Cgk = \frac{0{,}1 \cdot T - \lvert \bar{x} - x_m \rvert}{3 \cdot s}$	

The capability criterion is met when the indices fulfill the following condition:

$$Cg \geq 1{,}33$$

$$Cgk \geq 1{,}33$$

For capability indices smaller than 1,33, the supplier shall investigate on the root cause and take actions to improve the values. Log files, on which the calculations of the Cg and Cgk characteristic values are based, are to be supplied to Hilti as standard.

Deviations, Exceptions shall be agreed upon by Hilti Quality. All deviations from general requirements shall be released by Hilti Quality.

5. MSA type 2 capability study

a. Precondition for the MSA type 2 capability study

The MSA 2 type shall reveal the capability of the measurement process to be repeatable and reproducible as part of a serial production process. Therefore, it is mandatory to use serial parts, which were manufactured under serial production conditions. Sample parts or prototypes are not allowed to be used for MSA 2 studies. Furthermore, the measurements shall be done under all environmental conditions which can also influence the measurement system in series production.

For the execution of the study the following criteria shall be met:

- 10 randomly selected serial parts shall be chosen
- At least 2 measurement series shall be done, 3 series are optional.
- 3 operators shall do the measurements randomly

b. Procedure of MSA 2

The 10 serial parts shall be measured in a random order by all 3 operators consecutively in 2 to 3 measurement series. Once a measurement series is started by an operator, it shall be finished until another operator starts a new series. As well as for MSA type 1, all actions which occur during the series production process like clamping and unclamping a pcb shall be done for each measurement step during the study. The test results of the single test series shall be inaccessible for the other operators. For a detailed description see the flow chart.

Log files, on which the calculations of the %GRR characteristic values are based, are to be supplied to Hilti as standard.

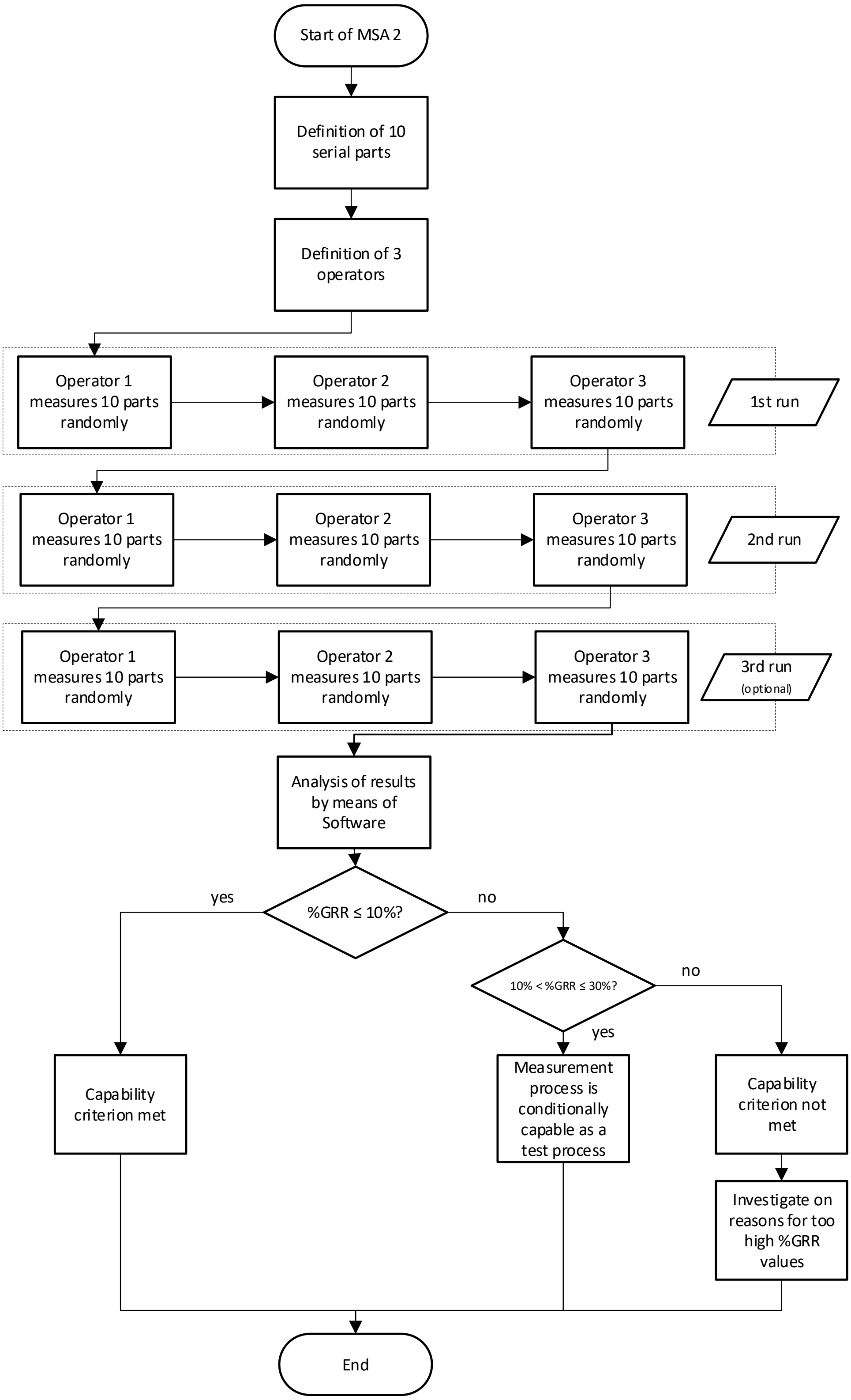

Figure 2: Flow chart of MSA type 2

6. MSA type 3 capability study

a. Precondition for the MSA type 3 capability study

The MSA 3 type shall, as the MSA type 2 does, reveal the capability of the measurement process to be repeatable and reproducible as part of a serial production process. Therefore, it is mandatory to use serial parts, which were manufactured under serial production conditions. Sample parts or prototypes are not allowed to be used for MSA 3 studies. Furthermore, the measurements shall be done under all environmental conditions which can also influence the measurement system in series production.

The MSA type 3 study shall be performed instead of a MSA type 2 study when it is ensured, that the measurement process is done without any operator influence. Usually, the operator has no influence on the process for example if:

- The position of the measuring object is adjusted completely automatically by the test setup.
- The operator cannot influence the force of clamping devices, which hold the measuring object inside the fixture
- The measurement procedure (e.g., adjusting measurement probes, changing measurement ranges) and the data analysis are done fully automatically.

Furthermore, the following requirements shall be met when executing the study:

- At least 25 randomly selected serial parts shall be chosen for the study
- At least 2 measurement series shall be done

The execution of the MSA 3 makes the requirement for a MSA 2 obsolete. This shall be agreed upon by Hilti Quality previously.

b. Procedure of MSA 3

The serial parts which were chosen for the type-3 study are measured in random order. After completion of this first measurement series all parts shall be measured again in a second series. The second series shall not be started until the first is completed.

As well as for MSA type 1 and 2, all actions which occur during the series production process like clamping and unclamping a pcb shall be done for each measurement step during the study. The test results of the single test series shall be inaccessible for the other operators.

Log files, on which the calculations of the %GRR characteristic values are based, are to be supplied to Hilti as standard.

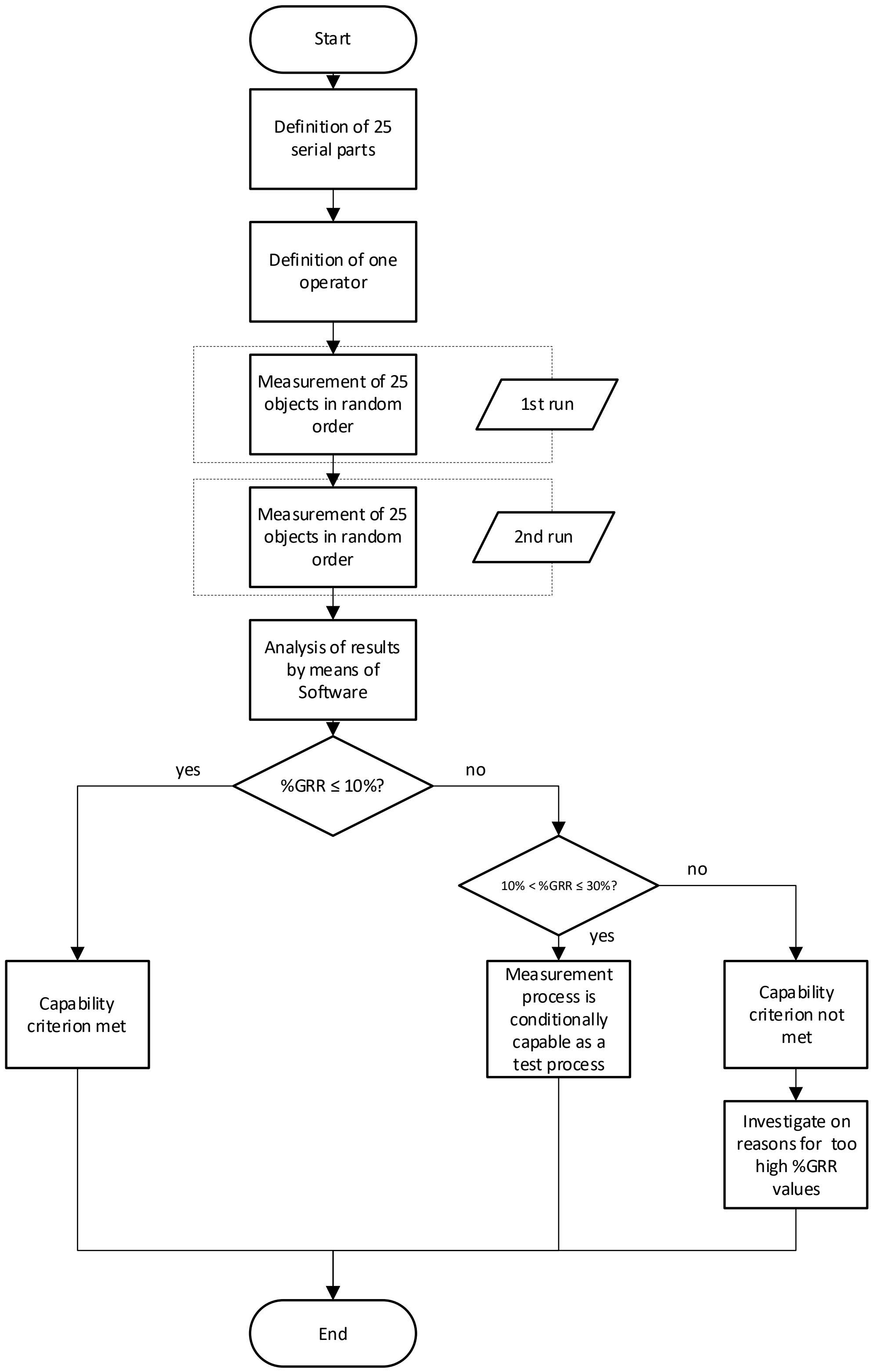

Figure 3: Flow chart of MSA type 3

7. Gage R&R result classification for MSA type 2 and 3

It is recommended to use statistics software using the ANOVA method to have the %GRR values calculated automatically.

If the measurement process is capable will be judged by the %GRR – value and is regulated by the following classification:

GRR	Classification	Hilti validation
≤ 10%	Measurement process is capable to be a test process	Result OK
10% < GRR ≤ 30%	Measurement is conditionally capable to be a test process	Result OK Further investigations on these values can be demanded by Hilti
GRR > 30%	Measurement is not capable to be a test process	Result not OK

a. Results ≤ 10%

These results indicate that the measurement process is fully capable to be a test process.

b. Investigation on 10% < GRR ≤ 30%

Is the result of the Gage R&R analysis between 10% and 30%, the measurement process is conditionally capable of being a test process. Hilti reserves the right to comment on these results and to demand further investigations on it.

Deviations, Exceptions shall be agreed upon by Hilti Quality. All deviations from general requirements shall be released by Hilti Quality.

c. Investigation on GRR > 30%

GRR – values above 30% are not accepted by Hilti. The supplier shall investigate on its root cause and provide and inform Hilti about the results. Changings to the measurement process to improve the GRR-value are mandatory.

Deviations, Exceptions shall be agreed upon by Hilti Quality. All deviations from general requirements shall be released by Hilti Quality.

8. Impact of MSA 1, MSA 2 and MSA 3 on production status

The delivery of the MSA type 1 capability study and its acceptance by Hilti is mandatory to achieve **C-sample** production status.

The delivery of the MSA type 2 capability study and its acceptance by Hilti is mandatory to achieve **D-sample** production status.

Is the MSA type 3 capability study accepted by Hilti to be executed in place of the MSA type 2 capability study, its delivery and its acceptance by Hilti is mandatory to achieve **D-sample** production status.