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Instructions on how to use the DCC schema to create a digital calibration certificate for gauge blocks

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Deutscher Kalibrierdienst (DKD) – **German Calibration Service**

Since its foundation in 1977, the German Calibration Service has brought together calibration laboratories of industrial enterprises, research institutes, technical authorities, inspection and testing institutes. On 3rd May 2011, the German Calibration Service was reestablished as a *technical body* of PTB and accredited laboratories.

This body is known as *Deutscher Kalibrierdienst* (DKD for short) and is under the direction of PTB. The guidelines and guides developed by DKD represent the state of the art in the respective areas of technical expertise and can be used by the *Deutsche Akkreditierungsstelle GmbH* (the German accreditation body – DAkkS) for the accreditation of calibration laboratories.

The accredited calibration laboratories are now accredited and supervised by DAkkS as legal successor to the DKD. They carry out calibrations of measuring instruments and measuring standards for the measurands and measuring ranges defined during accreditation. The calibration certificates issued by these laboratories prove the traceability to national standards as required by the family of standards DIN EN ISO 9000 and DIN EN ISO/IEC 17025.

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Foreword

DKD expert reports aim to provide background information and references in connection with other DKD documents as, for example, the DKD guidelines. In some cases, they may even go far beyond these documents. They do not replace the original DKD documents but do provide a lot of supplementary information worth knowing. The expert reports do not necessarily reflect the views of the DKD's Management Board or Technical Committees in all details.

DKD expert reports are intended to present significant aspects from the field of calibration. Through publication by the DKD they are made available to the large community of calibration laboratories, both nationally and internationally.

Table of contents

1 Background

Against the background of an increasing digitalisation in metrology, the Physikalisch-Technische Bundesanstalt (PTB) has developed the digital calibration certificate (DCC). The DCC enables the reporting of calibration results for all measurands in a machine-interpretable format and, at the same time, fulfils the requirements of DIN EN ISO/IEC 17025:2018 for the reporting of results. For this purpose, an XML schema definition (XSD) has been created. It specifies the type of data and the structure of an XML document. The developed XSD schema offers flexible and diverse solutions for presenting the results for any individual measurand, provided that the results are reported in a schema-compliant XML document. With regard to the machine interpretability of a document, however, it is of advantage to have a standardised structure which does not allow for all the freedoms of the XSD schema. Abandoning this flexibility enables an efficient and digitally continuous exchange of data by means of a DCC which can be implemented with reasonable effort. Furthermore, within each metrology community, it is essential that terms are used consistently when communicating measurement results. For this reason, the universally defined XML elements must be supplemented with information which can be interpreted by humans and machines. This additional information must be harmonised individually in each community to ensure the interpretability of the data exchanged there. Therefore, an example of good practice (GP) for a DCC for gauge blocks has been developed by DKD's Technical Committee '*Length*' in cooperation with PTB's Working Groups 5.32 and 5.43. The GP is presented in this expert report.

The DCC that has been developed is based on schema version 3.3.0 [1]. As the schema definition is continuously being developed, this document represents the status of the discussion at the time of publication.

1.1 Calibration item

Gauge blocks (for example according to DIN EN ISO 3650:1999 [2]) made of steel, ceramic or hard metal (carbide) are cuboid blocks with two parallel functional surfaces with a very high surface quality and accuracy (distance, parallelism, flatness). Gauge blocks can be joined together to form various lengths, a process known as wringing. In practice, gauge blocks are used as individual items or in the form of preconfigured gauge block sets with specific increments of the nominal length (e.g. 125-piece set). A set can contain several gauge blocks of the same nominal length but different materials.

Labelling with a serial number by the manufacturer is becoming more and more common. Users usually work with their own system of identification numbers. For sets, only the set itself is usually labelled with a unique identification number. Individual gauge blocks in a set must also be permanently identifiable. For this purpose, each gauge block is labelled with its nominal length or its own number, which is embossed, engraved or marked. This enables the calibration results to be clearly assigned to the individual gauge blocks in a set (see Chapter 5.2).

1.2 Objective

When using gauge block sets for measurement, the use of machine-readable DCCs eliminates the error-prone manual transfer of the calibration results by the user (for example, the central length or the deviation of the central length from the nominal length). To avoid interpretation errors between the generating system and the processing system of the DCC, a standardised presentation of the usable data in DCC format is desirable. With regard to the example of the gauge block sets, this report presents a solution which is considered to be good practice.

1.3 Calibration procedure: characteristic quantities

Gauge blocks are assigned fixed nominal lengths by the manufacturer. The aim of the calibration is to determine the deviation of the actual central length from the nominal length. Only if both values – the nominal and the actual length – are known can the gauge block be used as a measuring standard with the greatest possible accuracy. The result of a calibration of gauge blocks therefore consists in transferring the central length, or the deviation of the central length from the nominal length, stating the respective expanded measurement uncertainty.

When using gauge block comparators (up to 100 mm nominal length), the deviations f_o and f_u can additionally be determined and evaluated at a total of five measuring positions. This makes it possible to make statements about the parallelism/flatness of the functional surfaces.

In addition to the actual calibration process, the "calibration capability" of the gauge blocks is determined by a visual inspection. Rusted, heavily worn or damaged gauge blocks are usually rejected. The wringability is checked separately using an optical flat.

Depending on the thermal expansion properties of the gauge block material, the temperature has an influence on the calibration result and is therefore of considerable importance for the measurement uncertainty. For this reason, it is common practice to document the extreme values (maximum and minimum) of the temperature at the time of calibration in addition to the linear thermal expansion coefficient of the gauge blocks.

Gauge blocks are manufactured and offered in various accuracy classes. Usually, the accuracy class of an individual gauge block in a set can be better than that of the set itself. The "worst" value of all elements in the set determines the accuracy class of the set. The certified accuracy class therefore refers to the entire gauge block set. During calibration, a deviating accuracy class of the gauge block set may be certified based on the results for individual gauge blocks in the set. Accordingly, it is necessary to assign properties to both the gauge block set and the individual gauge blocks in the DCC and to report the results.

2 General structure of the DCC

The general structure of the DCC is described on the official documentation website [3]. The DCC consists of the root element *dcc:digitalCalibrationCertificate* with two mandatory child elements, *dcc:administrativeData* and *dcc:measurementResults*, and three further optional child elements, *dcc:comments*, *dcc:document* and *ds:Signature* which are not used in the present example. The five child elements of the root element *dcc:digitalCalibrationCertificate* can in turn have several child elements. The names of the elements are based on the requirements of DIN EN ISO/IEC 17025:2018 [4] which can be used for all communities.

As the XSD schema definition of the DCC can be used for all measurands and calibration items, individual properties and requirements must be specifically represented. The schema definition provides for some elements to be supplemented by attributes. These are key-value pairs, which are described below:

1) For human-readable texts, the language used is specified via the attribute with the key *lang*, the values are, for example, "de" or "en".
2) So-called refTypes (attributes with the key *refType*) enable machine interpretability, especially for elements that occur multiple times. The agreed values of these attributes as well as their explanation and use are published in a thesaurus database [5]. The refTypes used in this GP can be found in Chapter 3.1.

3) The attributes with the key *id* and the associated attributes with the key *refId* are used to form relationships within the DCC that cannot be mapped using the general tree structure of the entire XML document. The values of the *ids* are unique within the XML document. The values of the *refIds* are limited to the values of the *ids* used in the XML document.

3 Representation of the attributes used for the GP DCC for gauge blocks

3.1 Attributes used: refType

The *refType* attributes are used to make elements of the DCC machine interpretable. They identify the meaning of an element and are therefore an essential tool for the fully automated further processing of a DCC.

All *refType* definitions – including descriptions and notes regarding their use – can be viewed in the online database [5]. The *refTypes* are categorised into different scopes depending on their application. These so-called "broader terms" determine the scope of the terms. The GP for gauge blocks described here uses r*efTypes* from the broader term '*basic*', which applies to all areas of metrology, as well as those from the broader term '*length*' which are used specifically for the area of dimensional metrology. Another broader term used in this GP for gauge blocks is '*math*', which can be used for mathematical operations. At the time of publication of this document, the term '*math*' had not been finally confirmed. However, it can be assumed that the associated *refTypes* will be released by the responsible committee in the near future.

3.1.1 Basic identifiers

Broader term	***refType***	**Definition**
basic	calibrationMark	Specification of the calibration mark used
basic	calibrationMethod	Specification of the calibration method
basic	conformity	Conformity statement
basic	identificationNumber [1]	Unique identifier of the calibration item(s) in the system of the calibration laboratory or the customer
basic	isInCMC	Statement regarding CMC entry
basic	marking	Embossing or engraving of the calibration item
basic	membership	Statement regarding membership of an organisation
basic	metrologicallyTraceableToSI	Statement regarding the traceability
basic	orderNumber	Specification of the order number used
basic	referenceTemperature	Reference temperature

[1] The *refTypes* marked with the index were not yet published at the time of publication of the GP for gauge blocks but represent the most probable designation and use of the corresponding *refTypes* from the authors' point of view.

Broader term	*refType*	Definition
basic	serialNumber	Specification of the serial number
basic	temperature	Ambient temperature

3.1.2 Length identifiers

Broader term	*refType*	Definition
length	accuracyClass	Accuracy class of measuring systems or objects meeting the stated metrological requirements
length	linearThermalExpansionCoefficient	Coefficient of linear thermal expansion of the object
length	centralLength	Central length of the object
length	dimensionalResults	Results for dimensional measurands
length	deviationFromNominalLength	Deviation of the central length from the nominal length
length	gaugeBlock	Definition of the object as a gauge block
length	gaugeBlockSet	Definition of the object as a set of gauge blocks
length	inspectionMethod	Specification regarding the inspection method
length	lowerDeviationFu	f_u: Difference between the measured central length and the measured minimum length
length	material	Designation/description of the material of the object
length	measuringDeviceLength	Measuring device for carrying out dimensional measurements
length	nominalLength	Nominal value of the length of the object or characteristic
length	referenceMeasurementStandard	Reference standard used for the measurement
length	upperDeviationFo	f_o: Difference between the measured maximum length and the measured central length
length	visualInspection	Statement regarding the visual inspection of the object
length	wringability	Statement regarding the wringability of the object

3.1.3 Math identifiers

Broader term	*refType*	Definition
math	minimum [1]	Smallest of several values
math	maximum [1]	Largest of several values

3.2 Attributes used: id und refId

id	Use	Links (*refId*)	Description
setOfItems	dcc:item	dcc:result	Results of the functional tests and calibration are referenced to the setOfItems (gauge block set).
Item_*i*	dcc:item	dcc:result	Results of the calibration are referenced to the Item_*i* (individual gauge blocks; *i* = 1,..,*n*).
toSI	dcc:statement	dcc:measurementResult ->dcc:measurementMetaData ->dcc:metaData	Results that are metrologically traceable to the SI are linked to the associated statement via the metadata.
inCMC	dcc:statement	dcc:measurementResult ->dcc:measurementMetaData ->dcc:metaData	Results that lie within the CMCs of the laboratory are linked to the associated statement via the metadata.

In the present case, the use of the *id* values "setOfItems" and "Item_*i*" merely serves to improve comprehensibility for the software developers; in purely formal terms, the values in a DCC merely have to be unique and follow the global formation rules for *id* specifications.

4 Structure of the GP DCC for gauge blocks

Figure 1 shows the structure of the GP DCC for gauge blocks with the selected elements and the attributes used. The content of this expert report refers exclusively to the specific requirements and specifications for digital calibration certificates for gauge blocks. Specifications that apply to most of the elements in the *dcc:administrativeData* element or to several measurands are discussed in a separate expert report.

The illustration shows the elements relevant for this GP. The elements with the attribute *refType* are thickly underlined, with a distinction being made between three colours. Orange stands for *refTypes* with the identifier *basic*, the colour purple for the identifier *length* and the colour green for the identifier *math*. The identifier *basic* is used if the *refType* can be used for more than one measurand, the identifier *length* is particularly relevant for dimensional measurands. The identifier *math* serves to express the use of mathematical operations.

The *id*s and associated *refId*s used in the GP are highlighted in colour.

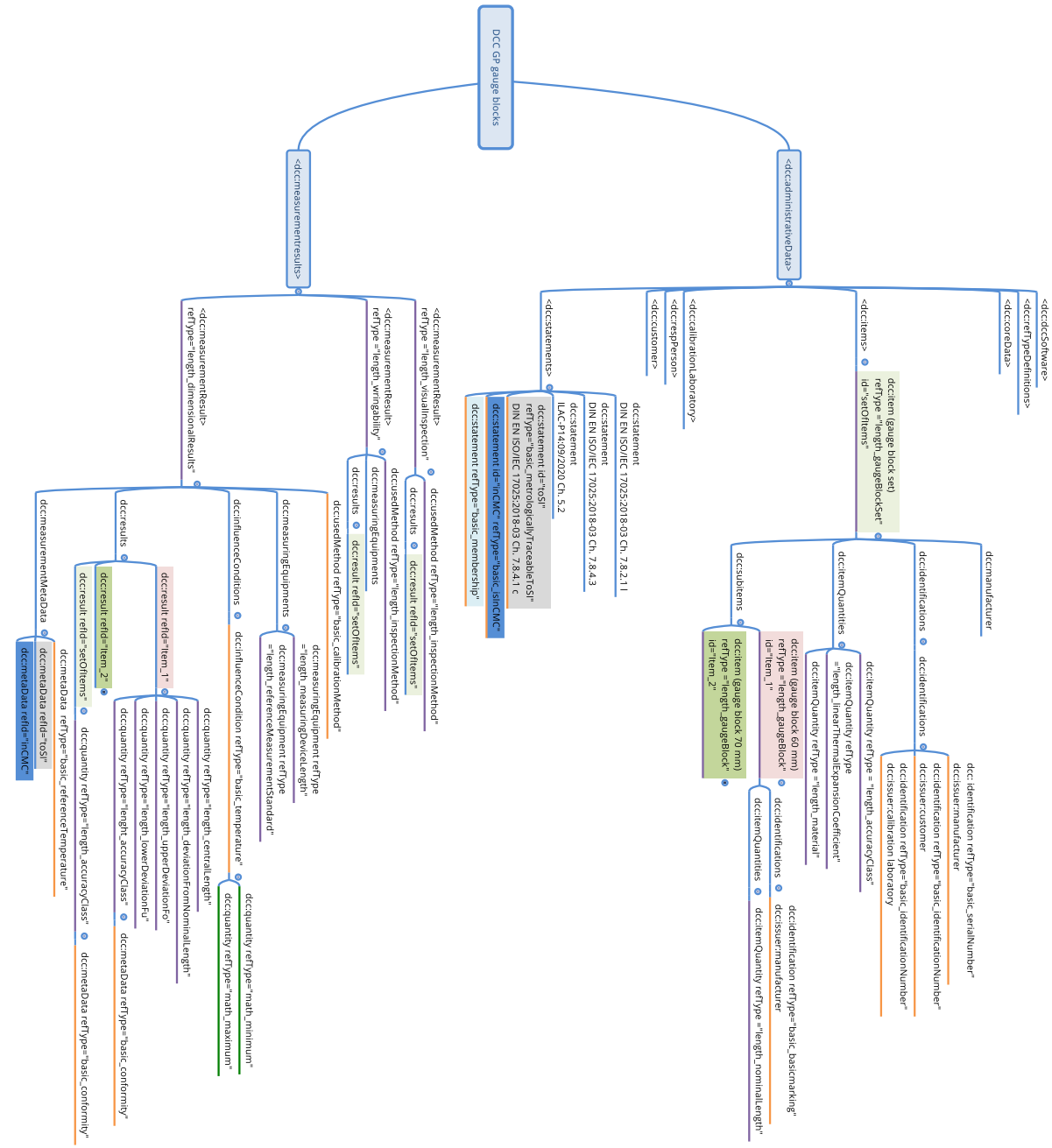

Figure 1: Structure of the GP DCC for gauge blocks

5 Representation of content for the administrative area

5.1 Calibration item and representation of the gauge block set structure in the DCC

Listing of the calibration items, e.g. individual gauge blocks and/or one or more gauge block sets, is done in the *dcc:items*list element at the parent element *dcc:administrativeData*. For this purpose, the child element *dcc:item* at the parent element *dcc:items* is used either to describe individual gauge blocks or to describe gauge block sets. To describe the content of a gauge block set, the child element *dcc:subItem* is used on the parent element *dcc:item* with the *refType*"length_gaugeBlockSet". The *dcc:subItem* element corresponds to the class of the list element *dcc:items*, i.e. it kind of puts brackets around the gauge blocks to be displayed in a set; each of these gauge blocks is in turn described via the child element *dcc:item* with the *refType*"length_gaugeBlock" on the parent element *dcc:subItems*.

The assignment of an *id* and a *refType* to the respective *dcc:item* elements is necessary in order to directly interpret whether it is a gauge block or a gauge block set and to be able to assign the measurement results to the respective object since these are reported in the *dcc:measurementResult* and therefore not as child elements of the respective element.

Among others, the following constellations of gauge blocks and gauge block sets are possible (only the second case is considered in the GP DCC gauge blocks):

Calibration items	**Representation in the DCC**
n individual gauge blocks	dcc:items ... dcc:item refType="length_gaugeBlock" id="Item_1" ... dcc:item refType="length_gaugeBlock" id="Item_2" ... ... dcc:item refType="length_gaugeBlock" id="Item_n" ... ...
One set of gauge blocks containing two gauge blocks	dcc:items ... dcc:item refType="length_gaugeBlockSet" id="setOfItems" ... dcc:subItems ... dcc:item refType="length_gaugeBlock" id="Item_1" ... dcc:item refType="length_gaugeBlock" id="Item_2" ... /dcc:subItems
Two individual gauge blocks and one set of gauge blocks containing two gauge blocks	dcc:items ... dcc:item refType="length_gaugeBlock" id="Item_1" ... dcc:item refType="length_gaugeBlock" id="Item_2" ... dcc:item refType="length_gaugeBlockset" id="setOfItems" ... dcc:subItem ... dcc:item refType="length_gaugeBlock" id="Item_3" ... dcc:item refType="length_gaugeBlock" id="Item_4" ... /dcc:subItems

Should several gauge block sets appear in a DCC, then the attributes *id*="setOfItems_*i*" must also be indexed accordingly.

The following rules are currently applied for the GP DCC gauge blocks:

1. If a set is to be displayed in the DCC, the corresponding *dcc:item* element is assigned the attribute *refType*="length_gaugeBlockSet" as well as an attribute of the type

id="setOfItems". This item represents the set as an element. All associated gauge blocks belonging to the set are in turn represented by *dcc:item* elements which are attached to the corresponding parent element *dcc:item* of the set via the parent element *dcc:subItems*. The *dcc:item* elements that represent gauge blocks are described by *refType* attributes with the value "length_gaugeBlock" and an *id* attribute whose respective value in the DCC is unique. In the GP, the value of the *id* is used for gauge blocks "*item_i*", with *i* being an incremental numerical index larger than zero.

2. Via the corresponding *refId*= "*Item_i*" with *i* = 1,...,*n* (*n* = number of individual gauge blocks), calibration results refer to the corresponding individual gauge blocks (*i* = 1,...,*n*) or with *refId*= "setOfItems" to the complete set.

3. To avoid recurring redundant elements, information relating to the entire set is displayed in the elements with the *refId*="setOfItems". If individual gauge blocks have different values, these are listed in the respective element (*id*="*Item_i*").

5.2 Description of gauge block sets and individual gauge blocks

To describe the gauge block set or the individual gauge blocks, this GP uses the elements *dcc:manufacturer* and *dcc:identification* which are hierarchically attached to the respective *dcc:item* elements.

One or more *dcc:identification* elements can be used to identify the gauge block set; each of these elements is to be labelled with a corresponding *refType*.

5.2.1 Serial number

If a serial number is available for the gauge block set, it is displayed via a *dcc:identification* element with the *refType*="basic_serialNumber". As the manufacturer usually assigns the serial number, the value "manufacturer" is entered in the sub-element *dcc:issuer*.

5.2.2 Identification number

For managing the measuring equipment, calibration laboratories and their customers often use their own IT systems. For this purpose, a leading and unique identification number is usually assigned in the respective IT system. In this case, the identification number is displayed using a *dcc:identification* element with the *refType*='basic_identificationNumber'. The *dcc:issuer* element with the values "calibrationLaboratory" or "customer" is used to differentiate whether it is the leading identification number of the laboratory or the customer. When calibrating individual gauge blocks which are not part of a set, then these individual gauge blocks can also have their own identification numbers.

5.2.3 Engraving and embossing

The individual gauge blocks, for example in a set, are usually distinguished by means of engraved or embossed markings. These markings are either applied directly to the gauge block or at the corresponding position in the gauge block set's box. Marking at the corresponding position of the gauge block in the box is mainly used for very small gauge blocks which do not allow engraving on their non-functional surfaces. The engraving or embossing is displayed using the element *dcc:identification* with the *refType*= "basic_marking". Here too, the respective value is entered using the sub-element *dcc:issuer*.

5.3 Representation of the properties known before calibration

The properties of the gauge block set or of the individual gauge blocks are displayed using *dcc:itemQuantity* elements which are hierarchically attached to the respective *dcc:item* elements.
These include, for example, dimensions, classifications and material properties.

5.3.1 Accuracy class of the gauge blocks, e.g. according to DIN EN ISO 3650:1999

The specified accuracy class of the gauge block set (e.g. according to the manufacturer) is displayed using a *dcc:itemQuantity* element with the *refType*="length_accuracyClass". The accuracy class is given as a subordinate *dcc:charsXMLList* element containing the respective class (e.g. C, 1 or 2). If the specified accuracy classes of the individual gauge blocks differ from the specified accuracy class of the gauge block set, the *dcc:itemQuantity* element with the *refType*="length_accuracyClass" must also be used accordingly on the *dcc:item* elements that describe the individual gauge blocks.

5.3.2 Linear coefficient of thermal expansion of the gauge blocks

In the case of gauge blocks, knowledge of the linear expansion coefficient is necessary to compensate for temperature-induced linear expansion, given that the calibration results are generally based on a reference temperature of 20 °C. The expansion coefficient is either specified with an uncertainty based on known material data or determined experimentally. In this GP DCC, the coefficient of thermal expansion is specified with reference to DIN EN ISO 3650:1999. The value of the expansion coefficient with the unit used is reported in a *si:real* element. The element *si:measurementUncertaintyUnivariate* is used to specify the measurement uncertainty. It is displayed using the element *dcc:itemQuantity* with the *refType*="length_linearThermalExpansionCoefficient". Again, the specification can refer to the entire set of gauge blocks, but individual gauge blocks may deviate.

Note: If the coefficient of thermal expansion has been determined experimentally as part of the calibration, the data should be documented in the area of the measurement results.

5.3.3 Nominal length of the gauge blocks

The specified nominal length of a single gauge block is represented using a *dcc:itemQuantity* element with the *refType*="length_nominalLength". The value of the nominal length is specified together with the SI base unit metre in an *si:real* element.

5.3.4 Material of the gauge blocks

The material of the gauge block is displayed via a *dcc:itemQuantity* element with the *refType*="length_material". The material itself is specified as a string via the subordinate element *dcc:noQuantity*. Again, depending on its use, the specification can refer to the entire set of gauge blocks, but individual gauge blocks may deviate.

Note: The designations of the specific materials have not yet been determined. We therefore recommend using the English terms “steel”, “ceramic” and “tungsten carbide” for the time being.

6 Representation of measurement results

6.1 Structure of the results in the GP DCC for gauge blocks

The *dcc:measurementResults* list has three child elements, each of which lists results which have been obtained having used the same method. Each method used is represented by its

own entry as *dcc:measurementResult*. The distinction between the results of the test process is represented by the following *refTypes*:

- Visual inspection — *refType*="length_visualInspection"
- Test of wringability — *refType*="length_wringability"
- Calibration — *refType*="length_dimensionalResults"

During visual inspection, the gauge blocks are checked, for example, for damage, scratches, stylus impressions or corrosion. Any abnormalities must be documented accordingly.
The wringability test with an optical flat evaluates the surface quality of the functional surfaces of the gauge blocks. If wringing of a gauge block is not possible or interference fringes appear on the optical flat, then the gauge block is not suited for calibration (no calibration capability).
The quantitative calibration results are displayed in a separate *dcc:measurementResult* element. Either the central lengths or the deviation of the central length from the nominal length of the gauge blocks are reported here. To avoid interpretation errors, redundant specification of both result values can be omitted. In this GP DCC, however, both specifications are used to clarify the *refTypes* used. Reporting of further information, as for example the deviations f_o and f_u, is possible.

6.2 Description of procedures and methods

The child element *dcc:usedMethods* in the parent element *dcc:measurementResult* is used to describe the test or measurement methods used.
The *refType*= "length_inspectionMethod" is used to identify the methods for visual inspection and testing wringability. The *refType*= "basic_calibrationMethod" identifies the description of the calibration method.
Both the test procedures and the calibration method are based on the guideline VDI/VDE/DGQ 2618 Part 3.1:2004-01 to which reference is made with the sub-element *dcc:norm*.

6.3 Description of the measuring and test equipment used

The child element *dcc:measuringEquipments* in the parent element *dcc:measurementResult* is used to document the measuring and test equipment used. There is no specification of measuring or test equipment for the visual inspection. The optical flat used for the wringability test is documented.
In the calibration results, the refType= "length_referenceMeasurementStandard" is used to identify the reference gauge blocks or the reference gauge block set used as reference standard for calibration. The *refType*= "length_measuringDeviceLength" identifies the length comparator used to determine the calibration results. If alternative methods are used, such as calibration using a laser interferometer, other reference devices must be listed accordingly. To document the metrological traceability of the calibration results obtained, the calibration certificates of the measuring equipment used are listed under the element *dcc:certificate* at the parent element *dcc:measuringEquipments*.

6.4 Description of the influencing conditions during calibration

The tolerated or specified properties in accordance with DIN EN ISO 3650:1999, such as the deviation of the central length from the nominal length, always refer to the reference temperature of 20 °C. Due to the material-dependent sensitivity of the length to temperature, which is expressed via the linear thermal expansion coefficient, the object temperature of the gauge blocks has an influence on the length determined during calibration. Typically, the ambient temperatures are recorded during the calibration of the gauge blocks and reported as the minimum and maximum ambient temperature.
For this purpose, the measured values of the recorded ambient temperatures are listed in the sub-element *dcc:influenceCondition* (with the *refType*="basic_temperature") in the parent element *dcc:measurementResult* (with the *refType*="length_dimensionalResults"). The

distinction between the minimum and maximum ambient temperature during the calibration of a set is made using two *dcc:quantity* elements with the refTypes *refType*="math_minimum" and *refType*="math_maximum" in the parent element *dcc:influenceCondition* (with the *refType*="basic_temperature").

Note: In addition to the recording and documentation of the ambient temperature during the calibration of gauge blocks, the metrological recording and documentation of the object temperatures of the gauge blocks is also common. In particular, if the determined results are to be corrected to the reference temperature of 20 °C using the linear thermal expansion coefficient. In these cases, the *refType* "length_itemTemperature" is used instead of the *refType* "basic_temperature".

6.5 Stating of results

The element *dcc:results* in the parent element *dcc:measurementResult* (with the respective *refTypes* from Chapter 6.1) is used to list the determined results. Its child elements *dcc:result* are used to differentiate between the results of the individual gauge blocks and the results for the entire set. To this end, the *dcc:result* elements must refer to the corresponding *dcc:item element* via the *refId*. Here, the rules from Chapter 5.1 are to be taken into account.

6.5.1 Representation of the calibration results

Central length

The central length of the gauge block is displayed using the *dcc:quantity element* with the *refType*="length_centralLength". The central length corrected to 20 °C and the associated expanded measurement uncertainty with a coverage probability of approx. 95 % (corresponds to k = 2 for a normal distribution) are to be specified.

Deviation of the central length form the nominal length

The deviation of the central length of the gauge block from its nominal length is displayed via the *dcc:quantity* element with the *refType*="length_deviationFromNominalLength". The deviation corrected to 20 °C and the associated expanded measurement uncertainty with a coverage probability of approx. 95 % (corresponds to k = 2 for a normal distribution) are to be specified.

Note: For the results referring to the individual gauge blocks, it is sufficient to list one of the two *dcc:quantity* elements under the respective *dcc:result* elements. It is recommended to avoid redundant information in different *dcc:quantity* elements.

Upper deviation from the central length f_o

The upper deviation from the central length of the gauge block is displayed using the *dcc:quantity* element with the *refType*="length_upperDeviationFo". What needs to be specified is the maximum upper deviation, corrected to 20 °C, and the associated expanded measurement uncertainty with a coverage probability of approx. 95 % (corresponds to k = 2 in the case of normal distribution).

Lower deviation from the central length f_u

The lower deviation from the central length of the gauge block is displayed using the *dcc:quantity* element with the *refType*="length_lowerDeviationFu". What needs to be stated is the maximum lower deviation, corrected to 20 °C, and the associated expanded measurement uncertainty with a coverage probability of approx. 95 % (corresponds to k = 2 in the case of normal distribution).

The calibration results are displayed as *si:real* element with a corresponding *si:value* and the unit metre (*si:unit*). The expanded measurement uncertainty is displayed via the *si:measurementUncertaintyUnivariate* element at the parent element *si:real* with the child element *si:expandedMU*, also using the unit metre. The value of the expanded measurement uncertainty is given using the element *si:valueExpandedMU* with the additional information of the coverage factor (*si:coverageFactor*) and the coverage probability (*si:coverageProbability*). This representation of a real measurement result with an expanded measurement uncertainty corresponds to the D-SI schema in its version 2.2.1. [6].

Accuracy class of the gauge blocks according to DIN EN ISO 3650:1999
The accuracy class of the individual gauge block is displayed based on the calibration values (central length or deviation from the nominal length as well as upper and lower deviation from the central length) via the *dcc:quantity* element with the *refType*="length_accuracyClass". The accuracy class is specified as a subordinate *dcc:charsXMLList* element with the content of the respective class (e.g. "C", "1" or "2"). The use of the list element *dcc:charsXMLList* is necessary because the possible contents may include not only numbers but also letters.
Based on the calibration results, the accuracy class of the calibrated gauge block may differ from the manufacturer's specified accuracy class. Therefore, a *metaData child* element of the associated *dcc:quantity* labelled *with refType*="basic_conformity" is used to indicate whether the element either complies with the specified accuracy requirement or is to be classified in a different accuracy class. This statement is made via the element *dcc:conformity* with the content "pass" or "fail". The specification of the underlying standard (e.g. DIN EN ISO 3650:1999) is necessary for the *pass/fail* decision as the tables containing the limit values are stored there.

Accuracy class of the entire gauge block set (e.g. according to DIN EN ISO 3650:1999)
In practice, the accuracy class of the complete set of gauge blocks often determines its suitability for certain measuring tasks. It is therefore useful for users to find an interpretable statement about the entire set in the calibration certificate. For this requirement, an additional element *dcc:result* with the *refId*="setOfItems" referring to the set item is needed. The accuracy class of the set - based on the worst accuracy class of a single gauge block of the set - is also represented via the element *dcc:quantity* with the *refType*="length_accuracyClass" and the associated element *dcc:metaData* with the *refType*="basic_conformity".

6.5.2 Further calibration metadata

In addition to the listing of calibration methods, the measuring equipment used, influencing conditions and the reported calibration results, further metadata are required to interpret the results.

Specification of the reference temperature
The value of the reference temperature used is 20 °C. This information is provided via the element d*cc:metaData* with the *refType*="basic_referenceTemperature" at the parent element *dcc:measurementResult* with the *refType*="length_dimensionalResults".
The reference value and its unit are listed using the subordinate element *dcc:quantity*. Given that the unit °C is used for temperature in length measurements, the SI base unit K is not shown here.

Metrological traceability to the International System of Units (SI)
Measurement results that are metrologically traceable to the SI refer via the element *dcc:metaData* with the *refId*="toSI" to the *dcc:statement* with the *refType*="basic_metrologicallyTraceableToSI" and the *id*="toSI". The element *dcc:valid* within the element *dcc:metaData* with the *refId*=”toSI” indicates, via the content “true” or “false”, which results are metrologically traceable to the SI.

Measurement results within the CMCs
Measurement results that are within the documented CMCs refer to the *dcc:statement* with the *refType*="basic_isInCMC" and the *id*="inCMC" via the element *dcc:metaData* with the *refId*=”inCMC”. The element *dcc:valid* within the element *dcc:metaData* with the *refId*=”inCMC” indicates, via the contents “true” or “false”, which results lie within the CMCs.

7 Bibliography

[1] https://www.ptb.de/dcc/dcc.xsd
viewed: 02.12.2024
[2] DIN EN ISO 3650:1999 „Geometrische Produktspezifikationen (GPS) - Längennormale - Parallelendmaße”, Deutsches Institut für Normung e.V., Berlin, 1999
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viewed: 02.12.2024

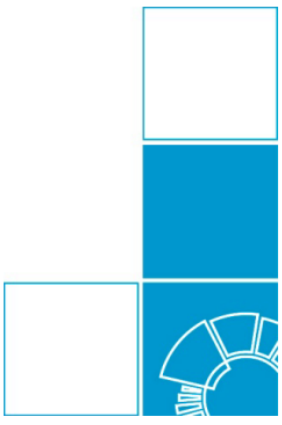
A. Appendix

A.1 Optional alternatives and additions

In the creation of good practice examples, different methods for presenting the measurement results in relation to the different measurands have become established. On the one hand, as in the above report, as a sequential listing of individual results with the parent element *si:real* or by using XML lists with the parent element *si:realListXMLList*.

XML lists are so-called "space-separated lists", i.e. sequences of data that are separated from each other by spaces. The DCC schema provides several XML elements for this purpose. Examples are *dcc:charsXMLList* or *si:realListXMLList*.

When using XML lists, care must be taken to ensure that the order of the data in conceptually related lists is identical. In this context, the following aspects are to be observed: 1.) The individual data in an XML list must not contain any spaces, otherwise the individual data will be erroneously interpreted as two or more data. 2.) Moreover, in XML lists, the data may only be separated by single spaces, otherwise the strict data sequence will no longer be correct during read-out. 3.) If individual data items in a list are blank spaces (e.g. invalid/discarded individual results of a series of measurements, intentional blank cells in tables, etc.), the value NaN (or ‘’ in *dcc:charsXMLList*) must be used for these in order to maintain the strict data sequence.



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