

# INTERNATIONAL STANDARD



OPC Unified Architecture –  
Part 13: Aggregates

**ITeh Standards**  
(<https://standards.iteh.ai>)  
Document Preview

[IEC 62541-13:2020](https://standards.iteh.ai/catalog/standards/iec/6f18ca63-f801-433c-8cf5-e358f4aee2dd/iec-62541-13-2020)

<https://standards.iteh.ai/catalog/standards/iec/6f18ca63-f801-433c-8cf5-e358f4aee2dd/iec-62541-13-2020>





**THIS PUBLICATION IS COPYRIGHT PROTECTED**  
**Copyright © 2020 IEC, Geneva, Switzerland**

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

**About the IEC**

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

**About IEC publications**

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

**IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)**

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

**IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)**

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

**IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)**

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

**Electropedia - [www.electropedia.org](http://www.electropedia.org)**

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

**IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)**

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

[IEC 62541-13:2020](https://standards.iteh.ai/catalog/standards/iec/6f18ca63-f801-433c-8cf5-e358f4aee2dd/iec-62541-13-2020)

<https://standards.iteh.ai/catalog/standards/iec/6f18ca63-f801-433c-8cf5-e358f4aee2dd/iec-62541-13-2020>



IEC 62541-13

Edition 2.0 2020-06  
REDLINE VERSION

# INTERNATIONAL STANDARD



OPC Unified Architecture –  
Part 13: Aggregates

iTeh Standards  
(<https://standards.itih.ai>)  
Document Preview

[IEC 62541-13:2020](https://standards.itih.ai/catalog/standards/iec/6f18ca63-f801-433c-8cf5-e358f4aee2dd/iec-62541-13-2020)

<https://standards.itih.ai/catalog/standards/iec/6f18ca63-f801-433c-8cf5-e358f4aee2dd/iec-62541-13-2020>

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 25.040.40; 35.100.05

ISBN 978-2-8322-8530-5

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD .....	7
1 Scope .....	9
2 Normative references .....	9
3 Terms, definitions, and abbreviated terms .....	9
3.1 Terms and definitions .....	9
3.2 Abbreviated terms .....	12
4 Aggregate information model .....	13
4.1 General .....	13
4.2 Aggregate Objects .....	13
4.2.1 General .....	13
4.2.2 AggregateFunction Object .....	14
4.3 MonitoredItem AggregateFilter .....	16
4.3.1 MonitoredItem AggregateFilter Defaults .....	16
4.3.2 MonitoredItem Aggregates and Bounding Values .....	16
4.4 Exposing Supported Functions and Capabilities .....	16
5 Aggregate specific usage of Services .....	17
5.1 General .....	17
5.2 Aggregate data handling .....	18
5.2.1 Overview .....	18
5.2.2 ReadProcessedDetails structure overview .....	18
5.2.3 AggregateFilter structure overview .....	18
5.3 Aggregates StatusCodes .....	19
5.3.1 Overview .....	19
5.3.2 Operation level result codes .....	19
5.3.3 Aggregate Information Bits .....	20
5.4 Aggregate details .....	21
5.4.1 General .....	21
5.4.2 Common characteristics .....	21
5.4.3 Specific aggregated data handling .....	24
Annex A (informative) Aggregate Specific examples – Historical Access .....	67
A.1 Historical Aggregate specific characteristics .....	67
A.1.1 Example Aggregate data – Historian 1 .....	67
A.1.2 Example Aggregate data – Historian 2 .....	68
A.1.3 Example Aggregate data – Historian 3 .....	69
A.1.4 Example Aggregate data – Historian 4 .....	70
A.2 Interpolative .....	71
A.2.1 Description .....	71
A.2.2 Interpolative data .....	71
A.3 Average .....	73
A.3.1 Description .....	73
A.3.2 Average data .....	73
A.4 TimeAverage .....	74
A.4.1 Description .....	74
A.4.2 TimeAverage data .....	75
A.5 TimeAverage2 .....	76
A.5.1 Description .....	76

A.5.2	TimeAverage2 data .....	76
A.6	Total .....	78
A.6.1	Description .....	78
A.6.2	Total data .....	78
A.7	Total2 .....	80
A.7.1	Description .....	80
A.7.2	Total2 data .....	80
A.8	Minimum .....	81
A.8.1	Description .....	81
A.8.2	Minimum data .....	82
A.9	Maximum .....	82
A.9.1	Description .....	82
A.9.2	Maximum data .....	83
A.10	MinimumActualTime .....	83
A.10.1	Description .....	83
A.10.2	MinimumActualTime data .....	84
A.11	MaximumActualTime .....	84
A.11.1	Description .....	84
A.11.2	MaximumActualTime data .....	85
A.12	Range .....	85
A.12.1	Description .....	85
A.12.2	Range data .....	86
A.13	Minimum2 .....	86
A.13.1	Description .....	86
A.13.2	Minimum2 data .....	87
A.14	Maximum2 .....	87
A.14.1	Description .....	87
A.14.2	Maximum2 data .....	88
A.15	MinimumActualTime2 .....	88
A.15.1	Description .....	88
A.15.2	MinimumActualTime2 data .....	89
A.16	MaximumActualTime2 .....	89
A.16.1	Description .....	89
A.16.2	MaximumActualTime2 data .....	90
A.17	Range2 .....	90
A.17.1	Description .....	90
A.17.2	Range2 data .....	91
A.18	AnnotationCount .....	91
A.18.1	Description .....	91
A.18.2	AnnotationCount data .....	91
A.19	Count .....	92
A.19.1	Description .....	92
A.19.2	Count data .....	92
A.20	DurationInStateZero .....	93
A.20.1	Description .....	93
A.20.2	DurationInStateZero data .....	93
A.21	DurationInStateNonZero .....	93
A.21.1	Description .....	93
A.21.2	DurationInStateNonZero data .....	93

A.22	NumberOfTransitions .....	94
A.22.1	Description .....	94
A.22.2	NumberOfTransitions data .....	94
A.23	Start .....	95
A.23.1	Description .....	95
A.23.2	Start data .....	95
A.24	End .....	95
A.24.1	Description .....	95
A.24.2	End data .....	96
A.25	StartBound .....	96
A.25.1	Description .....	96
A.25.2	StartBound data .....	97
A.26	EndBound .....	97
A.26.1	Description .....	97
A.26.2	EndBound data .....	98
A.27	Delta .....	98
A.27.1	Description .....	98
A.27.2	Delta data .....	99
A.28	DeltaBounds .....	99
A.28.1	Description .....	99
A.28.2	DeltaBounds data .....	100
A.29	DurationGood .....	100
A.29.1	Description .....	100
A.29.2	DurationGood data .....	101
A.30	DurationBad .....	102
A.30.1	Description .....	102
A.30.2	DurationBad data .....	102
A.31	PercentGood .....	103
A.31.1	Description .....	103
A.31.2	PercentGood data .....	103
A.32	PercentBad .....	104
A.32.1	Description .....	104
A.32.2	PercentBad data .....	104
A.33	WorstQuality .....	105
A.33.1	Description .....	105
A.33.2	WorstQuality data .....	105
A.34	WorstQuality2 .....	106
A.34.1	Description .....	106
A.34.2	WorstQuality2 data .....	106
A.35	StandardDeviationSample .....	107
A.35.1	Description .....	107
A.35.2	StandardDeviationSample data .....	107
A.36	VarianceSample .....	107
A.36.1	Description .....	107
A.36.2	VarianceSample data .....	108
A.37	StandardDeviationPopulation .....	108
A.37.1	Description .....	108
A.37.2	StandardDeviationPopulation data .....	108
A.38	VariancePopulation .....	109

<https://standards.iteh.ai/>  
 Document Preview  
 IEC 62541-13:2020  
<https://standards.iteh.ai/standards/iec/62541-13:2020>

A.38.1	Description .....	109
A.38.2	VariancePopulation data .....	109

## Bibliography .....

Figure 1	– Representation of Aggregate Configuration information in the AddressSpace.....	17
Figure 2	– Variable with Stepped = False and Simple Bounding Values .....	25
Figure 3	– Variable with Stepped = True and Interpolated Bounding Values .....	26
Figure A.1	– Historian 1 .....	68
Figure A.2	– Historian 2 .....	69
Figure A.3	– Historian 3 .....	70
Table 1	– Interpolation examples .....	10
Table 2	– AggregateConfigurationType Definition .....	13
Table 3	– Aggregate Functions Definition.....	14
Table 4	– AggregateFunctionType Definition.....	14
Table 5	– Standard AggregateType Nodes .....	15
Table 6	– ReadProcessedDetails .....	18
Table 7	– AggregateFilter structure.....	19
Table 8	– Bad operation level result codes.....	19
Table 9	– Uncertain operation level result codes.....	20
Table 10	– Data location .....	20
Table 11	– Additional information.....	20
Table 12	– History Aggregate interval information .....	22
Table 13	– Standard History Aggregate Data Type information .....	23
Table 14	– Aggregate table description.....	27
Table 15	– Interpolative Aggregate summary .....	30
Table 16	– Average Aggregate summary .....	31
Table 17	– TimeAverage Aggregate summary .....	32
Table 18	– TimeAverage2 Aggregate summary .....	33
Table 19	– Total Aggregate summary.....	34
Table 20	– Total2 Aggregate summary.....	35
Table 21	– Minimum Aggregate summary .....	36
Table 22	– Maximum Aggregate summary.....	37
Table 23	– MinimumActualTime Aggregate summary .....	38
Table 24	– MaximumActualTime Aggregate summary .....	39
Table 25	– Range Aggregate summary .....	40
Table 26	– Minimum2 Aggregate summary.....	41
Table 27	– Maximum2 Aggregate summary.....	42
Table 28	– MinimumActualTime2 Aggregate summary .....	43
Table 29	– MaximumActualTime2 Aggregate summary .....	44
Table 30	– Range2 Aggregate summary .....	45
Table 31	– AnnotationCount Aggregate summary.....	46
Table 32	– Count Aggregate summary .....	47

Table 33 – DurationInStateZero Aggregate summary ..... 48

Table 34 – DurationInStateNonZero Aggregate Summary ..... 49

Table 35 – NumberOfTransitions Aggregate summary ..... 50

Table 36 – Start Aggregate summary ..... 51

Table 37 – End Aggregate summary ..... 52

Table 38 – Delta Aggregate summary ..... 53

Table 39 – StartBound Aggregate summary ..... 54

Table 40 – EndBound Aggregate summary ..... 55

Table 41 – DeltaBounds Aggregate summary..... 56

Table 42 – DurationGood Aggregate summary ..... 57

Table 43 – DurationBad Aggregate summary ..... 58

Table 44 – PercentGood Aggregate summary ..... 59

Table 45 – PercentBad Aggregate summary ..... 60

Table 46 – WorstQuality Aggregate summary ..... 61

Table 47 – WorstQuality2 Aggregate summary..... 62

Table 48 – StandardDeviationSample Aggregate summary ..... 63

Table 49 – VarianceSample Aggregate summary ..... 64

Table 50 – StandardDeviationPopulation Aggregate summary ..... 65

Table 51 – VariancePopulation Aggregate summary ..... 66

Open Standards  
(<https://standards.iteh.ai>)  
Document Preview

[IEC 62541-13:2020](https://standards.iteh.ai/catalog/standards/iec/62541-13-2020)

<https://standards.iteh.ai/catalog/standards/iec/62541-13-2020>



## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## OPC UNIFIED ARCHITECTURE –

## Part 13: Aggregates

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

**This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.**

IEC 62541-13 has been prepared by subcommittee 65E: Devices and integration in enterprise systems, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition of IEC 62541-13, published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) no technical changes but numerous clarifications. Also some corrections to the examples.

The text of this standard is based on the following documents:

FDIS	Report on voting
65E/697/FDIS	65E/712/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

Throughout this document and the other Parts of the series, certain document conventions are used:

*Italics* are used to denote a defined term or definition that appears in the “Terms and definition” clause in one of the parts of the series.

*Italics* are also used to denote the name of a service input or output parameter or the name of a structure or element of a structure that are usually defined in tables.

The *italicized terms and names* are also often written in camel-case (the practice of writing compound words or phrases in which the elements are joined without spaces, with each element's initial letter capitalized within the compound). For example the defined term is *AddressSpace* instead of Address Space. This makes it easier to understand that there is a single definition for *AddressSpace*, not separate definitions for Address and Space.

A list of all parts of the IEC 62541 series, published under the general title *OPC Unified Architecture*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

# OPC UNIFIED ARCHITECTURE –

## Part 13: Aggregates

### 1 Scope

This part of IEC 62541 is part of the overall OPC Unified Architecture specification series and defines the information model associated with Aggregates.

### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TR 62541-1, *OPC Unified Architecture – Part 1: Overview and Concepts*

IEC 62541-3, *OPC Unified Architecture – Part 3: Address Space Model*

IEC 62541-4, *OPC Unified Architecture – Part 4: Services*

IEC 62541-5, *OPC Unified Architecture – Part 5: Information Model*

IEC 62541-8, *OPC Unified Architecture – Part 8: Data Access*

IEC 62541-11, *OPC Unified Architecture – Part 11: Historical Access*

### 3 Terms, definitions, and abbreviated terms

#### 3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TR 62541-1, IEC 62541-3, IEC 62541-4, and IEC 62541-11 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

##### 3.1.1

#### **ProcessingInterval**

timespan for which derived values are produced based on a specified *Aggregate*

Note 1 to entry: The total time domain specified for *ReadProcessed* is divided by the *ProcessingInterval*. For example, performing a 10-minute *Average* over the time range 12:00 to 12:30 would result in a set of three intervals of *ProcessingInterval* length, with each interval having a start time of 12:00, 12:10 and 12:20 respectively. The rules used to determine the interval *Bounds* are discussed in 5.4.2.2.

##### 3.1.2

#### **interpolated data**

data that is calculated from data samples

Note 1 to entry: Data samples may be historical data or buffered real time data. An *interpolated* value is calculated from the data points on either side of the requested timestamp.

**3.1.3**  
**EffectiveEndTime**

time immediately before *endTime*

Note 1 to entry: All *Aggregate* calculations include the *startTime* but exclude the *endTime*. However, it is sometimes necessary to return an *Interpolated* End Bound as the value for an *Interval* with a timestamp that is in the *interval*. *Servers* are expected to use the time immediately before *endTime* where the time resolution of the *Server* determines the exact value (do not confuse this with hardware or operating system time resolution). For example, if the *endTime* is 12:01:00, the time resolution is 1 second, then the *EffectiveEndTime* is 12:00:59. See 5.4.2.4.

If time is flowing backwards, *Servers* are expected to use the time immediately after *endTime* where the time resolution of the *Server* determines the exact value.

**3.1.4**  
**extrapolated data**

data constructed from a discrete data set but is outside of the discrete data set

Note 1 to entry: It is similar to the process of interpolation, which constructs new points between known points, but its result is subject to greater uncertainty. *Extrapolated* data is used in cases where the requested time period falls farther into the future than the data available in the underlying system. See example in Table 1.

**3.1.5**  
**SlopedInterpolation**

simple linear interpolation

Note 1 to entry: Compare to curve fitting using linear polynomials. See example in Table 1.

**3.1.6**  
**SteppedInterpolation**

*interpolation* holding the last data point constant or interpolating the value based on a horizontal line fit

Note 1 to entry: Consider the following Table 1 of raw and *Interpolated/Extrapolated* values:

**Table 1 – Interpolation examples**

Timestamp	Raw Value	Sloped Interpolation	Stepped Interpolation
12:00:00	10		
12:00:05		15	10
12:00:08		18	10
12:00:10	20		
12:00:15		25	20
12:00:20	30		
		SlopedExtrapolation	SteppedExtrapolation
12:00:25		35	30
12:00:27		37	30

**3.1.7**  
**bounding values**

values at the *startTime* and *endTime* needed for *Aggregates* to compute the result

Note 1 to entry: If *Raw data* does not exist at the *startTime* and *endTime* a value shall be estimated. There are two ways to determine *Bounding Values* for an interval. One way (called *Interpolated Bounding Values*) uses the first non-Bad data points found before and after the timestamp to estimate the bound. The other (called *Simple Bounding Values*) uses the data points immediately before and after the boundary timestamps to estimate the bound even if these points are Bad. Subclauses 3.1.8 and 3.1.9 describe the two different approaches in more detail.

In all cases the *TreatUncertainAsBad* (see 4.2.1.2) flag is used to determine whether Uncertain values are Bad or non-Bad.

If a Raw value was not found and a non-Bad bounding value exists the *Aggregate Bits* (see 5.3.3) are set to 'Interpolated'.

When calculating *bounding values*, the value portion of *Raw data* that has Bad status is set to null. This means the value portion is not used in any calculation and a null is returned if the raw value is returned. The status portion is determined by the rules specified by the bound or *Aggregate*.

The *Interpolated Bounding Values* approach (see 3.1.8) is the same as what is used in Classic OPC Historical Data Access (HDA) and is important for applications such as advanced process control where having useful values at all times is important. The *Simple Bounding Values* approach (see 3.1.9) is new in this standard and is important for applications which shall produce regulatory reports and cannot use estimated values in place of Bad data.

### 3.1.8 interpolated bounding values

*bounding values* determined by a calculation using the nearest Good value

Note 1 to entry: *Interpolated Bounding Values* using *SlopedInterpolation* are calculated as follows:

- if a non-Bad Raw value exists at the timestamp then it is the bounding value;
- find the first non-Bad Raw value before the timestamp;
- find the first non-Bad Raw value after the timestamp;
- draw a line between before value and after value;
- use point where the line crosses the timestamp as an estimate of the bounding value.

The calculation can be expressed with the following formula:

$$V_{\text{bound}} = (T_{\text{bound}} - T_{\text{before}}) \times (V_{\text{after}} - V_{\text{before}}) / (T_{\text{after}} - T_{\text{before}}) + V_{\text{before}}$$

where  $V_x$  is a value at 'x' and  $T_x$  is the timestamp associated with  $V_x$ .

If no non-Bad values exist before the timestamp the *StatusCode* is *Bad\_NoData*. The *StatusCode* is *Uncertain\_DataSubNormal* if any Bad values exist between the before value and after value. If either the before value or the after value are Uncertain the *StatusCode* is *Uncertain\_DataSubNormal*. If the after value does not exist the before value shall be extrapolated using *SlopedExtrapolation* or *SteppedExtrapolation*.

The period of time that is searched to discover the Good values before and after the timestamp is *Server* dependent, but if a Good value is not found within some reasonable time range then the *Server* will assume it does not exist. The *Server* as a minimum should search a time range which is at least the size of the *ProcessingInterval*.

*Interpolated Bounding Values* using *SlopedExtrapolation* are calculated as follows:

- find the first non-Bad Raw value before timestamp;
- find the second non-Bad Raw value before timestamp;
- draw a line between these two values;
- extend the line to where it crosses the timestamp;
- use the point where the line crosses the timestamp as an estimate of the bounding value.

The formula is the same as the one used for *SlopedInterpolation*.

The *StatusCode* is always *Uncertain\_DataSubNormal*. If only one non-Bad raw value can be found before the timestamp then *SteppedExtrapolation* is used to estimate the bounding value.

*Interpolated Bounding Values* using *SteppedInterpolation* are calculated as follows:

- if a non-Bad Raw value exists at the timestamp then it is the bounding value;
- find the first non-Bad Raw value before timestamp;
- use the value as an estimate of the bounding value.

The *StatusCode* is *Uncertain\_DataSubNormal* if any Bad values exist between the before value and the timestamp. If no non-Bad *Raw data* exists before the timestamp then the *StatusCode* is *Bad\_NoData*. If the value before the timestamp is Uncertain the *StatusCode* is *Uncertain\_DataSubNormal*. The value after the timestamp is not needed when using *SteppedInterpolation*; however, if the timestamp is after the end of the data then the bounding value is treated as extrapolated and the *StatusCode* is *Uncertain\_DataSubNormal*.

*SteppedExtrapolation* is a term that describes *SteppedInterpolation* when a timestamp is after the last value in the history collection.

### 3.1.9

#### simple bounding values

*bounding values* determined by a calculation using the nearest value

Note 1 to entry: *Simple Bounding Values* using *SlopedInterpolation* are calculated as follows:

- if any Raw value exists at the timestamp then it is the bounding value;
- find the first Raw value before timestamp;
- find the first Raw value after timestamp;
- if the value after the timestamp is Bad then the before value is the bounding value;
- draw a line between before value and after value;
- use point where the line crosses the timestamp as an estimate of the bounding value.

The formula is the same as the one used for *SlopedInterpolation* in Clause 3.1.5.

If a Raw value at the timestamp is Bad the *StatusCode* is *Bad\_NoData*. If the value before the timestamp is Bad the *StatusCode* is *Bad\_NoData*. If the value before the timestamp is Uncertain the *StatusCode* is *Uncertain\_DataSubNormal*. If the value after the timestamp is Bad or Uncertain the *StatusCode* is *Uncertain\_DataSubNormal*.

*Simple Bounding Values* using *SteppedInterpolation* are calculated as follows:

- if any Raw value exists at the timestamp then it is the bounding value;
- find the first Raw value before timestamp;
- if the value before timestamp is non-Bad then it is the bounding value.

If a Raw value at the timestamp is Bad the *StatusCode* is *Bad\_NoData*. If the value before the timestamp is Bad the *StatusCode* is *Bad\_NoData*. If the value before the timestamp is Uncertain the *StatusCode* is *Uncertain\_DataSubNormal*.

~~If either bounding time of an interval is beyond the last data point then extrapolation may be used if the Server feels it is appropriate for the data.~~

If either bounding time of an interval is beyond the last data point then the *Server* may use extrapolation or return an error. If extrapolation is used by the server the type [*SteppedExtrapolation* or *SloppedExtrapolation*] of extrapolation is server specific.

In some Historians, the last Raw value does not necessarily indicate the end of the data. Based on the Historian's knowledge of the data collection mechanism, i.e. frequency of data updates and latency, the Historian may extend the last value to a time known by the Historian to be covered. When calculating *Simple Bounding Values* the Historian will act as if there is another Raw value at this timestamp.

In the same way, if the earliest time of an interval starts before the first data point in history and the latest time is after the first data point in history, then the interval will be treated as if the interval extends from the first data point in history to the latest time of the interval and the *StatusCode* of the interval will have the Partial bit set (see 5.3.3.2).

The period of time that is searched to discover the values before and after the timestamp is *Server* dependent, but if a value is not found within some reasonable time range then the *Server* will assume it does not exist. The *Server* as a minimum should search a time range which is at least the size of the *ProcessingInterval*.

## 3.2 Abbreviated terms

DA	Data Access
HA	Historical Access (access to historical data or events)
HDA	Historical Data Access
UA	Unified Architecture