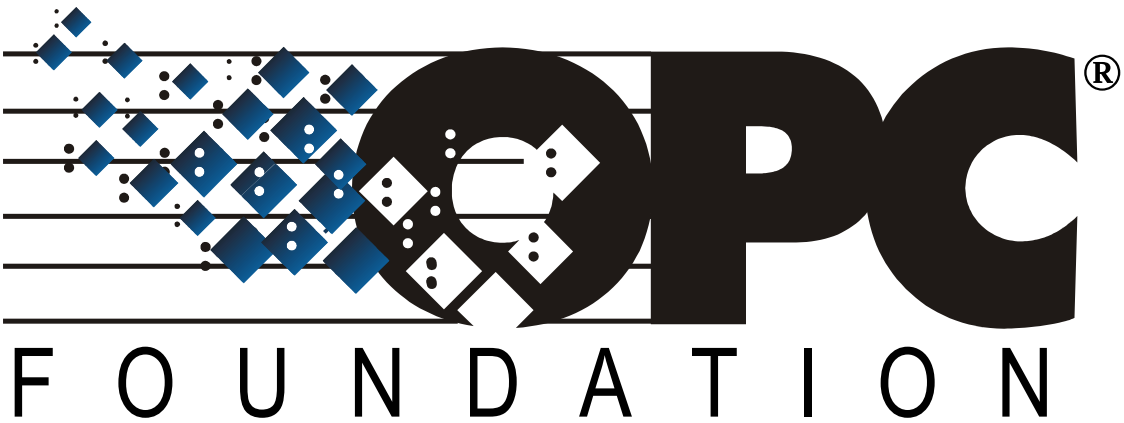

OPC Unified Architecture

Specification

Part 13: Aggregates

Release 1.04

November 22, 2017

Specification Type	Industry Standard Specification		
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UNIFIED ARCHITECTURE –

FOREWORD

This specification is the specification for developers of OPC UA applications. The specification is a result of an analysis and design process to develop a standard interface to facilitate the development of applications by multiple vendors that shall inter-operate seamlessly together.

AGREEMENT OF USE

GENERAL PROVISIONS

Should any provision of this Agreement be held to be void, invalid, unenforceable or illegal by a court, the validity and enforceability of the other provisions shall not be affected thereby.

This Agreement shall be governed by and construed under the laws of the State of Minnesota, excluding its choice or law rules.

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The OPC Foundation strives to maintain the highest quality standards for its published specifications, hence they undergo constant review and refinement. Readers are encouraged to report any issues and view any existing errata here: https://opcfoundation.org/developer-tools/specifications-unified-architecture/errata/.

Revision 1.04 Highlights

The following table includes the Mantis issues resolved with this revision.

Mantis ID	Summary	Resolution
3300 3312	StandardDeviation and Variance aggregates use Simple bounding but the example data has no bounding values	The specification was incorrect in listing use Simple bounding values. The tables for these aggregates (Table 48, 49, 50, and 51) have been changed to not use bounding values.
3301 3313	StandardDeviation and Variance aggregate examples for Historian1 using an uncertain value when it should not	All of the Standard Deviation and Variance examples have been corrected.
3302	Delta Aggregate example for Historian1 has UncertainDataSubnormal value instead of BadNoData	The invalide aggregate interval has had its quality changed to BadNoData
3310	Interpolated example for Historian 2 has the wrong value in the last interval	Corrected last historian interval value for Interpolative Historian 2 from 102.500 to 90.
3391	Contradiction in Timestamp definition of at least Minimum and Maximum Aggregates	The contradition has been removed and the correct timestamp given as the start of the interval timestamp.
3589	MinimumActualTime2 has the wrong aggregate for the base aggregate calculation	MinimumActualTime2 is now using the MinimumActualTime aggregate as its base aggregate.
3590	Delta Aggregate should always have Calculated flag set	The Delta aggregate has been changed in table 38 to have the Calculated flag always set.
3595	StandardDeviationPopulation Aggregate for Historian2 has wrong value for interval starting at 12:00:40.000	The value has been changed from 4 to 5.
3604	TimeAverage Aggregate is using stepped calculation for Historian3 and it shouldn't	The table in A.4.2 Historian3 has been edited to use a sloped line between points.
3605	The Aggregate Number of Transitions has some errors	The heading has been changed to the correct interval time. The values in all of the historian exaples have been corrected.
3736	Bounding Values mismatch for Start and End aggregates	Removed the text "using Interpolated Bounding Values" from the overview table for Start and End Aggregates.
3737	Clarification for "simple bounding values" and extrapolation needed	Added text to clarify what a UA Client can expect when looking at bounds.
3738	Definition for StartOfData and EndOfData needs to be added to terms/definitions	The terms have been replaced with their text equivalent.

OPC Unified Architecture Specification

Part 13: Aggregates

1 Scope

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

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application.

Part 1 OPC UA Specification: Part 1 – Concepts
http://www.opcfoundation.org/UA/Part1/

Part 3 OPC UA Specification: Part 3 – Address Space Model
http://www.opcfoundation.org/UA/Part3/

Part 4 OPC UA Specification: Part 4 – Services
http://www.opcfoundation.org/UA/Part4/

Part 5 OPC UA Specification: Part 5 – Information Model
http://www.opcfoundation.org/UA/Part5/

Part 8 OPC UA Specification: Part 8 – Data Access
http://www.opcfoundation.org/UA/Part8/

Part 11 OPC UA Specification: Part 11 – Historical Access
http://www.opcfoundation.org/UA/Par11/

3 Terms, definitions, and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in Part 1, Part 3, Part 4, and Part 11 as well as the following apply.

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 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 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
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:

$$V_{bound} = (T_{bound} - T_{before})x(V_{after} - V_{before})/(T_{after} - T_{before}) + V_{before}$$

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 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 Abbreviations

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

4 Aggregate Information Model

4.1 General

Part 3 and Part 5 standards define the representation of *Aggregate* historical or buffered real time data in the OPC Unified Architecture. This includes the definition of *Aggregates* used in processed data retrieval and in historical retrieval. This definition includes both standard *Reference* types and *Object* types.

4.2 Aggregate Objects

4.2.1 General

4.2.1.1 Overview

OPC UA *Servers* can support several different functionalities and capabilities. The following standard *Objects* are used to expose these capabilities in a common fashion, and there are several standard defined concepts that can be extended by vendors.

4.2.1.2 AggregateConfigurationType

The *AggregateConfigurationType* defines the general characteristics of a *Node* that defines the *Aggregate* configuration of any *Variable* or *Property*. *AggregateConfiguration Object* represents the browse entry point for information on how the *Server* treats *Aggregate* specific functionality such as handling Uncertain data. It is formally defined in Table 2.

Table 2 – AggregateConfigurationType Definition

Attribute	**Value**				
BrowseName	AggregateConfigurationType				
IsAbstract	False				
References	**NodeClass**	**BrowseName**	**DataType**	**TypeDefinition**	**ModellingRule**
Subtype of the *BaseObjectType* defined in Part 5					
HasProperty	Variable	TreatUncertainAsBad	Boolean	PropertyType	Mandatory
HasProperty	Variable	PercentDataBad	Byte	PropertyType	Mandatory
HasProperty	Variable	PercentDataGood	Byte	PropertyType	Mandatory
HasProperty	Variable	UseSlopedExtrapolation	Boolean	PropertyType	Mandatory

The *TreatUncertainAsBad Variable* indicates how the *Server* treats data returned with a *StatusCode* severity Uncertain with respect to *Aggregate* calculations. A value of True

indicates the *Server* considers the severity equivalent to *Bad*, a value of False indicates the *Server* considers the severity equivalent to *Good,* unless the *Aggregate* definition says otherwise. The default value is True. Note that the value is still treated as Uncertain when the *StatusCode* for the result is calculated.

The *PercentDataBad Variable* indicates the minimum percentage of Bad data in a given interval required for the *StatusCode* for the given interval for processed data request to be set to *Bad*. (Uncertain is treated as defined above.) Refer to 5.4.3 for details on using this *Variable* when assigning *StatusCodes*. For details on which *Aggregates* use the *PercentDataBad Variable*, see the definition of each *Aggregate*. The default value is 100.

The *PercentDataGood Variable* indicates the minimum percentage of Good data in a given interval required for the *StatusCode* for the given interval for the processed data requests to be set to *Good*. Refer to 5.4.3 for details on using this *Variable* when assigning *StatusCodes*. For details on which *Aggregates* use the *PercentDataGood Variable*, see the definition of each *Aggregate*. The default value is 100.

The *PercentDataGood* and *PercentDataBad* shall follow the following relationship *PercentDataGood* ≥ (100 – *PercentDataBad*). If they are equal the result of the *PercentDataGood* calculation is used. If the values entered for *PercentDataGood* and *PercentDataBad* do not result in a valid calculation (e.g. Bad = 80; Good = 0) the result will have a StatusCode of Bad_AggregateInvalidInputs The StatusCode Bad_AggregateInvalidInputs will be returned if the value of *PercentDataGood* or *PercentDataBad* exceed 100.

The *UseSlopedExtrapolation Variable* indicates how the *Server* interpolates data when no boundary value exists (i.e. extrapolating into the future from the last known value). A value of False indicates that the *Server* will use a *SteppedExtrapolation* format, and hold the last known value constant. A value of True indicates the *Server* will project the value using *UseSlopedExtrapolation* mode. The default value is False. For *SimpleBounds* this value is ignored.

4.2.2 AggregateFunction Object

4.2.2.1 General

This *Object* is used as the browse entry point for information about the *Aggregates* supported by a *Server*. The content of this *Object* is already defined by its type definition. All *Instances* of the *FolderType* use the standard *BrowseName* of ‘AggregateFunctions’. The *HasComponent Reference* is used to relate a *ServerCapabilities Object* and/or any *HistoricalServerCapabilities Object* to an *AggregateFunction Object*. AggregateFunctions is formally defined in Table 3.

Table 3 – Aggregate Functions Definition

Attribute	**Value**				
BrowseName	AggregateFunctions				
References	**Node Class**	**BrowseName**	**DataType**	**TypeDefinition**	**ModellingRule**
HasTypeDefinition	Object Type	*FolderType*	Defined in Part 5		

Each *ServerCapabilities* and *HistoricalServerCapabilities Object* shall reference an *AggregateFunction Object*. In addition, each *HistoricalConfiguration Object* belonging to a *HistoricalDataNode* may reference an *AggregateFunction Object* using the *HasComponent Reference*.

4.2.2.2 AggregateFunctionType

This *ObjectType* defines an *Aggregate* supported by a UA *Server*. This *Object* is formally defined in Table 4.

Table 4 – AggregateFunctionType Definition

Attribute	Value				
BrowseName	AggregateFunctionType				
IsAbstract	False				
References	**Node Class**	**BrowseName**	**DataType**	**Type Definition**	**Mod. Rule**
Subtype of the *BaseObjectType* defined in Part 5					

For the *AggregateFunctionType*, the *Description Attribute* (inherited from the *Base NodeClass*), is mandatory. The *Description Attribute* provides a localized description of the *Aggregate*.

Table 5 specifies the *BrowseName* and *Description Attributes* for the standard *Aggregate Objects*. The description is the localized “en” text. For other locales it shall be translated.

Table 5 – Standard AggregateType Nodes

BrowseName	Description
	Interpolation Aggregate
Interpolative	At the beginning of each interval, retrieve the calculated value from the data points on either side of the requested timestamp.
Average	Retrieve the average value of the data over the interval.
TimeAverage	Retrieve the time weighted average data over the interval using *Interpolated Bounding Values*.
TimeAverage2	Retrieve the time weighted average data over the interval using *Simple Bounding Values.*
Total	Retrieve the total (time integral) of the data over the interval using *Interpolated Bounding Values.*
Total2	Retrieve the total (time integral) of the data over the interval using *Simple Bounding Values*.
Minimum	Retrieve the minimum raw value in the interval with the timestamp of the start of the interval.
Maximum	Retrieve the maximum raw value in the interval with the timestamp of the start of the interval.
MinimumActualTime	Retrieve the minimum value in the interval and the timestamp of the minimum value.
MaximumActualTime	Retrieve the maximum value in the interval and the timestamp of the maximum value.
Range	Retrieve the difference between the minimum and maximum value over the interval.
Minimum2	Retrieve the minimum value in the interval including the *Simple Bounding Values.*
Maximum2	Retrieve the maximum value in the interval including the *Simple Bounding Values.*
MinimumActualTime2	Retrieve the minimum value with the actual timestamp including the *Simple Bounding Values.*
MaximumActualTime2	Retrieve the maximum value with the actual timestamp including the *Simple Bounding Values.*
Range2	Retrieve the difference between the Minimum2 and Maximum2 value over the interval.
Count	Retrieve the number of raw values over the interval.
DurationInStateZero	Retrieve the time a Boolean or numeric was in a zero state using *Simple Bounding Values*.
DurationInStateNonZero	Retrieve the time a Boolean or numeric was in a non-zero state using *Simple Bounding Values*.
NumberOfTransitions	Retrieve the number of changes between zero and non-zero that a Boolean or numeric value experienced in the interval.
Start	Retrieve the value at the beginning of the interval.
End	Retrieve the value at the end of the interval.
Delta	Retrieve the difference between the Start and End value in the interval.
StartBound	Retrieve the value at the beginning of the interval using *Simple Bounding Values*.
EndBound	Retrieve the value at the end of the interval using *Simple Bounding Values*.
DeltaBounds	Retrieve the difference between the StartBound and EndBound value in the interval using *Simple Bounding Values*.
DurationGood	Retrieve the total duration of time in the interval during which the data is Good.
DurationBad	Retrieve the total duration of time in the interval during which the data is Bad.
PercentGood	Retrieve the percentage of data (0 to 100) in the interval which has Good *StatusCode*.
PercentBad	Retrieve the percentage of data (0 to 100) in the interval which has Bad *StatusCode*.
WorstQuality	Retrieve the worst *StatusCode* of data in the interval.
WorstQuality2	Retrieve the worst *StatusCode* of data in the interval including the *Simple Bounding Values*.
AnnotationCount	Retrieve the number of *Annotation*s in the interval (applies to Historical *Aggregates* only).
StandardDeviationSample	Retrieve the standard deviation for the interval for a sample of the population (n-1).
VarianceSample	Retrieve the variance for the interval as calculated by the StandardDeviationSample.
StandardDeviation Population	Retrieve the standard deviation for the interval for a complete population (n) which includes *Simple Bounding Values*.
VariancePopulation	Retrieve the variance for the interval as calculated by the StandardDeviationPopulation which includes *Simple Bounding Values*.

4.3 MonitoredItem AggregateFilter

4.3.1 MonitoredItem AggregateFilter Defaults

The default values used for *MonitoredItem Aggregates* are the same as those used for historical *Aggregates*. They are defined in 4.2.1.2. For additional information on *MonitoredItem AggregateFilter* see Part 4.

4.3.2 MonitoredItem Aggregates and Bounding Values

When calculating *MonitoredItem Aggregates* that require the use of *Bounding Values*, the bounds may not be known. The calculation is done in the same manner as a historical read with the Partial Bit set. The historian may wait some amount of time (normally no more than one processing interval) before calculating the interval to allow for any latency in data collection and reduce the use of the Partial Bit.

A historical read done after data collection and the data from the *MonitoredItem* over the same interval may not be the same.

4.4 Exposing Supported Functions and Capabilities

Figure 1 outlines a possible representation of *Aggregate* information in the *AddressSpace*. In this example, although the *Server* at the highest level may support *Aggregate* functionality for Interpolative, Total, Average, and others, *DataVariable* X only supports Interpolative, Total and Average, while *DataVariable* Y supports Average, a vendor defined *Aggregate* and other (unstated) *Aggregates.*

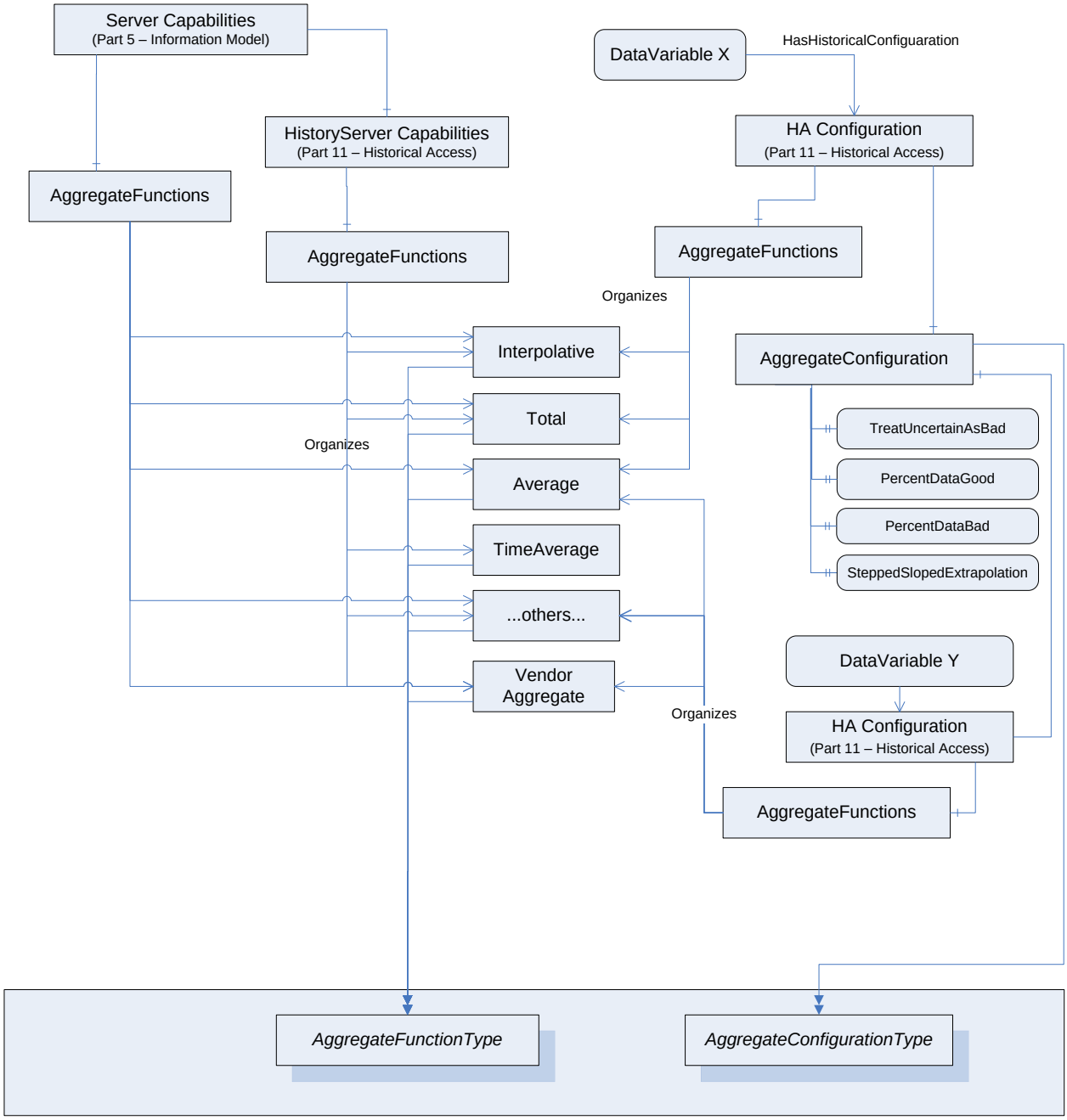


Figure 1 – Representation of Aggregate Configuration information in the AddressSpace

5 Aggregate specific usage of Services

5.1 General

Part 4 specifies all Services needed for OPC UA *Aggregates*. In particular:

- The Browse Service Set or Query Service Set to detect *Aggregates* and their configuration.
- The HistoryRead Service of the Attribute Service Set to read the aggregated history of the HistoricalNodes.
- The CreateMonitoredItems Service allows specifying a filter for each MonitoredItem to read aggregated data.

5.2 Aggregate data handling

5.2.1 Overview

The *HistoryRead* service defined in Part 4 can perform several different functions. The *historyReadDetails* parameter is an *Extensible Parameter* that specifies which function to perform. The *ReadProcessedDetails* structure is used to read aggregated data for *HistoricalDataNodes*.

The *CreateMonitoredItems Service* allows specifying a filter for each *MonitoredItem*. The *MonitoringFilter* is an extensible parameter whose structure depends on the type of item being monitored. The *AggregateFilter* structure is used to obtain aggregated data for a subscription.

5.2.2 ReadProcessedDetails structure overview

ReadProcessedDetails structure is formally detailed in Part 11. Table 6 outlines the components of the ReadProcessedDetails structure for the purposes of discussion in this document.

Table 6 – ReadProcessedDetails

Name	Description
ReadProcessedDetails	Specifies the details used to perform a “processed” history read.
startTime	Beginning of period to read.
endTime	End of period to read.
processingInterval	Interval between returned *Aggregate* values.
aggregateType[]	The *NodeIds* of the *AggregateFunction Objects*. *AggregateFunction Objects* indicate the list of *Aggregates* to be used when retrieving processed history.
aggregateConfiguration	*Aggregate* configuration structure.
useServerDefaults	If True the *Server*’s default values are used and any values specified for the other parameters are ignored.
treatUncertainAsBad	See 4.2.1.2.
percentDataBad	See 4.2.1.2.
percentDataGood	See 4.2.1.2.
useSlopedExtrapolation	See 4.2.1.2.

5.2.3 AggregateFilter structure overview

The *AggregateFilter* defines the *Aggregate* function that should be used to calculate the values to be returned. The *AggregateFilte*r is formally defined in Part 4. Table 7 outlines the components of the *AggregateFilter* structure for the purposes of discussion in this document.

Table 7 – AggregateFilter structure

Name	Description
AggregateFilter	
startTime	Beginning of period to calculate the *Aggregate* the first time.
aggregateType	The *NodeIds* of the *AggregateFunction Objects* that indicates the list of *Aggregates* to be used when retrieving processed data.
processingInterval	The period to be used to compute the *Aggregate*.
aggregateConfiguration	This parameter allows *Clients* to override the *Aggregate* configuration settings supplied by an *AggregateConfiguration Object* on a per monitored item basis.
useServerDefaults	If True the *Server*’s default values are used and any values specified for the other parameters are ignored.
treatUncertainAsBad	See 4.2.1.2.
percentDataBad	See 4.2.1.2.
percentDataGood	See 4.2.1.2.
useSlopedExtrapolation	See 4.2.1.2.

5.3 Aggregates StatusCodes

5.3.1 Overview

Subclause 5.3 defines additional codes and rules that apply to the *StatusCode* when used for *Aggregates*.

The general structure of the *StatusCode* is specified in Part 4. It includes a set of common operational result codes which also apply to *Aggregates.*

5.3.2 Operation level result codes

In OPC UA *Aggregates* the *StatusCode* is used to indicate the conditions under which a value or *Event* was stored, and thereby can be used as an indicator of its usability. Due to the nature of aggregated data, additional information beyond the basic quality and call result code needs to be conveyed to the client. For example, whether or not the result was *Interpolated*, were all data inputs to a calculation of Good quality, etc.

In the following, Table 8 contains codes with *Bad* severity indicating a failure; Table 9 contains codes with Uncertain severity indicating that the value has been retrieved under sub-normal conditions. It is important to note, that these are the codes that are specific for OPC UA *Aggregates* and that they supplement the codes that apply to all types of data; they are therefore defined in Part 4, Part 8 and Part 11.

Table 8 – Bad operation level result codes

Symbolic Id	Description
Bad_AggregateListMismatch	The requested number of *Aggregates* does not match the requested number of *NodeIds*. When multiple *Aggregates* are requested, a corresponding *NodeId* is required for each *AggregateFunction*.
Bad_AggregateNotSupported	The requested *AggregateFunction* is not supported by the *Server* for the specified *Node*.
Bad_AggregateInvalidInputs	The *Aggregate* value could not be derived due to invalid data inputs, errors attempting to perform data conversions or similar situations.

Table 9 – Uncertain operation level result codes

Symbolic Id	Description
Uncertain_DataSubNormal	The value is derived from raw values and has less than the required number of Good values.

5.3.3 Aggregate Information Bits

5.3.3.1 General

These bits are set only when obtaining *Aggregate* data. They indicate where the data value came from and provide information that affects how the client uses the data value. Table 10 lists the bit settings which indicate the data location (i.e. is the value stored in the underlying data repository, or is the value the result of data aggregation). These bits are mutually exclusive.

Table 10 – Data location

StatusCode	Description
Raw	A *Raw data* value.
Calculated	A data value which was calculated.
Interpolated	A data value which was interpolated.

In the case where *Interpolated* data is requested, and there is an actual raw value for that timestamp, the *Server* should set the ‘Raw’ bit in the *StatusCode* of that value.

Table 11 lists the bit settings which indicate additional important information about the data values returned.

Table 11 – Additional information

StatusCode	Description
Partial	A calculated value that is not based on a complete interval. See 5.3.3.2.
Extra Data	If a *Server* chooses to set this bit, it indicates that a *Raw data* value supersedes other data at the same timestamp.
Multiple Values	Multiple values match the *Aggregate* criteria (i.e. multiple minimum values or multiple worst quality at different timestamps within the same *ProcessingInterval*).

The conditions under which these information bits are set depend on how the data has been requested and state of the underlying data repository.

5.3.3.2 Partial Information Bit

Partial bit is used to indicate that the interval is not a complete interval and that a client may receive a different value for the *Aggregate* if it re-fetches the interval with the same parameters.

The Partial Bit will be set in the following examples:

Assume for these examples the first stored point in the collection is 1:01:10 and the last stored point in the collection is 1:31:20. Older data may exist but is unavailable or offline at the time of the query. Newer data may be available but has not yet been stored in the history collection.

- The interval that overlaps the beginning of the history collection. If the start time is 1:00:00 and end time is 1:10:00 and the interval is 2 minutes then the first interval would have a partial bit set since it has no data for the first 70 seconds. The partial bit will always be set for the first interval with data if the start time of the interval is before the first data value of the data collection. For intervals prior to the interval with a partial bit, these intervals will be flagged Bad_NoData.
- The interval that overlaps the latest point stored in the history collection. The last point in the collection is 1:31:20 and the historian was not shut down and is still running. A 6-minute interval that started at 1:30:00 would have the partial bit set because the historian is expecting data, but just has not yet received anything. The partial bit will always be set for the last interval with data if the end time of the interval is after the last data value stored in the data collection. Intervals entirely after the interval with a partial bit will be flagged Bad_NoData. For those *Aggregates* with extrapolation, the partial bit may be set. See the *Aggregate* specific characteristics for more details.
- If the start/end time does not result in an even interval and there is additional data beyond the end time then the last interval will have a partial bit. If the start time is 1:00:00 and end time is 1:20:00 and the interval is 6 minutes then the last interval is just 2 minutes long and will have the partial bit set. Extrapolation does not apply in this case.

The Partial Bit may be set with the Calculated bit when the Calculated bit is always set for the specific *Aggregate*.

5.4 Aggregate details

5.4.1 General

The purpose of 5.4 is to detail the requirements and behaviour for OPC UA *Servers* supporting *Aggregates*. The intent is to standardize the *Aggregates* so users can reliably predict the results of an *Aggregate* computation and understand its meaning. If users require custom functionality in the *Aggregates*, those *Aggregates* should be written as custom vendor defined *Aggregates*.

The standard *Aggregates* shall be as consistent as possible, meaning that each *Aggregate's* behaviour shall be similar to every other *Aggregate's* behaviour where input parameters, *Raw data*, and boundary conditions are similar. Where possible, the *Aggregates* should deal with input and preconditions in a similar manner.

Subclause 5.4 is divided up into two parts. Subclause 5.4.2 deals with *Aggregate* characteristics and behaviour that are common to all *Aggregates*. Subclause 5.4.3 deals with the characteristics and behaviour of *Aggregates* that are aggregate-specific.

5.4.2 Common characteristics

5.4.2.1 Description

Subclause 5.4.2 deals with *Aggregate* characteristics and behaviour that are common to all *Aggregates.*

5.4.2.2 Generating intervals

To read Historical *Aggregates*, OPC clients shall specify three time parameters:

- startTime (Start)
- endTime (End)
- *ProcessingInterval* (Int)

The OPC *Server* shall use these three parameters to generate a sequence of time intervals and then calculate an *Aggregate* for each interval. Subclause 5.4.2.2 specifies, given the three parameters, which time intervals are generated. Table 12 provides information on the intervals for each Start and End time combination. The range is defined to be |End - Start|.

All *Aggregates* return a timestamp of the start of the interval unless otherwise noted for the particular *Aggregate*.

Table 12 – History Aggregate interval information

Start/End Time	Interval	Resulting intervals
Start = *End*	*Int* = Anything	No intervals. Returns a *Bad_InvalidArgument StatusCode*, regardless of whether there is data at the specified time or not.
Start < *End*	*Int* = 0 or *Int* ≥ *Range*	One interval, starting at *Start* and ending at *End*. Includes *Start*, excludes *End*, i.e., *[Start, End).*
Start < *End*	*Int* ≠ 0, *Int* < *Range, Int* divides *Range* evenly.	*Range/Int* intervals. Intervals are *[Start, Start + Int), [Start + Int, Start + 2* x *Int),..., [End - Int, End).*
Start < *End*	*Int* ≠ 0, *Int* < *Range, Int* does not divide *Range* evenly.	⌈*Range/Int*⌉ intervals. Intervals are *[Start, Start + Int), [Start + Int, Start + 2* x *Int),..., [Start + (⌊*Range/Int*⌋ *- 1)* x *Int, Start +* ⌊*Range/Int*⌋ x *Int), [Start +* ⌊*Range/Int*⌋ x *Int, End).* In other words, the last interval contains the "rest" that remains in the range after taking away ⌊*Range/Int*⌋ intervals of size *Int*.
Start > *End*	*Int* = 0 or *Int* ≥ *Range*	One interval, starting at *Start* and ending at *End*. Includes *Start*, excludes *End*, i.e.,[*Start*, *End*). [a]
Start > *End*	*Int* ≠ 0, *Int* < *Range, Int* divides *Range* evenly.	*Range/Int* intervals. Intervals are *[Start, Start- Int), [Start– Int, Start – 2* x *Int),..., [End + Int, End).* [a]
Start > *End*	*Int* ≠ 0, *Int* < *Range, Int* does not divide *Range* evenly.	⌈*Range/Int*⌉ intervals. Intervals are *[Start, Start - Int), [Start – Int,Start - 2* x *Int),..., [Start – (⌊*Range/Int*⌋ *- 1)* x *Int , Start -* ⌊*Range/Int*⌋ x *Int), [Start -* ⌊*Range/Int*⌋ x *Int , End).* In other words, the last interval contains the "rest" that remains in the range after taking away ⌊*Range/Int*⌋ intervals of size *Int* starting at Start. [a]
a In this case time is running backwards on the intervals.		

The calculation of all *Aggregates* when time flows backwards is the same as when time flows forwards with the exception that the 'early time' is excluded from the interval and the 'late time' is included. In most cases this means the value will be the same except the timestamps are shifted by one *ProcessingInterval*. E.g. when time flows forward the value at $T = n$ is the same as the value at $T = n + 1$ when time flows backward.

Note that when determining *Aggregates* with *MonitoredItem*, the interval is simply the *ProcessingInterval* parameter as defined in the *AggregateFilter* structure. See Part 4 for more details.

5.4.2.3 Data types

Table 13 outlines the valid *DataType* for each *Aggregate*. Some *Aggregates* are intended for numeric data types – i.e. integers or real/floating point numbers. Dates, strings, arrays, etc. are not supported. Other *Aggregates* are intended for digital data types – i.e. Boolean or enumerations. In addition some *Aggregates* may return results with a different DataType than those used to calculate the *Aggregate* . Table 13 also outlines the data type returned for each *Aggregate* .

Table 13 – Standard History Aggregate Data Type information

BrowseName	Valid Data Type	Result Data Type
	Interpolation Aggregate	
Interpolative	Numeric	Raw Data Type
	Data Averaging Aggregates	
Average	Numeric	Double
TimeAverage	Numeric	Double
TimeAverage2	Numeric	Double
Total	Numeric	Double
Total2	Numeric	Double
	Data Variation Aggregates	
Minimum	Numeric	Raw data type
Maximum	Numeric	Raw data type
MinimumActualTime	Numeric	Raw data type
MaximumActualTime	Numeric	Raw data type
Range	Numeric	Raw data type
Minimum2	Numeric	Raw data type
Maximum2	Numeric	Raw data type
MinimumActualTime2	Numeric	Raw data type
MaximumActualTime2	Numeric	Raw data type
Range2	Numeric	Raw data type
	Counting Aggregates	
AnnotationCount	All	Integer
Count	All	Integer
DurationInStateZero	Numeric or Boolean	Duration
DurationInStateNonZero	Numeric or Boolean	Duration
NumberOfTransitions	Numeric or Boolean	Integer
	Time Aggregates	
Start	All	Raw data type
End	All	Raw data type
Delta	Numeric	Raw data type
StartBound	All	Raw data type
EndBound	All	Raw data type
DeltaBounds	Numeric	Raw data type
	Data Quality Aggregates	
DurationGood	All	Duration
DurationBad	All	Duration
PercentGood	All	Double
PercentBad	All	Double
WorstQuality	All	*StatusCode*
WorstQuality2	All	*StatusCode*
	Statistical Aggregates	
StandardDeviationSample	Numeric	Double
VarianceSample	Numeric	Double
StandardDeviationPopulation	Numeric	Double
VariancePopulation	Numeric	Double

5.4.2.4 Time calculation issues

The following issues may come up when calculating *Aggregates* that include time as part of the calculation.

- 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. If the *Server* time resolution is 1 millisecond the *EffectiveEndTime* is 12:00:59.999.

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.

- If there is one data point in the *Interval* and it falls on the *StartTime* the time duration used in calculations is one unit of the time resolution of the *Server*.

5.4.3 Specific Aggregated data handling

5.4.3.1 General

When accessing aggregated data using the *HistoryRead* or the *CreateMonitoredItems Service*, the following rules are used to handle specific *Aggregate* use cases.

If *ProcessingInterva*l is 0, the *Server* shall create one *Aggregate* value for the entire time range. This allows *Aggregates* over large periods of time. A value with a timestamp equal to *endTime* will be excluded from that *Aggregate*, just as it would be excluded from an interval with that ending time. If the *ProcessingInterval* of 0 is passed in the *MonitoredItemFilter* it shall be revised to a suitable non-zero value.

The timestamp returned with the *Aggregate* shall be the time at the beginning of the interval, except where the *Aggregate* specifies a different timestamp.

If a requested timestamp is set to anything but the source timestamp the operation shall return the *Bad_TimestampToReturnInvalid StatusCode*. If a requested timestamp is not supported in any other way for a *HistoricalDataNode*, the operation shall return the *Bad_TimestampNotSupported StatusCode*. For *MonitoredItem* the *Server* shall not return past data if a requested timestamp is not supported by the history collection.

5.4.3.2 StatusCode calculation

5.4.3.2.1 General

StatusCodes for an *Aggregate* value shall take into account the values used to calculate them. In addition, the configuration parameters *PercentDataGood* and *PercentDataBad* allow the client to control how this calculation is done if supported by the *Server*.

If an *Aggregate* operates on raw values (e.g. Average) the calculation is done by counting values. If an *Aggregate* operates on raw values but can also return a *Bounding Value* then the *Bounding Values* are included in the count when computing the *StatusCode*. If an *Aggregate* does any sort of a time weighted calculation (e.g. TimeAverage or TimeAverage2) then the *StatusCode* calculation shall also be time weighted.

For purposes of calculating time weighted *StatusCodes* each interval shall be divided into regions of Good or Bad data. Creating these regions requires that the *bounding values* be calculated for each interval and the type of bounding value depends on the *Aggregate*.

If *TreatUncertainAsBad* = False then Uncertain regions are included with the Good regions when calculating the above ratios, if the *TreatUncertainAsBad* = True then the Uncertain regions are included as Bad regions. The *StatusCode* of the value is still treated as Uncertain when the *StatusCode* for the result is calculated. If no Bad regions are in the interval then the *StatusCode* for the interval is Good. For any intervals containing regions where the *StatusCodes* are Bad, the total duration of all *Bad* regions is calculated and divided by the width of the interval. The resulting ratio is multiplied by 100 and compared to the *PercentDataBad* parameter. The *StatusCode* for the interval is Bad if the ratio is greater than or equal to the *PercentDataBad* parameter. For any interval which is not Bad, the total duration of all Good regions is then calculated and divided by the width of the interval. The resulting ratio is multiplied by 100 and compared to the *PercentDataGood* parameter. The *StatusCode* for the interval is Good if the ratio is greater than or equal to the *PercentDataGood* parameter. If for an interval neither ratio applies then that interval is *Uncertain_DataSubNormal*.

If there is no data in the interval and the interval is inside the range [start of data, end of data] and the *Aggregate* return data type is raw data type then the *StatusCodes* for the interval will be Bad_NoData unless an alternate status code is defined for a specific *Aggregate*.

The width of an interval is the *ProcessingInterval* unless it is a partial interval (i.e. has the Partial bit set). In these cases, the width is the time used when calculating the partial interval.

Subclauses 5.4.3.2.2 and 5.4.3.2.3 include diagrams that illustrate a request and data series. The colour of the time axis indicates the status for different regions. Red indicates Bad, green indicates Good and orange indicates Uncertain. These examples assume *TreatUncertainAsBad* = False.

5.4.3.2.2 Sloped Interpolation and Simple Bounding Values

Figure 2 illustrates a data series for *Variable* with Stepped = False and an *Aggregate* that uses *Simple Bounding Values*. The request being processed has a Start Time that falls before the first point in the series and an End Time that does not fall on an integer multiple of the *ProcessingInterval*.

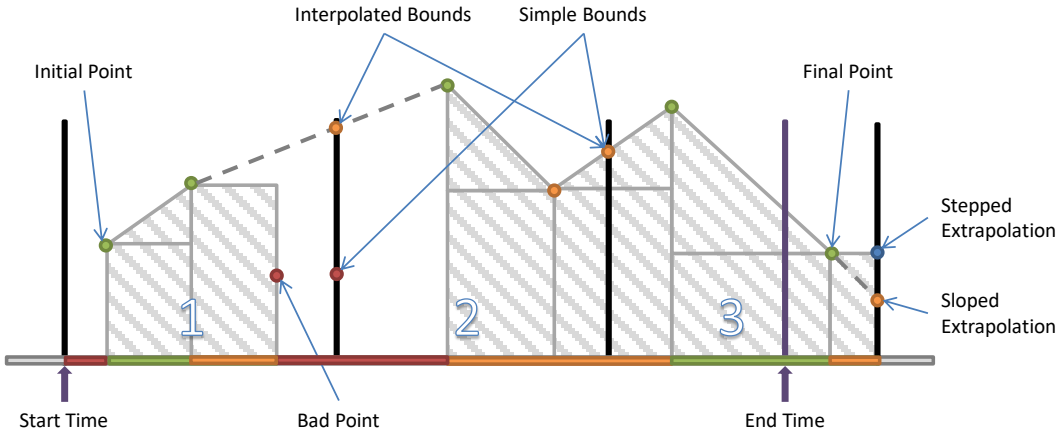


Figure 2 – Variable with Stepped = False and Simple Bounding Values

The first interval has four regions:

- the period before the first data point;
- the period between the first and second where *SlopedInterpolation* can be used;
- the period between the second and third point where *SteppedInterpolation* is used;
- the period after the Bad point where no data exists.

A region is Uncertain if a region ends in a Bad or Uuncertain value and *SlopedInterpolation* is used. The end point has no effect on the region if *SteppedInterpolation* is used.

The second interval has three regions:

- the period before the first Good data point where no data exists;
- the period between the first and second where *SlopedInterpolation* can be used;
- the period between the second point and the bound calculated with *SlopedInterpolation*.

The third interval has three regions:

- the period between the simple bound and the first data point;
- the period between the first point and an interpolated point that falls on the end time;
- the period after the end time which is ignored.

This is a partial region and the data after the end time is not used, however, if sloped interpolation is used and the point after the endpoint is Uncertain then the region between the last point and the end time will be Uncertain.

5.4.3.2.3 Stepped Interpolation and Interpolated Bounding Values

Figure 3 illustrates a data series for *Variable* with Stepped = True and an *Aggregate* that uses *Interpolated Bounding Values*. The request being processed has a Start Time that falls before the first point in the series and an End Time that does not fall on an integer multiple of the *ProcessingInterval*.

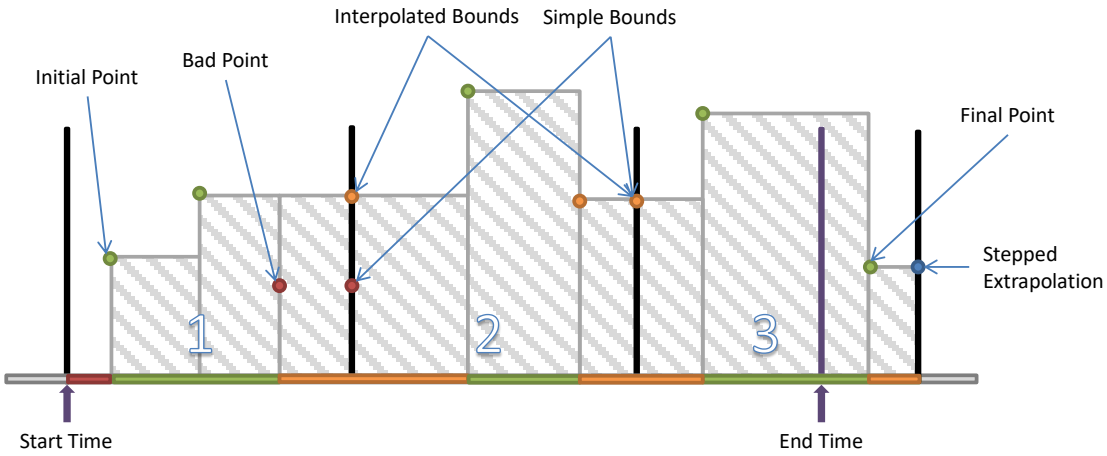


Figure 3 – Variable with Stepped = True and Interpolated Bounding Values

The first interval has three regions:

- the period before the first data point;
- the period between the first and second where *SteppedInterpolation* is used;
- the period between the second and the interpolated end bound.

The Bad point is ignored because of the interpolated end bound but this does create Uncertain regions. If *SlopedInterpolation* was used the Uncertain region would start at the second point. In this case, it only starts when the first Bad value is ignored.

The second interval has three regions:

- the period between the start bound and the first data point;
- the period between the first and second where *SteppedInterpolation* is used;
- the period between the second and the interpolated end bound.

The third interval has three regions:

- the period between the interpolated bound and the first data point;
- the period between the first point and an interpolated point that falls on the end time;
- the period after the end time which is ignored.

This is a partial region and the data after the end time is not used.

5.4.3.3 Description

Subclause 5.4.3.3 deals with *Aggregate* specific characteristics and behaviour that is specific to a particular *Aggregate*.

Each subclause has a table which formally expresses the *Aggregate* behaviour (including any exceptions). The meaning of each of the fields in the table is described in Table 14.

Description of Table 14:

- The first column is the common name for the item.
- The second column includes a description of the item and a list of the valid selections with for the item including a description of each selection.
- The second part of the table describes how the status associated with the *Aggregate* calculation is computed.
- The last part of the table lists what behaviour is expected from the *Aggregate* for some common special cases. These behaviours require text descriptions so there is no list of valid selections.

Table 14 – Aggregate table description

Aggregate Characteristics	
Type	The type of *Aggregate*. <Interpolated | Calculated | Raw> Interpolated: See definition for Interpolated. Calculated: Computed from defined calculation. Raw: Selects a raw value from within an interval.
Data Type	The data type of the result. <Double | Int32 | Same as Source>
Use Bounds	How the *Aggregate* deals with bounds. <None | Interpolated | Simple> None: Bounds do not apply to the *Aggregate*. Interpolated: Uses Interpolated Bounds. Simple: Uses Simple Bounds.
Timestamp	What is the time stamp of the resulting *Aggregate* value: <*startTime* | *endTime* | Raw> *startTime*: The time at the start of the interval. *endTime*: The time at the end of the interval. Raw: The time associated with a value in the interval.
Status Code Calculations	
Calculation Method	How the status code is calculated: <PercentValues | PercentTime | Custom> PercentValues: Based on percentage of value counts. PercentTime: Based on percentage of time interval. Custom: Specific to the *Aggregate* (description included).
Partial	For partial intervals does the *Aggregate* set this bit <Set Sometimes | Not Set> It may also describe any special cases for setting this bit
Calculated	Describes the usage of the calculated bit. <Set Always | Set Sometimes | Not Set> Set Always: The bit is always set. Set Sometimes: The bit is sometimes set (describes when). Not Set: The bit is never set.
Interpolated	Describes the usage of the interpolated bit. <Set Always | Set Sometimes | Not Set> Set Always: The bit is always set. Set Sometimes: The bit is sometimes set (describes when). Not Set: The bit is never set.
Raw	Describes the usage of the Raw bit. <Set Always | Set Sometimes | Not Set> Set Always: The bit is always set.

	Set Sometimes: The bit is sometimes set (describes when). Not Set: The bit is never set.
Multi Value	Describes the usage of the multi value bit. <Set Sometimes | Not Set> Set Sometimes: The bit is used (see Part 11). Not Set: The bit is never set.
Status Code Common Special Cases	
Before Start of Data	If the entire interval is before the start of data.
After End of Data	If the entire interval is after the end of data (as determined by the Historian).
Start Bound Not Found	If the starting bound is not found for the earliest interval and it is not partial, then what, if any, special processing should be done.
End Bound Not Found	If the ending bound is not found for the latest interval and it is not partial, then what, if any, special processing should be done.
Bound Bad	If the Bounding value is Bad, then what, if any, special processing should be done.
Bound Uncertain	If the Bounding value is uncertain, then what, if any, special processing should be done.

5.4.3.4 Interpolative

The Interpolative *Aggregate* defined in Table 15 returns the *Interpolated Bounding Value* (see 3.1.8) for the *startTime* of each interval.

When searching for Good values before or after the bounding value, the time period searched is *Server* specific, but the *Server* should search a time range which is at least the size of the *ProcessingInterval*.

Table 15 – Interpolative Aggregate summary

Interpolated Aggregate Characteristics	
Type	Interpolated
Data Type	Same as Source
Use Bounds	Interpolated
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom Good if no Bad values skipped and Good values are used, Uncertain if Bad values skipped or if Uncertain values are used. If no starting value then *Bad_NoData*. See description of Interpolated Bounds (see 3.1.8) for more details
Partial bit	Not Set
Calculated bit	Not Set
Interpolated bit	Set Sometimes Always set except for when the Raw bit is set
Raw bit	Set Sometimes If a value exists with the exact time of interval Start
Multi Value bit	Not Set
Status Code Common Special Cases	
Before Start of Data	Return *Bad_NoData*
After End of Data	Return extrapolated value (see 3.1.8) (sloped or stepped according to settings) Status code is *Uncertain_DataSubNormal*.
Start Bound Not Found	*Bad_NoData*.
End Bound Not Found	*See "After End of Data"*
Bound Bad	Does not return a Bad bound except as noted above

Bound Uncertain	Returned *Uncertain_DataSubNormal* if any Bad value(s) was/were skipped to calculate the bounding value.

5.4.3.5 Average

The Average *Aggregate* defined in Table 16 adds up the values of all Good *Raw data* for each interval, and divides the sum by the number of Good values. If any non-Good values are ignored in the computation, the *Aggregate StatusCode* will be determined using the *StatusCode* Calculation (see 5.3). This *Aggregate* is not time based so the PercentGood/PercentBad applies to the number of values in the interval.

Table 16 – Average Aggregate summary

Average Aggregate Characteristics	
Type	Calculated
Data Type	Double
Use Bounds	None
Timestamp	StartTime
Status Code Calculations	
Calculation Method	PercentValues
Partial	Not Set
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Bounds not used
No End Bound	Bounds not used
Bound Bad	Bounds not used
Bound Uncertain	Bounds not used

5.4.3.6 TimeAverage

The TimeAverage *Aggregate* defined in Table 17 uses *Interpolated Bounding Values* (see 3.1.8) to find the value of a point at the beginning and end of an interval. Starting at the starting bounding value a straight line is drawn between each value in the *interval* ending at the ending bounding value (see examples for illustrations). The area under the lines is divided by the length of the *ProcessingInterval* to yield the average. Note that this calculation always uses a sloped line between points; TimeAverage2 uses a stepped or sloped line depending on the value of the Stepped *Property* for the *Variable*.

If one or more Bad Values exist in the interval then they are omitted from the calculation and the *StatusCode* is set to *Uncertain_DataSubNormal*. Sloped lines are drawn between the Good values when calculating the area.

The time resolution used in this calculation is *Server* specific.

Table 17 – TimeAverage Aggregate summary

TimeAverage Aggregate Characteristics	
Type	Calculated
Data Type	Double
Use Bounds	Interpolated
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom

	Good if no Bad values skipped and Good values are used, Uncertain if Bad values are skipped or if Uncertain values are used
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Value extrapolated, Uncertain status
No Start Bound	Calculate Partial Interval
No End Bound	Extrapolate data, Uncertain status
Bound Bad	NA
Bound Uncertain	NA

5.4.3.7 TimeAverage2

The TimeAverage2 *Aggregate* defined in Table 18 uses *Simple Bounding Values* (see 3.1.9) to find the value of a point at the beginning and end of an interval. Starting at the starting bounding value a straight line is drawn between each value in the interval ending at the ending bounding value (see examples for illustrations). The area under the lines is divided by the length of the *ProcessingInterval* to yield the average. Note that this calculation uses a stepped or sloped line depending on what the value of the Stepped *Property* for the *Variable*; TimeAverage always uses a sloped line between points.

The time resolution used in this calculation is *Server* specific.

If any non-Good data exists in the interval, this data is omitted from the calculation and the time interval is reduced by the duration of the non-Good data; i.e. if a value was Bad for 1 minute in a 5-minute interval then the TimeAverage2 would be the area under the 4-minute period of Good values divided by 4 minutes. If a sub-interval ends at a Bad value then only the Good starting value is used to calculate the area of sub-interval preceding the Bad value.

The *Aggregate StatusCode* will be determined using the *StatusCode* Calculation (see 5.3).

Table 18 – TimeAverage2 Aggregate summary

TimeAverage2 Aggregate Characteristics	
Type	Calculated
Data Type	Double
Use Bounds	Simple
Timestamp	StartTime
Status Code Calculations	
Calculation Method	PercentTime
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Bound is Bad_NoData and treated as any other Bad value in the interval
No End Bound	Bound is Bad_NoData and treated as any other Bad value in the interval
Bound Bad	Treated as any other Bad value in the interval
Bound Uncertain	Treated as any other Uncertain value in the interval

5.4.3.8 Total

The Total *Aggregate* defined in Table 19 performs the following calculation for each interval:

Total = TimeAverage x *ProcessingInterval* (seconds)

where: TimeAverage is the result from the TimeAverage *Aggregate*, using the *ProcessingInterval* supplied to the Total call.

The resulting units would be normalized to seconds, i.e. [TimeAverage Units] x seconds.

The *Aggregate StatusCode* will be determined using the *StatusCode* Calculation (see 5.3).

Table 19 – Total Aggregate summary

Total Aggregate Characteristics	
Type	Calculated
Data Type	Double
Use Bounds	Interpolated
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom Good if no Bad values are skipped and Good values are used, Uncertain if Bad values are skipped or if Uncertain values are used
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set

Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Value extrapolated, Uncertain status
No Start Bound	Calculate Partial Interval
No End Bound	Extrapolate data, Uncertain status
Bound Bad	NA
Bound Uncertain	NA

5.4.3.9 Total2

The Total2 *Aggregate* defined in Table 20 performs the following calculation for each interval:

Total2 = TimeAverage2 x *ProcessingInterval* of Good data (seconds)

where TimeAverage2 is the result from the TimeAverage2 *Aggregate*, using the *ProcessingInterval* supplied to the Total2 call.

The interval of Good data is the sum of all sub-intervals where non-Bad data exists; i.e. if a value was Bad for 1 minute in a 5-minute interval then the interval of Good data would be the 4-minute period.

The resulting units would be normalized to seconds, i.e. [TimeAverage2 Units] x seconds.

The *Aggregate StatusCode* will be determined using the *StatusCode* Calculation (see 5.3).

Table 20 – Total2 Aggregate summary

Total2 Aggregate Characteristics	
Type	Calculated
Data Type	Double
Use Bounds	Simple
Timestamp	StartTime
Status Code Calculations	
Calculation Method	PercentTime
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Value for Bound is Bad_NoData and is treated like any other Bad quality value in the calculation (ignored)
No End Bound	Value for Bound is Bad_NoData and is treated like any other Bad quality value in the calculation (ignored)
Bound Bad	Value is treated like any other Bad quality value in the calculation (ignored)
Bound Uncertain	Value is treated like any other non-Good quality value in the calculation (ignored)

5.4.3.10 Minimum

The Minimum *Aggregate* defined in Table 21 retrieves the minimum Good raw value within the interval, and returns that value with the timestamp at the start of the interval. Note that if the same minimum exists at more than one timestamp the *MultipleValues* bit is set.

Unless otherwise indicated, *StatusCodes* are *Good, Calculated*. If the minimum value is on the start time the status code will be *Good, Raw.* If only Bad quality values are available then the status is returned as *Bad_NoData*.

The timestamp of the *Aggregate* will always be the start of the interval for every *ProcessingInterval*.

Table 21 – Minimum Aggregate summary

Minimum Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	None
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom If no Bad values then the Status is Good. If Bad values exist then the Status is *Uncertain_SubNormal.* If an Uncertain value is less than the minimum Good value the Status is *Uncertain_SubNormal*.
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Sometimes If the Minimum value is not on the StartTime of the interval or if the Status was set to *Uncertain_SubNormal* because of non-Good values in the interval
Interpolated	Not Set
Raw	Set Sometimes If Minimum value is on the StartTime of the interval
Multi Value	Set Sometimes If multiple Good values exist with the Minimum value
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Not Applicable
No End Bound	Not Applicable
Bound Bad	Not Applicable
Bound Uncertain	Not Applicable

5.4.3.11 Maximum

The Maximum *Aggregate* defined in Table 22 retrieves the maximum Good raw value within the interval, and returns that value with the timestamp at the start of the interval. Note that if the same maximum exists at more than one timestamp the *MultipleValues* bit is set.

Unless otherwise indicated, *StatusCodes* are *Good, Calculated*. If the minimum value is on the interval start time the status code will be *Good, Raw.* If only Bad quality values are available then the status is returned as *Bad_NoData*.

The timestamp of the *Aggregate* will always be the start of the interval for every *ProcessingInterval*.

Table 22 – Maximum Aggregate summary

Maximum Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	None
Timestamp	StartTime

Status Code Calculations	
Calculation Method	Custom If no Bad values then the Status is Good. If Bad values exist then the Status is *Uncertain_SubNormal.* If an Uncertain value is greater than the maximum Good value the Status is *Uncertain_SubNormal*
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Sometimes If the Maximum value is not on the *startTime* of the interval or if the Status was set to *Uncertain_SubNormal* because of non-Good values in the interval
Interpolated	Not Set
Raw	Set Sometimes If Maximum value is on the *startTime* of the interval
Multi Value	Set Sometimes If multiple Good values exist with the Maximum value
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Not Applicable
No End Bound	Not Applicable
Bound Bad	Not Applicable
Bound Uncertain	Not Applicable

5.4.3.12 MinimumActualTime

The MinimumActualTime *Aggregate* defined in Table 23 retrieves the minimum Good raw value within the interval, and returns that value with the timestamp at which that value occurs. Note that if the same minimum exists at more than one timestamp, the oldest one is retrieved and the *Aggregate Bits are* set to *MultipleValues*.

Table 23 – MinimumActualTime Aggregate summary

MinimumActualTime Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	None
Timestamp	Time of Minimum
Status Code Calculations	
Calculation Method	Custom If no Bad values then the Status is Good. If Bad values exist then the Status is *Uncertain_SubNormal.* If an Uncertain value is less than the minimum Good value the Status is *Uncertain_SubNormal*
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Sometimes If the Status was set to *Uncertain_SubNormal* because of non-Good values in the interval
Interpolated	Not Set
Raw	Set Sometimes If a Good minimum value is returned
Multi Value	Set Sometimes If multiple Good values exist with the Minimum value
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Not Applicable

No End Bound	Not Applicable
Bound Bad	Not Applicable
Bound Uncertain	Not Applicable

5.4.3.13 MaximumActualTime

The MaximumActualTime *Aggregate* defined in Table 24 is the same as the MinimumActualTime *Aggregate*, except that the value is the maximum raw value within the interval. Note that if the same maximum exists at more than one timestamp, the oldest one is retrieved and the *Aggregate Bits are* set to *MultipleValues.*

Table 24 – MaximumActualTime Aggregate summary

MaximumActualTime Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	None
Timestamp	Time of Maximum
Status Code Calculations	
Calculation Method	Custom If no Bad values then the Status is Good. If Bad values exist then the Status is *Uncertain_SubNormal.* If an Uncertain value is greater than the maximum Good value the Status is *Uncertain_SubNormal*
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Sometimes If the Status was set to *Uncertain_SubNormal* because of non-Good values in the interval
Interpolated	Not Set
Raw	Set Sometimes If a Good maximum value is returned
Multi Value	Set Sometimes If multiple Good values exist with the maximum value
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Not Applicable
No End Bound	Not Applicable
Bound Bad	Not Applicable
Bound Uncertain	Not Applicable

5.4.3.14 Range

The Range *Aggregate* defined in Table 25 finds the difference between the maximum and minimum Good raw values in the interval. If only one *Good* value exists in the interval, the range is zero. Note that the range is always zero or positive. If non-Good values are ignored when finding the minimum or maximum values or if Bad values exist then the status is *Uncertain_DataSubNormal.*

Table 25 – Range Aggregate summary

Range Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	None
Timestamp	StartTime
Status Code Calculations	

Calculation Method	Custom If no Bad values then the Status is Good. If Bad values exist then the Status is *Uncertain_SubNormal.* If an Uncertain value is greater than the maximum or less than the minimum Good value the Status is *Uncertain_SubNormal*
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Not Applicable
No End Bound	Not Applicable
Bound Bad	Not Applicable
Bound Uncertain	Not Applicable

5.4.3.15 Minimum2

The Minimum2 *Aggregate* defined in Table 26 retrieves the minimum Good value for each interval as defined for Minimum except that *Simple Bounding Values* are included. The *Simple Bounding Values* for the interval are found according to the definition of *Simple Bounding Values* (see 3.1.9). Any Bad values are ignored in the computation. The *Aggregate StatusCode* will be determined using the *StatusCode* Calculation (see 5.3) for time based *Aggregates*. If a bounding value is returned then the status will indicate, Raw, Calculated or Interpolated.

If *TreatUncertainAsBad* is false and an Uncertain raw value is the minimum then that Uncertain value is used. Uncertain values are ignored otherwise.

If sloped interpolation is used and the End bound is the minimum value then End bound is used as the Minimum with the timestamp set to the *startTime* of the interval. The End bound is ignored in all other cases.

Table 26 – Minimum2 Aggregate summary

Minimum2 Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	Simple
Timestamp	StartTime
Status Code Calculations	
Calculation Method	PercentTime
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Sometimes Set unless the StartBound is the Minimum
Interpolated	Set Sometimes If an Interpolated bound is the Minimum
Raw	Set Sometimes If a raw value is the Minimum.
Multi Value	Set Sometimes If more than one Good values exist with the same
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Treat the beginning value as Bad_NoData and compute the *Aggregate*
No End Bound	Treat the ending value as Bad_NoData and compute the *Aggregate*
Bound Bad	Use as value and compute the *Aggregate* as defined
Bound Uncertain	Use as value and compute the *Aggregate* as defined

5.4.3.16 Maximum2

The Maximum2 *Aggregate* defined in Table 27 retrieves the maximum Good value for each interval as defined for Maximum except that *Simple Bounding Values* are included. The *Simple Bounding Values* for the interval are found according to the definition of *Simple Bounding Values* (see 3.1.9). Any Bad values are ignored in the computation. The *Aggregate StatusCode* will be determined using the *StatusCode* Calculation (see 5.3) for time based *Aggregates*. If a bounding value is returned then the status will indicate, Raw, Calculated or Interpolated.

If *TreatUncertainAsBad* is false and an Uncertain raw value is the maximum then that Uncertain value is used. Uncertain values are ignored otherwise.

If sloped interpolation is used and the End bound is the maximum value then End bound is used as the maximum with the timestamp set to the *startTime* of the interval. The End bound is ignored in all other cases.

Table 27 – Maximum2 Aggregate summary

Maximum2 Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	Simple
Timestamp	StartTime
Status Code Calculations	
Calculation Method	PercentTime
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Sometimes Set unless the StartBound is the Maximum

Interpolated	Set Sometimes If an Interpolated bound is the Maximum
Raw	Set Sometimes If a raw value is the Maximum.
Multi Value	Set Sometimes If more than one Good values exist with the same
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Treat the beginning value as Bad_NoData and compute the *Aggregate*
No End Bound	Treat the ending value as Bad_NoData and compute the *Aggregate*
Bound Bad	Use as value and compute the *Aggregate* as defined
Bound Uncertain	Use as value and compute the *Aggregate* as defined

5.4.3.17 MinimumActualTime2

The MinimumActualTime2 *Aggregate* defined in Table 28 retrieves the minimum Good value for each interval as defined for MinimumActualTime except that *Simple Bounding Values* are included. The *Simple Bounding Values* for the interval are found according to the definition of *Simple Bounding Values* (see 3.1.9). Any Bad values are ignored in the computation. The *Aggregate StatusCode* will be determined using the *StatusCode* Calculation (see 5.3) for time based *Aggregates*. If a bounding value is returned then the status will indicate, Raw, Calculated or Interpolated.

If *TreatUncertainAsBad* is false and an Uncertain raw value is the minimum then that Uncertain value is used. Uncertain values are ignored otherwise.

If sloped interpolation is used and the End bound is the minimum value then End bound is used as the minimum with the timestamp set to the *EffectiveEndTime* of the interval. The End bound is ignored in all other cases.

Table 28 – MinimumActualTime2 Aggregate summary

MinumumActualTime2 Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	Simple
Timestamp	Time of minimum
Status Code Calculations	
Calculation Method	PercentTime
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Not Set
Interpolated	Set Sometimes If an Interpolated bound is the Minimum
Raw	Set Sometimes If a raw value is the Minimum
Multi Value	Set Sometimes If more than one Good values exist with the same value
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Treat the beginning value as Bad_NoData and compute the *Aggregate*
No End Bound	Treat the ending value as Bad_NoData and compute the *Aggregate*
Bound Bad	Use as value and compute the *Aggregate* as defined

Bound Uncertain	Use as value and compute the *Aggregate* as defined

5.4.3.18 MaximumActualTime2

The MaximumActualTime2 *Aggregate* defined in Table 29 retrieves the maximum Good value for each interval as defined for MaximumActualTime except that *Simple Bounding Values* are included. The *Simple Bounding Values* for the interval are found according to the definition of *Simple Bounding Values* (see 3.1.9). Any Bad values are ignored in the computation. The *Aggregate StatusCode* will be determined using the *StatusCode* Calculation (see 5.3) for time based *Aggregates*. If a bounding value is returned then the status will indicate, Raw, Calculated or Interpolated.

If *TreatUncertainAsBad* is false and an Uncertain raw value is the maximum then that Uncertain value is used. Uncertain values are ignored otherwise.

If sloped interpolation is used and the End bound is the maximum value then End bound is used as the maximum with the timestamp set to the EffectiveEndTime of the interval. The End bound is ignored in all other cases.

Table 29 – MaximumActualTime2 Aggregate summary

MaximumActualTime2 Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	Simple
Timestamp	Time of maximum
Status Code Calculations	
Calculation Method	PercentTime
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Not Set
Interpolated	Set Sometimes If an Interpolated bound is the Maximum
Raw	Set Sometimes If a raw value is the Maximum
Multi Value	Set Sometimes If more than one value is equal to the Maximum
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Treat the beginning value as Bad_NoData and compute the *Aggregate*
No End Bound	Treat the ending value as Bad_NoData and compute the *Aggregate*
Bound Bad	Use as value and compute the *Aggregate* as defined
Bound Uncertain	Use as value and compute the *Aggregate* as defined

5.4.3.19 Range2

The Range2 *Aggregate* defined in Table 30 finds the difference between the maximum and minimum values in the interval as returned by the Minimum2 and Maximum2 *Aggregates*. Note that the range is always zero or positive.

Table 30 – Range2 Aggregate summary

Range2 Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	Simple (used in Minimum2 and Maximum2 calculations)
Timestamp	StartTime

Status Code Calculations	
Calculation Method	Custom If Minimum2 or Maximum2 are Bad then the status is Bad_NoData. If Minimum2 or Maximum2 are Uncertain then the status is *Uncertain_DataSubNormal*. Good otherwise
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Handled by Minimum2 and Maximum2
No End Bound	Handled by Minimum2 and Maximum2
Bound Bad	Handled by Minimum2 and Maximum2
Bound Uncertain	Handled by Minimum2 and Maximum2

5.4.3.20 AnnotationCount

The AnnotationCount *Aggregate* defined in Table 31 returns a count of all *Annotations* in the interval.

The *StatusCodes* are *Good, Calculated*.

Table 31 – AnnotationCount Aggregate summary

AnnotationCount Aggregate Characteristics	
Type	Calculated
Data Type	Int32 (negative values are not allowed)
Use Bounds	None
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom Good unless the interval is before the start of data or after the end of data
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Does not apply
No End Bound	Does not apply
Bound Bad	Does not apply
Bound Uncertain	Does not apply

5.4.3.21 Count

The Count *Aggregate* defined in Table 32 retrieves a count of all the raw values within an interval. If one or more raw values are non-Good, they are not included in the count, and the

Aggregate StatusCode is determined using the *StatusCode* Calculation (see 5.4.3) for non-time based *Aggregates*. If no Good data exists for an interval, the count is zero.

Unless otherwise indicated, *StatusCodes* are *Good, Calculated*.

Table 32 – Count Aggregate summary

Count Aggregate Characteristics	
Type	Calculated
Data Type	Int32 (negative values are not allowed)
Use Bounds	None
Timestamp	StartTime
Status Code Calculations	
Calculation Method	PercentValues
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Does not apply
No End Bound	Does not apply
Bound Bad	Does not apply
Bound Uncertain	Does not apply

5.4.3.22 DurationInStateZero

The DurationInStateZero *Aggregate* defined in Table 33 returns the time *Duration* during the interval that the *Variable* was in the zero state. The *Simple Bounding Values* for the interval are used to determine initial value (start time < end time) or ending value (if start time > end time). If one or more raw values are non-Good, they are not included in the *Duration*, and the *Aggregate StatusCode* is determined using the *StatusCode* Calculation (see 5.3) for time based *Aggregates*. *Duration* is in milliseconds. Unless otherwise indicated, *StatusCodes* are *Good, Calculated*.

Table 33 – DurationInStateZero Aggregate summary

DurationInStateZero Aggregate Characteristics	
Type	Calculated
Data Type	Duration
Use Bounds	Simple
Timestamp	StartTime
Status Code Calculations	
Calculation Method	PercentTime
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData

No Start Bound	Treat the beginning value as Bad_NoData and compute the *Aggregate*
No End Bound	Treat the ending value as Bad_NoData and compute the *Aggregate*
Bound Bad	Use as value and compute the *Aggregate* as defined
Bound Uncertain	Use as value and compute the *Aggregate* as defined

5.4.3.23 DurationInStateNonZero

The DurationInStateNonZero *Aggregate* defined in Table 34 returns the time *Duration* during the interval that the *Variable* was in the one state. The *Simple Bounding Values* for the interval are used to determine initial value (start time < end time) or ending value (if start time > end time). If one or more raw values are non-Good, they are not included in the *Duration*, and the *Aggregate StatusCode* is determined using the *StatusCode* Calculation (see 5.3) for time based *Aggregates*.

Duration is in milliseconds. Unless otherwise indicated, *StatusCodes* are *Good, Calculated*.

Table 34 – DurationInStateNonZero Aggregate Summary

DurationInStateNonZero Aggregate Characteristics	
Type	Calculated
Data Type	Duration
Use Bounds	Simple
Timestamp	StartTime
Status Code Calculations	
Calculation Method	PercentTime
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Treat the beginning value as Bad_NoData and compute the *Aggregate*
No End Bound	Treat the ending value as Bad_NoData and compute the *Aggregate*
Bound Bad	Use as value and compute the *Aggregate* as defined
Bound Uncertain	Use as value and compute the *Aggregate* as defined

5.4.3.24 NumberOfTransitions

The NumberOfTransitions *Aggregate* defined in Table 35 returns a count of the number of transition the *Variable* had during the interval. If one or more raw values are Bad, they are not included in the count, and the *Aggregate StatusCode* is determined using the *StatusCode* Calculation (see 5.3) for non-time based *Aggregates*.

The earliest transition shall be calculated by comparing the earliest non-Bad value in the interval to the previous non-Bad value. A transition occurred if no previous non-Bad value exists or if the earliest non-Bad value is different. The *endTime* is not considered part of the interval, so a transition occurring at the *endTime* is not included.

Unless otherwise indicated, *StatusCodes* are *Good, Calculated*.

Table 35 – NumberOfTransitions Aggregate summary

NumberOfTransitions Aggregate Characteristics	
Type	Calculated

Data Type	Int32 (negative values are not allowed)
Use Bounds	Custom, a non-Bad value prior to the interval is used
Timestamp	StartTime
Status Code Calculations	
Calculation Method	PercentValues
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Treat the beginning value as Bad_NoData and compute the *Aggregate*
No End Bound	Treat the ending value as Bad_NoData and compute the *Aggregate*
Bound Bad	Use as value and compute the *Aggregate* as defined
Bound Uncertain	Use as value and compute the *Aggregate* as defined

5.4.3.25 Start

The Start *Aggregate* defined in Table 36 retrieves the earliest raw value within the interval, and returns that value and status with the timestamp at which that value occurs. If no values are in the interval then the *StatusCode* is *Bad_NoData*.

Table 36 – Start Aggregate summary

Start Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	None
Timestamp	Time of Raw Value
Status Code Calculations	
Calculation Method	Custom The raw value status is returned
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Not Set
Interpolated	Not Set
Raw	Always
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Does not apply
No End Bound	Does not apply
Bound Bad	Does not apply
Bound Uncertain	Does not apply

5.4.3.26 End

The End *Aggregate* defined in Table 37 retrieves the latest raw value within the interval, and returns that value and status with the timestamp at which that value occurs. If no values are in the interval then the *StatusCode* is *Bad_NoData*.

Table 37 – End Aggregate summary

End Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	None
Timestamp	Time of Raw Value
Status Code Calculations	
Calculation Method	Custom The raw value status is returned
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Not Set
Interpolated	Not Set
Raw	Always
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Does not apply
No End Bound	Does not apply
Bound Bad	Does not apply
Bound Uncertain	Does not apply

5.4.3.27 Delta

The Delta *Aggregate* defined in Table 38 retrieves the difference between the earliest and latest Good raw values in the interval. The *Aggregate* is negative if the latest value is less than the earliest value. The status is *Uncertain_DataSubNormal* if non-Good values are skipped while looking for the first or last values. The status is *Good* otherwise. The status is *Bad_NoData* if no Good raw values exist.

Table 38 – Delta Aggregate summary

Delta Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	None
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom *Uncertain_DataSubNormal* if non-Good values are skipped while looking for the first or last values
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Always
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Does not apply
No End Bound	Does not apply
Bound Bad	Does not apply
Bound Uncertain	Does not apply

5.4.3.28 StartBound

The StartBound *Aggregate* defined in Table 39 returns the value and status at the *StartTime* for the interval by calculating the *Simple Bounding Values* for the interval (see 3.1.9).

Table 39 – StartBound Aggregate summary

StartBound Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	Simple
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom The status of the start bound.
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Not Set
Interpolated	Set Sometimes If the bound is interpolated
Raw	Set Sometimes If a value exists at the start time
Multi Value	Not Set

Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Bad_NoData
No End Bound	Does not apply
Bound Bad	Same as bound
Bound Uncertain	Same as bound

5.4.3.29 EndBound

The EndBound *Aggregate* defined in Table 40 returns the value and status at the *EndTime* for the interval by calculating the *Simple Bounding Values* for the interval (see 3.1.9).

The timestamp returned is always the start of the interval and Calculated bit is set.

Table 40 – EndBound Aggregate summary

EndBound Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	Simple
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom The status of the end bound.
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Does not apply
No End Bound	Bad_NoData
Bound Bad	Same as bound
Bound Uncertain	Same as bound

5.4.3.30 DeltaBounds

The DeltaBounds *Aggregate* defined in Table 41 returns the difference between the *StartBound* and the *EndBound Aggregates* with the exception that both the start and end shall be Good. If the end value is less than the start value, the result will be negative. If the end value is the same as the start value the result will be zero. If the end value is greater than the start value, the result will be positive. If one or both values are Bad the return status will be *Bad_NoData*. If one or both values are Uncertain the status will be *Uncertain_DataSubNormal*.

Table 41 – DeltaBounds Aggregate summary

DeltaBounds Aggregate Characteristics	
Type	Calculated
Data Type	Same as Source
Use Bounds	Simple
Timestamp	StartTime
Status Code Calculations	

Calculation Method	Custom Good if both bounds are Good *Uncertain_DataSubNormal* if either bound is uncertain Bad_NoData if either bound is Bad
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	Bad_NoData
No End Bound	Bad_NoData
Bound Bad	Bad_NoData
Bound Uncertain	Uncertain_DataSubNormal

5.4.3.31 DurationGood

The DurationGood *Aggregate* defined in Table 42 divides the interval into regions of Good and non-Good data. Each region starts with a data point in the interval. If that data point is Good the region is Good. The *Aggregate* is the sum of the duration of all Good regions expressed in milliseconds.

The status of the first region is determined by finding the first data point at or before the start of the interval. If no value exists, the first region is Bad.

Each *Aggregate* is returned with timestamp of the start of the interval. *StatusCodes* are *Good, Calculated*.

Table 42 – DurationGood Aggregate summary

DurationGood Aggregate Characteristics	
Type	Calculated
Data Type	Duration
Use Bounds	Uses status of bounding value
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom *StatusCode* is always *Good*, *Calculated*
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	No special handing required
No End Bound	No special handing required
Bound Bad	No special handing required
Bound Uncertain	No special handing required

5.4.3.32 DurationBad

The DurationBad *Aggregate* defined in Table 43 divides the interval into regions of Bad and non-Bad data. Each region starts with a data point in the interval. If that data point is Bad the region is Bad. The *Aggregate* is the sum of the duration of all Bad regions expressed in milliseconds.

The status of the first region is determined by finding the first data point at or before the start of the interval. If no value exists, the first region is Bad.

Each *Aggregate* is returned with timestamp of the start of the interval. *StatusCodes* are *Good, Calculated*.

Table 43 – DurationBad Aggregate summary

DurationBad Aggregate Characteristics	
Type	Calculated
Data Type	Duration
Use Bounds	Uses status of bounding value
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom *StatusCode* is always *Good, Calculated*
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	No special handing required
No End Bound	No special handing required
Bound Bad	No special handing required
Bound Uncertain	No special handing required

5.4.3.33 PercentGood

The PercentGood *Aggregate* defined in Table 44 performs the following calculation:

PercentGood = DurationGood / *ProcessingInterval* x 100

where:

DurationGood is the result from the DurationGood *Aggregate*, calculated using the *ProcessingInterval* supplied to *PercentGood* call.

ProcessingInterval is the duration of interval.

If the last interval is a partial interval then the duration of the partial interval is used in the calculation. Each *Aggregate* is returned with timestamp of the start of the interval. *StatusCodes* are *Good, Calculated*.

Table 44 – PercentGood Aggregate summary

PercentGood Aggregate Characteristics	
Type	Calculated
Data Type	Double (percent)
Use Bounds	Simple (used in DurationGood calculation)
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom Always Good
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	No special handing required
No End Bound	No special handing required
Bound Bad	No special handing required
Bound Uncertain	No special handing required

5.4.3.34 PercentBad

The PercentBad *Aggregate* defined in Table 45 performs the following calculation:

PercentBad = DurationBad / *ProcessingInterval* x 100

where:

DurationBad is the result from the DurationBad *Aggregate*, calculated using the *ProcessingInterval* supplied to *PercentBad* call.

ProcessingInterval is the duration of interval.

If the last interval is a partial interval then the duration of the partial interval is used in the calculation. Each *Aggregate* is returned with timestamp of the start of the interval. *StatusCodes* are *Good, Calculated*.

Table 45 – PercentBad Aggregate summary

PercentBad Aggregate Characteristics	
Type	Calculated
Data Type	Double (percent)
Use Bounds	Simple (used in DurationBad calculation)
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom Always Good.
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set

Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	No special handing required
No End Bound	No special handing required
Bound Bad	No special handing required
Bound Uncertain	No special handing required

5.4.3.35 WorstQuality

The WorstQuality *Aggregate* defined in Table 46 returns the worst status of the raw values in the interval where a *Bad* status is worse than *Uncertain*, which is worse than *Good*. No distinction is made between the specific reasons for the status.

If multiple values exist with the worst quality but different *StatusCodes* then the *StatusCode* of the first value is returned and the *MultipleValues* bit is set.

This *Aggregate* returns the worst *StatusCode* as the value of the *Aggregate*.

The timestamp is always the start of the interval. The *StatusCodes* are *Good, Calculated*.

Table 46 – WorstQuality Aggregate summary

WorstQuality Aggregate Characteristics	
Type	Calculated
Data Type	StatusCode
Use Bounds	None
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom Always Good
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Used
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	No special handing required
No End Bound	No special handing required
Bound Bad	No special handing required
Bound Uncertain	No special handing required

5.4.3.36 WorstQuality2

The *WorstQuality2 Aggregate* defined in Table 47 returns the worst status of the raw values in the interval where a *Bad* status is worse than *Uncertain*, which is worse than *Good*. No distinction is made between the specific reasons for the status.

The start bound calculated using *Simple Bounding Values* (see 3.1.9) is always included when determining the worst quality.

If multiple values exist with the worst quality but different *StatusCodes* then the *StatusCode* of the first value is returned and the *MultipleValues* bit is set.

This *Aggregate* returns the worst *StatusCode* as the value of the *Aggregate*.

The timestamp is always the start of the interval. The *StatusCodes* are *Good, Calculated*.

Table 47 – WorstQuality2 Aggregate summary

WorstQuality2 Aggregate Characteristics	
Type	Calculated
Data Type	Status Code
Use Bounds	Simple
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom Always Good
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Used
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	No special handing required
No End Bound	No special handing required
Bound Bad	No special handing required
Bound Uncertain	No special handing required

5.4.3.37 StandardDeviationSample

The *StandardDeviationSample Aggregate* defined in Table 48 uses the formula:

$$\sqrt{\frac{\sum_{1}^{n}(X - \text{Avg}(X))^2}{n-1}}$$

where X is each Good raw value in the interval, Avg(X) is the average of the Good raw values, and n is the number of Good raw values in the interval.

For every interval where n = 1, a value of 0 is returned.

If any non-Good values were ignored, the *Aggregate* quality is uncertain/subnormal.

All interval *Aggregates* return timestamp of the start of the interval. Unless otherwise indicated, qualities are *Good, Calculated*.

This calculation is for a sample population where the calculation is done on a subset of the full set of data. Use *StandardDeviationPopulation* to calculate the standard deviation of a full set of data (see 5.4.3.39). An example would be when the underlying data is sampled from the data source versus stored on an exception basis.

Table 48 – StandardDeviationSample Aggregate summary

StandardDeviationSample Aggregate Characteristics	
Type	Calculated
Data Type	Status Code
Use Bounds	None
Timestamp	StartTime
Status Code Calculations	

Calculation Method	Custom Always Good
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	No special handing required
No End Bound	No special handing required
Bound Bad	No special handing required
Bound Uncertain	No special handing required

5.4.3.38 VarianceSample

The *VarianceSample Aggregate* defined in Table 49 retrieves the square of the standard deviation. Its behaviour is the same as the *StandardDeviationSample Aggregate*. Unless otherwise indicated, qualities are *Good, Calculated*.

This calculation is for a sample population where the calculation is done on a subset of the full population. Use *VariancePopulation* to calculate the variance of a full set of data (5.4.3.40).

Table 49 – VarianceSample Aggregate summary

VarianceSample Aggregate Characteristics	
Type	Calculated
Data Type	Status Code
Use Bounds	None
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom Always Good
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	No special handing required
No End Bound	No special handing required
Bound Bad	No special handing required
Bound Uncertain	No special handing required

5.4.3.39 StandardDeviationPopulation

The *StandardDeviation Population Aggregate* defined in Table 50 uses the formula:

$$\sqrt{\frac{\sum_{1}^{n}(X - \text{Avg}(X))^2}{n}}$$

where X is each Good raw value in the interval, Avg(X) is the average of the Good raw values, and n is the number of Good raw values in the interval.

For every interval where n = 1, a value of 0 is returned.

If any non-Good values were ignored, the *Aggregate* quality is uncertain/subnormal.

All interval *Aggregates* return timestamp of the start of the interval. Unless otherwise indicated, qualities are *Good, Calculated*.

This calculation is for a full population where the calculation is done on the full set of data. Use *StandardDeviationSample* to calculate the standard deviation of a subset of the full population (5.4.3.37). An example would be when the underlying data is collected on an exception basis versus sampled from the data source.

Table 50 – StandardDeviationPopulation Aggregate summary

StandardDeviationPopulation Aggregate Characteristics	
Type	Calculated
Data Type	Status Code
Use Bounds	None
Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom Always Good
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	No special handing required
No End Bound	No special handing required
Bound Bad	No special handing required
Bound Uncertain	No special handing required

5.4.3.40 VariancePopulation

The *VariancePopulation Aggregate* defined in Table 51 retrieves the square of the standard deviation. Its behaviour is the same as the *StandardDeviationPopulation Aggregate*. Unless otherwise indicated, qualities are *Good, Calculated*.

This calculation is for a full population where the calculation is done on the full set of data. Use *VarianceSample* to calculate the variance of a subset of the full population (5.4.3.38).

Table 51 – VariancePopulation Aggregate summary

VariancePopulation Aggregate Characteristics	
Type	Calculated
Data Type	Status Code
Use Bounds	None

Timestamp	StartTime
Status Code Calculations	
Calculation Method	Custom Always Good
Partial	Set Sometimes If an interval is not a complete interval
Calculated	Set Always
Interpolated	Not Set
Raw	Not Set
Multi Value	Not Set
Status Code Common Special Cases	
Before Start of Data	Bad_NoData
After End of Data	Bad_NoData
No Start Bound	No special handing required
No End Bound	No special handing required
Bound Bad	No special handing required
Bound Uncertain	No special handing required

Annex A
(informative)

Aggregate Specific examples – Historical Access

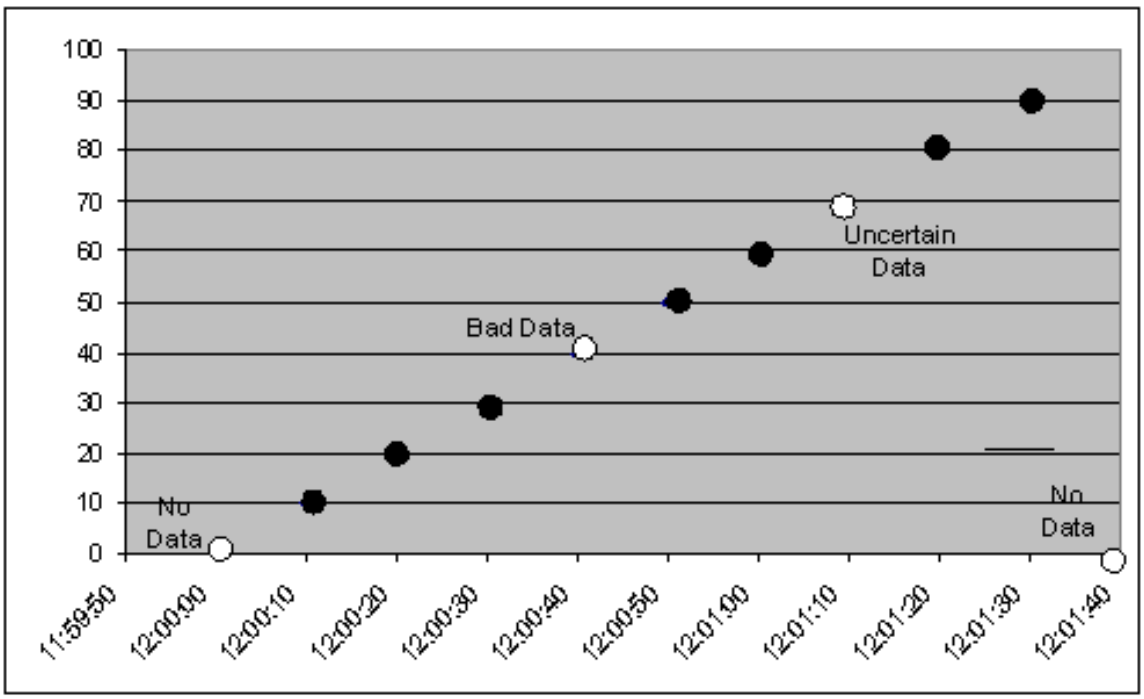
A.1 Historical Aggregate specific characteristics

A.1.1 Example Aggregate data – Historian 1

For the purposes of Historian 1 examples consider a source historian with the following data:

Timestamp	Value	StatusCode	Notes
12:00:00	-	Bad_NoData	First archive entry, Point created
12:00:10	10	Raw, Good	
12:00:20	20	Raw, Good	
12:00:30	30	Raw, Good	
12:00:40	40	Raw, Bad	**ANNOTATION**: Operator 1 Jan-02-2012 8:00:00 Scan failed, Bad data entered **ANNOTATION:** Jan-04-2012 7:10:00 Value cannot be verified
12:00:50	50	Raw, Good	**ANNOTATION**: Engineer1 Jan-04-2012 7:00:00 Scanner fixed
12:01:00	60	Raw, Good	
12:01:10	70	Raw, Uncertain	**ANNOTATION: Technician_1** Jan-02-2012 8:00:00 Value flagged as questionable
12:01:20	80	Raw, Good	
12:01:30	90	Raw, Good	
	null	No Data	No more entries, awaiting next scan

The example historian also has *Annotations* associated with three data points.



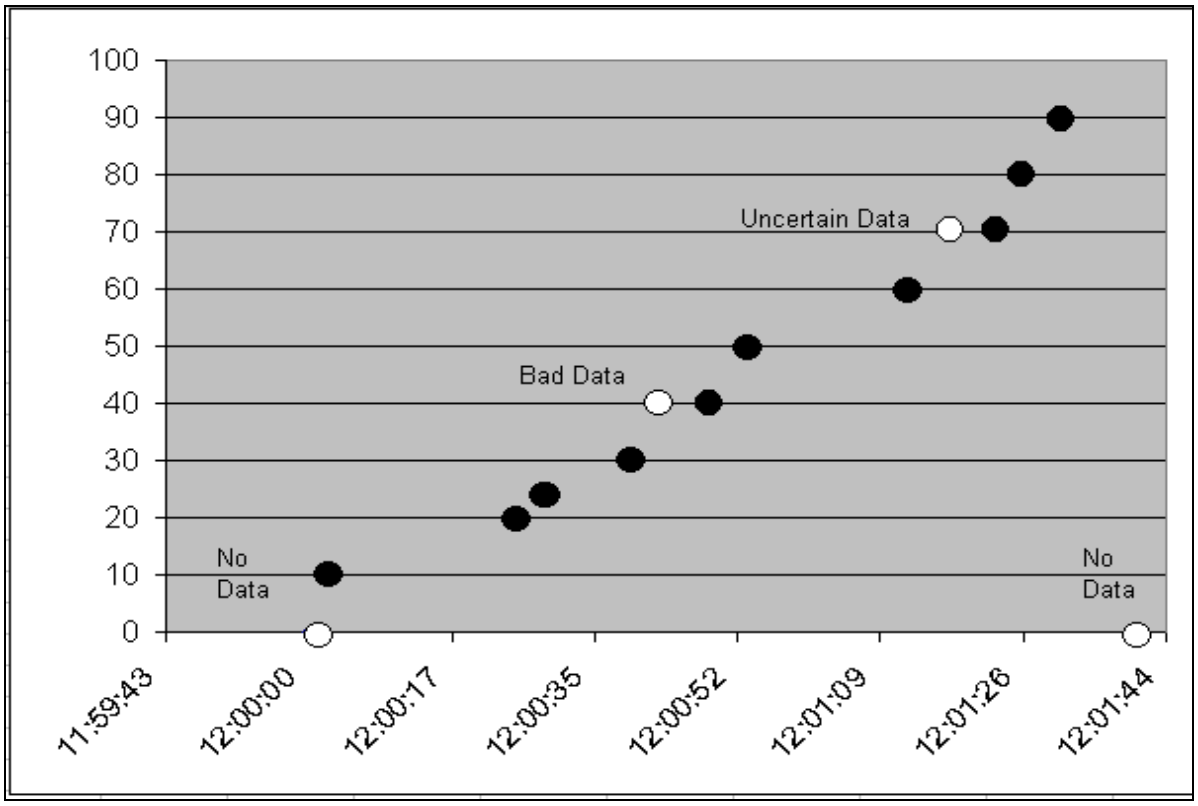
For the purposes of all Historian 1 examples:

1) *TreatUncertainAsBad* = False. Therefore Uncertain values are included in *Aggregate* calls.
2) *Stepped Attribute* = False. Therefore *SlopedInterpolation* is used between data points.
3) *UseSlopedExtrapolation* = False. Therefore *SteppedExtrapolation* is used at end boundary conditions.
4) *PercentBad* = 100, *PercentGood* = 100. Therefore if all values are Good then the quality will be Good, or if all values are Bad then the quality will be Bad, but if there is some Good and some Bad then the quality will be Uncertain.

A.1.2 Example Aggregate data – Historian 2

This example is included to illustrate non-periodic data. For the purposes of Historian 2 examples consider a source historian with the following data:

Timestamp	Value	StatusCode	Notes
12:00:00	-	Bad_NoData	First archive entry, Point created
12:00:02	10	Raw, Good	
12:00:25	20	Raw, Good	
12:00:28	25	Raw, Good	
12:00:39	30	Raw, Good	
12:00:42	-	Raw, Bad	Bad quality data received, Bad data entered
12:00:48	40	Raw, Good	Received Good *StatusCode* value
12:00:52	50	Raw, Good	
12:01:12	60	Raw, Good	
12:01:17	70	Raw, Uncertain	Value is flagged as questionable
12:01:23	70	Raw, Good	
12:01:26	80	Raw, Good	
12:01:30	90	Raw, Good	
	-	No Data	No more entries, awaiting next Value



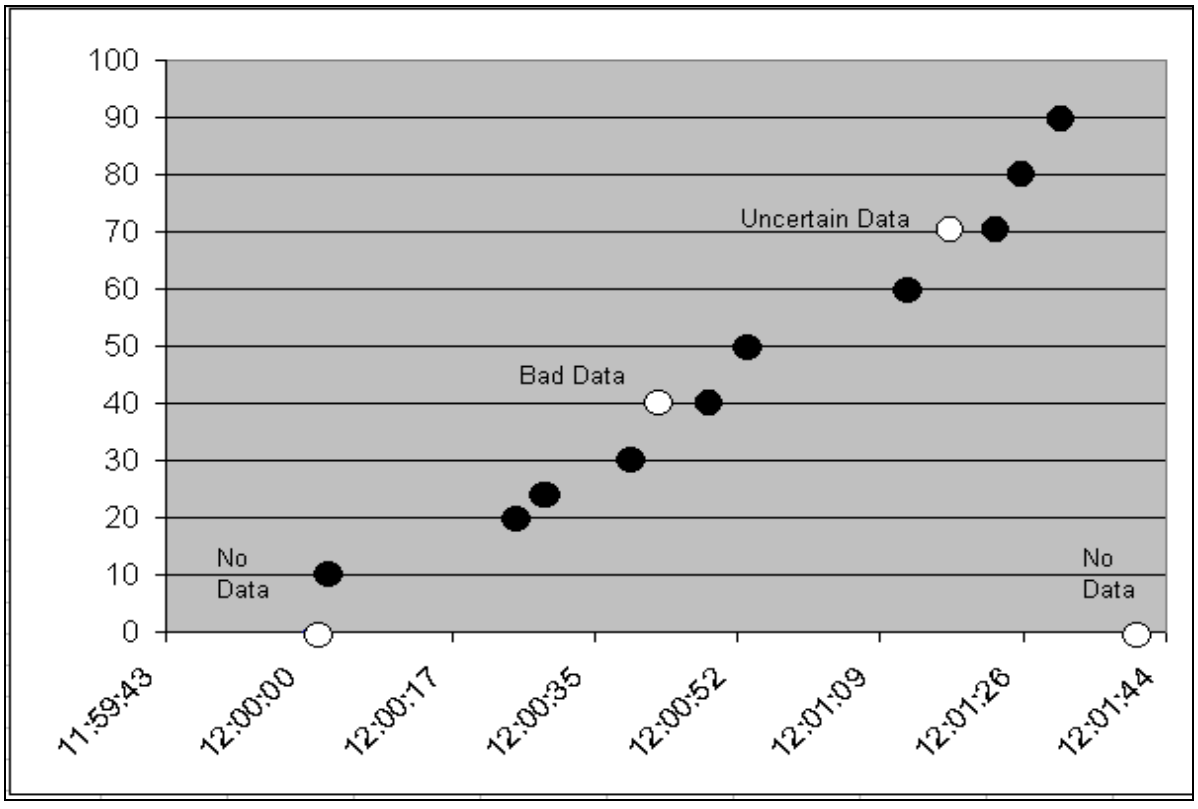
For the purposes of all Historian 2 examples:

1) *TreatUncertainAsBad* = True. Therefore Uncertain values are treated as *Bad*, and not included in the *Aggregate* call.
2) *Stepped Attribute* = False. Therefore *SlopedInterpolation* is used between data points.
3) *UseSlopedExtrapolation* = False. Therefore *SteppedExtrapolation* is used at end boundary conditions.
4) *PercentBad* = 100, *PercentGood* = 100. Therefore unless if all values are Good then the quality will be Good, or if all values are Bad then the quality will be Bad, but if there is some Good and some Bad then the quality will be Uncertain.

A.1.3 Example Aggregate data – Historian 3

This example is included to illustrate stepped data. For the purposes of Historian 3 examples consider a source historian with the following data:

Timestamp	Value	StatusCode	Notes
12:00:00	-	Bad_NoData	First archive entry, Point created
12:00:02	10	Raw, Good	
12:00:25	20	Raw, Good	
12:00:28	25	Raw, Good	
12:00:39	30	Raw, Good	
12:00:42	-	Raw, Bad	Bad quality data received, Bad data entered
12:00:48	40	Raw, Good	Received Good *StatusCode* value
12:00:52	50	Raw, Good	
12:01:12	60	Raw, Good	
12:01:17	70	Raw, Uncertain	Value is flagged as questionable
12:01:23	70	Raw, Good	
12:01:26	80	Raw, Good	
12:01:30	90	Raw, Good	
	-	No Data	No more entries, awaiting next Value



For the purposes of all Historian 3 examples:

1) *TreatUncertainAsBad* = True. Therefore Uncertain values are treated as *Bad*, and not included in the *Aggregate* call.
2) *Stepped Attribute* = True. Therefore *SteppedInterpolation* is used between data points.
3) *UseSlopedExtrapolation* = False. Therefore *SteppedExtrapolation* is used at end boundary conditions.
4) *PercentBad* = 50, *PercentGood* = 50. Therefore data will be either Good or Bad quality. Uncertain should not happen since a value is either Good or Bad.

A.1.4 Example Aggregate data – Historian 4

This example is included to illustrate Boolean data. For the purposes of Historian 4 examples consider a source historian with the following data:

Timestamp	Value	StatusCode	Notes
12:00:00	-	Bad_NoData	First archive entry, Point created
12:00:02	TRUE	Raw, Good	
12:00:25	FALSE	Raw, Good	
12:00:28	TRUE	Raw, Good	
12:00:39	TRUE	Raw, Good	
12:00:42	-	Raw, Bad	Bad quality data received, Bad data entered
12:00:48	TRUE	Raw, Good	Received Good *StatusCode* value
12:00:52	FALSE	Raw, Good	
12:01:12	FALSE	Raw, Good	
12:01:17	TRUE	Raw, Uncertain	Value is flagged as questionable
12:01:23	TRUE	Raw, Good	
12:01:26	FALSE	Raw, Good	
12:01:30	TRUE	Raw, Good	
	-	No Data	No more entries, awaiting next Value

For the purposes of all Historian 4 examples:

1) *TreatUncertainAsBad* = True. Therefore Uncertain values are treated as *Bad*, and not included in the *Aggregate* call.
2) *Stepped Attribute* = True. Therefore *SteppedInterpolation* is used between data points.
3) *UseSlopedExtrapolation* = False. Therefore *SteppedExtrapolation* is used at end boundary conditions.
4) *PercentGood = 100, PercentBad = 100.*

For Boolean data interpolation and extrapolation shall always be stepped.

A.2 Interpolative

A.2.1 Description

The following examples demonstrate Interpolative *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:05, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.2.2 Interpolative data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData	
12:00:05.000		BadNoData	
12:00:10.000	10	Good	
12:00:15.000	15	Good, Interpolated	
12:00:20.000	20	Good	
12:00:25.000	25	Good, Interpolated	
12:00:30.000	30	Good	
12:00:35.000	35	UncertainDataSubNormal, Interpolated	

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:40.000	40	UncertainDataSubNormal, Interpolated	
12:00:45.000	45	UncertainDataSubNormal, Interpolated	
12:00:50.000	50	Good	
12:00:55.000	55	Good, Interpolated	
12:01:00.000	60	Good	
12:01:05.000	65	UncertainDataSubNormal, Interpolated	
12:01:10.000	70	Uncertain	
12:01:15.000	75	UncertainDataSubNormal, Interpolated	
12:01:20.000	80	Good	
12:01:25.000	85	Good, Interpolated	
12:01:30.000	90	Good	
12:01:35.000	90	UncertainDataSubNormal, Interpolated	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData	
12:00:05.000	11.304	Good, Interpolated	
12:00:10.000	13.478	Good, Interpolated	
12:00:15.000	15.652	Good, Interpolated	
12:00:20.000	17.826	Good, Interpolated	
12:00:25.000	20	Good	
12:00:30.000	25.909	Good, Interpolated	
12:00:35.000	28.182	Good, Interpolated	
12:00:40.000	31.111	UncertainDataSubNormal, Interpolated	
12:00:45.000	36.667	UncertainDataSubNormal, Interpolated	
12:00:50.000	45	Good, Interpolated	
12:00:55.000	51.500	Good, Interpolated	
12:01:00.000	54	Good, Interpolated	
12:01:05.000	56.500	Good, Interpolated	
12:01:10.000	59	Good, Interpolated	
12:01:15.000	62.727	UncertainDataSubNormal, Interpolated	
12:01:20.000	67.273	UncertainDataSubNormal, Interpolated	
12:01:25.000	76.667	Good, Interpolated	
12:01:30.000	90	Good	
12:01:35.000	90	UncertainDataSubNormal, Interpolated	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData	
12:00:05.000	10	Good, Interpolated	
12:00:10.000	10	Good, Interpolated	
12:00:15.000	10	Good, Interpolated	
12:00:20.000	10	Good, Interpolated	
12:00:25.000	20	Good	
12:00:30.000	25	Good, Interpolated	
12:00:35.000	25	Good, Interpolated	
12:00:40.000	30	Good, Interpolated	
12:00:45.000	30	UncertainDataSubNormal, Interpolated	
12:00:50.000	40	Good, Interpolated	
12:00:55.000	50	Good, Interpolated	
12:01:00.000	50	Good, Interpolated	
12:01:05.000	50	Good, Interpolated	
12:01:10.000	50	Good, Interpolated	
12:01:15.000	60	Good, Interpolated	
12:01:20.000	60	UncertainDataSubNormal, Interpolated	
12:01:25.000	70	Good, Interpolated	
12:01:30.000	90	Good	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:01:35.000	90	UncertainDataSubNormal, Interpolated	

A.3 Average

A.3.1 Description

The following examples demonstrate Average *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:05, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.3.2 Average data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData	
12:00:05.000		BadNoData	
12:00:10.000	10	Good, Calculated	
12:00:15.000		BadNoData	
12:00:20.000	20	Good, Calculated	
12:00:25.000		BadNoData	
12:00:30.000	30	Good, Calculated	
12:00:35.000		BadNoData	
12:00:40.000		BadNoData	
12:00:45.000		BadNoData	
12:00:50.000	50	Good, Calculated	
12:00:55.000		BadNoData	
12:01:00.000	60	Good, Calculated	
12:01:05.000		BadNoData	
12:01:10.000		BadNoData	
12:01:15.000		BadNoData	
12:01:20.000	80	Good, Calculated	
12:01:25.000		BadNoData	
12:01:30.000	90	Good, Calculated	
12:01:35.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	Good, Calculated	
12:00:05.000		BadNoData	
12:00:10.000		BadNoData	
12:00:15.000		BadNoData	
12:00:20.000		BadNoData	
12:00:25.000	22.500	Good, Calculated	
12:00:30.000		BadNoData	
12:00:35.000	30	Good, Calculated	
12:00:40.000		BadNoData	
12:00:45.000	40	Good, Calculated	
12:00:50.000	50	Good, Calculated	
12:00:55.000		BadNoData	
12:01:00.000		BadNoData	
12:01:05.000		BadNoData	
12:01:10.000	60	Good, Calculated	
12:01:15.000		BadNoData	
12:01:20.000	70	Good, Calculated	
12:01:25.000	80	Good, Calculated	
12:01:30.000	90	Good, Calculated	
12:01:35.000		BadNoData	

Historian3

Timestamp	Value	StatusCode	Notes
12:00:00.000	10	Good, Calculated	
12:00:05.000		BadNoData	
12:00:10.000		BadNoData	
12:00:15.000		BadNoData	
12:00:20.000		BadNoData	
12:00:25.000	22.500	Good, Calculated	
12:00:30.000		BadNoData	
12:00:35.000	30	Good, Calculated	
12:00:40.000		BadNoData	
12:00:45.000	40	Good, Calculated	
12:00:50.000	50	Good, Calculated	
12:00:55.000		BadNoData	
12:01:00.000		BadNoData	
12:01:05.000		BadNoData	
12:01:10.000	60	Good, Calculated	
12:01:15.000		BadNoData	
12:01:20.000	70	Good, Calculated	
12:01:25.000	80	Good, Calculated	
12:01:30.000	90	Good, Calculated	
12:01:35.000		BadNoData	

A.4 TimeAverage

A.4.1 Description

The following examples demonstrate TimeAverage *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:05, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40

A.4.2 TimeAverage data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData	
12:00:05.000		BadNoData	
12:00:10.000	12.500	Good, Calculated	
12:00:15.000	17.500	Good, Calculated	
12:00:20.000	22.500	Good, Calculated	
12:00:25.000	27.500	Good, Calculated	
12:00:30.000	32.500	UncertainDataSubNormal, Calculated	
12:00:35.000	37.500	UncertainDataSubNormal, Calculated	
12:00:40.000	42.500	UncertainDataSubNormal, Calculated	
12:00:45.000	47.500	UncertainDataSubNormal, Calculated	
12:00:50.000	52.500	Good, Calculated	
12:00:55.000	57.500	Good, Calculated	
12:01:00.000	62.500	UncertainDataSubNormal, Calculated	
12:01:05.000	67.500	UncertainDataSubNormal, Calculated	
12:01:10.000	72.500	UncertainDataSubNormal, Calculated	
12:01:15.000	77.500	UncertainDataSubNormal, Calculated	
12:01:20.000	82.500	Good, Calculated	
12:01:25.000	87.500	Good, Calculated	
12:01:30.000	90	UncertainDataSubNormal, Calculated	
12:01:35.000	90	UncertainDataSubNormal, Calculated	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10.652	UncertainDataSubNormal, Calculated, Partial	
12:00:05.000	12.391	Good, Calculated	
12:00:10.000	14.565	Good, Calculated	

12:00:15.000	16.739	Good, Calculated	
12:00:20.000	18.913	Good, Calculated	
12:00:25.000	23.682	Good, Calculated	
12:00:30.000	27.046	Good, Calculated	
12:00:35.000	29.384	UncertainDataSubNormal, Calculated	
12:00:40.000	33.889	UncertainDataSubNormal, Calculated	
12:00:45.000	40	UncertainDataSubNormal, Calculated	
12:00:50.000	49.450	Good, Calculated	
12:00:55.000	52.750	Good, Calculated	
12:01:00.000	55.250	Good, Calculated	
12:01:05.000	57.750	Good, Calculated	
12:01:10.000	60.618	UncertainDataSubNormal, Calculated	
12:01:15.000	65	UncertainDataSubNormal, Calculated	
12:01:20.000	70.515	UncertainDataSubNormal, Calculated	
12:01:25.000	83.667	Good, Calculated	
12:01:30.000	90	UncertainDataSubNormal, Calculated	
12:01:35.000	90	UncertainDataSubNormal, Calculated	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10.652	UncertainDataSubNormal, Calculated, Partial	
12:00:05.000	12.391	Good, Calculated	
12:00:10.000	14.565	Good, Calculated	
12:00:15.000	16.739	Good, Calculated	
12:00:20.000	18.913	Good, Calculated	
12:00:25.000	23.682	Good, Calculated	
12:00:30.000	27.046	Good, Calculated	
12:00:35.000	29.384	UncertainDataSubNormal, Calculated	
12:00:40.000	33.889	UncertainDataSubNormal, Calculated	
12:00:45.000	40	UncertainDataSubNormal, Calculated	
12:00:50.000	49.450	Good, Calculated	
12:00:55.000	52.750	Good, Calculated	
12:01:00.000	55.250	Good, Calculated	
12:01:05.000	57.750	Good, Calculated	
12:01:10.000	60.618	UncertainDataSubNormal, Calculated	
12:01:15.000	65	UncertainDataSubNormal, Calculated	
12:01:20.000	70.515	UncertainDataSubNormal, Calculated	
12:01:25.000	83.667	Good, Calculated	
12:01:30.000	90	UncertainDataSubNormal, Calculated, Partial	
12:01:35.000	90	UncertainDataSubNormal, Calculated	

A.5 TimeAverage2

A.5.1 Description

The following examples demonstrate TimeAverage2 *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:05, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.5.2 TimeAverage2 data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData	
12:00:05.000		BadNoData	
12:00:10.000	12.500	Good, Calculated	
12:00:15.000	17.500	Good, Calculated	
12:00:20.000	22.500	Good, Calculated	

12:00:25.000	27.500	Good, Calculated	
12:00:30.000	30	UncertainDataSubNormal, Calculated	
12:00:35.000	30	UncertainDataSubNormal, Calculated	
12:00:40.000		BadNoData	
12:00:45.000		BadNoData	
12:00:50.000	52.500	Good, Calculated	
12:00:55.000	57.500	Good, Calculated	
12:01:00.000	62.500	UncertainDataSubNormal, Calculated	
12:01:05.000	67.500	UncertainDataSubNormal, Calculated	
12:01:10.000	72.500	UncertainDataSubNormal, Calculated	
12:01:15.000	77.500	UncertainDataSubNormal, Calculated	
12:01:20.000	82.500	Good, Calculated	
12:01:25.000	87.500	Good, Calculated	
12:01:30.000	90	UncertainDataSubNormal, Calculated, Partial	
12:01:35.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10.652	UncertainDataSubNormal, Calculated, Partial	
12:00:05.000	12.391	Good, Calculated	
12:00:10.000	14.565	Good, Calculated	
12:00:15.000	16.739	Good, Calculated	
12:00:20.000	18.913	Good, Calculated	
12:00:25.000	23.682	Good, Calculated	
12:00:30.000	27.046	Good, Calculated	
12:00:35.000	29.273	UncertainDataSubNormal, Calculated	
12:00:40.000	30	UncertainDataSubNormal, Calculated	
12:00:45.000	42.500	UncertainDataSubNormal, Calculated	
12:00:50.000	49.450	Good, Calculated	
12:00:55.000	52.750	Good, Calculated	
12:01:00.000	55.250	Good, Calculated	
12:01:05.000	57.750	Good, Calculated	
12:01:10.000	59.800	UncertainDataSubNormal, Calculated	
12:01:15.000	60	UncertainDataSubNormal, Calculated	
12:01:20.000	73.333	UncertainDataSubNormal, Calculated	
12:01:25.000	83.667	Good, Calculated	
12:01:30.000	90	UncertainDataSubNormal, Calculated, Partial	
12:01:35.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	Good, Calculated, Partial	
12:00:05.000	10	Good, Calculated	
12:00:10.000	10	Good, Calculated	
12:00:15.000	10	Good, Calculated	
12:00:20.000	10	Good, Calculated	
12:00:25.000	22	Good, Calculated	
12:00:30.000	25	Good, Calculated	
12:00:35.000	26	Good, Calculated	
12:00:40.000		Bad, Calculated	
12:00:45.000		Bad, Calculated	
12:00:50.000	46	Good, Calculated	
12:00:55.000	50	Good, Calculated	
12:01:00.000	50	Good, Calculated	
12:01:05.000	50	Good, Calculated	
12:01:10.000	56	Good, Calculated	
12:01:15.000		Bad, Calculated	
12:01:20.000		Bad, Calculated	
12:01:25.000	78	Good, Calculated	
12:01:30.000	90	Good, Calculated, Partial	
12:01:35.000		BadNoData	

A.6 Total

A.6.1 Description

The following examples demonstrate Total *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:05, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.6.2 Total data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData	
12:00:05.000		BadNoData	
12:00:10.000	62.500	Good, Calculated	
12:00:15.000	87.500	Good, Calculated	
12:00:20.000	112.500	Good, Calculated	
12:00:25.000	137.500	Good, Calculated	
12:00:30.000	162.500	UncertainDataSubNormal, Calculated	
12:00:35.000	187.500	UncertainDataSubNormal, Calculated	
12:00:40.000	212.500	UncertainDataSubNormal, Calculated	
12:00:45.000	237.500	UncertainDataSubNormal, Calculated	
12:00:50.000	262.500	Good, Calculated	
12:00:55.000	287.500	Good, Calculated	
12:01:00.000	312.500	UncertainDataSubNormal, Calculated	
12:01:05.000	337.500	UncertainDataSubNormal, Calculated	
12:01:10.000	362.500	UncertainDataSubNormal, Calculated	
12:01:15.000	387.500	UncertainDataSubNormal, Calculated	
12:01:20.000	412.500	Good, Calculated	
12:01:25.000	437.500	Good, Calculated	
12:01:30.000	450	UncertainDataSubNormal, Calculated	
12:01:35.000	450	UncertainDataSubNormal, Calculated	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	31.957	UncertainDataSubNormal, Calculated, Partial	
12:00:05.000	61.957	Good, Calculated	
12:00:10.000	72.826	Good, Calculated	
12:00:15.000	83.696	Good, Calculated	
12:00:20.000	94.565	Good, Calculated	
12:00:25.000	118.409	Good, Calculated	
12:00:30.000	135.227	Good, Calculated	
12:00:35.000	146.919	UncertainDataSubNormal, Calculated	
12:00:40.000	169.444	UncertainDataSubNormal, Calculated	
12:00:45.000	200	UncertainDataSubNormal, Calculated	
12:00:50.000	247.250	Good, Calculated	
12:00:55.000	263.750	Good, Calculated	
12:01:00.000	276.250	Good, Calculated	
12:01:05.000	288.750	Good, Calculated	
12:01:10.000	303.091	UncertainDataSubNormal, Calculated	
12:01:15.000	325	UncertainDataSubNormal, Calculated	
12:01:20.000	352.576	UncertainDataSubNormal, Calculated	
12:01:25.000	418.333	Good, Calculated	
12:01:30.000	481.250	UncertainDataSubNormal, Calculated	
12:01:35.000	543.750	UncertainDataSubNormal, Calculated	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	30	UncertainDataSubNormal, Calculated, Partial	
12:00:05.000	50	Good, Calculated	
12:00:10.000	50	Good, Calculated	
12:00:15.000	50	Good, Calculated	
12:00:20.000	50	Good, Calculated	
12:00:25.000	110	Good, Calculated	
12:00:30.000	125	Good, Calculated	
12:00:35.000	130	Good, Calculated	
12:00:40.000	150	UncertainDataSubNormal, Calculated	
12:00:45.000	170	UncertainDataSubNormal, Calculated	
12:00:50.000	230	Good, Calculated	
12:00:55.000	250	Good, Calculated	
12:01:00.000	250	Good, Calculated	
12:01:05.000	250	Good, Calculated	
12:01:10.000	280	Good, Calculated	
12:01:15.000	300	UncertainDataSubNormal, Calculated	
12:01:20.000	320	UncertainDataSubNormal, Calculated	
12:01:25.000	390	Good, Calculated	
12:01:30.000	450	UncertainDataSubNormal, Calculated	
12:01:35.000	450	UncertainDataSubNormal, Calculated	

A.7 Total2

A.7.1 Description

The following examples demonstrate Total2 *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:05, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.7.2 Total2 data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData	
12:00:05.000		BadNoData	
12:00:10.000	62.500	Good, Calculated	
12:00:15.000	87.500	Good, Calculated	
12:00:20.000	112.500	Good, Calculated	
12:00:25.000	137.500	Good, Calculated	
12:00:30.000	150	UncertainDataSubNormal, Calculated	
12:00:35.000	150	UncertainDataSubNormal, Calculated	
12:00:40.000		BadNoData	
12:00:45.000		BadNoData	
12:00:50.000	262.500	Good, Calculated	
12:00:55.000	287.500	Good, Calculated	
12:01:00.000	312.500	UncertainDataSubNormal, Calculated	
12:01:05.000	337.500	UncertainDataSubNormal, Calculated	
12:01:10.000	362.500	UncertainDataSubNormal, Calculated	
12:01:15.000	387.500	UncertainDataSubNormal, Calculated	
12:01:20.000	412.500	Good, Calculated	
12:01:25.000	437.500	Good, Calculated	
12:01:30.000	0.090	UncertainDataSubNormal, Calculated, Partial	
12:01:35.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	31.957	UncertainDataSubNormal, Calculated, Partial	
12:00:05.000	61.957	Good, Calculated	
12:00:10.000	72.826	Good, Calculated	
12:00:15.000	83.696	Good, Calculated	
12:00:20.000	94.565	Good, Calculated	
12:00:25.000	118.409	Good, Calculated	
12:00:30.000	135.227	Good, Calculated	
12:00:35.000	146.364	UncertainDataSubNormal, Calculated	
12:00:40.000	60	UncertainDataSubNormal, Calculated	
12:00:45.000	85	UncertainDataSubNormal, Calculated	
12:00:50.000	247.250	Good, Calculated	
12:00:55.000	263.750	Good, Calculated	
12:01:00.000	276.250	Good, Calculated	
12:01:05.000	288.750	Good, Calculated	
12:01:10.000	299	UncertainDataSubNormal, Calculated	
12:01:15.000	120	UncertainDataSubNormal, Calculated	
12:01:20.000	146.667	UncertainDataSubNormal, Calculated	
12:01:25.000	418.333	Good, Calculated	
12:01:30.000	0.090	UncertainDataSubNormal, Calculated, Partial	
12:01:35.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	30	Good, Calculated, Partial	
12:00:05.000	50	Good, Calculated	
12:00:10.000	50	Good, Calculated	
12:00:15.000	50	Good, Calculated	
12:00:20.000	50	Good, Calculated	
12:00:25.000	110	Good, Calculated	
12:00:30.000	125	Good, Calculated	
12:00:35.000	130	Good, Calculated	
12:00:40.000		Bad, Calculated	
12:00:45.000		Bad, Calculated	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:50.000	230	Good, Calculated	
12:00:55.000	250	Good, Calculated	
12:01:00.000	250	Good, Calculated	
12:01:05.000	250	Good, Calculated	
12:01:10.000	280	Good, Calculated	
12:01:15.000		Bad, Calculated	
12:01:20.000		Bad, Calculated	
12:01:25.000	390	Good, Calculated	
12:01:30.000	0.090	Good, Calculated, Partial	
12:01:35.000		BadNoData	

A.8 Minimum

A.8.1 Description

The following examples demonstrate Minimum *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.8.2 Minimum data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	Good, Calculated, Partial	
12:00:16.000	20	Good, Calculated	
12:00:32.000		BadNoData	
12:00:48.000	50	Good, Calculated	
12:01:04.000		BadNoData	
12:01:20.000	80	Good, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	Good, Calculated, Partial	
12:00:16.000	20	Good, Calculated	
12:00:32.000	30	UncertainDataSubNormal, Calculated	
12:00:48.000	40	Good	
12:01:04.000	60	UncertainDataSubNormal, Calculated	
12:01:20.000	70	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	Good, Calculated, Partial	
12:00:16.000	20	Good, Calculated	
12:00:32.000	30	UncertainDataSubNormal, Calculated	
12:00:48.000	40	Good	
12:01:04.000	60	UncertainDataSubNormal, Calculated	
12:01:20.000	70	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.9 Maximum

A.9.1 Description

The following examples demonstrate Maximum *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.9.2 Maximum data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	Good, Calculated, Partial	
12:00:16.000	30	Good, Calculated	
12:00:32.000		BadNoData	
12:00:48.000	60	Good, Calculated	
12:01:04.000		BadNoData	
12:01:20.000	90	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	Good, Calculated, Partial	
12:00:16.000	25	Good, Calculated	
12:00:32.000	30	UncertainDataSubNormal, Calculated	
12:00:48.000	50	Good, Calculated	
12:01:04.000	60	UncertainDataSubNormal, Calculated	
12:01:20.000	90	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	Good, Calculated, Partial	
12:00:16.000	25	Good, Calculated	
12:00:32.000	30	UncertainDataSubNormal, Calculated	
12:00:48.000	50	Good, Calculated	
12:01:04.000	60	UncertainDataSubNormal, Calculated	
12:01:20.000	90	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.10 MininumActualTime

A.10.1 Description

The following examples demonstrate the MinimumActualTime *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.10.2 MinimumActualTime data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:10.000	10	Good, Partial	
12:00:20.000	20	Good	
12:00:32.000		BadNoData	
12:00:50.000	50	Good	
12:01:04.000		BadNoData	
12:01:20.000	80	Good, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:02.000	10	Good, Partial	
12:00:25.000	20	Good	
12:00:39.000	30	UncertainDataSubNormal	
12:00:48.000	40	Good	
12:01:12.000	60	UncertainDataSubNormal	
12:01:23.000	70	Good, Partial	

12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:02.000	10	Good, Partial	
12:00:25.000	20	Good	
12:00:39.000	30	UncertainDataSubNormal	
12:00:48.000	40	Good	
12:01:12.000	60	UncertainDataSubNormal	
12:01:23.000	70	Good, Partial	
12:01:36.000		BadNoData	

A.11 MaximumActualTime

A.11.1 Description

The following examples demonstrate MaximumActualTime *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.11.2 MaximumActualTime data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:10.000	10	Good, Partial	
12:00:30.000	30	Good	
12:00:32.000		BadNoData	
12:01:00.000	60	Good	
12:01:04.000		BadNoData	
12:01:30.000	90	Good, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:02.000	10	Good, Partial	
12:00:28.000	25	Good	
12:00:39.000	30	UncertainDataSubNormal	
12:00:52.000	50	Good	
12:01:12.000	60	UncertainDataSubNormal	
12:01:30.000	90	Good, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:02.000	10	Good, Partial	
12:00:28.000	25	Good	
12:00:39.000	30	UncertainDataSubNormal	
12:00:52.000	50	Good	
12:01:12.000	60	UncertainDataSubNormal	
12:01:30.000	90	Good, Partial	
12:01:36.000		BadNoData	

A.12 Range

A.12.1 Description

The following examples demonstrate Range *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.12.2 Range data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:16.000	10	Good, Calculated	
12:00:32.000		BadNoData	
12:00:48.000	10	Good, Calculated	
12:01:04.000		BadNoData	
12:01:20.000	10	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:16.000	5	Good, Calculated	
12:00:32.000	0	UncertainDataSubNormal, Calculated	
12:00:48.000	10	Good, Calculated	
12:01:04.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	20	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:16.000	5	Good, Calculated	
12:00:32.000	0	UncertainDataSubNormal, Calculated	
12:00:48.000	10	Good, Calculated	
12:01:04.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	20	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.13 Minimum2

A.13.1 Description

The following examples demonstrate Minimum2 *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.13.2 Minimum2 data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	UncertainDataSubNormal, Calculated, Partial	
12:00:16.000	16	UncertainDataSubNormal, Interpolated	
12:00:32.000	30	UncertainDataSubNormal, Interpolated	
12:00:48.000	50	UncertainDataSubNormal, Calculated	
12:01:04.000	64	UncertainDataSubNormal, Interpolated	
12:01:20.000	80	UncertainDataSubNormal, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	UncertainDataSubNormal, Calculated, Partial	
12:00:16.000	16.087	Good, Interpolated	
12:00:32.000	26.818	UncertainDataSubNormal, Interpolated	
12:00:48.000	40	Good	
12:01:04.000	56	UncertainDataSubNormal, Interpolated	
12:01:20.000	70	UncertainDataSubNormal, Calculated, Partial	

12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	Good, Calculated, Partial	
12:00:16.000	10	Good, Interpolated	
12:00:32.000	25	Good, Interpolated	
12:00:48.000	40	Good	
12:01:04.000	50	Good, Interpolated	
12:01:20.000	70	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.14 Maximum2

A.14.1 Description

The following examples demonstrate Maximum2 *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.14.2 Maximum2 data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	16	UncertainDataSubNormal, Interpolated, Partial	
12:00:16.000	30	UncertainDataSubNormal, Calculated, MultipleValues	
12:00:32.000	30	UncertainDataSubNormal, Interpolated	
12:00:48.000	64	UncertainDataSubNormal, Interpolated	
12:01:04.000	80	UncertainDataSubNormal, Calculated	
12:01:20.000	90	UncertainDataSubNormal, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	16.087	UncertainDataSubNormal, Interpolated, Partial	
12:00:16.000	26.818	Good, Interpolated	
12:00:32.000	40	UncertainDataSubNormal, Calculated	
12:00:48.000	56	Good, Interpolated	
12:01:04.000	60	UncertainDataSubNormal, Calculated	
12:01:20.000	90	UncertainDataSubNormal, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	Good, Calculated, Partial	
12:00:16.000	25	Good, Calculated	
12:00:32.000	30	Good, Calculated	
12:00:48.000	50	Good, Calculated	
12:01:04.000	60	Good, Calculated	
12:01:20.000	90	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.15 MinimumActualTime2

A.15.1 Description

The following examples demonstrate MinimumActualTime2 *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.15.2 MinimumActualTime2 data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:10.000	10	UncertainDataSubNormal, Partial	
12:00:16.000	16	UncertainDataSubNormal, Interpolated	
12:00:32.000	30	UncertainDataSubNormal, Interpolated	
12:00:50.000	50	UncertainDataSubNormal	
12:01:04.000	64	UncertainDataSubNormal, Interpolated	
12:01:20.000	80	UncertainDataSubNormal, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:02.000	10	UncertainDataSubNormal, Partial	
12:00:16.000	16.087	Good, Interpolated	
12:00:32.000	26.818	UncertainDataSubNormal, Interpolated	
12:00:48.000	40	Good	
12:01:04.000	56	UncertainDataSubNormal, Interpolated	
12:01:23.000	70	UncertainDataSubNormal, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:02.000	10	Good, Partial	
12:00:16.000	10	Good, Interpolated	
12:00:32.000	25	Good, Interpolated	
12:00:48.000	40	Good	
12:01:04.000	50	Good, Interpolated	
12:01:23.000	70	Good, Partial	
12:01:36.000		BadNoData	

A.16 MaximumActualTime2

A.16.1 Description

The following examples demonstrate MaximumActualTime2 *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.16.2 MaximumActualTime2 data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:15.999	16	UncertainDataSubNormal, Interpolated, Partial	
12:00:30.000	30	UncertainDataSubNormal, MultipleValues	
12:00:32.000	30	UncertainDataSubNormal, Interpolated	
12:01:03.999	64	UncertainDataSubNormal, Interpolated	
12:01:19.999	80	UncertainDataSubNormal, Interpolated	
12:01:30.000	90	UncertainDataSubNormal, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:15.999	16.087	UncertainDataSubNormal, Interpolated, Partial	
12:00:31.999	26.818	Good, Interpolated	
12:00:47.999	40	UncertainDataSubNormal, Interpolated	
12:01:03.999	56	Good, Interpolated	
12:01:12.000	60	UncertainDataSubNormal	
12:01:30.000	90	UncertainDataSubNormal, Partial	

12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:02.000	10	Good, Partial	
12:00:28.000	25	Good	
12:00:39.000	30	Good	
12:00:52.000	50	Good	
12:01:12.000	60	Good	
12:01:30.000	90	Good, Partial	
12:01:36.000		BadNoData	

A.17 Range2

A.17.1 Description

The following examples demonstrate Range2 *Aggregate* scenarios. This *Aggregate* does not apply to Historian 4. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.17.2 Range2 data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	6	UncertainDataSubNormal, Calculated, Partial	
12:00:16.000	14	UncertainDataSubNormal, Calculated	
12:00:32.000	0	UncertainDataSubNormal, Calculated	
12:00:48.000	14	UncertainDataSubNormal, Calculated	
12:01:04.000	16	UncertainDataSubNormal, Calculated	
12:01:20.000	10	UncertainDataSubNormal, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	6.087	UncertainDataSubNormal, Calculated, Partial	
12:00:16.000	10.731	Good, Calculated	
12:00:32.000	13.182	UncertainDataSubNormal, Calculated	
12:00:48.000	16	Good, Calculated	
12:01:04.000	4	UncertainDataSubNormal, Calculated	
12:01:20.000	20	UncertainDataSubNormal, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:16.000	15	Good, Calculated	
12:00:32.000	5	Good, Calculated	
12:00:48.000	10	Good, Calculated	
12:01:04.000	10	Good, Calculated	
12:01:20.000	20	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.18 AnnotationCount

A.18.1 Description

The following examples demonstrate AnnotationCount *Aggregate* scenarios. This *Aggregate* does not apply to current values, since annotations are features of historical data. ***ProcessingInterval***: 00:01:00, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.18.2 AnnotationCount data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	3	Good, Calculated	
12:01:00.000	1	Good, Calculated	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated	
12:01:00.000	0	Good, Calculated	

A.19 Count

A.19.1 Description

The following examples demonstrate Count *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.19.2 Count data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	1	Good, Calculated, Partial	
12:00:16.000	2	Good, Calculated	
12:00:32.000		Bad	
12:00:48.000	2	Good, Calculated	
12:01:04.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	2	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	1	Good, Calculated, Partial	
12:00:16.000	2	Good, Calculated	
12:00:32.000	1	UncertainDataSubNormal, Calculated	
12:00:48.000	2	Good, Calculated	
12:01:04.000	1	UncertainDataSubNormal, Calculated	
12:01:20.000	3	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3

Timestamp	Value	StatusCode	Notes
12:00:00.000	1	Good, Calculated, Partial	
12:00:16.000	2	Good, Calculated	
12:00:32.000		Bad	
12:00:48.000	2	Good, Calculated	
12:01:04.000	1	Good, Calculated	
12:01:20.000	3	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian4			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	1	Good, Calculated, Partial	
12:00:16.000	2	Good, Calculated	
12:00:32.000	1	UncertainDataSubNormal, Calculated	
12:00:48.000	2	Good, Calculated	
12:01:04.000	1	UncertainDataSubNormal, Calculated	
12:01:20.000	3	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.20 DurationInStateZero

A.20.1 Description

The following examples demonstrate DurationInStateZero *Aggregate* scenarios. The *Aggregate* only applies to Historian 4. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.20.2 DurationInStateZero data

Historian4			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	UncertainDataSubNormal, Calculated, Partial	
12:00:16.000	3000	Good, Calculated	
12:00:32.000	0	UncertainDataSubNormal, Calculated	
12:00:48.000	12000	Good, Calculated	
12:01:04.000	13000	UncertainDataSubNormal, Calculated	
12:01:20.000	4000	UncertainDataSubNormal, Calculated, Partial	
12:01:36.000		BadNoData	

A.21 DurationInStateNonZero

A.21.1 Description

The following examples demonstrate DurationInStateNonZero *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.21.2 DurationInStateNonZero data

Historian4			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	14000	UncertainDataSubNormal, Calculated, Partial	
12:00:16.000	13000	Good, Calculated	
12:00:32.000	10000	UncertainDataSubNormal, Calculated	
12:00:48.000	4000	Good, Calculated	
12:01:04.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	3001	UncertainDataSubNormal, Calculated, Partial	
12:01:36.000		BadNoData	

A.22 NumberOfTransitions

A.22.1 Description

The following examples demonstrate NumberOfTransitions *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.22.2 NumberOfTransitions data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	1	Good, Calculated, Partial	
12:00:16.000	2	Good, Calculated	
12:00:32.000		Bad	
12:00:48.000	2	Good, Calculated	
12:01:04.000	1	UncertainDataSubNormal, Calculated	
12:01:20.000	2	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	1	Good, Calculated, Partial	
12:00:16.000	2	Good, Calculated	
12:00:32.000	1	UncertainDataSubNormal, Calculated	
12:00:48.000	2	Good, Calculated	
12:01:04.000	1	UncertainDataSubNormal, Calculated	
12:01:20.000	3	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	1	Good, Calculated, Partial	
12:00:16.000	2	Good, Calculated	
12:00:32.000		Bad	
12:00:48.000	2	Good, Calculated	
12:01:04.000	1	Good, Calculated	
12:01:20.000	3	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian4			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	1	Good, Calculated, Partial	
12:00:16.000	2	Good, Calculated	
12:00:32.000	0	UncertainDataSubNormal, Calculated	
12:00:48.000	1	Good, Calculated	
12:01:04.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	3	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.23 Start

A.23.1 Description

The following examples demonstrate Start *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.23.2 Start data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:10.000	10	Good, Partial	

12:00:20.000	20	Good	
12:00:40.000		Bad	
12:00:50.000	50	Good	
12:01:10.000	70	Uncertain	
12:01:20.000	80	Good, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:02.000	10	Good, Partial	
12:00:25.000	20	Good	
12:00:39.000	30	Good	
12:00:48.000	40	Good	
12:01:12.000	60	Good	
12:01:23.000	70	Good, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:02.000	10	Good, Partial	
12:00:25.000	20	Good	
12:00:39.000	30	Good	
12:00:48.000	40	Good	
12:01:12.000	60	Good	
12:01:23.000	70	Good, Partial	
12:01:36.000		BadNoData	

A.24 End

A.24.1 Description

The following examples demonstrate End *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.24.2 End data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:10.000	10	Good, Partial	
12:00:30.000	30	Good	
12:00:40.000		Bad	
12:01:00.000	60	Good	
12:01:10.000	70	Uncertain	
12:01:30.000	90	Good, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:02.000	10	Good, Partial	
12:00:28.000	25	Good	
12:00:42.000		Bad	
12:00:52.000	50	Good	
12:01:17.000	70	Uncertain	
12:01:30.000	90	Good, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:02.000	10	Good, Partial	
12:00:28.000	25	Good	
12:00:42.000		Bad	
12:00:52.000	50	Good	
12:01:17.000	70	Uncertain	
12:01:30.000	90	Good, Partial	
12:01:36.000		BadNoData	

A.25 StartBound

A.25.1 Description

The following examples demonstrate StartBound *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.25.2 StartBound data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData, Partial	
12:00:16.000	16	Good, Interpolated	
12:00:32.000	30	UncertainDataSubNormal, Interpolated	
12:00:48.000		BadNoData	
12:01:04.000	64	UncertainDataSubNormal, Interpolated	
12:01:20.000	80	Good, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData, Partial	
12:00:16.000	16.087	Good, Interpolated	
12:00:32.000	26.818	Good, Interpolated	
12:00:48.000	40	Good	
12:01:04.000	56	Good, Interpolated	
12:01:20.000		BadNoData, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData, Partial	
12:00:16.000	10	Good, Interpolated	
12:00:32.000	25	Good, Interpolated	
12:00:48.000	40	Good	
12:01:04.000	50	Good, Interpolated	
12:01:20.000		BadNoData, Partial	
12:01:36.000		BadNoData	

A.26 EndBound

A.26.1 Description

The following examples demonstrate End *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.26.2 EndBound data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	16	Good, Calculated, Partial	
12:00:16.000	30	UncertainDataSubNormal, Calculated	
12:00:32.000		BadNoData	
12:00:48.000	64	UncertainDataSubNormal, Calculated	
12:01:04.000	80	Good, Calculated	
12:01:20.000		BadNoData, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	16.087	Good, Calculated, Partial	
12:00:16.000	26.818	Good, Calculated	
12:00:32.000	40	Good, Calculated	
12:00:48.000	56	Good, Calculated	
12:01:04.000		BadNoData	
12:01:20.000		BadNoData, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10	Good, Calculated, Partial	
12:00:16.000	25	Good, Calculated	
12:00:32.000	40	Good, Calculated	
12:00:48.000	50	Good, Calculated	
12:01:04.000		BadNoData	
12:01:20.000		BadNoData, Partial	
12:01:36.000		BadNoData	

A.27 Delta

A.27.1 Description

The following examples demonstrate Delta *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.27.2 Delta data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:16.000	10	Good, Calculated	
12:00:32.000	0	BadNoData	
12:00:48.000	10	Good, Calculated	
12:01:04.000	0	BadNoData	
12:01:20.000	10	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:16.000	5	Good, Calculated	
12:00:32.000	0	UncertainDataSubNormal, Calculated	
12:00:48.000	10	Good, Calculated	
12:01:04.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	20	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:16.000	5	Good, Calculated	
12:00:32.000	0	UncertainDataSubNormal, Calculated	
12:00:48.000	10	Good, Calculated	
12:01:04.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	20	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.28 DeltaBounds

A.28.1 Description

The following examples demonstrate DeltaBounds *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.28.2 DeltaBounds data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData, Partial	
12:00:16.000	14	UncertainDataSubNormal, Calculated	
12:00:32.000		BadNoData	
12:00:48.000		BadNoData	
12:01:04.000	16	UncertainDataSubNormal, Calculated	
12:01:20.000		BadNoData, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData, Partial	
12:00:16.000	10.731	Good, Calculated	
12:00:32.000	13.182	Good, Calculated	
12:00:48.000	16	Good, Calculated	
12:01:04.000		BadNoData	
12:01:20.000		BadNoData, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000		BadNoData, Partial	
12:00:16.000	15	Good, Calculated	
12:00:32.000	15	Good, Calculated	
12:00:48.000	10	Good, Calculated	
12:01:04.000		BadNoData	
12:01:20.000		BadNoData, Partial	
12:01:36.000		BadNoData	

A.29 DurationGood

A.29.1 Description

The following examples demonstrate DurationGood *Aggregate* scenarios. Duration values are in milliseconds. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.29.2 DurationGood data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	6000	Good, Calculated, Partial	
12:00:16.000	16000	Good, Calculated	
12:00:32.000	0	Good, Calculated	
12:00:48.000	14000	Good, Calculated	
12:01:04.000	0	Good, Calculated	
12:01:20.000	10001	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	14000	Good, Calculated, Partial	
12:00:16.000	16000	Good, Calculated	
12:00:32.000	10000	Good, Calculated	
12:00:48.000	16000	Good, Calculated	
12:01:04.000	13000	Good, Calculated	
12:01:20.000	7001	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	14000	Good, Calculated, Partial	
12:00:16.000	16000	Good, Calculated	
12:00:32.000	10000	Good, Calculated	
12:00:48.000	16000	Good, Calculated	
12:01:04.000	13000	Good, Calculated	
12:01:20.000	7001	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian4			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	14000	Good, Calculated, Partial	
12:00:16.000	16000	Good, Calculated	
12:00:32.000	10000	Good, Calculated	
12:00:48.000	16000	Good, Calculated	
12:01:04.000	13000	Good, Calculated	
12:01:20.000	7001	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.30 DurationBad

A.30.1 Description

The following examples demonstrate DurationBad *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.30.2 DurationBad data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	10000	Good, Calculated, Partial	
12:00:16.000	0	Good, Calculated	
12:00:32.000	8000	Good, Calculated	
12:00:48.000	2000	Good, Calculated	
12:01:04.000	0	Good, Calculated	
12:01:20.000	0	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	2000	Good, Calculated, Partial	
12:00:16.000	0	Good, Calculated	
12:00:32.000	6000	Good, Calculated	
12:00:48.000	0	Good, Calculated	
12:01:04.000	3000	Good, Calculated	
12:01:20.000	3000	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	2000	Good, Calculated, Partial	
12:00:16.000	0	Good, Calculated	
12:00:32.000	6000	Good, Calculated	
12:00:48.000	0	Good, Calculated	
12:01:04.000	3000	Good, Calculated	
12:01:20.000	3000	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian4			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	2000	Good, Calculated, Partial	
12:00:16.000	0	Good, Calculated	
12:00:32.000	6000	Good, Calculated	
12:00:48.000	0	Good, Calculated	
12:01:04.000	3000	Good, Calculated	
12:01:20.000	3000	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.31 PercentGood

A.31.1 Description

The following examples demonstrate PercentGood *Aggregate* scenarios. **ProcessingInterval**: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.31.2 PercentGood data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	37.500	Good, Calculated, Partial	
12:00:16.000	100	Good, Calculated	
12:00:32.000	0	Good, Calculated	
12:00:48.000	87.500	Good, Calculated	
12:01:04.000	0	Good, Calculated	
12:01:20.000	100	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	87.500	Good, Calculated, Partial	
12:00:16.000	100	Good, Calculated	
12:00:32.000	62.500	Good, Calculated	
12:00:48.000	100	Good, Calculated	
12:01:04.000	81.250	Good, Calculated	
12:01:20.000	70.003	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	87.500	Good, Calculated, Partial	
12:00:16.000	100	Good, Calculated	
12:00:32.000	62.500	Good, Calculated	
12:00:48.000	100	Good, Calculated	
12:01:04.000	81.250	Good, Calculated	
12:01:20.000	70.003	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian4			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	87.500	Good, Calculated, Partial	
12:00:16.000	100	Good, Calculated	
12:00:32.000	62.500	Good, Calculated	
12:00:48.000	100	Good, Calculated	
12:01:04.000	81.250	Good, Calculated	
12:01:20.000	70.003	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.32 PercentBad

A.32.1 Description

The following examples demonstrate PercentBad *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.32.2 PercentBad data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	62.500	Good, Calculated, Partial	
12:00:16.000	0	Good, Calculated	
12:00:32.000	50	Good, Calculated	
12:00:48.000	12.500	Good, Calculated	
12:01:04.000	0	Good, Calculated	
12:01:20.000	0	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	12.500	Good, Calculated, Partial	
12:00:16.000	0	Good, Calculated	
12:00:32.000	37.500	Good, Calculated	
12:00:48.000	0	Good, Calculated	
12:01:04.000	18.750	Good, Calculated	
12:01:20.000	29.997	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	12.500	Good, Calculated, Partial	
12:00:16.000	0	Good, Calculated	
12:00:32.000	37.500	Good, Calculated	
12:00:48.000	0	Good, Calculated	
12:01:04.000	18.750	Good, Calculated	
12:01:20.000	29.997	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian4			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	12.500	Good, Calculated, Partial	
12:00:16.000	0	Good, Calculated	
12:00:32.000	37.500	Good, Calculated	
12:00:48.000	0	Good, Calculated	
12:01:04.000	18.750	Good, Calculated	
12:01:20.000	29.997	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.33 WorstQuality

A.33.1 Description

The following examples demonstrate WorstQuality *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.33.2 WorstQuality data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	Good	Good, Calculated, Partial	
12:00:16.000	Good	Good, Calculated	
12:00:32.000	Bad	Good, Calculated	
12:00:48.000	Good	Good, Calculated	
12:01:04.000	Uncertain	Good, Calculated	
12:01:20.000	Good	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	Good	Good, Calculated, Partial	
12:00:16.000	Good	Good, Calculated	
12:00:32.000	Bad	Good, Calculated	
12:00:48.000	Good	Good, Calculated	
12:01:04.000	Uncertain	Good, Calculated	
12:01:20.000	Good	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	Good	Good, Calculated, Partial	
12:00:16.000	Good	Good, Calculated	
12:00:32.000	Bad	Good, Calculated	
12:00:48.000	Good	Good, Calculated	
12:01:04.000	Uncertain	Good, Calculated	
12:01:20.000	Good	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian4

Timestamp	Value	StatusCode	Notes
12:00:00.000	Good	Good, Calculated, Partial	
12:00:16.000	Good	Good, Calculated	
12:00:32.000	Bad	Good, Calculated	
12:00:48.000	Good	Good, Calculated	
12:01:04.000	Uncertain	Good, Calculated	
12:01:20.000	Good	Good, Calculated, Partial	
12:01:36.000		BadNoData	

A.34 WorstQuality2

A.34.1 Description

The following examples demonstrate WorstQuality2 *Aggregate* scenarios. ***ProcessingInterval***: 00:00:16, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.34.2 WorstQuality2 data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	BadNoData	Good, Calculated, Partial	
12:00:16.000	UncertainDataSubNormal	Good, Calculated	
12:00:32.000	Bad	Good, Calculated, MultipleValues	
12:00:48.000	BadNoData	Good, Calculated	
12:01:04.000	UncertainDataSubNormal	Good, Calculated, MultipleValues	
12:01:20.000	BadNoData	Good, Calculated, Partial	
12:01:36.000		BadNoData	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	BadNoData	Good, Calculated, Partial	
12:00:16.000	Good	Good, Calculated	
12:00:32.000	Bad	Good, Calculated	
12:00:48.000	Good	Good, Calculated	
12:01:04.000	BadNoData	Good, Calculated	
12:01:20.000	BadNoData	Good, Calculated, Partial, MultipleValues	
12:01:36.000		BadNoData	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	BadNoData	Good, Calculated, Partial	
12:00:16.000	Good	Good, Calculated	
12:00:32.000	Bad	Good, Calculated	
12:00:48.000	Good	Good, Calculated	
12:01:04.000	BadNoData	Good, Calculated	
12:01:20.000	BadNoData	Good, Calculated, Partial, MultipleValues	
12:01:36.000		BadNoData	

Historian4			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	BadNoData	Good, Calculated, Partial	
12:00:16.000	Good	Good, Calculated	
12:00:32.000	Bad	Good, Calculated	
12:00:48.000	Good	Good, Calculated	
12:01:04.000	BadNoData	Good, Calculated	
12:01:20.000	BadNoData	Good, Calculated, Partial, MultipleValues	
12:01:36.000		BadNoData	

A.35 StandardDeviationSample

A.35.1 Description

The following examples demonstrate StandardDeviationSample *Aggregate* scenarios. ***ProcessingInterval***: 00:00:20, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.35.2 StandardDeviationSample data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	7.071	Good, Calculated	
12:00:40.000	0	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	7.071	Good, Calculated, Partial	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	5	Good, Calculated	
12:00:40.000	7.071	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	10	Good, Calculated, Partial	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	5	Good, Calculated	
12:00:40.000	7.071	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	10	Good, Calculated, Partial	

A.36 VarianceSample

A.36.1 Description

The following examples demonstrate VarianceSample *Aggregate* scenarios. ***ProcessingInterval***: 00:00:20, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.36.2 VarianceSample data

Historian1

Timestamp	Value	StatusCode	Notes
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	50	Good, Calculated	
12:00:40.000	0	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	50	Good, Calculated, Partial	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	25	Good, Calculated	
12:00:40.000	50	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	100	Good, Calculated, Partial	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	25	Good, Calculated	
12:00:40.000	50	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	100	Good, Calculated, Partial	

A.37 StandardDeviationPopulation

A.37.1 Description

The following examples demonstrate StandardDeviationPopulation *Aggregate* scenarios. ***ProcessingInterval***: 00:00:20, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.37.2 StandardDeviationPopulation data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	5	Good, Calculated	
12:00:40.000	0	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	5	Good, Calculated, Partial	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	4.082	Good, Calculated	
12:00:40.000	5	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	8.165	Good, Calculated, Partial	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	4.082	Good, Calculated	
12:00:40.000	5	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	

12:01:20.000	8.165	Good, Calculated, Partial	

A.38 VariancePopulation

A.38.1 Description

The following examples demonstrate VariancePopulation *Aggregate* scenarios. ***ProcessingInterval***: 00:00:20, ***StartTime***: 12:00:00, ***EndTime***: 12:01:40.

A.38.2 VariancePopulation data

Historian1			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	25	Good, Calculated	
12:00:40.000	0	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	25	Good, Calculated, Partial	

Historian2			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	16.667	Good, Calculated	
12:00:40.000	25	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	66.667	Good, Calculated, Partial	

Historian3			
Timestamp	**Value**	**StatusCode**	**Notes**
12:00:00.000	0	Good, Calculated, Partial	
12:00:20.000	16.667	Good, Calculated	
12:00:40.000	25	UncertainDataSubNormal, Calculated	
12:01:00.000	0	UncertainDataSubNormal, Calculated	
12:01:20.000	66.667	Good, Calculated, Partial	

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