BS EN 62361-2:2013

BSI Standards Publication

Power systems management and associated information exchange — Interoperability in the long term

Part 2: End to end quality codes for supervisory control and data acquisition (SCADA)

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 62361-2:2013. It is identical to IEC 62361-2:2013.

The UK participation in its preparation was entrusted to Technical Committee PEL/57, Power systems management and associated information exchange.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2014

ISBN 978 0 580 53001 2
ICS 33.200

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 January 2014.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 62361-2

December 2013

ICS 33.200

English version

Power systems management and associated information exchange - Interoperability in the long term - Part 2: End to end quality codes for supervisory control and data acquisition (SCADA)

(IEC 62361-2:2013)

Gestion des systèmes de puissance et échanges d'informations associés - Interopérabilité à long terme - Partie 2: Codes de qualité de bout en bout pour le contrôle de supervision et acquisition de données (SCADA)
(CEI 62361-2:2013)

Angleichung der Codes für die Datenqualität innerhalb des TC 57 - Allgemeine Liste der Codes für die Datenqualität
(IEC 62361-2:2013)

CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Avenue Marnix 17, B - 1000 Brussels

Ref. No. EN 62361-2:2013 E

Foreword

The text of document 57/1374/FDIS, future edition 1 of IEC 62361-2, prepared by IEC/TC 57, "Power systems management and associated information exchange" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62361-2:2013.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-07-30
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2016-10-30

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 62361-2:2013 was approved by CENELEC as a European Standard without any modification.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60870-5	Series	Telecontrol equipment and systems - Part 5: Transmission protocols	EN 60870-5	Series
IEC 60870-6	Series	Telecontrol equipment and systems	EN 60870-6	Series
IEC 61850	Series	Communication networks and systems in substations	EN 61850	Series
IEC 61850-3	-	Communication networks and systems for power utility automation - Part 3: General requirements	FprEN 61850-3[1)]	-
IEC 61850-7-2	2010	Communication networks and systems for power utility automation - Part 7-2: Basic information and communication structure - Abstract communication service interface (ACSI)	EN 61850-7-2	2010
IEC 61850-7-3	-	Communication networks and systems for power utility automation - Part 7-3: Basic communication structure - Common data classes	EN 61850-7-3	-
IEC 61970	Series	Energy management system application program interface (EMS-API)	EN 61970	Series
IEC 61970-301	-	Energy management system application program interface (EMS-API) - Part 301: Common information model (CIM) base	FprEN 61970-301[1)]	-
ISO 8601	2004	Data elements and interchange formats - Information interchange - Representation of dates and times	-	-

DAIS Data Access formal/05-06-01; www.omg.com

OPC Data Access version 2.03; www.opcfoundation.org.

OPC UA Part 8 -Data Access RC 1.01.10 Specification.doc

[1)] At draft stage.

CONTENTS

INTRODUCTION

The scope of IEC 62361-2 is to create a common list of SCADA quality codes for reference by other standards to avoid embedding quality code lists in other standards.

POWER SYSTEMS MANAGEMENT AND ASSOCIATED INFORMATION EXCHANGE – INTEROPERABILITY IN THE LONG TERM –

Part 2: End to end quality codes for supervisory control and data acquisition (SCADA)

1 Scope

This part of IEC 62361 documents the quality codes used by existing IEC standards related to supervisory control and data acquisition (SCADA) in the field of power systems management. Meter reading quality coding is not considered to be in the scope of this version of the document. It determines and documents mapping between these standards. Eventual loss of quality information that might occur in mapping is documented. A cohesive and common list of quality codes with semantics is defined. The identified standards to be dealt with in this document are: IEC 60870-5, IEC 60870-6 TASE.2, IEC 61850, IEC 61970, DAIS DA, OPC DA and OPC UA.

Data covered by this part of IEC 62361 is measurements provided by the following links, applications or interfaces:

- RTU, 61850 or OPC DA links to SCADA
- Validation added by state estimation
- TASE.2 (ICCP) or TASE.1 (ELCOM) links between control centers
- Servers, e.g. SCADA, that provide OPC or DAIS DA-data.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60870-5 (all parts), *Telecontrol equipment and systems – Part 5: Transmission protocols*

IEC 60870-6 (all parts), *Telecontrol equipment and systems – Part 6: Telecontrol protocols compatible with ISO standards and ITU-T recommendations*

IEC 61850 (all parts), *Communication networks and systems for power utility automation*

IEC 61850-3, *Communication networks and systems for power utility automation – Part 3: General requirements*

IEC 61850-7-2:2010, *Communication networks and systems for power utility automation – Part 7-2: Basic information and communication structure – Abstract communication service interface (ACSI)*

IEC 61850-7-3, *Communication networks and systems for power utility automation – Part 7-3: Basic communication structure – Common data classes*

IEC 61970 (all parts), *Energy management system application program interface (EMS-API)*

IEC 61970-301, *Energy management system application program interface (EMS-API) – Part 301: Common information model (CIM) base*

ISO 8601, *Data elements and interchange formats – Information interchange – Representation of dates and times*

DAIS Data Access formal/05-06-01; www.omg.com

OPC Data Access version 2.03; www.opcfoundation.org.

OPC UA Part 8 -Data Access RC 1.01.10 Specification.doc

3 Terms and definitions

No special terms or definitions are required to understand this document.

4 Overview of applicable IEC standards

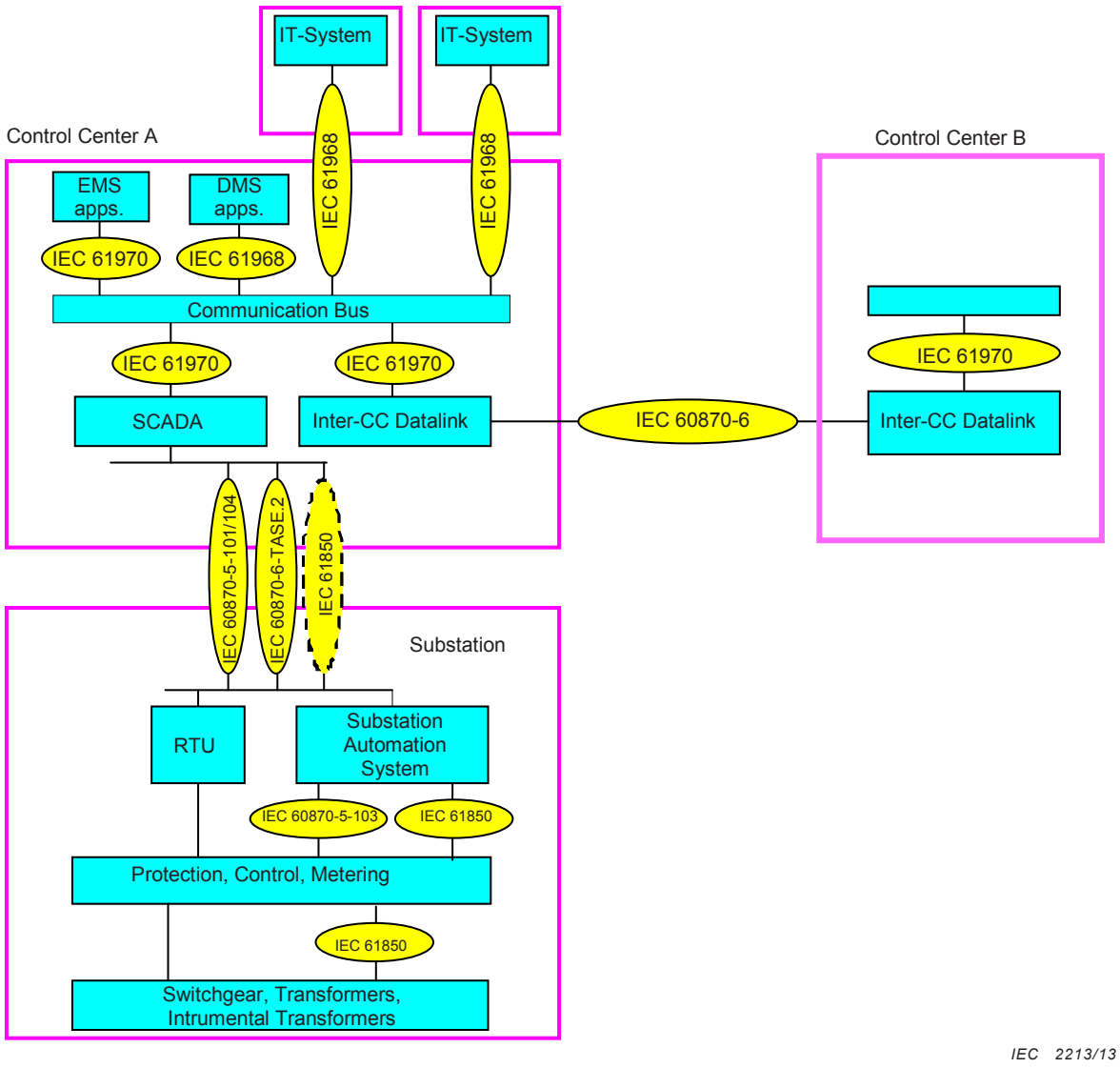


Figure 1 – Overview of IEC power systems information exchange standards

Figure 1 provides an overview of the IEC power systems information exchange standards. Refer to IEC/TR 62357-1 (*Power systems management and associated information exchange – Part 1: Reference architecture*) for further information.

When data is transmitted using a telecommunications protocol, the quality of the data must be preserved, and have a common meaning on both side of the transmission.

To facilitate harmonization and simplify maintenance of the standards, all IEC standards in the field of power systems management and associated information exchange should refer to this standard regarding quality codes. Specifications for quality codes should not be developed in the other standards. Upcoming revisions of this document can then work to harmonize quality codes across several standards.

5 Quality code flow diagram from substation to control center

IEC power systems information exchange standards for substation communication, control center communication and communication standards intended for exchange of information between applications at the control center level do have their own quality codes.

The quality codes flow through this chain of hierarchical systems from the IED to the control center. The quality codes need to be mapped between these standards. As different standards do not today support the same quality codes and semantics definitions for quality codes are not identical in the standards, mapping is difficult and loss of quality information can likely happen.

Figure 2 provides an example of the quality code flow diagram from substation to remote control center.

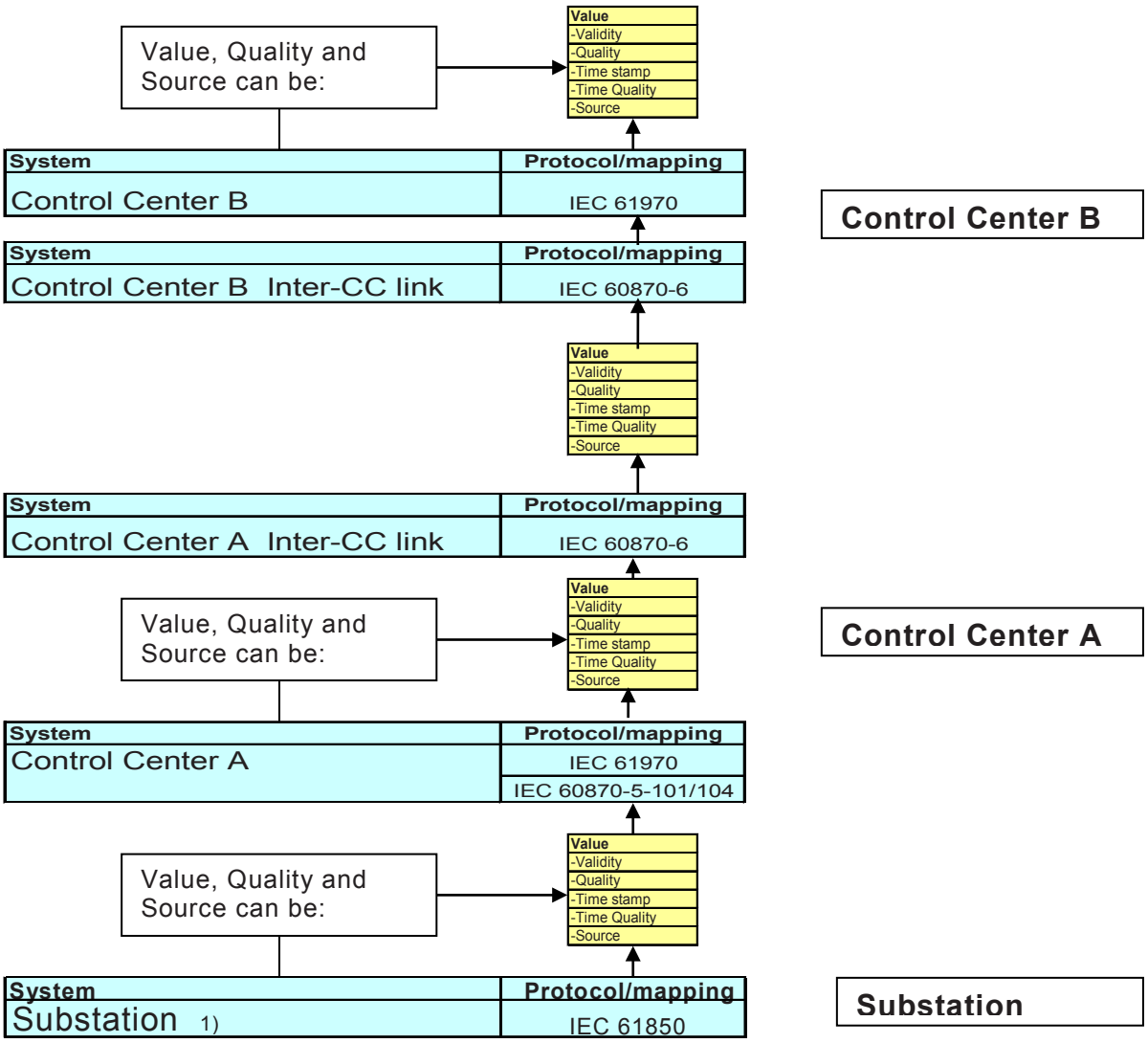


Figure 2 – Example of quality code flow diagram from substation to remote control center

NOTE A number of systems with multiple Client-Server relationships can also exist within the substation

The primary purpose of the quality code is to provide information to applications and users of control systems if a value is good or not.

Most standards also have detailed quality codes that can help applications decide if questionable values can be used or provide information why a value is Invalid and cannot be used.

Some applications utilize the time stamp of values. Time quality codes must be provided to indicate if the time stamp can be used. For special applications also the time accuracy of the time stamp is relevant.

In addition to quality codes most standards have source quality that gives information about the origin of the value. Quality codes and value can also be set by local supervision functions or by operator input in systems in the acquisition chain.

Quality codes are important in the maintenance of control systems and are used to identify erroneous signals in the control systems. The quality codes should if possible indicate what type of failure has occurred.

Test activities in substations during commissioning and maintenance will generate values that are not “real”. The quality code test should indicated that these of values are not for operational use.

6 List of quality codes by existing standards

6.1 Comparison of quality codes in existing standards

Table 1 provides an overview of quality codes in existing standards.

Table 1 – Overview of quality codes in existing standards

Quality information	IEC and OMG SCADA related protocols:				
	IEC 61850	IEC 60870-5-101/104	IEC 60870-6 TASE.2	DAIS DA	OPC DA
Data/Information related quality					
Good	Validity-good	-	Validity-valid	Good	Good
Invalid	Validity-invalid	Invalid/Counter reading invalid	Validity-notvalid	Bad	Bad
	Overflow	-	-	-	-
	OutofRange	-	-	-	-
	BadReference	-	-	-	-
	Oscillatory	-	-	-	-
	Failure	-	-	Device failure	Device failure
				Configuration error	Configuration error
				Not connected	Not connected
				Sensor failure	Sensor failure
				Comm failure	Comm failure
				Last known value	Last known value
				Out of service	Out of service
Questionable	Validity-questionable	Not topical/Counter not adjusted	Validity-suspect	Uncertain	Uncertain
	OutofRange	-	-	Engineering units exceeded	Engineering units exceeded
	BadReference	-	-	Sensor not accurate	Sensor not accurate
	Oscillatory	-	-	Quality ocillatory	-
	OldData	-	-	Last usable value	Last usable value
	Inconsistent	-	-	Sub-normal	Sub-normal
	Inaccurate	-	-	Sensor not accurate	Sensor not accurate
	-	-	-		
Data source related information					
Process	Source-process (4)	-	Source-telemetered	Source process	-
Substituted	Source-substituted	Substituted	Source-entered	Primary substituted	Local override (5)
Calculated	-	-	Source-calculated		-
Estimated	-	-	Source-estimated	Source-corrected	-
	-	-	-	Source inherited substituted	-
Defaulted	-	-	-	Remote defaulted	-
Additional data quality information					
Test	Test	Test		TEST_MASK	-
OperatorBlocked	OperatorBlocked	Blocked (1)	Validity-held	OPERATOR_BLOCKED_MASK	-
Timestamp related quality					
Invalid time	ClockFailure	Invalid time	Time stamp quality	TS_ACC_BAD_TIME	-
Clock not synchronized	ClockNot synchronized	-	-	-	-
TimeAccuracy	TimeAccuracy	-	-	TS_ACC_10_MSEC TS_ACC_100_MSEC TS_ACC_SECOND	-

NOTE 1 Blocking and deblocking may be initiated e.g. by a local lock or a local automatic function.

NOTE 2 A correlation function has detected that the value is not consistent with other data. Typically set by a network state estimator.

NOTE 3 Value has been replaced by state estimator (This is an additional quality code and not an enumeration of source).

NOTE 4 Source Process is defined to be from process I/O or calculated by some application function.

NOTE 5 Validity shall be GOOD when code Local Override is set.

6.2 IEC 60870-5-101/ IEC 60870-5-104 quality codes

6.2.1 Data related quality

The following quality bits are used for single point information, double point information, step position information, bitstring of 32 bit and measured value:

OVERFLOW/NO OVERFLOW (OV)
The value of the information object is beyond a predefined range of value (mainly applicable to analogue values).

BLOCKED/NOT BLOCKED (BL)
The value of the information object is blocked for transmission; the value remains in the state that was acquired before it was blocked. Blocking and deblocking may be initiated e.g. by a local lock or a local automatic cause.

SUBSTITUTED/NOT SUBSTITUTED (SB)
The value of the information object is provided by input of an operator (dispatcher) or by an automatic source.

NOT TOPICAL/TOPICAL (NT)
A value is topical if the most recent update was successful. It is not topical if it was not updated successfully during a specified time interval or it is unavailable.

INVALID/VALID (IV)
A value is valid if it was correctly acquired. After the acquisition function recognizes abnormal conditions of the information source (missing or non operating updating devices) the value is then marked invalid. The value of the information object is not defined under this condition. The mark invalid is used to indicate to the destination that the value may be incorrect and cannot be used.

TEST (T)
Test - classifies the value as being a test value and not to be used for operational purposes.

The following quality bits are used for integrated totals:

CARRY/NO CARRY (CY)
Counter overflow occurred in the corresponding integration period/no counter overflow occurred in the corresponding integration period

COUNTER WAS ADJUSTED/ COUNTER WAS NOT ADJUSTED (CA)
Counter was adjusted since last reading/Counter was not adjusted since last reading

INVALID/VALID (IV)
Counter reading is invalid/Counter reading is valid
Although these quality bits are defined in the IEC 60870-5-101/ IEC 60870-5-104 standards, many implementations don't support all quality bits. Support IV and OV quality bits for measured values and IV bit for the other data types can be considered to be mandatory.

6.2.2 Timestamp and related quality

The short timestamp format is a three octet short time stamp format, CP24Time2a.

B^7			Milliseconds				B^0	Three octet binary time
B^{15}			Milliseconds				B^8	Milliseconds 0..59 999 ms Minutes 0..59 min
IV	Res	B^5		Minutes			B^0	IV = Invalid time, Res = Spare bit

The full timestamp format is a seven octet binary time stamp format, CP56Time2a.

B^7			Milliseconds				B^0	Milliseconds 0..59 999 ms
B^{15}			Milliseconds				B^8	
IV	Res1	B^5		Minutes			B^0	IV = Invalid time, Res = Spare bit Minutes 0..59 min
SU	Res2		B^4	Hours			B^0	Hours 0..23 h
B^2		B^0						Days of month 1..31
Day of week			B^4	Day of month			B^0	Days of week 1..7 (Not used = 0)
Res3				B^3	Months		B^0	Months 1..12
Res4	B^6				Years		B^0	Years 0..99

SU=1 …Summer time (local time used, not UTC time)

Time stamp source:
RES1=GEN for Genuine time or Substituted time (specified in Edition 2).

Timestamp related quality:

INVALID TIME (IV)
The time stamp is invalid

6.3 IEC 60870-5-103 quality codes

Available quality bits are limited compared to quality bits defined in IEC 60870-5–101/ IEC 60870-5-104. Example - Quality bits for measurands:

OVERFLOW/NO OVERFLOW (OV)
Measured value overflow / no overflow

ERROR (ER) (INVALID)
Measured value invalid / measured value valid

6.4 IEC 60870-6 (TASE.2) quality codes

6.4.1 Data related quality

6.4.1.1 Validity

The Validity attribute shown in Table 2 specifies the validity or quality of its associated PointValue. This is based on the source system's interpretation as shown in Table 2:

Table 2 – Validity attribute values

Validity	Description
VALID	Data value is valid
HELD	The previous data value has been held over. Interpretation is local
SUSPECT	Data value is questionable. Interpretation is local
NOTVALID	Data value is not valid

6.4.1.2 CurrentSource

The CurrentSource attribute shown in Table 3 specifies the current source of the PointValue data it is associated with:

Table 3 – CurrentSource attribute values

CurrentSource	Description
TELEMETERED	The data value was received from a telemetered site
CALCULATED	The data value was calculated based on other data values
ENTERED	The data value was entered manually
ESTIMATED	The data value is estimated (State Estimator, etc.)

6.4.1.3 NormalSource

The NormalSource attribute shown in Table 4 specifies the normal source of the PointValue data it is associated with:

Table 4 – NormalSource attribute values

NormalSource	Description
TELEMETERED	The data value is normally received from a telemetered site
CALCULATED	The data value is normally calculated based on other data values
ENTERED	The data value is normally entered manually
ESTIMATED	The data value is normally estimated (State Estimator, etc.)

6.4.1.4 NormalValue

The NormalValue attribute shown in Table 5 reports whether value of the PointValue attribute is normal. One bit is set, defined as shown in Table 5:

Table 5 – NormalValue attribute values

NormalValue	Description
NORMAL	The point value is that which has been configured as normal for the point
ABNORMAL	The point value is not that which has been configured as normal for the point

6.4.2 Timestamp and related quality

The following Timestamp attributes provide additional clarification and definition for the timestamp quality used in the TASE.2 quality codes.

a) **TimeStampClass attribute –** has the value TIMESTAMP or TIMESTAMPEXTENDED if the IndicationPoint is time stamped, and has the value NOTIMESTAMP if the IndicationPoint contains no TimeStamp attribute.

b) **TimeStamp attribute –** provides a time stamp (with a minimum resolution of one second) of when the value (attribute PointRealValue, PointStateValue or PointDiscreteValue) of the IndicationPoint was last changed. It is set at the earliest possible time after collection of the IndicationPoint value from the end device.

c) **TimeStampExtended attribute –** provides a time stamp (with a resolution of one millisecond) of when the value (attribute PointRealValue, PointStateValue or PointDiscreteValue) of the IndicationPoint was last changed. It is set at the earliest possible time after collection of the IndicationPoint value from the end device.

d) **TimeStampQuality attribute –** has the value VALID if the current value of the TimeStamp attribute contains the time stamp of when the value was last changed, and has the value INVALID at all other times.

UTC Time is used in IEC 60870-6.

6.5 IEC 61850 quality codes (from IEC 61850-7-3)

6.5.1 Data related quality

Quality type shall be as defined as shown in Figure 3:

Quality Type Definition			
Attribute Name	**Attribute Type**	**Value/Value Range**	**M/O/C**
	PACKED LIST		
validity	CODED ENUM	good | invalid | reserved | questionable	M
detailQual	PACKED LIST		M
overflow	BOOLEAN		M
outOfRange	BOOLEAN		M
badReference	BOOLEAN		M
oscillatory	BOOLEAN		M
failure	BOOLEAN		M
oldData	BOOLEAN		M
inconsistent	BOOLEAN		M
inaccurate	BOOLEAN		M
source	CODED ENUM	process | substituted DEFAULT process	M
test	BOOLEAN	DEFAULT FALSE	M
operatorBlocked	BOOLEAN	DEFAULT FALSE	M

IEC 2215/13

Figure 3 – Quality type definitions

The DEFAULT value shall be applied, if the functionality of the related attribute is not supported. The mapping may specify to exclude the attribute from the message, if it is not supported or if the DEFAULT value applies.

Quality shall be an attribute that contains information on the quality of the information from the server. The different quality identifiers are not independent. Basically, there are the following quality identifiers:

– validity
– source
– test
– operatorBlocked

NOTE 1 The quality, as used within the scope of 61850, is related to the quality of the information from the server.

There may be a requirement that the client uses additional quality information within its local database. This is a local issue and not part of the scope of IEC 61850. However, the quality of a client may have an impact on the quality supplied by a server of a client – server relationship at a higher level (see Figure 6).

The following quality type attributes provide additional clarification and definition for the data related quality.

1) validity

Validity shall be good, questionable or invalid.

a) **good:** The value shall be marked good if no abnormal condition of the acquisition function or the information source is detected.

b) **invalid:** The value shall be marked invalid when an abnormal condition of the acquisition function or the information source (missing or non-operating updating devices) is detected. The value shall not be defined under this condition. The mark invalid shall be used to indicate to the client that the value may be incorrect and shall not be used.

EXAMPLE If an input unit detects an oscillation of one input it will mark the related information as invalid.

c) **questionable:** The value shall be marked questionable if a supervision function detects an abnormal behavior, however the value could still be valid. The client shall be responsible for determining whether or not values marked "questionable" should be used.

2) detailQual

The reason for an invalid or questionable value of an attribute may be specified in more detail with further quality identifiers. If one of these identifiers is set then validity shall be set to invalid or questionable. Table 6 shows the relation of the detailed quality identifiers with invalid or questionable quality.

Table 6 – DetailQual relation to invalid or questionable

DetailQual	Invalid	Questionable
Overflow	X	
Out of Range	X	X
Bad Reference	X	X
Oscillatory	X	X
Failure	X	
Old data		X
Inconsistent		X
Inaccurate		X

a) **Overflow:** this identifier shall indicate a quality issue that the value of the attribute to which the quality has been associated is beyond the capability of being represented properly (used for measurand information only).

EXAMPLE A measured value may exceed the range that may be represented by the selected data type, for example the data type is a 16-bit unsigned integer and the value exceeds 65 535.

b) **outOfRange:** this identifier shall indicate a quality issue that the attribute to which the quality has been associated is beyond a predefined range of values. The server shall decide if validity shall be set to invalid or questionable (used for measurand information only).

EXAMPLE: A measured value may exceed a predefined range, however the selected data type can still represent the value, for example the data type is a 16-bit unsigned integer, the predefined range is 0 to 40 000, if the value is between 40 001 and 65 535 it is considered to be out of range.

c) **badReference:** this identifier shall indicate that the value may not be a correct value due to a reference being out of calibration. The server shall decide if validity shall be set to invalid or questionable (used for measurand information and binary counter information only).

d) **oscillatory:** to prevent overloading of event driven communication channels, it is desirable to detect and suppress oscillating (fast changing) binary inputs. If a signal changes in a defined time (tosc) twice in the same direction (from 0 to 1 or from 1 to 0) then it shall be defined as an oscillation and the detail quality identifier “oscillatory”

shall be set. If a configured numbers of transient changes is detected, they shall be suppressed. In this time, the validity status "questionable" shall be set. If the signal is still in the oscillating state after the defined number of changes, the value shall be left in the state it was in when the oscillatory bit was set. In this case, the validity status "questionable" shall be reset and "invalid" shall be set as long as the signal is oscillating. If the configuration is such that all transient changes should be suppressed, the validity status "invalid" shall be set immediately in addition to the detail quality identifier "oscillatory" (used for status information only).

e) **failure:** this identifier shall indicate that a supervision function has detected an internal or external failure.

f) **oldData:** a value shall be oldData if an update is not made during a specific time interval. The value may be an old value that may have changed in the meantime. This specific time interval may be defined by an allowed-age attribute.

NOTE 2 "Fail silent" errors, where the equipment stops sending data will cause an oldData condition. In this case, the last received information was correct.

g) **inconsistent:** this identifier shall indicate that an evaluation function has detected an inconsistency.

h) **inaccurate:** this identifier shall indicate that the value does not meet the stated accuracy of the source.

EXAMPLE: The measured value of power factor may be noisy (inaccurate) when the current is very small.

3) source

Source shall give information related to the origin of a value. The value may be acquired from the process or be a substituted value.

a) **process:** the value is provided by an input function from the process I/O or is calculated from some application function.

b) **substituted:** the value is provided by input of an operator or by an automatic source.

NOTE 3 Substitution may be done locally or via the communication services. In the second case, specific attributes with a FC SV are used.

NOTE 4 There are various means to clear a substitution. As an example, a substitution that was done following an invalid condition may be cleared automatically if the invalid condition is cleared. However, this is a local issue and therefore not in the scope of this standard.

4) test

Test shall be an additional identifier that may be used to classify a value being a test value and not to be used for operational purposes. The processing of the test quality in the client shall be a local issue. The bit shall be completely independent from the other bits within the quality descriptor.

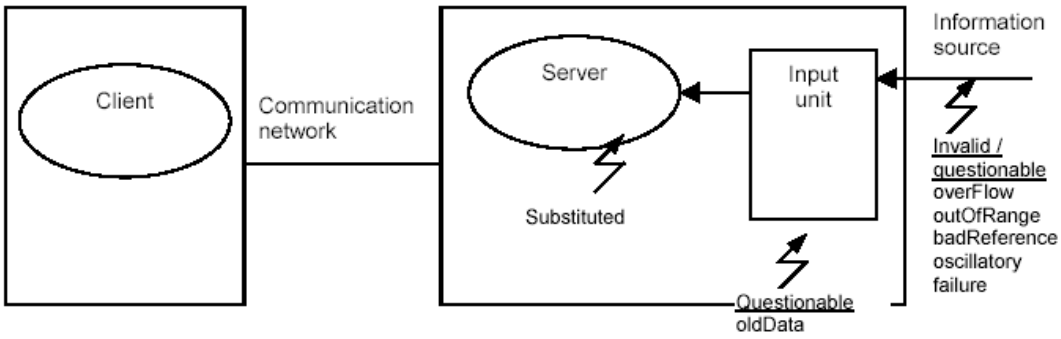
The test identifier should normally be propagated through all hierarchical levels.

5) operatorBlocked: this identifier shall be set if further update of the value has been blocked by an operator. The value shall be the information that was acquired before blocking. If this identifier is set then the identifier oldData of detailQual shall also be set.

NOTE 5 Both an operator as well as an automatic function may block communication updating as well as input updating. In both cases, detailQual.oldData will be set. If the blocking is done by an operator, then the identifier operatorBlocked is set additionally. In that case, an operator activity is required to clear the condition.

EXAMPLE An operator may block the update of an input, to save the old value, if the auxiliary supply is switched off.

6.5.2 Quality in the client server context

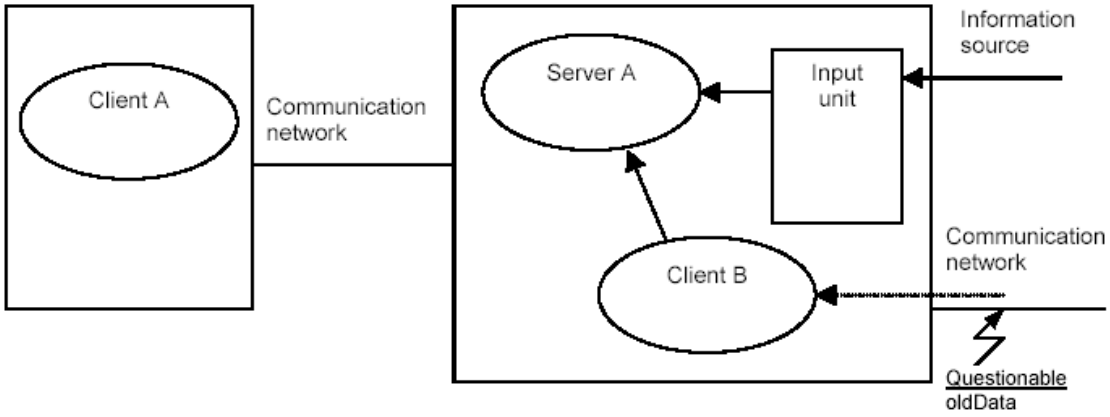


IEC 2216/13

Figure 4 – Quality identifiers in a single client – server relationship

The quality identifier shall reflect the quality of the information in the server, as it is supplied to the client. Figure 4 shows potential sources that may influence the quality in a single client – server relationship. "Information Source" is the (hardwired) connection of the process information to the system. The information may be invalid or questionable as indicated in Figure 4. Further abnormal behavior of the information source may be detected by the input unit. In that case, the input unit may keep the old data and flag it accordingly.

In a multiple client - server relationship, as shown in Figure 5, information may be acquired over a communication link (with Client B). If that communication link is broken, client B will detect that error situation and qualify the information as questionable/old data.



IEC 2217/13

Figure 5 – Quality identifiers in a multiple client – server relationship

In the multiple client-server relationship, the quality of the server A shall reflect both the quality of the server B (acquired with client B) as well as its own quality. Therefore, handling of prioritization of quality from different levels may require further specification beyond that included in this standard. For the identifier validity, the value invalid shall dominate over the value questionable, since this is the worst case. For the identifier source, the higher level of the multiple client–server relationship shall dominate over the lower level.

EXAMPLE Let A be the higher level and B the lower level. The quality from server B is invalid. If now the communication fails (questionable, oldData) between server B and client B, the quality will remain invalid and not become questionable, since the last information was not correct. Server A therefore will report the information as invalid.

6.5.3 Relation between quality identifiers

Validity and **source** have a prioritized relation. If source is in the “process” state, then validity shall determine the quality of the origin value. If source is in the “substitute” state, then validity shall be overruled by the definition of the substituted value. This is an important feature, since substitution is used to replace invalid values with substituted values that may be used by the client such as good values.

EXAMPLE 1: If both questionable and substituted are set, this means that the substituted value is questionable.

This may happen if, in a hierarchical configuration, a substitution is performed at the lowest level and the communication fails on a higher level.

EXAMPLE 2: If an invalid value is substituted, the invalid field will be cleared and the substituted field will be set to indicate the substitution.

The quality identifier **operatorBlocked** is independent of the other quality identifiers.

EXAMPLE 3: An oscillating input may cause the invalid field to be set. Due to the continuing changes in the value many reports are generated, loading the communication network. An operator may block the update of the input. In this case the field operatorBlocked will also be set.

An example for the interaction between the quality identifiers and the impact of multiple client–server relations is shown in Figure 6. In this example, it is assumed that a bay level device acts as a client of the process level server and as a server to the station level client.

NOTE This is one example of a multiple client – server relationship; other multiple client-server relationships may exist, but the behavior will not change.

In case A, the input is blocked, the quality of the information is marked as questionable and oldData.

In case B, a substitution is done at process level. Now, the quality of the information to the next higher level (the bay level) is marked as substituted (but good).

In case C, the communication between process and bay level fails. Between bay level and station level, the information is still marked as substituted. In addition, questionable and oldData is set to indicate that the (substituted) information may be old.

In case D, a new substitution is made at bay level. Now the quality of the information to the next higher level is marked as substituted (and good) and is independent from the first substitution.

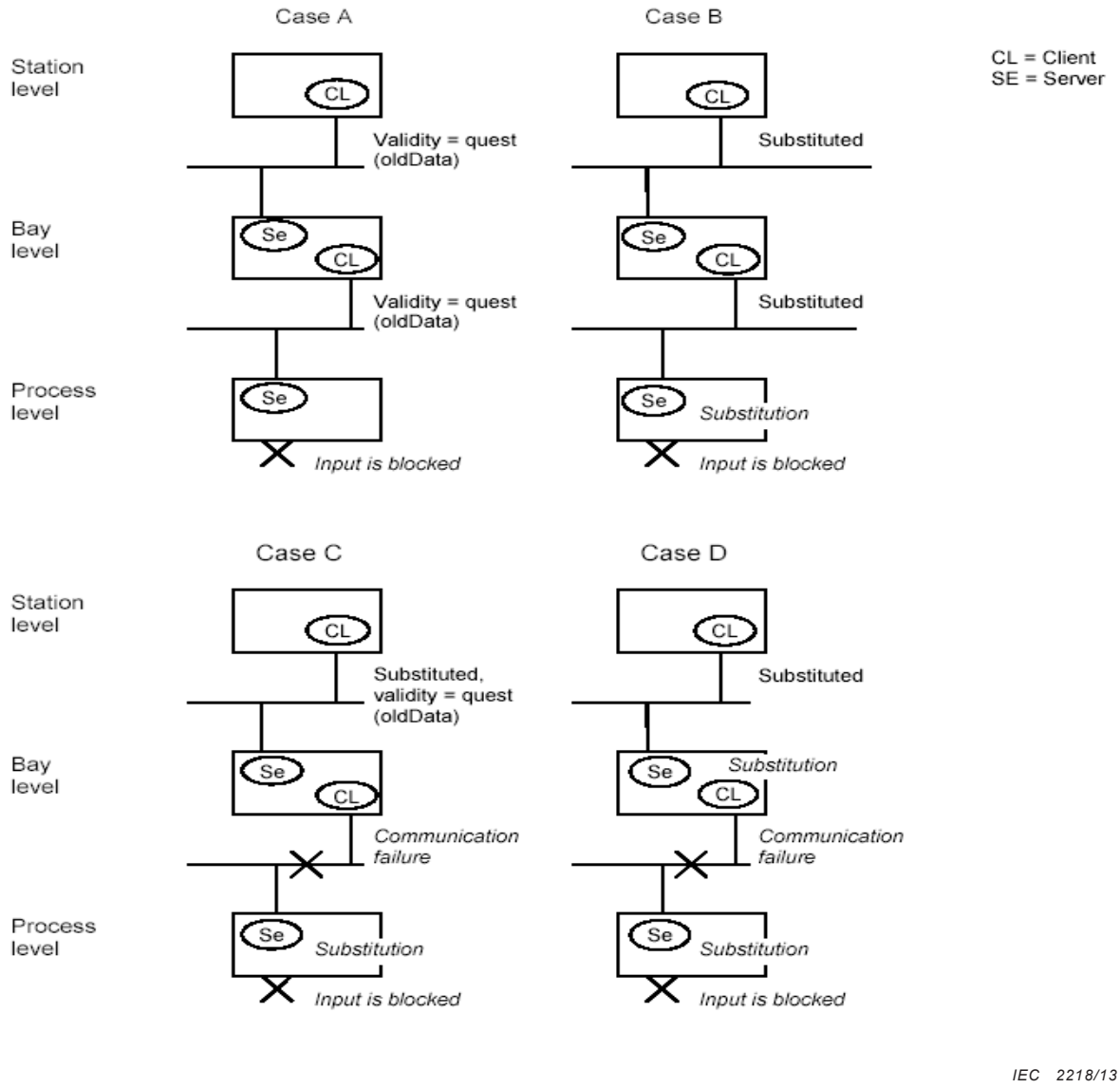


Figure 6 – Interaction of substitution and validity

6.5.4 Timestamp and related quality

6.5.4.1 General

The time and time-synchronization model shall provide the UTC synchronized time to applications located in server and client utility IEDs. The components of the time and time synchronization model are depicted in Clause 21 and Figure 46 of IEC 61850-7-2:2010.

6.5.4.2 TimeStamp syntax

The TimeStamp type shall represent a UTC time with the epoch of midnight (00:00:00) of 1970-01-01 specified in Table 7.

Table 7 – TimeStamp type definition

TimeStamp type definition			
Attribute name	**Attribute type**	**Value/value range/explanation**	**M/O**
SecondSinceEpoch	INT32	(0...MAX)	M
FractionOfSecond	INT24U	Value = SUM from i=0 to 23 of bi*2**–(i+1); Order = b0, b1, b2, b3, ...	M
TimeQuality	TimeQuality		M

The Timestamp attributes shown in Table 7 provide additional clarification and definition for the timestamp quality used in the IEC 61850 quality codes.

1) **SecondSinceEpoch** – shall be the interval in seconds continuously counted from the epoch1970-01-01 00:00:00 UTC.

   NOTE 3 SecondSinceEpoch corresponds with the Unix epoch.

2) **FractionOfSecond** – shall be the fraction of the current second when the value of the TimeStamp has been determined. The fraction of second shall be calculated as (SUM from I = 0 to 23 of bi*2**–(I+1) s).

   NOTE 4 The resolution is the smallest unit by which the time stamp is updated. The 24 bits of the integer provides 1 out of 16777216 counts as the smallest unit; calculated by 1/2**24 which equals approximately 60 ns.

   NOTE 5 The resolution of a time stamp may be 1/2**1 (= 0,5 s) if only the first bit is used; or may be 1/2**2 (= 0,25 s) if the first two bits are used; or may be approximately 60 ns if all 24 bits are used. The resolution provided by an IED is outside the scope of this standard.

6.5.4.3 Timestamp related quality (as described in IEC 61850-7-2)

The TimeQuality shall provide information about the time source of the sending IED. The TimeQuality definition is shown in Table 8.

Table 8 – TimeQuality definition excerpt from IEC 61850-7-2:2010, Table 8

Table 8 – TimeQuality definition

TimeQuality definition			
Attribute name	**Attribute type**	**Value/Value range/explanation**	**M/O**
	PACKED LIST		
LeapSecondsKnown	BOOLEAN		M
ClockFailure	BOOLEAN		M
ClockNotSynchronized	BOOLEAN		O
TimeAccuracy	CODED ENUM	Number of significant bits in the FractionOfSecond: Minimum time interval shall be: 2**–n	M

The following points 1) to 4) provide additional clarification and definition for the attributes shown in Table 8.

1) **LeapSecondsKnown:** The value TRUE of the attribute LeapSecondsKnown shall indicate that the value for SecondSinceEpoch takes into account all leap seconds occurred. If it is FALSE then the value does not take into account the leap seconds that occurred before the initialization of the time source of the device.

   NOTE 6 Leap Second - an intercalary second added to Coordinated Universal Time to compensate for the slowing of the earth's rotation and keep Coordinated Universal Time in synchrony with solar time

2) **clockFailure:** The attribute ClockFailure shall indicate that the time source of the sending device is unreliable. The value of the TimeStamp shall be ignored.

3) **clockNotSynchronized:** The attribute **clockNotSynchronized** shall indicate that the time source of the sending device is not synchronized with the external UTC time.

4) **TimeAccuracy:** The attribute **TimeAccuracy** shall represent the time accuracy class of the time source of the sending device relative to the external UTC time. The timeAccuracy classes shall represent the number of significant bits in the FractionOfSecond. The values of n shall be as listed in Table 9.

NOTE 7 The TimeAccuracy meets the requirements specified in IEC 61850-5 for the selected values of n.

Table 9 – TimeAccuracy excerpt from IEC 61850-5:2013, Table 9

n	Resulting TimeAccuracy (2**–n)	Corresponding time performance class defined in IEC 61850-5
31	–	– unspecified
7	approx. 7,8 ms	10 ms (performance class T0)
10	approx. 0,9 ms	1 ms (performance class T1)
14	approx. 61 µs	100 µs (performance class T2)
16	approx. 15 µs	25 µs (performance class T3)
18	approx. 3,8 µs	4 µs (performance class T4)
20	approx. 0,9 µs	1 µs (performance class T5)

6.6 IEC 61970-301 quality codes

6.6.1 General

The quality codes in IEC 61970-301 are a compilation from other specifications. This specification takes over the role of compiling this common set of quality codes. Only quality codes specifically defined in IEC 61970-301 are carried over from IEC 61970-301 to this specification.

6.6.2 MeasurementValueQuality Attributes defined in IEC 61970-301

Figure 7 shows the UML linkage between IEC 61970-301 and IEC 61850 to provide the following attributes for MeasurementValueQuality:

- Quality61850.operatorBlocked (Boolean) – measurement value is blocked and hence unavailable for transmission.
- Quality61850.source (Source) – source gives information related to the origin of a value. The value may be acquired from the process, defaulted or substituted.
- Quality61850.estimatorReplaced (Boolean) – value has been replaced by state estimator. Estimator replaced is not an IEC 61850 quality bit but has been put in this class for convenience.

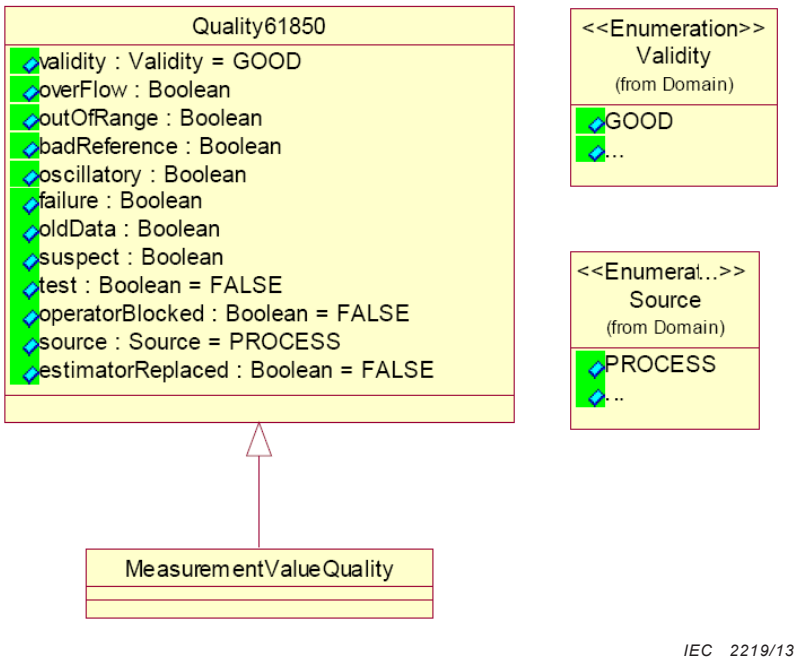


Figure 7 – MeasurementValueQuality attributes inherited from IEC 61850

6.6.3 MeasurementValueSource naming conventions

The MeasurementValueSource describes the alternative sources updating a MeasurementValue. User conventions for how to use the MeasurementValueSource exists. Examples of these conventions are provided in Table 10:

Table 10 – Example MeasurementValueSource naming conventions

Name	Description
SCADA	Telemetered values received from a local SCADA system
CCLink	Value received from a remote control center via TASE.2 or other control center protocol
Operator	Operator entered value (always manually maintained, PSR is not connected to an RTU)
Estimated	Value updated by a state estimator
PowerFlow	Value updated as result of a powerflow
Calculated	Calculated from other measurement values (e.g., a sum)
Allocated	Calculated by a load allocator

Following these conventions:

– Each measurement instance represents a technological quantity of a power system resource.

– Each MeasurementValue of a measurement represents a current value for the technological quantity, as supplied from a single source.

– The *source* attribute in MeasurementValueQuality then indicates whether the source actually provided the current value, or whether it had been substituted or defaulted.

6.7 OPC and OMG quality codes

6.7.1 OPC DA quality codes

6.7.1.1 Quality BitField

These flags represent the quality state for an item's data value. This is intended to be similar to but slightly simpler than the fieldbus data quality specification (section 4.4.1 in the H1 final specifications). This design makes it fairly easy for both servers and client applications to determine how much functionality they want to implement.

The low 8 bits of the Quality flags are currently defined in the form of three bit fields; quality, substatus and limit status as shown in Table 11. The 8 quality bits are arranged as follows:

Table 11 – Lower 8 bits of OPC DA quality flags

Quality	Substatus	Limit status
QQ	SSSS	LL

The high 8 bits of the Quality Word are available for vendor specific use. If these bits are used, the standard OPC Quality bits must still be set as accurately as possible to indicate what assumptions the client can make about the returned data. In addition it is the responsibility of any client interpreting vendor specific quality information to insure that the server providing it uses the same ‘rules’ as the client. The details of such a negotiation are not specified in this standard although a QueryInterface call to the server for a vendor specific interface such as IMyQualityDefinitions is a possible approach.

Details of the OPC standard quality bits follow and the quality BitField definition is provided in Table 12.

Table 12 – OPC standard quality BitField definition

QQ	BIT VALUE	DEFINE	DESCRIPTION
0	00SSSSLL	Bad	Value is not useful for reasons indicated by the substatus.
1	01SSSSLL	Uncertain	The quality of the value is uncertain for reasons indicated by the substatus.
2	10SSSSLL	N/A	Not used by OPC
3	11SSSSLL	Good	The quality of the value is good.

A server which supports no quality information must return 3 (good). It is also acceptable for a server to simply return bad or good (0x00 or 0xC0) and to always return 0 for substatus and limit.

It is recommended that clients minimally check the Quality Bit field of all results (even if they do not check the substatus or limit fields).

Even when a ‘BAD’ value is indicated, the contents of the value field must still be a well defined VARIANT even though it does not contain an accurate value. This is to simplify error handling in client applications. For example, clients are always expected to call VariantClear() on the results of a sychronous read. Similarly the IAdviseSink needs to be able to interpret and ‘unpack’ the Value and Data included in the Stream even if that data is BAD.

If the server has no known value to return then some reasonable default should be returned such as a NUL string or a 0 numeric value.

6.7.1.2 The Substatus BitField

The layout of this field depends on the value of the quality field and is shown in Table 13, Table 14 or Table 15.

Table 13 – Substatus for BAD quality

SSSS	*BIT VALUE*	*DEFINE*	*DESCRIPTION*
0	000000LL	Non-specific	The value is bad but no specific reason is known
1	000001LL	Configuration error	There is some server specific problem with the configuration. For example the item is question has been deleted from the configuration.
2	000010LL	Not connected	The input is required to be logically connected to something but is not. This quality may reflect that no value is available at this time, for reasons like the value may have not been provided by the data source.
3	000011LL	Device failure	A device failure has been detected
4	000100LL	Sensor failure	A sensor failure had been detected (the 'Limits' field can provide additional diagnostic information in some situations.)
5	000101LL	Last known value	Communications have failed. However, the last known value is available. Note that the 'age' of the value may be determined from the TIMESTAMP in the OPCITEMSTATE.
6	000110LL	Comm failure	Communications have failed. There is no last known value is available.
7	000111LL	Out of service	The block is off scan or otherwise locked This quality is also used when the active state of the item or the group containing the item is InActive.
8-15		N/A	Not used by OPC

Servers which do not support substatus should return 0. Note that an 'old' value may be returned with the quality set to BAD (0) and the substatus set to 5. This is for consistency with the fieldbus specification. This is the only case in which a client may assume that a 'BAD' value is still usable by the application.

Table 14 – Substatus for UNCERTAIN quality

SSSS	*BIT VALUE*	*DEFINE*	*DESCRIPTION*
0	010000LL	Non-specific	There is no specific reason why the value is uncertain.
1	010001LL	Last usable value	Whatever was writing this value has stopped doing so. The returned value should be regarded as 'stale'. Note that this differs from a BAD value with substatus 5 (last known value). That status is associated specifically with a detectable communications error on a 'fetched' value. This error is associated with the failure of some external source to 'put' something into the value within an acceptable period of time. Note that the 'age' of the value can be determined from the TIMESTAMP in OPCITEMSTATE.
2-3		N/A	Not used by OPC
4	010100LL	Sensor not accurate	Either the value has 'pegged' at one of the sensor limits (in which case the limit field should be set to 1 or 2) or the sensor is otherwise known to be out of calibration via some form of internal diagnostics (in which case the limit field should be 0).

SSSS	*BIT VALUE*	*DEFINE*	*DESCRIPTION*
5	010101LL	Engineering units exceeded	The returned value is outside the limits defined for this parameter. Note that in this case (per the Fieldbus Specification) the 'Limits' field indicates which limit has been exceeded but does NOT necessarily imply that the value cannot move farther out of range.
6	010110LL	Sub-normal	The value is derived from multiple sources and has less than the required number of Good sources.
7-15		N/A	Not used by OPC

Servers which do not support substatus should return 0.

Table 15 – Substatus for GOOD quality

SSSS	*BIT VALUE*	*DEFINE*	*DESCRIPTION*
0	110000LL	Non-specific	The value is good. There are no special conditions
1-5		N/A	Not used by OPC
6	110110LL	Local override	The value has been overridden. Typically this is means the input has been disconnected and a manually entered value has been 'forced'.
7-15		N/A	Not used by OPC

Servers which do not support Substatus should return 0.

6.7.1.3 The limit BitField

The limit field is valid regardless of the quality and substatus. In some cases such as sensor failure it can provide useful diagnostic information. The limit BitField components are shown in Table 16.

Table 16 – Limit BitField contents

LL	*BIT VALUE*	*DEFINE*	*DESCRIPTION*
0	QQSSSS00	Not limited	The value is free to move up or down
1	QQSSSS01	Low limited	The value has 'pegged' at some lower limit
2	QQSSSS10	High limited	The value has 'pegged' at some high limit.
3	QQSSSS11	Constant	The value is a constant and cannot move.

Servers which do not support limit should return 0.

Symbolic equates are defined for values and masks for these BitFields in the "QUALITY" section of the OPC header files.

6.7.2 DAIS Data Access Quality codes

6.7.2.1 General information for DAIS quality codes

The DAIS Data Access Quality codes extend the OPC Data Access quality codes. The codes are defined in OMG IDL and the defining IDL is shown in Figure 8.

```
typedef unsigned long                                   OPCQuality;
typedef unsigned long                                   UserQuality;

struct Quality {
      OPCQuality                                        opc_quality;
      UserQuality       u                               ser_quality;
};

// Masks for extracting quality subfields
// (note 'status' mask also includes 'Quality' bits)

const OPCQuality OPC_QUALITY_MASK                       = 0x000000C0;
const OPCQuality OPC_STATUS_MASK                        = 0x000000FC;
const OPCQuality OPC_LIMIT_MASK                         = 0x00000003;

// Values for QUALITY_MASK bit field

const OPCQuality        OPC_QUALITY_BAD                 = 0x00000000;
const OPCQuality        OPC_QUALITY_UNCERTAIN           = 0x00000040;
const OPCQuality        OPC_QUALITY_GOOD                = 0x000000C0;

// STATUS_MASK Values for Quality = BAD

const OPCQuality        OPC_QUALITY_CONFIG_ERROR        = 0x00000004;
const OPCQuality        OPC_QUALITY_NOT_CONNECTED       = 0x00000008;
const OPCQuality        OPC_QUALITY_DEVICE_FAILURE      = 0x0000000C;
const OPCQuality        OPC_QUALITY_SENSOR_FAILURE      = 0x00000010;
const OPCQuality        OPC_QUALITY_LAST_KNOWN          = 0x00000014;
const OPCQuality        OPC_QUALITY_COMM_FAILURE        = 0x00000018;
const OPCQuality        OPC_QUALITY_OUT_OF_SERVICE      = 0x0000001C;

// STATUS_MASK Values for Quality = UNCERTAIN

const OPCQuality        OPC_QUALITY_LAST_USABLE         = 0x00000044;
const OPCQuality        OPC_QUALITY_SENSOR_CAL          = 0x00000050;
const OPCQuality        OPC_QUALITY_EGU_EXCEEDED        = 0x00000054;
const OPCQuality        OPC_QUALITY_SUB_NORMAL          = 0x00000058;
const OPCQuality        DAIS_QUALITY_OCILLATORY         = 0x0000005C;

// STATUS_MASK Values for Quality = GOOD

//const OPCQuality      OPC_QUALITY_LOCAL_OVERRIDE      = 0xD8;
//use EXQ_Source_xxx instead of OPC_QUALITY_LOCAL_OVERRIDE

// Values for Limit Bitfield

const OPCQuality        OPC_LIMIT_OK                    = 0x00000000;
const OPCQuality        OPC_LIMIT_LOW                   = 0x00000001;
const OPCQuality        OPC_LIMIT_HIGH                  = 0x00000002;
const OPCQuality                                        OPC_LIMIT_CONST
      = 0x00000003;

//DAIS Quality extension masks

const OPCQuality EXQ_SOURCE_MASK                        = 0x00000700;
const OPCQuality EXQ_TEST_MASK                          = 0x00000800;
const OPCQuality EXQ_OPERATOR_BLOCKED_MASK              = 0x00001000;
const OPCQuality EXQ_TIMESTAMP_ACCURACY_MASK            = 0x00006000;

//DAIS Quality source extension
const OPCQuality EXQ_SOURCE_NONE                        = 0x00000000;
```

```
const OPCQuality EXQ_SOURCE_PROCESS                    = 0x00000100;
const OPCQuality EXQ_SOURCE_PRIMARY_SUBSTITUTED        = 0x00000200;
const OPCQuality EXQ_SOURCE_INHERITED_SUBSTITUTED      = 0x00000300;
const OPCQuality EXQ_SOURCE_CORRECTED                  = 0x00000400;
const OPCQuality EXQ_SOURCE_DEFAULTED                  = 0x00000500;

//DAIS Time stamp accuracy
const OPCQuality EXQ_TS_ACC_10_MSEC                    = 0x00000000;
const OPCQuality EXQ_TS_ACC_100_MSEC                   = 0x00002000;
const OPCQuality EXQ_TS_ACC_SECOND                     = 0x00004000;
const OPCQuality EXQ_TS_ACC_BAD_TIME                   = 0x00006000;
};
```

Figure 8 – OMG DAIS quality codes

The DAIS quality consists of OPCQuality and ExtendedQuality.

6.7.2.2 DAIS OPCQuality

There are two OPCQuality members as shown in Table 17.

Table 17 – OPCQuality members

Member	Description
opc_quality	The quality as specified by OPC including extensions from DAIS.
user_quality	A user specific quality.

A flag word giving the OPC quality. Four groups of flags exist. Each flag has a specific meaning as described below:

- main quality telling if a value is good, bad or uncertain (see Table 19);
- detailed quality (see Table 20 and Table 21);
- limits telling if the value is stuck (see Table 22);
- historical data access flags. Those flags are described in the OMG HDAIS specification.

Bit masks are defined to extract these flags. There are 3 possible bit masks as defined in Table 18.

Table 18 – Quality, status and limit bit masks

Mask	*Description*
OPC_QUALITY_MASK	Bit mask for main quality.
OPC_STATUS_MASK	Bit mask for detailed quality.
OPC_LIMIT_MASK	Bit mask for the limits.

Table 19 – Main quality enumerations

Enum	*Description*
OPC_QUALITY_BAD	The number for bad quality.
OPC_QUALITY_UNCERTAIN	The number for uncertain quality.
OPC_QUALITY_GOOD	The number for good quality.

After application of the OPC_QUALITY_MASK the quality shall be compared directly to the enumeration numbers to decide the quality.

Table 20 – Detailed quality flags for bad quality

Flag	*Description*
OPC_QUALITY_CONFIG_ERROR	There is a server configuration error concerning this value.
OPC_QUALITY_NOT_CONNECTED	The source of the value is not connected.
OPC_QUALITY_DEVICE_FAILURE	A device failure has been detected.
OPC_QUALITY_SENSOR_FAILURE	A sensor failure has been detected.
OPC_QUALITY_LAST_KNOWN	The updating has stopped but there is an old value available.
OPC_QUALITY_COMM_FAILURE	Communication has failed and no value available
OPC_QUALITY_OUT_OF_SERVICE	The updating of the value is manually blocked for update (the item is not active)

Table 21 – Detailed quality flags for uncertain quality

Flag	*Description*
OPC_QUALITY_LAST_USABLE	The value is old. The time stamp gives the age.
OPC_QUALITY_EGU_EXCEEDED	The value is beyond the predefined range.
OPC_QUALITY_EGU_EXCEEDED	The value is beyond the capability of representation (e.g. counter overflow).
OPC_QUALITY_SENSOR_CAL	The sensor calibration is bad.
OPC_QUALITY_SUB_NORMAL	Value is derived from multiple sources where the majority has less than required good quality.
DAIS_QUALITY_OCILLATORY	If a binary value changes cyclically with a frequency higher than a specific threshold it is oscillating. This quality compliant with IEC 61850-7-3.

Table 22 – Definition of limit flags

Flag	*Description*
OPC_LIMIT_OK	The value is not limited, i.e. it moves freely up or down.
OPC_LIMIT_LOW	The value is stuck at a low limit.
OPC_LIMIT_HIGH	The value is stuck at a high limit.
OPC_LIMIT_CONST	The value is stuck constant.

6.7.2.3 DAIS extended quality

The part of the flag word giving the DAIS extended quality. Each flag has a specific meaning as described in the tables below. These quality definitions are based on the revised IEC 61850-7-3 definitions of quality.

The DAIS masks defined in Table 23.

Table 23 – DAIS masks

Mask	*Description*
EXQ_SOURCE_MASK	Bit mask for the source.
EXQ_TEST_MASK	Bit mask for the test status. The test status indicates that the value is generated by a test and shall not be regarded as an operational value.
EXQ_OPERATOR_BLOCKED_MASK	Bit mask for the operator blocked status. The status indicates that the value has been blocked for update and is old. The OPC_QUALITY_LAST_USABLE quality shall be set as well.
EXQ_TIMESTAMP_ACCURACY_MASK	Bit mask for the time stamp accuracy.

The DAIS flags to define the source are provided in Table 24.

Table 24 – DAIS flags defining source

Flag	*Description*
EXQ_SOURCE_NONE	There is no source for this data item. The code is used for spare items not yet allocated.
EXQ_SOURCE_PROCESS	The source for this value is the process.
EXQ_SOURCE_PRIMARY_SUBSTITUTED	The value is manually substituted.
EXQ_SOURCE_INHERITED_SUBSTITUTED	A substituted value has been copied or used as input to some calculation. The result value is then marked with EXQ_SOURCE_INHERITED_SUBSTITUTED.
EXQ_SOURCE_CORRECTED	An alternate and more accurate value has been calculated by some application, e.g. a State Estimator. If this value has been used to correct the original value it shall be indicated EXQ_SOURCE_CORRECTED.
EXQ_REMOTE_DEFAULTED	The value is initialized by a default value.

6.7.3 Timestamp and related quality

OPC and DAIS do have a timestamp format with resolution down to 1 millisecond.

Flags defining time stamp quality is part of the DAIS Quality flags and are shown in Table 25.

Table 25 – Timestamp for DAIS quality flags

Flag:	*Description:*
EXQ_TS_ACC_10_MSEC	The flags (=0) indicate that the accuracy is 10 milliseconds or better (IEC61850-7-2 performance class T0).
EXQ_TS_ACC_100_MSEC	MSECThe flags (=1) indicate that the accuracy is 100 milliseconds or better.
EXQ_TS_ACC_SECOND	The flags (=2) indicate that the accuracy is in the range of seconds or better
EXQ_TS_ACC_BAD_TIME	The flags (=3) indicate that the time stamp is bad

UTC Time is used in OPC DA /DAIS DA.

6.8 OPC UA Data Access Status Codes

6.8.1 Overview

Subclause 6.8 defines additional codes and rules that apply to the StatusCode when used for Data Access values.

The general structure of the StatusCode includes a set of common operational result codes that also apply to Data Access.

6.8.2 Operation level result codes

Certain conditions under which a Variable value was generated are only valid for automation data and in particular for device data. They are similar, but slightly more generic than the description of data quality in the various fieldbus specifications.

Table 26 contains codes with BAD severity, indicating a failure.

Table 26 – Bad operation level result codes

Symbolic Id	Description
Bad_ConfigurationError	There is a problem with the configuration that affects the usefulness of the value.
Bad_NotConnected	The variable should receive its value from another variable, but has never been configured to do so.
Bad_DeviceFailure	There has been a failure in the device/data source that generates the value that has affected the value.
Bad_SensorFailure	There has been a failure in the sensor from which the value is derived by the device/data source. The limits bits are used to define if the limits of the value have been reached.
Bad_NoCommunication	Communications to the data source is defined, but not established, and there is no last known value available. This status/substatus is used for cached values before the first value is received.
Bad_OutOfService	The source of the data is not operational.
Bad_DeadbandFilterInvalid	The specified *PercentDeadband* is not supported, since an *EURange* is not configured.

Table 27 contains codes with UNCERTAIN severity, indicating that the value has been generated under sub-normal conditions.

Table 27 – Uncertain operation level result codes

Symbolic Id	Description
Uncertain_ NoCommunicationLastUsable	Communication to the data source has failed. The variable value is the last value that had a good quality and it is uncertain whether this value is still current. The server timestamp in this case is the last time that the communication status was checked. The time at which the value was last verified to be true is no longer available.
Uncertain_ LastUsableValue	Whatever was updating this value has stopped doing so. This happens when an input variable is configured to receive its value from another variable and this configuration is cleared after one or more values have been received. This status/substatus is not used to indicate that a value is stale. Stale data can be detected by the client looking at the timestamps.
Uncertain_SubstituteValue	The value is an operational value that was manually overwritten.
Uncertain_InitialValue	The value is an initial value for a variable that normally receives its value from another variable. This status/substatus is set only during configuration while the variable is not operational (while it is out-of-service).
Uncertain_ SensorNotAccurate	The value is at one of the sensor limits. The Limits bits define which limit has been reached. Also set if the device can determine that the sensor has reduced accuracy (e.g. degraded analyzer), in which case the Limits bits indicate that the value is not limited.
Uncertain_ EngineeringUnitsExceeded	The value is outside of the range of values defined for this parameter. The Limits bits indicate which limit has been reached or exceeded.
Uncertain_SubNormal	The value is derived from multiple sources and has less than the required number of Good sources.

Table 28 contains GOOD (success) codes.

Note again, that these are the codes that are specific for Data Access and supplement the codes that apply to all types of data.

Table 28 – Good operation level result codes

Symbolic Id	Description
Good_LocalOverride	The value has been overridden. Typically this is means the input has been disconnected and a manually-entered value has been ”forced”.

The bottom 16 bits of the StatusCode are bit flags that contain additional information, but do not affect the meaning of the StatusCode. Of particular interest for DataItems is the LimitBits field. In some cases, such as sensor failure it can provide useful diagnostic information.

Servers that do not support Limit have to set this field to 0.

7 Mapping of quality codes between standards

7.1 General

This document contains examples of mapping between IEC power systems information exchange standards.

Loss of quality information is possible in the mapping of quality codes between standards, since not all standards have the same resolution or support the same quality information. Loss of quality information is documented as part of each mapping example.

The quality codes do not have the same format or data type in the different standards. Negations in the definition of quality codes exist, e.g. Invalid time (IEC 60870-5-101/ IEC 60870-5-104) and Time Stamp Quality (IEC 60870-6).

The classification of the quality codes as Validity codes, Detailed Quality codes and Source codes are not identical in all standards. Some standards do not have a grouping of the quality codes at all (IEC 60870-5 Standards). A quality code in one standard can correspond to a validity code and detailed quality code in another standard. A quality code in one standard can correspond to a source code in another standard.

If mapping of a quality code will imply that several quality codes must be set in the protocol it is mapped to, the validity **Invalid** has been selected prior to **Questionable** and the quality code representing the “worst” condition has been selected if case of a choice been several quality codes.

7.2 Mapping from IEC 61850 to IEC 60870-5-101/ IEC 60870-5-104

Table 29 provides a cross reference of between the quality codes defined in the IEC 61850 and IEC 60870-5-101/IEC 60870-5-104 standards.

Table 29 – Mapping from IEC 61850 to IEC 60870-5-101/IEC 60870-5-104

Mapping	From			To
	IEC 61850			IEC 60870-5-101/IEC 60870-5-104
	Quality	Detailed quality (1)	Source	Quality (1)
Data/Information related quality				
Good	Validity - good	-	Source -process	(Not invalid)
Invalid	Validity - invalid		Source -process	Invalid
		Overflow	Source -process	Overflow, Invalid
		OutofRange	Source -process	Invalid
		BadReference	Source -process	Invalid
		Oscillatory	Source -process	Invalid
		Failure	Source -process	Invalid
Questionable	Validity – questionable		Source -process	Not topical
		OutofRange	Source -process	Not topical
		BadReference	Source -process	Not topical
		Oscillatory	Source -process	Not topical
		OldData	Source - process/ substituted	Not topical
		Inconsistent	Source -process	Not topical
		Inaccurate	Source -process	Not topical
Additional data quality information				
Substituted (by function)	Validity - Good	-	Source -substituted	Substituted
Substituted (by operator)	Validity – good and OperatorBlocked	-	Source -substituted	Substituted, Blocked
Test (2)	Test			**Test**
OperatorBlocked	Validity - questionable and OperatorBlocked	OldData	Source -process	Blocked, Not topical
Timestamp related quality				
Invalid time	ClockFailure			Invalid time
Clock not synchronized	ClockNot synchronized			-

NOTE 1 Combinations of these quality identifiers can be set simultaneously.

NOTE 2 The test bit is an additional identifier that may be used to classify a value being a test value not to be used for operational purposes. The bit is completely independent from the other bits within the quality descriptor

Loss of quality information in the mapping:

- Loss of Detailed Quality bits
  The information provided by the detailed quality bits from IEC 61850 are lost in the mapping, except overflow
- Validity Questionable cannot be mapped. Questionable should be mapped to “Not topical” as opposed to invalid. It is likely that both codes will result in that the value is set as Invalid by a control center. However the use of “Not topical” indicates indicate that the value *may* be correct.
- Time accuracy specified for the IEC 61850 timestamp is lost

- Quality code “Clock not synchronized” is lost

The IEC 60870-5-101/IEC 60870-5-104 protocols have the quality bit Substituted which indicates if the value is substituted or originating from the process.

There should not be any loss of precision in the conversion of the Timestamp that is relevant for current use of data in control centers

Mapping of time from UTC to local time with SU-bit is needed (daylights savings time).

7.3 Mapping from IEC 60870-5-101/IEC 60870-5-104 to IEC 61970-301

Table 30 provides a cross reference of between the quality codes defined in the IEC 60870-5-101/IEC 60870-5-104 and IEC 61970-301.

Table 30 – Mapping from IEC 60870-5-101/IEC 60870-5-104 to IEC 61970-301

Mapping	From	To		
	IEC 60870-5-101/IEC 60870-5-104	IEC 61970-301		
	Quality	Quality identifier	Quality identifier	Source
Data/Information related quality				
Good	Not invalid	Quality61850.validity - good	-	Quality61850.source – process
Invalid	Invalid	Quality61850.validity – invalid	Quality61850. failure	Quality61850.source – process
Invalid	Overflow	Quality61850.validity – invalid	Quality61850. overflow	Quality61850.source – process
Questionable	Not topical	Quality61850.validity-questionable	Quality61850. oldData	Quality61850.source – process
Substituted	Substituted	Quality61850.validity - good	-	**Quality61850.source – substituted**
Additional data quality information				
OperatorBlocked	Blocked	Quality61850.validity - invalid	Quality61850. operatorBlocked	
Timestamp related quality				
Invalid time	Invalid time	-	-	-

Loss of quality information in the mapping:

- Loss of precision in conversion of the Timestamp. No support of time resolution below 1 second in the current IEC 61970 Timestamp format.
- No support for Time quality in IEC 61970-301.

The IEC 60870-5-101/IEC 60870-5-104 protocols have the quality bit Substituted that indicates if the value is substituted or originating from the process. The Source as defined in IEC 61970 (Process and Substituted) should be possible to derive by the IEC 60870-5-101/IEC 60870-5-104 Quality bits: **Substituted** and **Blocked**.

However if the quality code **Substituted** from IEC 60870-5-101/IEC 60870-5-104 is mapped to source **Quality61850.source – Substituted,** it will not later be possible to know if the value was substituted locally or in a remote system.

If the quality code **Substituted** from IEC 60870-5-101/IEC 60870-5-104 is mapped to source **Quality61850.source – Process,** than a new quality code representing Substitution is needed IEC 61970 as Substituted values should be considered as Good values.

If the quality code **Blocked** from IEC 60870-5-101/IEC 60870-5-104 is mapped setting the source to **Quality61850.source – Substituted,** it will not later be possible to know if the value was blocked locally or in a remote system. Source could be set to **Quality61850.source – Process,** then this will be an operator blocked value originating from the process. This is not consistent with current definition of the source **Quality61850.source - Process**.

Mapping of local time with SU-bit to UTC is needed for Daylight Savings time.

7.4 Mapping from IEC 61850 to IEC 61970-301

Table 31 provides a cross reference of between the quality codes defined in the IEC 61970-301 and IEC 61850 standards.

Table 31 – Mapping from IEC 61850 to IEC 61970-301

Mapping	From		To	
	IEC 61850		IEC 61970-301	
	Quality / Detailed quality		Quality identifier	
Data/Information related quality				
Good	Validity - good	-	Quality61850.validity - good	-
Invalid	Validity - invalid	-	Quality61850.validity - invalid	-
		Overflow		Quality61850.overflow
		OutofRange		Quality61850.outofRange
		BadReference		Quality61850.badReference
		Oscillatory		Quality61850.oscillatory
		Failure		Quality61850.failure
Questionable	Validity - questionable	-	Quality61850.validity – questionable	-
		OutofRange		Quality61850.outofRange
		BadReference		Quality61850.badReference
		Oscillatory		Quality61850.oscillatory
		OldData		Quality61850.oldData
		Inconsistent	Quality61850.validity - questionable	Quality61850.suspect
		Inaccurate	Quality61850.validity - questionable	
Data source related information				
Process	Source – process		Source - process	
Substituted	Source - substituted		**Source – substituted**	
Additional data quality information				
Test (1)	Test		Quality61850. test	
OperatorBlocked	OperatorBlocked	OldData	Quality61850. operatorBlocked	Quality61850.oldData
			Quality61850. estimatorReplaced	
			Quality61850. suspect	
Timestamp related quality				
Invalid time	ClockFailure			
Clock not synchronized	ClockNot synchronized			
Time accuracy	TimeAccuracy			

Loss of information in the mapping:

- Detailed Quality bits
  There is a mismatch between detailed quality codes in IEC 61850 and IEC 61970. The IEC 61850 quality codes **Inconsistent** and **Inaccurate** are not available in IEC 61970 and

IEC 61970 has a quality code **Quality61850.suspect** that is not available in IEC 61850. The information provided by the IEC 61850 detailed quality bits **Inconsistent** and **Inaccurate** seems to be lost in the mapping

- If the quality code **Substituted** from IEC 61850 is mapped to source to **Quality61850.source – Substituted,** it will not later be possible to know it the value was substituted locally or in a remote system.
- Loss of precision in conversion of the Timestamp. No support of time resolution below 1 second in the current IEC 61970 Timestamp format
- Time accuracy specified for the IEC 61850 timestamp are lost in mapping
- No support for Time quality in IEC 61970-301

7.5 Mapping from IEC 60870-6 to IEC 61970-301

Table 32 provides a cross reference of between the quality codes defined in the IEC 61970-301 and IEC 60870-6 standards.

Table 32 – Mapping from IEC 60870-6 to IEC 61970-301

Mapping	From	To		
	IEC 60870-6	IEC 61970-301		
	Quality	Quality	Quality	Source/Quality
Data/Information related quality				
Good	Validity - valid	Quality61850.validity - good	-	
Invalid	Validity – not valid	Quality61850.validity - invalid	Quality61850. failure	
Questionable	Validity -suspect	Quality61850.validity - questionable	Quality61850. oldData	
Data source related information				
Process	CurrentSource – telemetered			Quality61850.source – process
Substituted	CurrentSource – entered			Quality61850.source – substituted
Estimated	CurrentSource – estimated		**Quality61850. estimatorReplaced**	**Source -**
Calculated	CurrentSource – calculated			**Source -**
Additional data quality information				
OperatorBlocked	Validity – held	Quality61850.validity - invalid	Quality61850. operatorBlocked	Quality61850. oldData
Timestamp related quality				
Invalid time	TimeStampQuality			

The IEC 60870-6 have in addition to the Validity and Source attribute a NormalValue attribute which represents whether the value of the PointValue attribute is normal, e.g. abnormal state or outside limits.

Loss of information in the mapping:

- NormalValue - This attribute may have no relevance in the mapping, but some IEC 61970 detailed quality bits may be derived from the NormalValue attribute.
- IEC 60870-6 CurrentSource - Estimated.
  The quality bit Quality61850.estimatorReplaced is defined in IEC 61970, with description: "A correlation function has detected that the value is not consistent with other values. Typically set by a network State Estimator" This is a quality code for use when values are locally replaced by the State estimator. To differentiate between a locally estimated value and remote estimated value source shall be set to Quality61850.source – Process. This is not consistent with the current definition of the source Quality61850.source - Process.
- IEC 60870-6 CurrentSource – Calculated
- Loss of precision in conversion of the Timestamp. No support of time resolution below 1 second in the current IEC 61970 Timestamp format (IEC 61970 should be extended with a timestamp).
- No support for Time quality in IEC 61970 (IEC 61970 should be extended with a time quality).

7.6 Mapping from IEC 61970-301 to IEC 60870-6

Table 33 provides a cross reference of between the quality codes defined in the IEC 61970-301 and IEC 60870-6 standards.

Table 33 – Mapping from IEC 61970-301 to IEC 60870-6

Mapping	From		To	
	IEC 61970-301		IEC 60870-6	
	Quality	Quality (1)	Quality	NormalValue attribute
Data/Information related quality				
Good	Quality61850.validity - good	-	Validity - valid	Normal
Invalid	Quality61850.validity-invalid		Validity - not valid	Abnormal
		Quality61850. overflow	Validity - not valid	Abnormal
		Quality61850. outofRange	Validity - not valid	Abnormal
		Quality61850. badReference	Validity - not valid	Abnormal
		Quality61850. oscillatory	Validity - not valid	Abnormal
		Quality61850. failure	Validity - not valid	Abnormal
Questionable	Quality61850.validity-questionable	-	Validity – suspect	Abnormal
		Quality61850. outofRange	Validity – suspect	Abnormal
		Quality61850. badReference	Validity – Suspect	Abnormal
		Quality61850. oscillatory	Validity – suspect	Abnormal
		Quality61850. oldData	Validity – suspect	Abnormal
		Quality61850. suspect	Validity – suspect	Abnormal
Data source related information				
Process	Quality61850.source-process		CurrentSource– telemetered	
Substituted	Quality61850.source-substituted		CurrentSource– entered	Normal
Estimated		Quality61850. estimatorReplaced	CurrentSource– estimated	Normal
Calculated			CurrentSource– calculated	
Additional data quality information				
Test	Quality61850. test		Validity – **not valid**	
OperatorBlocked	Quality61850. operatorBlocked	Quality61850. oldData	Validity – held	Abnormal
Timestamp related quality				
Invalid time			Invalid time	
NOTE Combinations of these quality identifiers can be set simultaneously				

Loss of information in the mapping:

- None of the IEC 61970 detailed quality bits as Overflow, OutofRange, BadReference, OldData, and Oscillatory are available in IEC 60870-6.
- The IEC 61970 test bit cannot be mapped. The IEC 60870-6 Validity should be mapped to Not Valid.
- No support for Time quality in IEC 61970.

IEC 61970-301 criteria for setting the IEC 60870-5 Source to Calculated must be defined.

IEC 61970-301 criteria for setting the NormalValue attribute must be defined.

7.7 Mapping from IEC 61850 to DAIS DA and OPC DA

The mapping shown in Table 34 applies to the case where 61850 data is published though a DAIS DA interface, i.e. the 61850 quality codes are translated into DAIS DA quality codes.

Table 34 – Mapping from IEC 61850 to DAIS DA and OPC DA

Mapping	From	To	
	IEC 61850	DAIS DA	OPC DA
	Quality / Detailed quality	Quality identifier	Quality identifier
Data/Information related quality			
Good	Validity - good	OPC_QUALITY_GOOD	OPC_QUALITY_GOOD
Invalid	Validity - invalid	OPC_QUALITY_BAD	OPC_QUALITY_BAD
	Overflow	-	-
	OutofRange	-	-
	BadReference	-	-
	Oscillatory		-
	Failure	OPC_QUALITY_DEVICE_FAILURE	OPC_QUALITY_DEVICE_FAILURE
	-	OPC_QUALITY_CONFIG_ERROR	OPC_QUALITY_CONFIG_ERROR
	-	OPC_QUALITY_NOT_CONNECTED	OPC_QUALITY_NOT_CONNECTED
	-	OPC_QUALITY_SENSOR_FAILURE	OPC_QUALITY_SENSOR_FAILURE
	-	OPC_QUALITY_COMM_FAILURE	OPC_QUALITY_COMM_FAILURE
	-	OPC_QUALITY_LAST_KNOWN	OPC_QUALITY_LAST_KNOWN
	-	-	OPC_QUALITY_UNSPECIFIED
Questionable	Validity - questionable	OPC_QUALITY_UNCERTAIN	OPC_QUALITY_UNCERTAIN
	OutofRange	OPC_QUALITY_EGU_EXCEEDED	OPC_QUALITY_EGU_EXCEEDED
	BadReference	OPC_QUALITY_SENSOR_CAL	OPC_QUALITY_SENSOR_CAL
	Oscillatory	DAIS_QUALITY_OCILLATORY	-
	OldData	OPC_QUALITY_LAST_USABLE	OPC_QUALITY_LAST_USABLE
	Inconsistent	OPC_QUALITY_SUB_NORMAL	OPC_QUALITY_SUB_NORMAL
	Inaccurate		
			OPC_QUALITY_UNSPECIFIED
Additional data quality information			
Test (1)	Test	EXQ_TEST_MASK	-
OperatorBlocked	operatorBlocked	EXQ_OPERATOR_BLOCKED_MASK	-
Data source related information			
Process	Source – process	EXQ_SOURCE_PROCESS	OPC_QUALITY_LOCAL_OVERRIDE

Substituted	Source - substituted	EXQ_SOURCE_PRIMARY_SUBSTITUTED	OPC_QUALITY_LOCAL_OVERRIDE
	-	EXQ_SOURCE_INHERITED_SUBSTITUTED	-
	-	EXQ_SOURCE_CORRECTED	-
	-	EXQ_SOURCE_DEFAULTED	-
	-	EXQ_SOURCE_NONE	-
Timestamp related quality			
Invalid time	ClockFailure	EXQ_TS_ACC_BAD_TIME	-
Clock not synchronized	ClockNot Synchronized	EXQ_TS_ACC_BAD_TIME	-
Time accuracy	TimeAccuracy	EXQ_TS_ACC_10_MSEC EXQ_TS_ACC_100_MSEC EXQ_TS_ACC_SECOND	-

Loss of quality information in the mapping to DAIS DA:

- Combination of IEC 61850 Validity **Invalid** and Detailed Quality codes **Overflow**, **OutofRange**, **BadReference** can not be mapped and information contained in the detailed quality codes will be lost. Corresponding detailed quality codes are currently only defined with Validity Questionable in DAIS DA.
- IEC 61850 **TimeAccuracy** which is better than 10 mSecond can not be mapped to DAIS DA.
- No support for **ClockNot Synchronized** in DAIS DA.

Loss of quality information in the mapping to OPC DA:

- Limited support for Data Source Related Quality codes.
- No support for Timestamp related quality codes.

The use of detailed quality codes in DAIS DA/OPC DA and IEC 61850 is different. DAIS/OPC have several detailed quality codes representing the cause of a failure:

- Configuration error
- Not connected
- Device failure
- Sensor failure
- Comm failure

These detailed quality codes are not currently supported by IEC 61850. DAIS/OPC do on the other hand only support the following detailed quality codes when the validity is uncertain (Questionable):

- OutofRange
- BadReference
- Oscillatory
- OldData
- Inconsistent
- Inaccurate

8 Common quality codes across the power systems information exchange standards

8.1 Common quality codes

The common quality codes are based on codes defined in IEC 61850 and IEC 61970 which have the most comprehensive set of quality codes of the power systems information exchange standards. Relevant quality codes from other IEC standards and OPC UA are also included.

The following quality identifiers are defined:

1) Validity codes that include:

- Good
- Invalid
- Questionable

2) Detailed quality codes

The detailed quality codes will provide information why validity is set to questionable or invalid.

The detailed quality codes that will help applications decide if questionable values can be used or provide information why a value is Invalid and cannot be used.

3) Time stamp quality and TimeAccuracy

Time Stamp Quality codes must be provided to indicate if the time stamp can be used. For special applications the time accuracy of the time stamp is also relevant.

4) Source

Source shall give information related to the origin of a value. The source is used to identify if the value is originating from the process (Process) or locally set (Substituted).

5) Additional quality codes

The additional quality codes are independent from the Validity and the Detailed Quality Codes. Additional quality codes represent the states set by operator action as:

- Operator blocked
- Test

The quality codes are related to the quality information available from a server. There may be requirements that require a client to use additional quality information within its own local database.

8.2 Quality code definitions

8.2.1 Validity quality codes

Valid quality codes are described in Table 35.

Table 35 – Validity quality codes

QUALITY CODE	DESCRIPTION
Good	(IEC 61850) The value shall be marked good if no abnormal condition of the acquisition function or the information source is detected. (OPC DA2.03) The quality of the value is good. (IEC 60870-5) A value is valid if it was correctly acquired.
Invalid	(IEC 61850) The value shall not be defined under this condition. The mark invalid shall be used to indicate to the client that the value may be incorrect and shall not be used. Example, if an input unit detects an oscillation of one input it will mark the related information as invalid. (IEC 60870-5) After the acquisition function recognizes abnormal conditions of the information source (missing or non operating updating devices) the value is then marked invalid. The value of the information object is not defined under this condition. The mark invalid is used to indicate to the destination that the value may be incorrect and cannot be used. (OPC DA2.03) Value is not useful for reasons indicated by the substatus.
Questionable	(IEC 61850) The value shall be marked questionable if a supervision function detects an abnormal behavior, however the value could still be valid. The client shall be responsible for determining whether or not values marked "questionable" should be used. (OPC DA2.03) The quality of the value is uncertain for reasons indicated by the substatus. (IEC 60870-5) NOT TOPICAL/TOPICAL (NT) A value is topical if the most recent update was successful. It is not topical if it was not updated successfully during a specified time interval or it is unavailable.

8.2.2 Detailed quality codes

8.2.2.1 Detailed quality codes – good

The quality codes in Table 36 can be conveyed from the Process or set locally:

Table 36 – Detailed good quality codes

QUALITY CODE	DESCRIPTION
LocalOverride	(OPC UA) The value has been Overridden. Typically this is means the input has been disconnected and a manually-entered value has been ”forced”.
Estimator replaced	(IEC 61970-301) Quality61850.estimatorReplaced (Boolean) Value has been replaced by State Estimator. Estimator Replaced is not an IEC 61850 quality bit but has been put in this class for convenience

8.2.2.2 Detailed quality codes – invalid

The quality codes in Table 37 can be conveyed from the process.

Table 37 – Detailed invalid quality codes

QUALITY CODE	DESCRIPTION
Failure	(IEC 61850) **failure:** this identifier shall indicate that a supervision function has detected an internal or external failure. Quality61850.failure (Boolean) this identifier indicates that a supervision function has detected an internal or external failure, for example communication failure.
DeviceFailure	(OPC UA) A device failure has been detected. There has been a failure in the device/data source that generates the value that has affected the value.
SensorFailure	(OPC UA) A sensor failure has been detected. There has been a failure in the sensor from which the value is derived by the device/data source. The limits bits are used to define if the limits of the value have been reached.
NoCommunication	(OPC UA) Communication has failed and no value available. Communications to the data source is defined, but not established, and there is no last known value available. This status/substatus is used for cached values before the first value is received.
ConfigurationError	There is a server configuration error concerning the value. There is a problem with the configuration that affects the usefulness of the value.
NotConnected	(OPC UA) The source of the value is not connected. The variable should receive its value from another variable, but has never been configured to do so.
OutOfService	(OPC UA) The source of the data is not operational.
OldData	(IEC 61850) **oldData:** a value shall be oldData if an update is not made during a specific time interval. The value may be an old value that may have changed in the meantime. This specific time interval may be defined by an allowed-age attribute. NOTE "Fail silent" errors, where the equipment stops sending data will cause an oldData condition. In this case, the last received information was correct
Overflow	(IEC 61850) **Overflow:** this identifier shall indicate a quality issue that the value of the attribute to which the quality has been associated is beyond the capability of being represented properly (used for measurand information only). Example, a measured value may exceed the range that may be represented by the selected data type, for example the data type is a 16-bit unsigned integer and the value exceeds 65535. (IEC 60870-5) OVERFLOW/NO OVERFLOW (OV) The value of the INFORMATION OBJECT is beyond a predefined range of value (mainly applicable to analogue values).
Oscillatory	(IEC 61850) **oscillatory:** to prevent overloading of event driven communication channels, it is desirable to detect and suppress oscillating (fast changing) binary inputs. If a signal changes in a defined time (t_{osc}) twice in the same direction (from 0 to 1 or from 1 to 0) then it shall be defined as an oscillation and the detail quality identifier “oscillatory” shall be set. If a configured numbers of transient changes is detected, they shall be suppressed. In this time, the validity status "questionable” shall be set. If the signal is still in the oscillating state after the defined number of changes, the value shall be left in the state it was in when the oscillatory bit was set. In this case, the validity status "questionable” shall be reset and “invalid” shall be set as long as the signal is oscillating. If the configuration is such that all transient changes should be suppressed, the validity status “invalid” shall be set immediately in addition to the detail quality identifier “oscillatory” (used for status information only).

8.2.2.3 Detailed quality codes – questionable

The quality codes shown in Table 38 can be conveyed from the process:

Table 38 – Detailed questionable quality codes

QUALITY CODE	DESCRIPTION
OutofRange	(IEC 61850) **outOfRange:** this identifier shall indicate a quality issue that the attribute to which the quality has been associated is beyond a predefined range of values. The server shall decide if validity shall be set to invalid or questionable (used for measurand information only). Example, a measured value may exceed a predefined range, however the selected data type can still represent the value, for example the data type is a 16-bit unsigned integer, the predefined range is 0 to 40 000, if the value is between 40001 and 65535 it is considered to be out of range.
Uncertain EngineeringUnitsExceeded	(OPC UA) The value is outside of the range of values defined for this parameter. The Limits bits indicate which limit has been reached or exceeded.
BadReference	(IEC 61850) **badReference:** this identifier shall indicate that the value may not be a correct value due to a reference being out of calibration. The server shall decide if validity shall be set to invalid or questionable (used for measurand information and binary counter information only).
Uncertain SensorNotAccurate	(OPC UA) The value is at one of the sensor limits. The Limits bits define which limit has been reached. Also set if the device can determine that the sensor has reduced accuracy (e.g. degraded analyzer), in which case the Limits bits indicate that the value is not limited.
Uncertain SubNormal	(OPC UA) The value is derived from multiple sources and has less than the required number of Good sources.
Inconsistent	(IEC 61850) **inconsistent:** this identifier shall indicate that an evaluation function has detected an inconsistency.
Uncertain NoCommunication LastUsable	(OPC UA) Communication to the data source has failed. The variable value is the last value that had a good quality and it is uncertain whether this value is still current. The server timestamp in this case is the last time that the communication status was checked. The time at which the value was last verified to be true is no longer available.
Uncertain LastUsableValue	(OPC UA) Whatever was updating this value has stopped doing so. This happens when an input variable is configured to receive its value from another variable and this configuration is cleared after one or more values have been received. This status/substatus is not used to indicate that a value is stale. Stale data can be detected by the client looking at the timestamps.
Uncertain InitialValue	(OPC UA) The value is an initial value for a variable that normally receives its value from another variable. This status/substatus is set only during configuration while the variable is not operational (while it is out-of-service).
Uncertain SubstituteValue	(OPC UA) The value is an operational value that was manually overwritten.
Operator Blocked	(IEC 61850) **operatorBlocked:** this identifier shall be set if further update of the value has been blocked by an operator. The value shall be the information that was acquired before blocking. If this identifier is set then the identifier oldData of detailQual shall also be set. NOTE Both an operator as well as an automatic function may block communication updating as well as input updating. In both cases, detailQual.oldData will be set. If the blocking is done by an operator, then the identifier operatorBlocked is set additionally. In that case, an operator activity is required to clear the condition. Example, an operator may block the update of an input, to save the old value, if the auxiliary supply is switched off (IEC 60870-5) BLOCKED/NOT BLOCKED (BL) The value of the INFORMATION OBJECT is blocked for transmission; the value remains in the state that was acquired before it was blocked. Blocking and deblocking may be initiated e.g. by a local lock or a local automatic cause

QUALITY CODE	DESCRIPTION
Inaccurate	(IEC 61850) **inaccurate:** this identifier shall indicate that the value does not meet the stated accuracy of the source. Example, the measured value of power factor may be noisy (inaccurate) when the current is very small
Suspect	(IEC 61970-301) Quality61850.suspect (Boolean) A correlation function has detected that the value is not consistent with other values. Typically set by a network State Estimator

8.2.3 Additional quality codes

The quality codes in Table 39 can be conveyed from the process or set locally:

Table 39 – Additional quality codes

QUALITY CODE	DESCRIPTION
Blocked (Locally)	(IEC 61970-301) Quality61850.operatorBlocked (Boolean) Measurement value is blocked and hence unavailable for transmission.
Test	(IEC 61850) **test:** Test shall be an additional identifier that may be used to classify a value being a test value and not to be used for operational purposes. The processing of the test quality in the client shall be a local issue. The bit shall be completely independent from the other bits within the quality descriptor. The test identifier should normally be propagated through all hierarchical levels. (IEC 60870-5) TEST (T) (Test - classifies the value as being a test value and not to be used for operational purposes.)

8.2.4 Timestamp related quality codes

The timestamp related quality codes are presented in Table 40.

Table 40 – Timestamp quality codes

QUALITY CODE	COMMON DESCRIPTION
ClockFalure	
ClockNotSynchronized	
TimeAccuracy	

8.2.5 Source quality codes

In an acquisition chain that embraces a number of hierarchical systems, substitution can be performed in any system in the chain. Current standards have limited possibilities to convey information identifying the originator system throughout the information chain. Improvement should be considered in future revisions for all involved standards.

Source quality codes defined in IEC standards **can** both express the source of the value and be a quality code related to some type of substitution.

Source quality shall give information of the origin of a value if the value has been acquired from the process or is a locally substituted value (see Table 41). Substitution includes also substitution performed of functions as e.g. State estimators. The detailed quality codes shall give information of the type of substitution that has been performed.

Table 41 – Process and substituted quality codes

QUALITY CODE	DESCRIPTION
Process	(IEC 61850) **process:** the value is provided by an input function from the process I/O or is calculated from some application function Quality61850.source (Source) Source gives information related to the origin of a value. The value may be acquired from the process, defaulted or substituted.
Substituted	(IEC 61850) **substituted:** the value is provided by input of an operator or by an automatic source. NOTE 1 Substitution may be done locally or via the communication services. In the second case, specific attributes with a FC SV are used. NOTE 2 There are various means to clear a substitution. As an example, a substitution that was done following an invalid condition may be cleared automatically if the invalid condition is cleared. However, this is a local issue and therefore not in the scope of this standard. (IEC 61970-301) Quality61850.source (Source) Source gives information related to the origin of a value. The value may be acquired from the process, defaulted or substituted. SUBSTITUTED/NOT SUBSTITUTED (SB) The value of the INFORMATION OBJECT is provided by input of an operator (dispatcher) or by an automatic source.

This page deliberately left blank

This page deliberately left blank

British Standards Institution (BSI)

BSI is the national body responsible for preparing British Standards and other standards-related publications, information and services.

BSI is incorporated by Royal Charter. British Standards and other standardization products are published by BSI Standards Limited.

About us

We bring together business, industry, government, consumers, innovators and others to shape their combined experience and expertise into standards -based solutions.

The knowledge embodied in our standards has been carefully assembled in a dependable format and refined through our open consultation process. Organizations of all sizes and across all sectors choose standards to help them achieve their goals.

Information on standards

We can provide you with the knowledge that your organization needs to succeed. Find out more about British Standards by visiting our website at bsigroup.com/standards or contacting our Customer Services team or Knowledge Centre.

Buying standards

You can buy and download PDF versions of BSI publications, including British and adopted European and international standards, through our website at bsigroup.com/shop, where hard copies can also be purchased.

If you need international and foreign standards from other Standards Development Organizations, hard copies can be ordered from our Customer Services team.

Subscriptions

Our range of subscription services are designed to make using standards easier for you. For further information on our subscription products go to bsigroup.com/subscriptions.

With **British Standards Online (BSOL)** you'll have instant access to over 55,000 British and adopted European and international standards from your desktop. It's available 24/7 and is refreshed daily so you'll always be up to date.

You can keep in touch with standards developments and receive substantial discounts on the purchase price of standards, both in single copy and subscription format, by becoming a **BSI Subscribing Member**.

PLUS is an updating service exclusive to BSI Subscribing Members. You will automatically receive the latest hard copy of your standards when they're revised or replaced.

To find out more about becoming a BSI Subscribing Member and the benefits of membership, please visit bsigroup.com/shop.

With a **Multi-User Network Licence (MUNL)** you are able to host standards publications on your intranet. Licences can cover as few or as many users as you wish. With updates supplied as soon as they're available, you can be sure your documentation is current. For further information, email bsmusales@bsigroup.com.

BSI Group Headquarters

389 Chiswick High Road London W4 4AL UK

Revisions

Our British Standards and other publications are updated by amendment or revision.

We continually improve the quality of our products and services to benefit your business. If you find an inaccuracy or ambiguity within a British Standard or other BSI publication please inform the Knowledge Centre.

Copyright

Useful Contacts:

Customer Services
Tel: +44 845 086 9001
Email (orders): orders@bsigroup.com
Email (enquiries): cservices@bsigroup.com

Subscriptions
Tel: +44 845 086 9001
Email: subscriptions@bsigroup.com

Knowledge Centre
Tel: +44 20 8996 7004
Email: knowledgecentre@bsigroup.com

Copyright & Licensing
Tel: +44 20 8996 7070
Email: copyright@bsigroup.com

bsi.

...making excellence a habit.™