BS EN 61069-4:2016

BSI Standards Publication

Industrial-process measurement, control and automation — Evaluation of system properties for the purpose of system assessment

Part 4: Assessment of system performance

bsi.

National foreword

This British Standard is the UK implementation of EN 61069-4:2016. It is identical to IEC 61069-4:2016. It supersedes BS EN 61069-4:1998 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee GEL/65, Measurement and control, to Subcommittee GEL/65/1, System considerations.

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

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Mesure, commande et automation dans les processus industriels - Appréciation des propriétés d'un système en vue de son évaluation - Partie 4: Évaluation des caractéristiques de fonctionnement d'un système (IEC 61069-4:2016)

Leittechnik für industrielle Prozesse - Ermittlung der Systemeigenschaften zum Zweck der Eignungsbeurteilung eines Systems - Teil 4: Eignungsbeurteilung des Systembetriebsverhaltens (IEC 61069-4:2016)

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European foreword

The text of document 65A/792/FDIS, future edition 2 of IEC 61069-4, prepared by SC 65A “System aspects” of IEC/TC 65 “Industrial-process measurement, control and automation” was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61069-4:2016.

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)	2017-05-11
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2019-11-11

This document supersedes EN 61069-4:1997.

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The text of the International Standard IEC 61069-4:2016 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60359	NOTE	Harmonized as EN 60359.
IEC 60546-1	NOTE	Harmonized as EN 60546-1.
IEC 60770 Series	NOTE	Harmonized as EN 60770 Series.
IEC 60870 Series	NOTE	Harmonized as EN 60870 Series.
IEC 60873 Series	NOTE	Harmonized as EN 60873 Series.
IEC 61069-3:2016	NOTE	Harmonized as EN 61069-3:2016 (not modified).
IEC 61069-5:2016	NOTE	Harmonized as EN 61069-5:2016 (not modified).
IEC 61298-1	NOTE	Harmonized as EN 61298-1.
IEC 61298-2	NOTE	Harmonized as EN 61298-2.
IEC 61298-3	NOTE	Harmonized as EN 61298-3.
IEC 61298-4	NOTE	Harmonized as EN 61298-4.
IEC/TS 62603-1:2014	NOTE	Harmonized as CLC/TS 62603-1:2014 (not modified).

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 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

Publication	Year	Title	EN/HD	Year
IEC 60068	Series	Environmental testing	EN 60068	Series
IEC 60654	Series	Industrial-process measurement and control equipment - Operating conditions	EN 60654	Series
IEC 60721-2	Series	Classification of environmental conditions	EN 60721-2	Series
IEC 61000-1	Series	Electromagnetic compatibility (EMC)	-	-
IEC 61069-1	2016	Industrial-process measurement, control and automation - Evaluation of system properties for the purpose of system assessment - Part 1: Terminology and basic concepts	EN 61069-1	2016
IEC 61069-2	2016	Industrial-process measurement, control and automation - Evaluation of system properties for the purpose of system assessment - Part 2: Assessment methodology	EN 61069-2	2016
IEC 61326	Series	Electrical equipment for measurement, control and laboratory use - EMC requirements	EN 61326	Series

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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INDUSTRIAL-PROCESS MEASUREMENT, CONTROL AND AUTOMATION – EVALUATION OF SYSTEM PROPERTIES FOR THE PURPOSE OF SYSTEM ASSESSMENT –

Part 4: Assessment of system performance

FOREWORD

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International Standard IEC 61069-4 has been prepared by subcommittee 65A: System aspects, of IEC technical committee 65: Industrial-process measurement, control and automation.

This second edition cancels and replaces the first edition published in 1997. This edition constitutes a technical revision.

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

a) Reorganization of the material of IEC 61069-4:1997 to make the overall set of standards more organized and consistent;
b) IEC TS 62603-1:2014 has been incorporated into this edition.

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

FDIS	Report on voting
65A/792/FDIS	65A/801/RVD

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

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

A list of all parts in the IEC 61069 series, published under the general title *Industrial-process measurement, control and automation – Evaluation of system properties for the purpose of system assessment*, can be found on the IEC website.

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

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

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

INTRODUCTION

IEC 61069 deals with the method which should be used to assess system properties of a basic control system (BCS). IEC 61069 consists of the following parts:

Part 1: Terminology and basic concepts

Part 2: Assessment methodology

Part 3: Assessment of system functionality

Part 4: Assessment of system performance

Part 5: Assessment of system dependability

Part 6: Assessment of system operability

Part 7: Assessment of system safety

Part 8: Assessment of other system properties

Assessment of a system is the judgement, based on evidence, of the suitability of the system for a specific mission or class of missions.

To obtain total evidence would require complete evaluation (for example under all influencing factors) of all system properties relevant to the specific mission or class of missions.

Since this is rarely practical, the rationale on which an assessment of a system should be based is:

– the identification of the importance of each of the relevant system properties;
– the planning for evaluation of the relevant system properties with a cost-effective dedication of effort to the various system properties.

In conducting an assessment of a system, it is crucial to bear in mind the need to gain a maximum increase in confidence in the suitability of a system within practical cost and time constraints.

An assessment can only be carried out if a mission has been stated (or given), or if any mission can be hypothesized. In the absence of a mission, no assessment can be made; however, evaluations can still be specified and carried out for use in assessments performed by others. In such cases, IEC 61069 can be used as a guide for planning an evaluation and it provides methods for performing evaluations, since evaluations are an integral part of assessment.

In preparing the assessment, it can be discovered that the definition of the system is too narrow. For example, a facility with two or more revisions of the control systems sharing resources, for example a network, should consider issues of co-existence and inter-operability. In this case, the system to be investigated should not be limited to the “new” BCS; it should include both. That is, it should change the boundaries of the system to include enough of the other system to address these concerns.

The part structure and the relationship among the parts of IEC 61069 are shown in Figure 1.

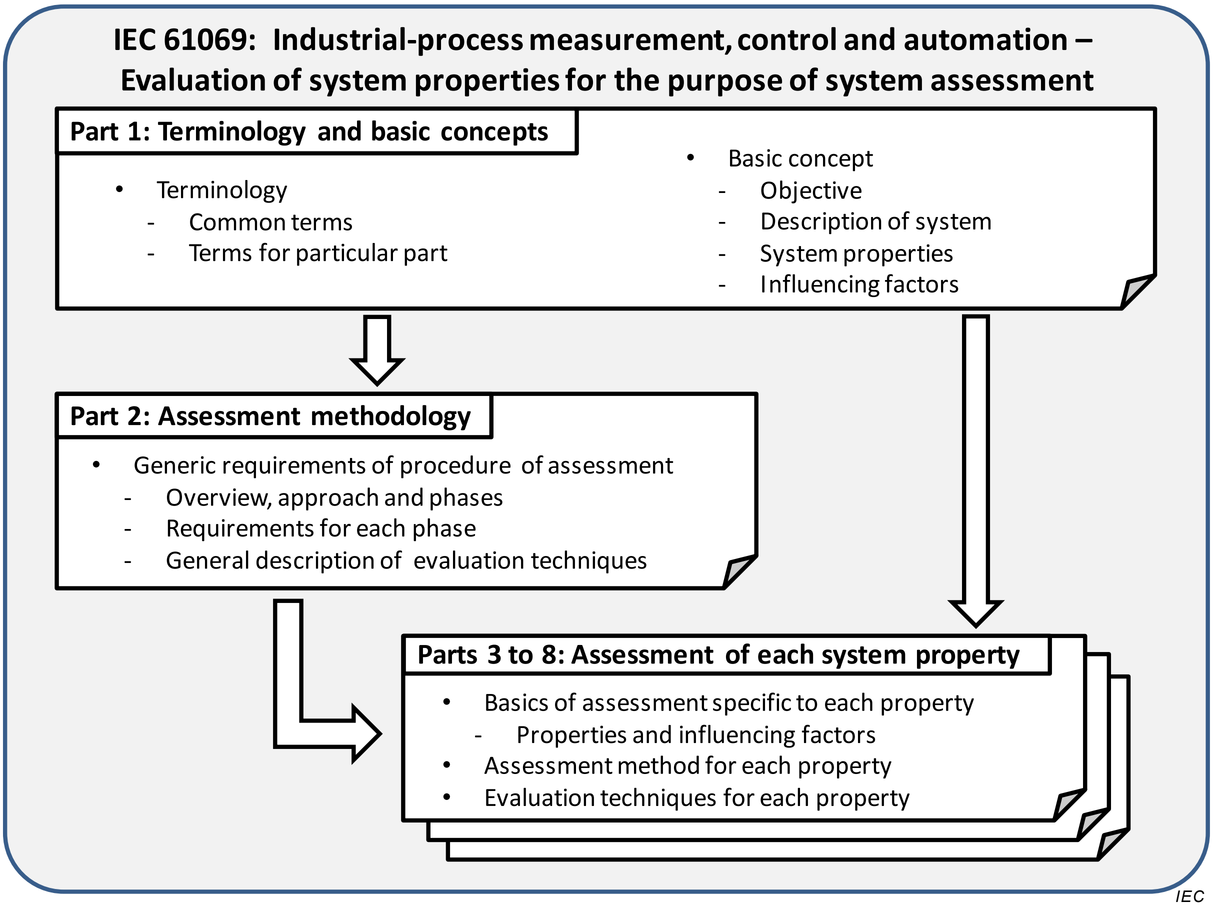

Figure 1 – General layout of IEC 61069

Some example assessment items are integrated in Annex C.

INDUSTRIAL-PROCESS MEASUREMENT, CONTROL AND AUTOMATION – EVALUATION OF SYSTEM PROPERTIES FOR THE PURPOSE OF SYSTEM ASSESSMENT –

Part 4: Assessment of system performance

1 Scope

This part of IEC 61069:

– specifies the detailed method of the assessment of performance of a basic control system (BCS) based on the basic concepts of IEC 61069-1 and methodology of IEC 61069-2,
– defines basic categorization of performance properties,
– describes the factors that influence performance and which need to be taken into account when evaluating performance, and
– provides guidance in selecting techniques from a set of options (with references) for evaluating the performance.

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 60068 (all parts), *Environmental testing*

IEC 60654 (all parts), *Industrial-process measurement and control equipment – Operating conditions*

IEC 60721 (all parts), *Classification of environmental conditions*

IEC 61000 (all parts), *Electromagnetic compatibility (EMC)*

IEC 61069-1:—[1], *Industrial-process measurement, control and automation – Evaluation of system properties for the purpose of system assessment – Part 1: Terminology and basic concepts*

IEC 61069-2:—[2], *Industrial-process measurement, control and automation – Evaluation of system properties for the purpose of system assessment – Part 2: Assessment methodology*

IEC 61326 (all parts), *Electrical equipment for measurement, control and laboratory use – EMC requirements*

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1 Second edition to be published simultaneously with this part of IEC 61069.

2 Second edition to be published simultaneously with this part of IEC 61069.

3 Terms, definitions, abbreviated terms, acronyms, conventions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61069-1 apply.

3.2 Abbreviated terms, acronyms, conventions and symbols

For the purposes of this document, the abbreviated terms, acronyms, conventions and symbols given in IEC 61069-1 apply.

4 Basis of assessment specific to performance

4.1 Performance properties

4.1.1 General

A system is expected to be able to perform tasks required by the system mission with accuracy and within a specified response time. If the system executes several tasks, it handles these tasks without obstructing the execution of the other tasks. Hence capacity, which indicates the number of tasks which can be executed within a time frame, is important.

To assess the performance of a system it is therefore necessary to categorise system properties in a hierarchical way.

Performance properties are categorized as shown in Figure 2.

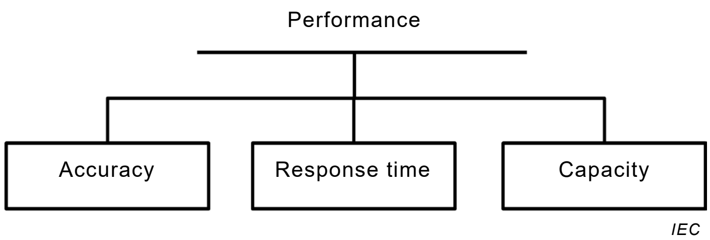

Figure 2 – Performance

Performance cannot be assessed directly and cannot be described by a single property. Performance can only be determined by analysis and testing of each of performance properties individually.

To be able to determine the system performance properties it is necessary to analyze the system in terms of information translations.

It is necessary to examine the system performance properties for each of the information translations in the system.

It should be noted that the system performance properties can be mutually dependent.

When a system accomplishes several tasks, the performance can vary, and for each of the relevant tasks a separate analysis is required.

Performance should be described for each task, which is represented by an information translation, with specified conditions for the other tasks concurrently operating.

4.1.2 Accuracy

Accuracy indicates closeness of agreement between the specified and the realized information translation executed by the system under defined conditions.

The accuracy of an information translation function includes potentially many system properties, for example:

– hysteresis,
– dead band,
– repeatability error,
– resolution.

4.1.3 Response time

Response time indicates the time interval between the initiation of an information translation and the instant when the associated response is made available under defined conditions.

An information translation function generally comprises the following functional steps:

– information collection, which depends on the time constant of input filters (hard and/or software) and input cycle times;
– information processing, which depends on the processing cycle time;
– output actuation, which depends on the times of output filters (hard and/or software) and output cycle times.

Each of the above functional steps of an information translation function can be executed in a synchronous or asynchronous way.

Attention should be paid to the fact that the overall response time of an information translation is not simply the sum of the time spent for functional steps, due to interdependencies. For example, new initiation can coincide in time with a running information translation resulting in an increase in response time.

The response time differs with respect to each information translation, and depends on priority settings of concurrent tasks, cycle time settings, activated credibility mechanisms, etc.

The response time can be quantified for individual tasks. In some cases, the value calculated may contain a degree of uncertainty and that should be recorded with the value, for example 50 % ± 10 % or 50 % with a 90 % certainty.

4.1.4 Capacity

Capacity is a property of the system performance which indicates the maximum number of information translations of a given information translation function which the system is able to execute within a defined period of time, without negatively impacting any other system capabilities.

The capacity of a system depends on the amount of calculation capability, the available storage, and the available I/O bandwidth.

For a given system, the capacity (maximum load) is fixed. Capacity can only be changed through additions or changes to the given system. The following are some concepts of interest:

$$\text{Capacity} = \text{base load} + \text{operating load} + \text{spare capacity}$$

A system is at maximum load when there is no spare capacity available. Overload occurs when the user-defined tasks do not operate in the designed time frame due to resource restrictions.

The evaluation of the system capacity should be done by checking that the spare capacity is available under that operating load as specified in the SRD. The assessment will ensure that the spare capacity is available under that operating load.

4.2 Factors influencing performance

The performance of a system can be affected by the influencing factors listed in IEC 61069-1:—, 5.3.

For each of the system performance properties listed in 4.1, the primary influencing factors are as follows:

Accuracy can be affected by influencing factors originating from:

- the environment, such as ambient temperature;
- infrastructure, such as voltage variations and surges expected from the main power supply;
- electrical noise, such as pick-up by in-coming and out-going lines from and to field-mounted equipment, due to earthing problems, and/or conducted and/or radiated electro-magnetic interferences;
- time exposed to temperature and heat radiation;
- humidity;
- vibration.

Accuracy should be tested over at least the total range to which the system will be subjected.

Response time is mainly affected by conditions originating in the tasks, such as:

- increase in activities (e.g. an alarm burst);
- externally generated interruptions, for example from the main power supply, and/or from electrical noise.

Capacity and spare capacity are affected by:

- increase in activities (e.g. an alarm burst);
- enhancing the system;
- externally generated interruptions, for example from the main power supply, and/or from electrical noise;
- loss of memory due to poor memory management.

In general, any deviations from the operating conditions specified can affect the performance of the system.

When specifying tests to evaluate the effects of influencing factors, the following International standards shall be consulted:

- IEC 60068;
- IEC 60721;
- IEC 60654;
- IEC 61000;
- IEC 61326.

5 Assessment method

5.1 General

The assessment shall follow the method as laid down in IEC 61069-2:—, Clause 5.

5.2 Defining the objective of the assessment

Defining the objective of the assessment shall follow the method as laid down in IEC 61069-2:—, 5.2.

5.3 Design and layout of the assessment

Design and layout of the assessment shall follow the method as laid down in IEC 61069-2:—, 5.3.

Defining the scope of assessment shall follow the method laid down in IEC 61069-2:—, 5.3.1.

Collation of documented information shall be conducted in accordance with IEC 61069-2:—, 5.3.3.

The statements compiled in accordance with IEC 61069-2:—, 5.3.3, should include the following in addition to the items listed in IEC 61069-2:—, 5.3.3:

– the required task(s) as defined in the SRD, and the information translation functions provided by the system to support these;
– the location of the end points of each information translation function.

Documenting collated information shall follow the method in IEC 61069-2:—, 5.3.4.

Selecting assessment items shall follow IEC 61069-2:—, 5.3.5.

Assessment specification should be developed in accordance with IEC 61069-2:—, 5.3.6.

Comparison of the SRD and the SSD shall follow IEC 61069-2:—, 5.3.

NOTE 1 A checklist of the SRD for system dependability is provided in Annex A.

NOTE 2 A checklist of the SSD for system dependability is provided in Annex B.

5.4 Planning of the assessment program

Planning the assessment program shall follow the method as laid down in IEC 61069-2:—, 5.4.

Assessment activities shall be developed in accordance with IEC 61069-2:—, 5.4.2.

The final assessment program should specify the points specified in IEC 61069-2:—, 5.4.3.

5.5 Execution of the assessment

The execution of the assessment shall be in accordance with IEC 61069-2:—, 5.5.

5.6 Reporting of the assessment

The reporting of the assessment shall be in accordance with IEC 61069-2:—, 5.6.

The report shall include information specified in IEC 61069-2:—, 5.6. Additionally, the assessment report should address the following points:

– No additional items are noted.

6 Evaluation techniques

6.1 General

Within IEC 61069-4, several evaluation techniques are suggested. Other methods may be applied but, in all cases, the assessment report should provide references to documents describing the techniques used.

Those evaluation techniques are categorized as described in IEC 61069-2:—, Clause 6.

NOTE An example of a list of assessment items is provided in Annex C.

Factors influencing system performance properties as per 4.2 shall be taken into account.

The techniques as given in 6.2, 6.3 and 6.4 are recommended to evaluate system performance properties.

6.2 Analytical evaluation techniques

An analytical evaluation is a qualitative analysis of the system configuration complemented with quantification of the basic performance properties of the elements.

In order to evaluate performance properties, it is recommended to use models which represent the way in which the elements are used to implement the required information translations.

The same model can be used to infer system performance from the evaluation of the performance of the individual elements.

An example of such a model is developed in Annex D.

The model, representing the performance aspects, shows the information translations, the elements used and their interconnection.

Basic quantified performance data are added to each of the elements shown in the model. These quantitative data can be obtained from generic data, system documentation, and data obtained from evaluations of the elements and/or a detailed analysis of the design of the elements. The data used shall be those applicable for the range of influencing factors for which the evaluation is required.

The values on accuracy, response time and capacity are then obtained by inference, based upon the individual specification of the modules and elements and the chaining of these to support the information translations.

A more refined method of analyzing the performance properties can be made by the construction of a simulation model of the analytical model described above, simulating random agitation of the input channels and recording the outputs, traffic on busses, etc.

6.3 Empirical evaluation techniques

6.3.1 General topics

Although it is often feasible to conduct an empirical evaluation, (also called a test) in isolated individual modules and elements within an information translation function, these tests do not often provide sufficient data on the performance of the task(s) required. Such tests can only be performed at the boundary of each information translation.

The design of these tests should be guided by a qualitative analysis of the system, and based on a selected task or set of tasks which represents the performance of the information translation function. At least one test should be conducted for each class of information translation functions such as:

– process measurement indication (e.g. analogue, digital);
– process control action;
– keyboard manipulated process action;
– keyboard manipulated display call-up;
– refreshment of displayed data;
– alarm monitor;
– time recording;
– communications link;
– feedback of manipulated values (e.g. indication, correcting device).

In general, each performance test of a particular information translation should be executed with the conditions of the other information translation(s) at those as given in the SRD.

The performance of a system is affected by influencing factors as stated in 4.2.

6.3.2 Tests to evaluate accuracy

For the purpose of evaluating/measuring the accuracy, the information translations can be categorized into two types of information translations.

a) Time-independent information translations

   A guidance on measuring the accuracy of time-independent information translations can be found in IEC 61298-2.

   Information translations, which can partly be treated as time-independent are, for example:

   – measurement and indication of process values (e.g. analogue, digital, counter type);
   – output of manipulated values;
   – feedback of manipulated values (e.g. indication, correcting device).

b) Time-dependent information translations

   Time-dependent information translations include mostly time-independent parts. It is advisable to separately evaluate or measure the accuracy of these parts before the overall accuracy of the information translation is evaluated.

   Accuracy of process control action(s) in a system should be evaluated using process simulation.

The objective of evaluating the overall accuracy is principally to check:

– whether the system internal image of all statuses and values of the process reflects the current real-time situation of the process at each moment in time, and is complete and consistent;

  NOTE 1 This could be tested by stimulating each input after another and checking whether its contents in the process image contains the correct value and/or status.

– whether the internal system times of each element are identical, have the same resolution and are equal to the local time;

  NOTE 2 This could be tested by extracting and displaying the current day and time on all relevant modules and elements and comparing those with each other and with the local time.

– whether the resolution of the system internal time is able to identify, note and correctly time stamp the sequence of fast changes in the values and statuses of the same or different event(s);

NOTE 3 This could be evaluated by stimulating in a chronological order a set of inputs with a defined number of events per second and noting the timestamp, status and value changes in the process image.

- whether the resolution of the system internal time is able to identify, note and correctly time stamp the sequence of fast changes in the values and statuses of the same or different event(s).

NOTE 4 That could be evaluated by stimulating in a chronological order a set of inputs with a defined number of events per second and noting the timestamp, status and value changes in the process image.

The accuracy of each information translation should be tested from the source to the destination of the information at the system boundaries.

The results, for each class of information translation, should be expressed as an average of the results obtained from a series of tests, with the translation tolerances stated.

6.3.3 Tests to evaluate response time

The tests should measure the response time of the information translations under consideration from the source to the destination of the information.

The results should be expressed as an average of the time periods obtained over a series of tests, with the translation tolerances stated, for each class of information translation.

Effects obtained on the results because of special conditions, such as change-over to a stand-by controller, should be separately stated.

6.3.4 Tests to evaluate capacity

The tests should measure the capacity of the system. This should be executed for each class of information translation. The measured capacity should be evaluated as to whether it is enough for the expected task, taking into account the base load of the system.

Where data and event recording and storage are key functions, tests should address any deterioration of capacity over time due to poor memory management.

During these tests, the other information translations should be kept constant at the values required in the SRD.

For each of the values precise and detailed information should be given of the conditions under which these have been obtained, such as:

- the nature and volume of each of the information translations, whether these are refreshed periodically or by exception, the effects of buffering, etc.;
- the effects of the occurrence of random system tasks on the results, for example change-over to a stand-by controller, request of a report, an alarm burst, etc.

The results should be expressed as an average of the results obtained from a series of tests, with the translation tolerances stated, for each class of information translation.

6.4 Additional topics for evaluation techniques

No additional items are noted.

Annex A
(informative)

Checklist and example of SRD for system performance

The matrix in Table A.1 provides an example check list of the type of information (task by task and/or information translation) which should be given in the SRD for the purpose of performance assessment.

It should be checked whether the performance requirements are stated under specific operating conditions, for example, steady state, bursts of input information, etc., for each of the system tasks.

These requirements should have been provided both in relation to individual tasks as well as in relation to the total mission.

Table A.1 – SRD performance checklist *(1 of 3)*

Performance property items	SRD Performance specification
General	Description of tasks supported by: • process control and measurement diagram • description of the control and measurement requirements in support of each task • operational and monitoring requirements of each task • importance of task for mission • a plot showing suggested location of measurement and control points, operators control desk/panel, etc.
Sizing parameters	Number of operator consoles: • 2 triple, 1 double and 5 single screen consoles Extent of process control and measurement requirements: • measured values (direct connected) 900 • measured values (teletransmitted) 150 • accumulated values (teletransmitted) 50 • statuses (direct connected) 250 • statuses (teletransmitted) 100 • value calculations 20 • alarm points (from calculations) 75 • alarm points (from statuses) 125 • calculations 35 • control algorithms 50 • output analogue (direct connected) 35 • output analogue (telemetered) 10 • CRT-diagram displays 125 • CRT-reports 75 • …… •

Table A.1 *(2 of 3)*

Performance property items	SRD Performance specification				
Accuracy	**Measurement**	**Accuracy %**	**Resolution**	**Update frequency**	**Comments**
	Temperature	0,5	1 °C	0,2/s	
	Pressure	0,5	1 bar	5 /s	
	Level	1	1 %	0,1/s	
	Flow				
	– instant	0,5	1 kg/h	1 /s	Alternatively T/h
	– accumulated	0,5	1 T	0,01/s	
	Status		0,01 s [a]	100 /s	
	Alarm		0,01 s [a]	1 /s	
	….				
	….				
	[a] Resolution of time tagging				

Performance property items	Type of request, display, function, etc.	State of activity		
Response		**Normal operation**	**High**	**Emergency**
	General:			
	– request for new display	1 s <..< 3 s	1 s <..< 3 s	1 s <..< 3 s
	– updating within display:			
	50 % of points	< 10 s	< 15 s	< 25 s
	68 % of points	< 15 s	< 25 s	< 50 s
	99 % of points	< 25 s	< 50 s	< 100 s
	– control station display including data and update	1 s <..< 3 s	1 s <..< 3 s	1 s <..< 3 s
	– alarm list	1 s <..< 3 s	1 s <..< 3 s	1 s <..< 3 s
	– point request completion time (depends on priority setting) but always	< 2 s	< 2,5 s	< 5 s
	– report display			
	acknowledgement	1 s <..< 3 s	1 s <..< 3 s	1 s <..< 3 s
	initially	< 10 s	< 30 s	< 60 s
	completion	< 60 s	< 120 s	< 300 s
	– trend value display			
	acknowledgement	1 s <..< 3 s	1 s <..< 3 s	1 s <..< 3 s
	latest value	1 s <..< 3 s	< 5 s	< 10 s
	completion (99 %)	< 10 s	< 60 s	< 300 s
	update frequency	< 10 s	< 10 s	< 10 s

Table A.1 *(3 of 3)*

Performance property items	SRD Performance specification			
Evaluation scenarios	Total system in operation			
	– triple console no. 1	control	control	control
		trend	trend	control
		alarm	alarm	alarm
	– triple console no. 2	control	control	control
		trend	trend	control
		report	alarm	alarm
	– double console	archiving	archiving	trend
	– single consoles	control	alarm	control/alarm
	Activity level, changes in:			
	– analogue values	5/min	25/min	100/min
	– calculations	2/min	10/min	40/min
	– status	1/min	20/min	200/min
	– alarm initiations	1/min	5/min	150/min
	–			
	– operator's requests			
	points	2/min	20/min	50/min
	control	30/h	2/min	5/min
	trend	5/h	10/h	1/min
	alarm	1/h	3/h	1/min

Annex B
(informative)

Check list and/or example of SSD for system performance

B.1 SSD information

The system specification document should be reviewed to check that the properties given in the SRD are listed as described in IEC 61069-2:—, Annex B.

B.2 Check points for system performance

Particular attention should be paid to check that information is given on:

– the information translation functions to support the required task(s);
– modules and elements, supporting the information translations;
– the location of the end points of each information translation function;
– quantified data for each of performance of the information translation functions provided by the system;
– facilities provided by the system which, in the assembled operational system, support analysis of system performance properties, such as calculation of spare capacity on memory devices, statistical analysis of system resource utilization, etc.;
– notes made in the specification of any side-effects which can occur when changes are made to any of the other system properties.

Annex C
(informative)

An example of a list of assessment items (information from IEC TS 62603-1)

C.1 Overview

Annex C provides some examples about influencing factors related to this part of IEC 61069 which were extracted from IEC TS 62603-1.

The classifications of values of properties described in this document are only examples.

C.2 Accuracy – Time performances of the BCS

C.2.1 Absolute time synchronisation

Evaluation of process data requires that all the components of the process control system work synchronously, allowing messages to be assigned in a correct time sequence.

To ensure that the time base of the PCS is unique, time synchronization should be configured for each controller and workstation.

Time synchronization is based either on a centralised architecture, or on a distributed one. In case of a centralised architecture, one “time master” sends a synchronisation signal to all the “time slaves”. For a distributed architectures each node has its own synchronisation device (e.g. GPS).

The user should specify the type of required architecture and the number of nodes to synchronise.

C.2.2 Requirements of the time stamping

The capacity of discriminating events very close in time is defined in the IEC 60870 that is specific to telecommunication equipment and systems but can be applied to any BCS. The basic concepts and definitions are:

– discrimination capacity: the minimum time between two events that allows to detect their proper sequence,
– time resolution: the minimum time between two events so that their time tags are different,
– suppression time: the period of time when the acquisition of changes of status is suppressed to avoid errors due to noise or bounces,
– acquisition time: the minimum duration of a status variation to be detected and properly elaborated.

The required time resolution and discrimination capacity of the BCS can be defined using the classes defined in Table C.1.

Table C.1 – Resolution and discrimination time

		Classes			
Discrimination capacity		SP1	SP2	SP3	SP4
	ms	< 50	< 10	< 5	< 1
Time resolution		TR1	TR2	TR3	TR4
	ms	<1,000	< 100	< 10	< 1

C.3 Response time

C.3.1 Overall response time of the BCS

The maximum overall response time of the BCS should be indicated. The overall response time of the BCS measures the time elapsed between the inputs of a command through a given HMI device, its transmission to the field device, its physical execution, and its feed-back on the HMI. The time of the physical execution of a command does not depend on the BCS, so it should not be considered in the evaluation of the response time.

C.3.2 Switch-over time for redundant CPUs

The switch-over time is the time necessary to switch, after a fault, from the faulted CPU to the back-up CPU.

The maximum admissible switch-over time should be defined.

C.3.3 Real-time constraints for control functions

Some functions should satisfy real-time constraints, i.e. the function should perform within a determined time span.

Real-time requirements can be divided into two categories according to the effects on the system deriving from missing a deadline:

– hard real-time: a specific function should be performed at a given time that cannot be missed unless losing the performance. This means that if a function is defined as hard real-time, the completion of this function after the scheduled deadline is useless or, worse, might cause a critical failure of the system;
– soft real-time: the function has to be performed within a specific deadline. If the function is not completed within the deadline, the system can work but in degraded conditions.

For each function with real-time constraints, the following features have to be addressed:

– type of real-time constrain: hard or soft;
– deadline that should be satisfied for the completion of the real-time function.

C.3.4 Controller cyclic time

The controller cyclic time is the period needed by a controller to execute all the control programs, including the update of the involved I/O signals. The maximum admissible controller cyclic time should be specified. In case the controller supports multitasking, the maximum time considers all the tasks running simultaneously.

C.3.5 Time constraints for display

The HMI functions that require an execution within a specified time delay should be defined. The maximum time to show up a display variation should be specified, starting from the physical variation of the driving signal.

C.3.6 Call-up time

The call-up time of a HMI page is the time necessary to up-load and to open a standard graphic page after the operator request.

The maximum admissible call-up time should be specified.

C.3.7 Video screen page refresh time

The refresh time is an indication on how often the displayed page is updated, i.e. the frequency of acquisition of data displayed on the HMI pages.

The maximum admissible refresh time should be specified.

Annex D
(informative)

Model of an evaluation

D.1 General

The three performance properties – accuracy, response times and capacity – are related to data entering the system from one external domain and exiting the system after one or more information translations in another or the same domain. The data can follow various relevant routes through a system, as indicated in Figure D.1.

In each information translation, various cycle times can exist and either be fixed by design or through configuration by the user.

Both for analytical and empirical assessment techniques, it is important to first define the routes relevant for performing the mission stated in the SRD.

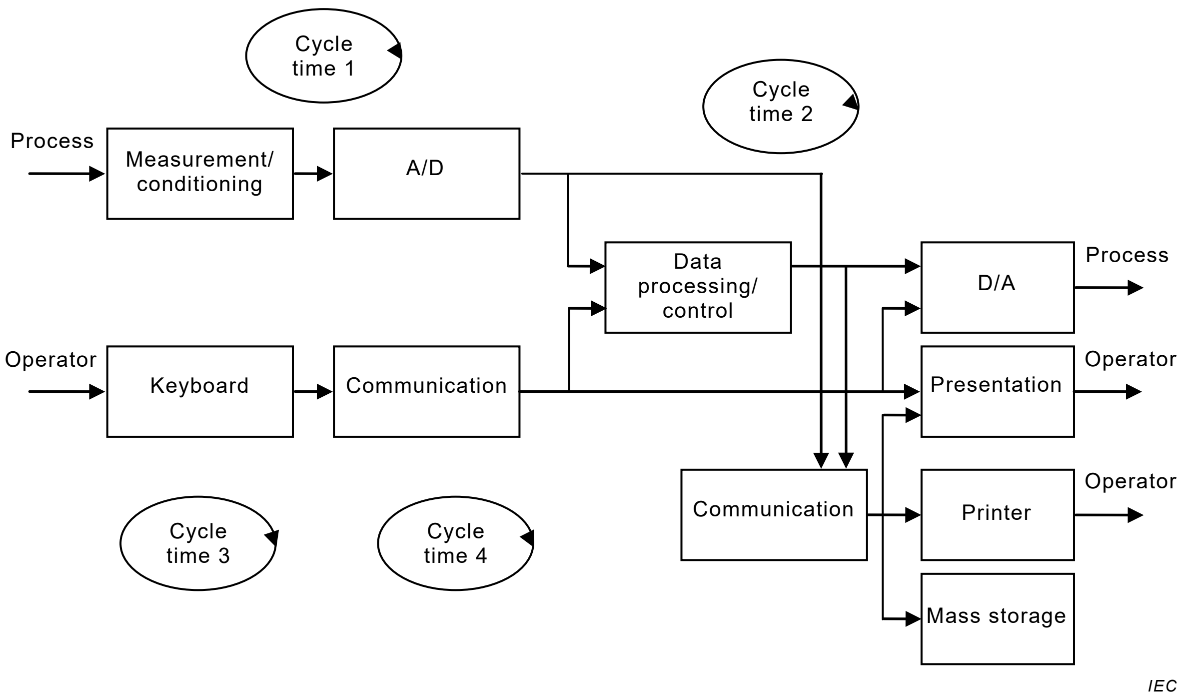

Figure D.1 – Schematic functional diagram of a system

Bearing in mind the influencing factors described in IEC 61069-1:—, 5.3, and approaching the system as a black box, the following relevant external information flows for performing process control can be identified:

– information flow from and to the process;
– information flow from and to the operator;
– information flow from and to the external systems.

These information flows are indispensable for controlling and safeguarding the energy and material flows, product quality, etc., of a process.

Within the boundaries of the physical model of a system as shown in Figure D.2, the following information translations can be distinguished at operational level. They are interconnecting the above-mentioned external information flows:

– process to process via a local control loop in a controller;
– process to process via a communication and a control loop allocated in two controllers (peer-to-peer loop);
– process to control via controller, communication and workstation (data presentation);
– process to mass storage device or printers via controller and communication;
– operator to process via workstation, communication, and controller;
– operator to mass storage back to workstation (presentation of historic data);
– process or operator to external system via communication;
– external system to process or to operator via communication.

In the various information translations, one or more of the following main groups of system functions are utilized:

– process interface functions;
– data processing (and control) functions;
– communication functions;
– human interface functions;
– external systems interface functions.

Based on the defined information translations, capacity can, for instance, be expressed as one or a combination of the following items:

– control loops per cycle or per unit of time when different cycle times are used in one and the same application program;
– number of algorithms processed per cycle;
– number of data (measurements) transferred peer-to-peer per communication cycle;
– number of data transferred to operator interfaces per communication cycle;
– number of alarm messages transferred per cycle;
– number of operator actions transferred to controllers per cycle;
– etc.

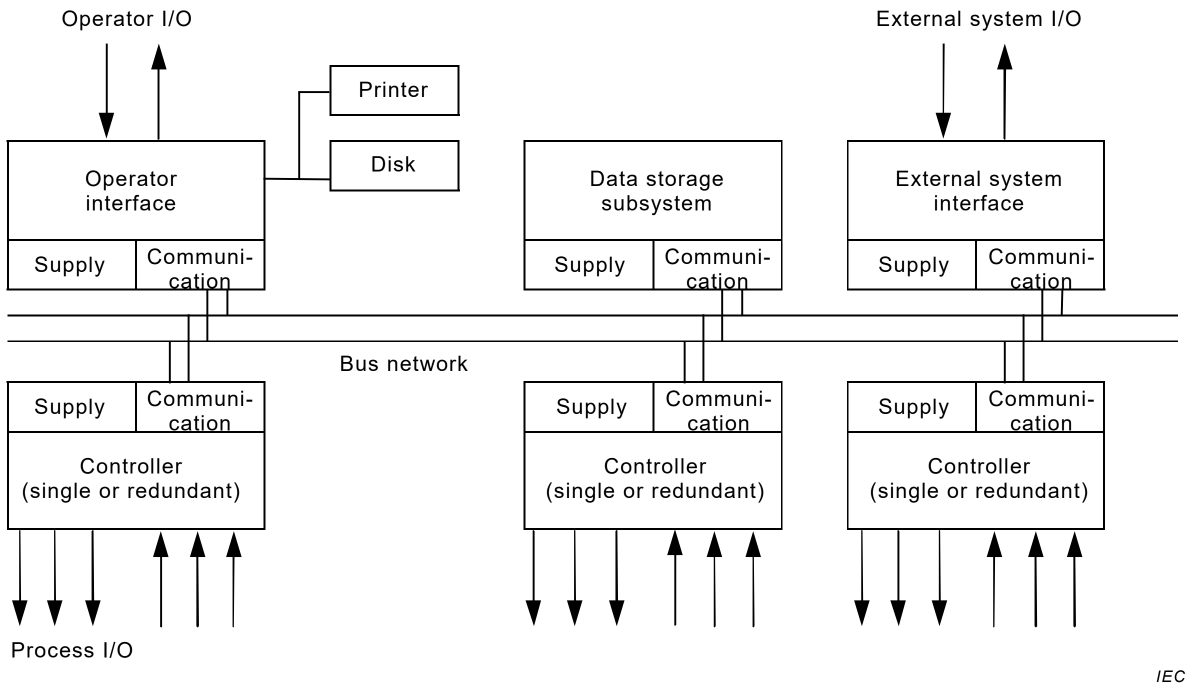

Figure D.2 – Generic physical system model

D.2 Analytical evaluation techniques

D.2.1 General

An analytical evaluation is based on a qualitative and quantitative analysis of the performance properties of each function, module and element of a system separately and their contribution to the overall performance of the system.

For the analytical evaluation, a model should be defined that takes into account and depends on the physical and functional system configuration of the system. It shall describe shared resources and individual elements (I/O devices, A/D and D/A converters, etc.) and functions (multitasking software, cycle times, algorithms, etc.) to be used in the various information translations and the physical entities of the system.

The relevant data may originate from specifications provided by the system manufacturer or from measured data.

D.2.2 Accuracy

The values on accuracy are for the larger part determined by the accuracy of the circuits in an information translation that provide the analogue-to-digital and digital-to-analogue conversions. Other circuits involved in the information translations have in general predetermined resolution effects on the accuracy. The conformity of the algorithms performing the information translations can only be partially evaluated analytically.

The emphasis shall therefore be on the empirical evaluation.

D.2.3 Response time

The response time cannot be expressed in one figure for the whole system. The response time is directly related to the size and system configuration of the physical system and the size and functional system configuration of its software with respect to the assignment (adjustability) of priority levels and cycle times to the various parts and/or information translations (algorithms, control loops, etc.). In many systems, the response time can be freely adjusted or configured per algorithm, loop or individual information translation.

Basically at low demand, the response times can be obtained from adding up the cycle times of the various parts involved in a certain data flow route. The variability of these parameters however makes the analytical approach very difficult and time-consuming. Especially when a system is loaded to its limits the combined effects of different tasks, when demanded simultaneously, can hardly be established analytically.

Response time has a direct relation with capacity. High loading factors may obstruct configured cycle times.

D.2.4 Capacity

Capacity cannot be expressed in one figure for a whole system.

The capacity depends on the size and physical system configuration of a system and the size and functional system configuration of its software and choices made with respect to cycle times.

The capacity can be measured for each information translation by measuring the maximum number of information translations which can be obtained per unit of time at reference conditions.

Capacity should be determined at least for each major information translation that can be defined.

Ultimately it can comprise of a combination of information translations (data transfer) for (local) automatic control, peer-to-peer communication, alarm handling, operator actions, archiving, etc.

D.3 Empirical evaluation techniques

D.3.1 General

An empirical evaluation is based on a qualitative and quantitative analysis of the performance properties of each function, module and element of a system separately and their expected contribution to the overall performance of the system.

For an empirical evaluation, a real system should be defined that contains all features required for a certain mission taking into account the physical and functional system configuration of the system as described above. It shall describe shared resources and individual elements (I/O devices, A/D and D/A converters, etc.) and functions (multitasking software, cycle times, algorithms, etc.) to be used in the various data information translations and the physical entities of the system.

For empirical evaluations it is important to define relevant reference conditions in particular for response time and capacity tests.

D.3.2 Accuracy

D.3.2.1 General

The values on accuracy are for the larger part determined by the accuracy of the circuits in the information translation that provide the analogue-to-digital and digital-to-analogue conversions.

Other circuits providing information translations have mostly predetermined resolution effects on the accuracy.

Furthermore, it can be possible that the resolution in an information translation is dynamically altered due to high load demands, thereby showing a certain degree of graceful degradation.

The empirical evaluation of the static accuracy can for a large part follow the methods and instructions defined for elements of systems as generically described in IEC 61298.

The influencing factors for evaluating accuracy arise from the process, utility and environment domains as detailed in 4.2 and in IEC 61069-1. Dynamic effects on accuracy can be observed when performing capacity tests as described in D.3.3.

D.3.2.2 Function block (algorithm) tests

D.3.2.2.1 General

A BCS is in general provided with a library of more or less standardized algorithms often called function blocks. These can be stringed together in a certain order and connected to the physical I/O circuits and can be used to realize a number of control functions to serve the external world. The variety of function blocks is enormous. Each system make has its own set and, though often the same names appear, the algorithms can show significant differences. Subclause D.3.2.2 gives some generic rules for designing empirical test procedures.

The function blocks can be divided into two groups:

a) time dependent functions (totalizer, controllers, timers, lead/lag);
b) time independent functions, which can again roughly be divided into:
   - calculation blocks,
   - logic blocks (and, or, etc.)

For both types of function blocks, the following qualitative checks can be performed:

– bumpless transfer from manual-to-automatic and set point tracking facilities;
– restart conditions at short power interrupts for outputs and control modes as far as provided to be checked for correct operation;
– effects of introducing negative parameters.

D.3.2.2.2 Time-dependent function blocks

For time-dependent function blocks with integral action, measurements over extended periods are required to reveal the actual time behaviour.

Each function block can require a specific test:

– linear algorithms can be tested with a frequency response test, step or ramp or pulse test. The various measured responses of the time-dependent function blocks are to be compared with the expected responses calculated from the specified differential equations. The differential equations of possible hardware filters in the input circuits have to be taken into account;
– non-linear control algorithms can be tested using benchmark processes showing their capabilities.

The effects of (continuous) operation under software overload conditions may be determined. Overload conditions may lead – depending on the software structure – to, for instance, irregular output updating or continuous skipping of loops at lower priority levels.

For control algorithms (PID) having an integral action, the following tests can be additionally performed:

- reset wind-up protection (protection against saturation effects) is in general as a software provision available by setting function block output limits. It shall however be checked whether automatic adaptation of the software wind-up protection is provided with respect to the physical limitations of the hardware output circuits. If not, real reset wind-up protection may be partial or ineffective;
- the resolution with which the integral action is calculated shall be checked. In case of a too small resolution the integral action will become inactive although a deviation may still exist between the set point and the measured value.

D.3.2.2.3 Time-independent function blocks

For calculation and other time-independent function blocks, the following checks are to be made as well:

- the extent to which calculations are performed in engineering units and how scaling is done at the connections to I/O circuits;
- whether or not protection is provided against division by zero and how it is realized;
- whether or not protection is provided against unrealistic parameter settings (such as low limit exceeding high limit);
- the effects of exceeding the resolution of the calculation capacity (single or double precision). An inefficient method of calculation may cause considerable errors;
- some actual calculations should be performed at extreme inputs and parameter settings and compared with the theoretic formula.

D.3.3 Response time/capacity

D.3.3.1 General

Because of the complexity of this subject, the manufacturer shall preferably be present at the test site during this part of an evaluation to provide support and explanation of unexpected behaviour.

D.3.3.2 Rationale

Microprocessor-based BCS can operate cyclically and are thus inherently time-critical with respect to control demand.

In general, systems nowadays are very flexible and to a large extent freely configurable with respect to hardware and software and the allocation of the control tasks in the various system modules.

The behaviour of these systems with respect to response times and load factors has probabilistic aspects.

Cycle times for data processing in controllers can be configured at multiples of the basic cycle time.

In many cases also, the communication cycle time between system modules can be configured.

The complexity of BCS requires from the user a large amount of discipline with respect to configuration and documenting the data, in order to avoid violation of configuration (software) loading rules for the system modules with respect to cycle times for processing and communication, and the assignment of alarm settings for process variables.

Violation of loading rules can cause, under certain circumstances, timing problems and consequently overload either continuously or temporarily.

Moreover, the effects of overloading can further be amplified by poorly setting the priority levels of the different tasks and the data transfer for inter-modular communication.

One should realize that manufacturers are often not fully clear and explicit about system loading and the effects that can appear on reaching overload conditions. This is because the extreme complexity of the multitasking mechanisms combined with their distribution in the physical system modules makes it difficult to predict the system behaviour when for instance a number of different tasks are demanded simultaneously.

For the evaluation of the system capacity, it is further important to distinguish:

a) the controller in a system as a stand-alone unit, which can be overloaded without affecting other modules;
b) the communication and operator interfaces as system parts where high data rates have to pass "narrow roads" that can become "congested".

An evaluation scenario is described below for both situations.

When increasing the load starting from low load at reference (base load) conditions, the response times will remain constant to a certain level.

Coming to overload conditions, the following can appear:

– the system or a module stops operation;
– the system or a module operates in a degraded manner (for instance at double cycles) but no data is lost;
– the system or a module operates in a degraded manner and data is lost.

In these cases, two types of overload conditions can be distinguished:

1) continuous overload by a too extensive control task (configuration) with respect to the assigned cycle time(s) or by continuous alarm generation at high rates;
2) temporary or intermittent overload by high demand due to, for instance, an alarm burst or an alarm burst appearing at the moment that an hourly report is requested or by incorrect scheduling of control tasks running at different cycle times.

D.3.3.3 Reference conditions for response time and throughput measurements

The reference conditions considered are relevant for consideration of response time and capacity.

Besides the definition of the hardware configuration and number of software packages to be embedded in the system, a base load should be defined comprising a minimum size application program to execute the information translations required by the external information flows as explained in Clause D.1.

To evaluate the response time and load of the system, the following items have to be measured in each relevant information translation, as a reference, to obtain base data for comparison, when the actual load is gradually increased:

– cycle times for controllers, communication and operator interface;
– update rates of outputs at each different information translation;
– call-up times of the various types of displays (process-to-operator) in the defined order and access times (operator-to-process).

The manufacturers shall further provide:

a) their procedures and methods for calculating and/or predicting the load factors with respect to the basic cycle times for processing and communication and the execution times of the various function blocks (algorithms);
b) limits in relation to cycle times and the effects to be expected when reaching these limits, as well as a listing of measures taken in the system to prevent passing these limits;
c) information on the (software) size of each reference display (loop, group, group and historic trend, real time trend, overview) in terms of static data and dynamic data;
d) information on the sizes of communication buffer memories and the mechanisms to transfer data and messages through the system;
e) information on the multitasking software structure including the assignment of priority levels to the various system tasks and methods of data transfer over the serial communication links.

These data will have to be taken into account during the design of the test procedures.

D.3.3.4 Parameters to be considered when increasing the system load

Function blocks will be added to one controller from the base load to a specified maximum load in predefined steps. For each load condition the above-mentioned measurements and those mentioned below under symptoms to be determined will be made while the following parameters are taken into account in the relevant combinations:

a) control task:
   1) inputs steady except for reference loops,
   2) all inputs to added function blocks varying at a steady rate,
   3) change priority of reference loops,
   4) change priority of communication for peer-to-peer loop;
b) communication task:
   1) different displays with different amounts of dynamic information from the controller under consideration;
c) alarm/event handling task:
   1) alarm burst,
   2) steady continuous alarm rates (1, 2, 5 per cycle);
d) interrupt handling task (relevant if user-configurable):
   1) steady continuous interrupt rates;
e) report request;
f) on-line configuration:
   1) changing configuration in one controller,
   2) up- or down-loading configuration or data from one controller;
g) communication and operator interface loading;
h) two or more controllers will be loaded simultaneously to, for example approximately 90 % of the throughput limit determined under previous test.

The controllers will be stressed simultaneously with:

– pre-defined alarm bursts,
– steady continuous alarm rates,
– combination of continuous alarm rates and report request.

The testing can be further expanded, if required, by adding more controllers and operator stations and by routing the information to different operator stations. By expanding the system tests, clues can be found for extrapolation to a large size system of the same make. System configuration may be another important parameter to be considered here for systems that have for instance:

– control stations of different size and capacity,
– multilevel bus topology.

D.3.3.5 Initial conditions

The system under consideration and the required application software configuration outlined above shall operate before any load test is applied as described under reference conditions.

D.3.3.6 Symptoms to be determined

During each test as described above, the following observations and measurements will be performed:

– the output update rates may be slowed down and/or temporarily or continuously be stopped;
– operation of operator I/O devices; call-up or access may become sluggish;
– the order of calling-up displays, etc. can influence the call-up times;
– access time to a control loop;
– system alarm message indicating overload;
– loss of information.

During alarm stress tests (introduction of either alarm bursts or continuous alarm rates), the following observations may be added:

a) determination of points of overflow and loss of messages (number of messages and/or time to reach overflow);
b) correct time labelling (sequence of events) at printer and mass storage.

All observations and measurements shall be compared and related with the measurements at base load described under reference conditions.

The observations and measurements can also be compared with the specified load calculation and prediction procedures provided by the manufacturer.

NOTE The operation of the added function blocks will not be monitored.

D.4 Precautions

It is important to take into account, when designing the test procedures for a specific system, the way the modules and tasks (embedded in the multitasking software structure) are inherently interacting or can be made interacting by the user. Setting, for instance, wrong priority levels or assuming a data transfer method not used in the system under consideration may lead to incorrect test methods and conclusions.

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3 Second edition to be published simultaneously with this part of IEC 61069.

4 Second edition to be published simultaneously with this part of IEC 61069.

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