

NORSOK STANDARD

SYSTEM CONTROL DIAGRAMS

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FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead time and eliminate unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and supported by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Manufacturing Industries). NORSOK standards are administered and issued by NTS (Norwegian Technology Standards Institution).

The purpose of NORSOK standards is to contribute to meet the NORSOK goals, e.g. to develop standards that ensure adequate safety, value adding and cost effectiveness and thus are used in existing and future petroleum industry developments.

The NORSOK standards make extensive references to international standards. Where relevant, the contents of a NORSOK standard will be used to provide input to the international standardisation process. Subject to implementation into international standards, the NORSOK standard will be withdrawn.

Section 4.4 is informative.

Annexes A and B are normative.

Annexes C and D are informative.

INTRODUCTION

The success of a plant development project depends on good and efficient means of communication between the involved parties, during all phases of the project.

Present extensive use of computerised systems and 3D modeling provide efficient tools for specifying and handling of physical equipment in a standardised manner. However, the development of methods and tools to specify functional relationships has not reached a corresponding level.

During the plant development the process engineers specify the process through the development of the P&IDs. Throughout this work process the process engineers acquire a thorough understanding of the total plant behavior. However, the P&IDs provide limited facilities for documentation of the overall functionality as well as operational aspects of the plant.

It's the control system engineer's task to design the control system so as to fulfil the process functionality required to achieve product specifications as well as the requirements imposed by the overall operating & control philosophy and manning levels. To conserve the functional relationships implicitly specified by the P&IDs, the control system engineers have to transform the process engineers imagination of plant behavior into the control system design and implementation.

The operator's evaluation of the operational efficiency of the plant is a difficult task without any proper documentation of the overall control and monitoring functions available. Often, operational

problems within the different systems can not be identified until the system is in operation, leading to major modifications in late project phases in the worst case.

The logic and arithmetic functions available for implementing the required control system functionality are accurate, but vendor specific. In-depth system knowledge is required to understand both the available functions as well as their interconnections. There is no intuitive link between the control system functions and their interconnections, and the process flow itself. The interactions between the process and the control functions are identified through single tags only.

Due to the missing link between the functions implemented in the control system and the P&IDs defining the process flow, the process engineer's possibility to verify that all process aspects have been properly catered for in the implementation of the control system is very limited.

The SCD Approach has been introduced in order to eliminate this missing link. The SCD Approach represents a structured methodology based on the development of the System Control Diagram (SCD).

Work is ongoing on SCD Application Guidelines (Informative) and SCD Readers Manual (Informative), and will be included in later revisions of this standard.

1 SCOPE

This standard is intended to cover functional as well as drawing related requirements for use of System Control Diagrams.

The standard will also establish a general framework for implementation of the SCD Approach in terms of Project Execution Guidelines and Application Guidelines. The Project Execution Guidelines defines a strategy for project execution and is intended for project responsible engineers. The Application Guidelines provides a basis for application design and is intended for application engineers responsible for developing SCDs.

The Readers Manual will contain a simplified introduction for engineers and operators using SCDs for verification and documentation of control functionality.

The Functional Standard as well as the Drawing Standard shall be considered normative, while the other documents are informative only.

2 NORMATIVE REFERENCES

The following standards include provisions, which, through reference in this text, constitute provisions of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. Other recognized standards may be used provided it can be shown that they meet or exceed the requirements of the standards referenced below.

NORSOK I-002	Safety and Automation Systems (SAS)
NORSOK L-003	Piping details
NORSOK Z-004	CAD Symbol Libraries
IEC 61131-1	Programmable controllers - Part 1: General information
IEC 61131-3	Programmable controllers - Part 3: Programming languages
ISO 3511 (all parts)	Process measurement control functions and instrumentation - Symbolic representation
NS 1710	Technical drawings – Drawing symbols for piping systems
NS 1438	Process measurement control functions and instrumentation – Symbolic representation – Part 1: Basic requirements

3 DEFINITIONS AND ABBREVIATIONS

3.1 General definitions

Normative references Shall mean normative (a requirement) in the application of NORSOK Standards.

Informative references Shall mean informative in the application of NORSOK Standards.

Shall	Shall is an absolute requirement to be followed strictly in order to conform to the standard. Shall requirements shall preferably be used in all NORSOK standards. Non-compliance to shall-requirements shall be subject to acceptance by the client.
Should	Should is a recommendation. Alternative solutions having the same functionality and quality are acceptable to the client.
May	May indicates a course of action that is permissible within the limits of the standard (a permission).
Can	Can-statements are conditional and indicates a possibility open to the user of the standard.

3.2 Function definitions

All definitions are based on positive logic; defined state is true when logical equal to '1'.

Definition	Explanation
Alarm	Discrete change of state resulting in an audio/visual annunciation requiring operator acknowledges.
Alarm categories	The following categories are defined, not reflecting priority or criticality of the alarm: Action alarm: Alarm feature including blocking facilities intended for automatic safeguarding actions in order to protect equipment, environment or human beings. (Ref. figure in A 3.2.1) Warning alarm: Alarm without blocking facilities intended for abnormal conditions enabling operator intervention in order to prevent further escalation.(Ref. figure in A 3.2.2) Fault alarm: Alarm associated to fault or failure in the instrument and/or control device.(Ref. figure in A 3.2.3)
Alarm filtering	Alarms determined by additional processing to be less important, irrelevant or otherwise unnecessary are not presented to the operator, but can be accessed upon request.
Alarm hysteresis	The degree of normalisation required to reset an active alarm state, measured from the alarm activation limit. Normally expressed in terms of a fraction (%) of the operating range.
Alarm suppression	Disable alarm annunciation as well as any associated automatic actions.
Blocking	Disable of a safeguarding action, but allowing associated alarm annunciation as well as manual / automatic control. Blocking applies to both individual action alarms and input signals effecting safeguarding and disables functions. (Ref. Figure in A 3.4)
Commands	Manipulation affecting the mode of the function template.

Definition	Explanation
	The following commands are defined: Set: Memory variable set to true state on being true. Reset: Memory variable reset to false state on being true. Reset shall have priority over set. Force: Action overruling any other signal while being true. The mode is reset to its original state when signal is no longer true. Lock: Action overruling any other signal while being true. The new mode is maintained when lock signal is no longer true.
Control option	Pre-defined properties of the function template defined during the configuration of the system reflecting the specific control requirements.
Deviation warning	State calculated in a modulating controller by subtracting the measured value from the set point value. A warning will be announced if deviation is outside working area.
Disabled mode	Function not available for external control commands
Dynamic information	Information displayed on the VDUs reflecting the state of the process or system. The following dynamic information elements are defined : Alarm: Discrete change of data resulting in an audio / visual annunciation in the control room, requiring operator acknowledgement as well as input to alarm list. Event: Discrete change of state resulting in a displayed status in the control room as well as input to the event list. (Ref. figure in section A 3.3.1) Status: Binary state. Indication: Continuous display of information.
Enabled mode	Function available for external/remote control commands.
Flow element	Device used to control/ shut down or manipulates a flow of fluid or electric energy, ex. Valve, pump. Where the flow device only has two positions, it is referred to as a binary flow device ex. Motor - on/ off, valve - Open/Close. High position: No flow restriction Low position: No flow
Function template	Function assembly detailed requirements for operation and control.
Limit switch	Device connected to the actuator or valve providing a positive signal when the valve reaches a pre-established position.

Definition	Explanation
MCC	Motor Control Center (electrical protection relay assembly)
Mode	State of operation selected by the operator or resulting from an external event The following operation modes are defined: Auto: Operation of process objects automatically performed by the control logic. (Ref. figure in A 3.4) Outside: Flow element operated from a field device. I.e. local panel.(Ref. figure in A 3.4) Manual: Flow element manually controlled by the operator from the CCR.(Ref. figure in A 3.4) Duty/ Standby: Intended for automatic supervision of flow element operating in parallel to increase the system availability. One flow element will be assigned duty (priority 1) and will thus normally be in operation. The other is assigned standby (priority 2) and will automatically be put in operation if duty fails. All flow elements will have to be selected auto to obtain automatic duty/standby function.(Ref. figure in A 3.4) Blocked: Alarm status signals from process variable limit checking are blocked within the function, giving annunciation, but not allowing all related automatic safeguarding actions. Associated safeguarding function disabled. Related alarm annunciation not disabled (i.e. no external signal outputs are blocked).(Ref. figure in A 3.4) Suppress: Disable alarm annunciation as well as related safeguarding actions.(Ref. figure in A 3.4) Internal set point mode: Sub- mode to auto mode used for PID controllers. The set point to be entered by the operator. External set point mode: Sub- mode to auto mode used for PID controllers. The set point to be entered from external functions in the control logic. Typically use in cascading PID controllers. Track: To follow another signal. I.e. “set-point” tracking etc. Safeguarding: Flow device is in safe state. The term safe is related to the protection of equipment, environment and human beings. (Ref. Figure in A 3.4) Disabled: Function not available for external control commands. Safeguarding commands will not be affected in

Definition	Explanation
	disabled mode. (Ref. Figure in A 3.4)
Override	Override function intended to set the output signal to predefined state, independent of changes in logic states. Normally used in connection with mimic/matrix panels for test purpose.
Position	Actual position: The feedback-position of a flow element, independent of the state of the control output. Confirmed position: Compared actual position and control output. True if no mismatch and false if there are a mismatch. (Ref. Figure in A 3.4)
Process	A sequence of chemical, physical, or biological activities for the conversion, transport, or storage of material or energy.
Shutdown	Signal to set an element to safeguarding mode. (Ref. figure in A 3.4)
Shutdown level	Signal latch included in the common signal path between a group of initiators and a group of flow elements.

3.3 Abbreviations

API	American Petroleum Institute
C&E	Cause & Effect
CCR	Central Control Room
ESD	Emergency Shutdown System
F&G	Fire & Gas
HIPPS	High Integrity Pressure Protection System
HMI	Human Machine Interface
HVAC	Heating, Ventilation and Air Condition
MCC	Motor Control Center
NPD	Norwegian Petroleum Directorate
P&ID	Piping & Instrument Diagram
PCS	Process Control System
PSD	Process Shutdown System
SAS	Safety and Automation System
SCD	System Control Diagram
VDU	Visual Display Unit

4 THE SCD APPROACH

4.1 Conceptual definition

The SCD concept returns to the basis of the P&ID, the process schematic. Information not required for the design of the control system is removed. The SCD shall focus on representing systems and functional relationships, not individual physical equipment.

The SCD combines all functional design requirements into a common unambiguous document and represents a top-down approach to the design of the system.

The process schematic includes a simplified representation of process lines and equipment. Instrumentation & control objects are represented by simplified symbols only.

The automation functions are represented by a limited number of high-level function templates. Each template represents a specific control philosophy selected for a class of objects. The control philosophy is defined/limited by a general range of attributes made available for the specific application. The application level is defined by using the applicable attributes.

Complex control and interlocking strategies are developed by inter-connecting templates. Additional logic and arithmetic functions may be used.

The SCD function templates are vendor independent, thus a set of SCDs may serve as a functional SAS specification, even before the system vendor is selected. The vendor on his side has an unambiguous basis for system bid and eventually implementation. Functional monitoring and control solutions may be reused from one plant development to the other, even if different control systems are used to implement the functions.

Because the SCDs can be developed in parallel with the P&IDs, introduction of the SCD approach facilitate a parallel development of both the physical and functional relationships visualised on dedicated documents. The approach encourage team work between different disciplines during the process development phases and the traditional artificial split between the development of physical and functional relationships may be eliminated. Thus enhanced overall quality is achievable.

4.2 Framework

The SCD standard represents an open standard in terms of operation & control philosophy. The standard is based on a basic core made up by function elements and terminology. The function elements are further combined into functional templates. These templates represent a level of standardisation intended for the system application design. Templates may be adapted and combined differently in order to represent various control strategies.

The standard is neither based on nor limited to any specific control system. A reduced number of attributes may thus be implemented in order to accomplish an optimised implementation for a specific control system. However, suppliers should consider an initial effort in order to implement the complete range of attributes for the templates defined within this standard.

The SCD approach has been developed with a view to industrial processes controlled by state-of-the-art process control systems, but as it provides a general process oriented approach for development of the documents, no field of application are explicitly excluded. However,

sequencing, global safeguarding functions as well as fire & gas functions are less suitable for the SCD representation as such. Please refer to the figure below.

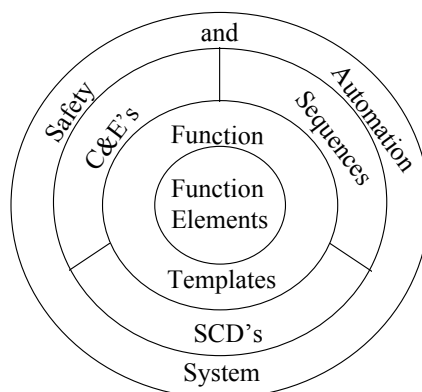


Figure 1, SCD Framework

Typical applications proven suitable for the SCD representation are the following:

- ☐ Control of process and utility systems
- ☐ Process Shutdown applications
- ☐ Package Control
- ☐ HVAC

A cause & effect representation will typically be used for fire & gas and emergency shutdown systems. Cause & effects may additionally be used for high level PSD levels in order to provide a complementary overview. However, the SCD should be defined master to ensure system consistency.

Sequence logic should be specified according to IEC 61131-3. The graphical language - Sequential Function Chart (SCF) should be used.

4.3 Life Cycle Concept

The SCD standard is intended to cover the complete life cycle of a process plant.

The System Control Diagram, where used, will form the single source of documentation for the Safety and Automation System control and shutdown strategies for all life cycle phases.

- ☐ Engineering
- ☐ Implementation
- ☐ Commissioning
- ☐ Operations
- ☐ Modifications

The objectives will be different within each phase. Annex C will provide an introductory overview of what the SCD Approach implies for the different life cycle phases. However, it is important to

emphasise that this standard is only intended to provide an overview of the standard as well as an initial starting point for inexperienced users.

4.4 Basic Design (Informative)

The Basic System Design is closely related to the overall engineering strategy for the SAS System focusing on the following main design activities:

- ☐ Basic System Design
- ☐ Basic Function Design
- ☐ Basic Application Design

Please refer to the figure below for an introductory overview.

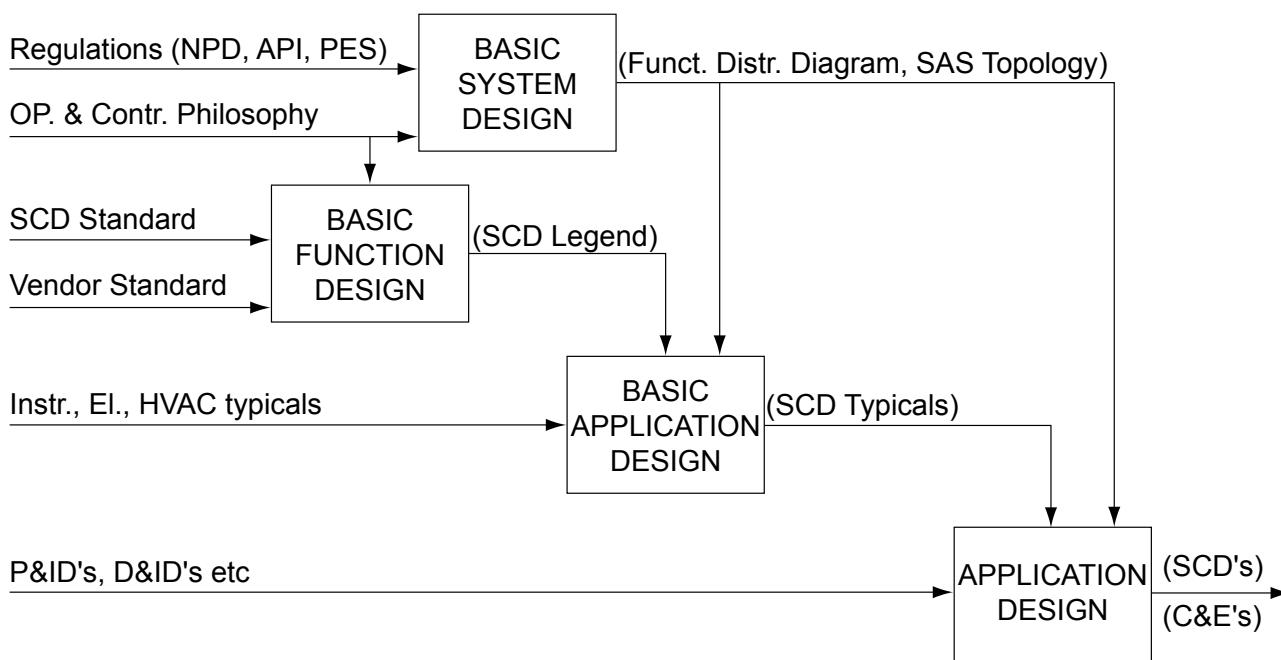


Figure 2, Basic Design

4.4.1 Basic System Design

The Basic System Design is a general control system design activity, but is closely allied to the SCD functional template development. Based on authority regulations as well as company operational & control philosophies the actual system distribution is developed. The system distribution defines the interface between the different types of field components and the control system in terms of sub-system connection.

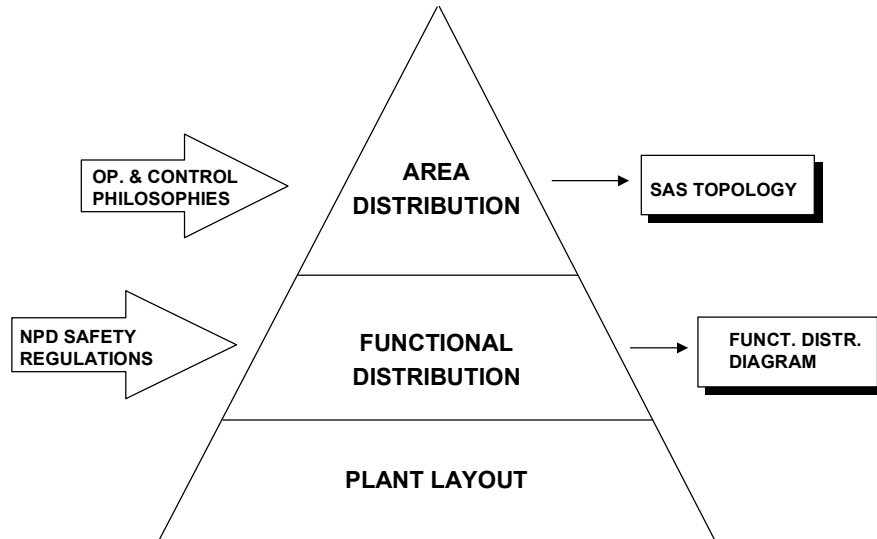


Figure 3, Basic System Design

4.4.2 Basic Function Design

The Basic Function Design should be based on a joint effort between the involved parties in order to achieve an optimized use of the supplier standard functionality. Each functional element should be referred to the corresponding supplier standard functions and combined into an optimal set of templates. It is important that the resulting templates are consistent with the general standard.

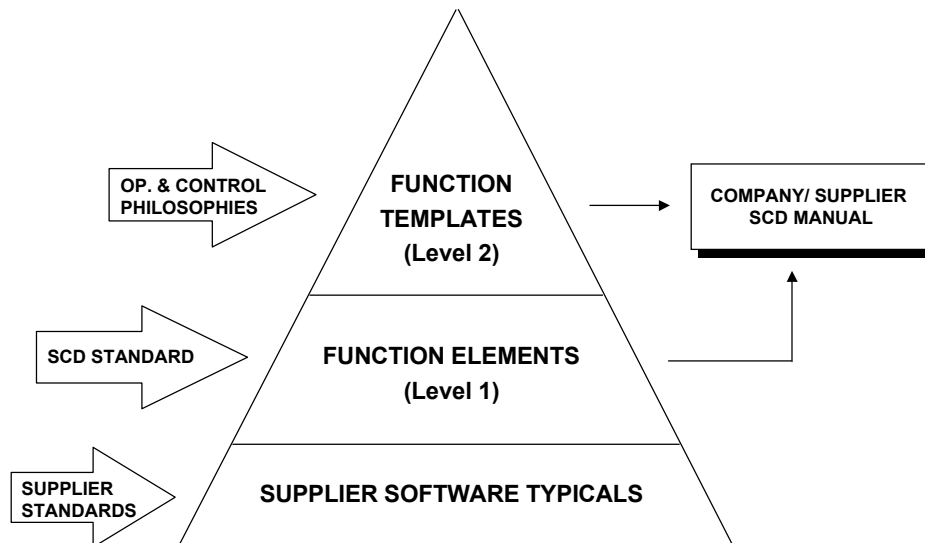


Figure 4, Basic Function Design

4.4.3 Basic Application Design

The Basic Application Design focuses on developing typical solutions that will form the basis for the development of the actual SCDs. The typical are developed on two levels.

- ☐ Object Typical
- ☐ SCD Applications

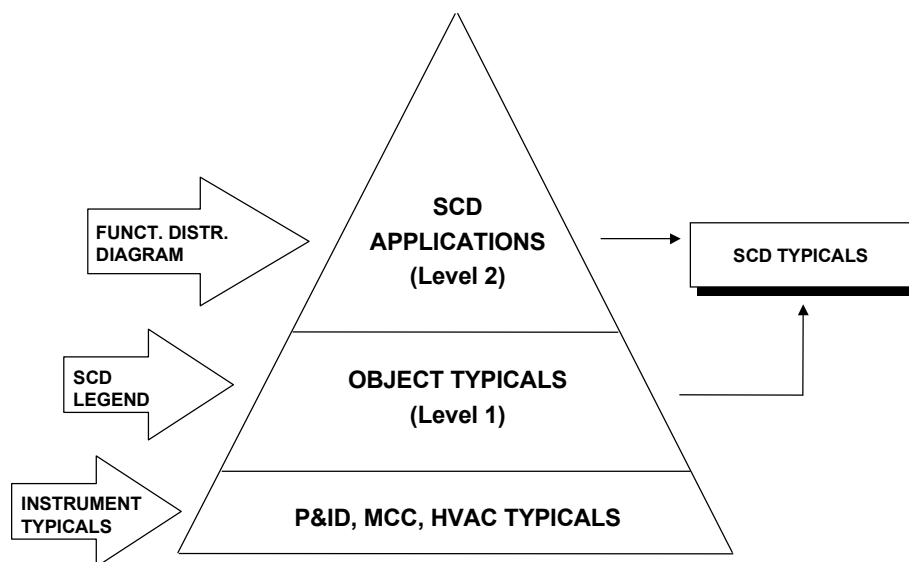


Figure 5, Basic Application Design, Application Typical

The purpose of the object typical is to reflect a typical signal interface for a specific control object as well as the functional operator interface. The main objectives are listed below.

- ☐ Verify the completeness of the function templates.
- ☐ Reduce the number of typical solutions.
- ☐ Improve the quality of the SCD Development.
- ☐ Standardised solutions.

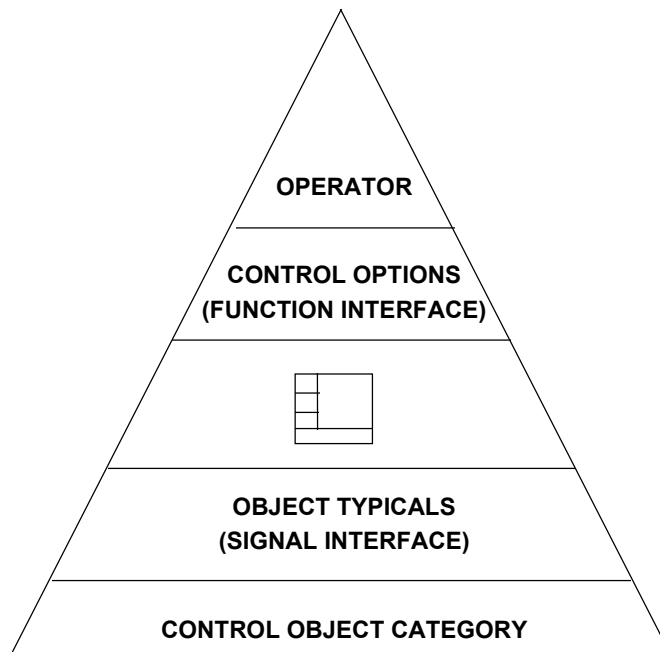


Figure 6, Object Typical

The purpose of the application typical is to reflect comprehensive application in order to reduce the number of different solutions as well as verify the completeness of the object typical.

4.4.4 Application Design

The SCDs should be jointly developed by the System Disciplines, driven by user requirements, not by technology/discipline organisation.

The SCDs should as far as possible be developed in parallel with the P&IDs. The application design may be represented by means of a traditional water-fall model.

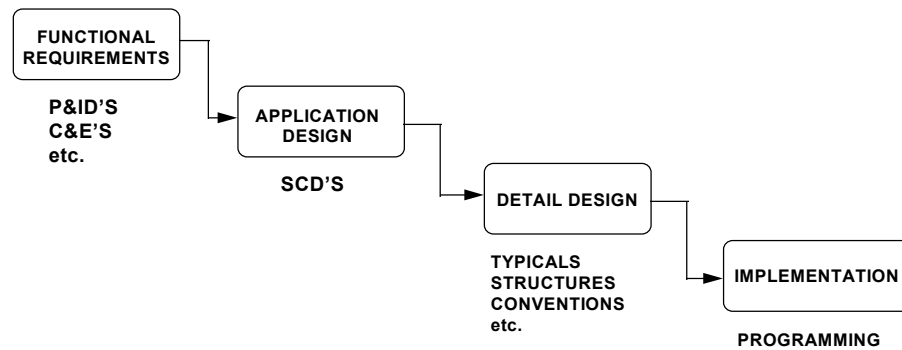


Figure 7, Application Design

Development of SCDs are made up of the following main steps:

- ☐ Establish process schematic and identify all control objects.
- ☐ Define applicable function templates.
- ☐ Develop basic interlocking strategies based on an overall interlocking hierarchy/philosophy.
- ☐ Develop automatic control strategies. (e.g. package start/stop, duty/standby, sequencing)
- ☐ Develop alarm strategies including automatic suppression of secondary alarms.

ANNEX A - SCD FUNCTION STANDARD (NORMATIVE)

A.1 Introduction

This annex contains a collection of definitions, explanations and descriptions of function templates, the main bricks for the SCD approach. It holds the legend of functional templates and their terminal names. Templates are normally implemented in the various control systems, employing special developed “Function Blocks” or by combining other properties built in the control system. This annex shall be considered to be normative.

It is permitted to reject terminals or introduce additional terminals on the templates to meet special requirements. However, the terminals that are included shall have the same functionality as described in this annex.

A.2 Terminal codes

A.2.1 Syntax

A.2.1.1 Standard

The general syntax for standard terminals is:

() = Has to be used

[] = Optional

A.2.2 Overview

Each function has defined input and output signals. Input denoted with X is acting on the output Y and/or on operator presentation as described by the main function tag. The template contains necessary monitoring functions to ensure that the most frequent faults regarding to the field object are detected and reported.

Each signal interconnecting two functions uses terminal codes for identification.

The codes are established from the following table. If numbers are used in the code, it shall always be considered to be a modifier to the proceeding letter (letter + number = one code).

Letter	1.Character	Succeeding characters
A	Action Alarm	Auto mode
B	Binary status	Blocked mode
C		Confirmed
D		Disabled transition mode
E		Enabled status
F	Force command	Fault / Failed
G		Position

Letter	1.Character	Succeeding characters
H		High
I		Internal set point mode
J		Not used
K		Not used
L	Lock command	Low
M		Manual mode
N		Not used
O		Outside mode
P		Priority allocation
Q		Quantity
R	Reset command	Reference signal
S	Set command	Safeguarding mode
T		Track mode
U		suppressed mode
V		Variance / Deviation
W	Warning alarm	Warning alarm
X	External input	External set-point mode. Note: Together with B as 1.st character - X= external
Y	Normal function output	Not used
Z		Not used
#		Number
%	User defined (to be shown on SCDs)	
&	Parameters (User & system dependent - not to be shown on SCDs)	

Only positive logic shall be used. This implies that a defined state of terminal is true when it is logical equal to ' 1 '.

A.2.3 Signal types (1.Character)

A.2.3.1 Inputs

X = External function Input

A.2.3.2 Commands

S = Set

R = Reset

F = Force

L = Lock

A.2.3.3 Outputs

Y	=	Normal function output (Related to main function of element)
A	=	Action Alarm
W	=	Warning alarm
B	=	Binary status

A.2.3.4 Special characters

%	=	User defined (To be shown on SCDs)
&	=	Parameters (User & system dependent, not shown on SCDs)

A.2.4 Explanatory code (Succeeding characters)**A.2.4.1 Modes**

A	=	Auto mode
B	=	Blocked mode
D	=	Disabled transition mode
I	=	Internal Set point mode
M	=	Manual mode
O	=	Outside mode (Locally - Field - operated)
S	=	Safeguarding mode
T	=	Track mode
U	=	Suppressed mode
X	=	External Set point mode

A.2.4.2 Signal Identifiers

C	=	Confirmed
E	=	Enabled status
F	=	Fault/Failed
G	=	Position
Q	=	Quantity
R	=	Reference
W	=	Warning
X	=	External

A.2.4.3 Sub functions

H	=	High
HH	=	High High
L	=	Low
LL	=	Low Low
V	=	Variance / deviation

A.2.5 Terminal description for function templates

Index of normative terminal codes used in this annex. New terminal codes shall be created to section 2.2.

Terminal Code	Signal Type	Terminal Name	Supplementary description
AHH	binary output	Action alarm High-High	True, when X-value >AHH limit
ALL	binary output	Action alarm Low-Low	True, when X-value <ALL limit
BA	binary output	Status auto/man. mode	True: auto , false: manual
BB	binary output	Status blocked mode	The function is in blocked mode (no action output). I.e. all safeguarding signals are blocked
BBHH	binary output	Action alarm High-High is blocked	
BBLL	binary output	Action alarm Low-Low is blocked	
BCH	binary output	Output position high confirmed	Output Y compared to feedback position high from MCC or limit switch and validated as true
BCL	binary output	Output position low confirmed	Output Y compared to feedback position Low from MCC or limit switch and validated as true
BG	analogue output	Binary status of position	Position of the valve-for use in downstream logic
BHH	binary output	Status alarm High-High	Status alarm annunciation (HH) without blocking logic
BLL	binary output	Status alarm Low-Low	Status alarm annunciation (LL) without blocking logic
BO	binary output	Status outside mode	The control function is in outside mode
BP1	integer output	Status priority 1	
BP1F	binary output	Priority 1 faulty	Start Priority 2 (For Standby logic)
BP2	integer output	Status priority 2	
BP2F	binary output	Priority 2 faulty	Start Priority 3 (For Standby logic)
BS	binary output	Status safeguarding mode	A shutdown signal of the process function is true
BT	binary output	Status tracking mode	In tracking mode as long as signal is true. Ex. Set point tracking.

Terminal Code	Signal Type	Terminal Name	Supplementary description
BU	binary output	Status suppressed mode	Process output function is suppressed. No action output and no alarm annunciation.
BX	binary output	Status external mode or function input	True: extern and false: intern or image of input.
BXH	binary output	Binary status High	True, when X-value > High limit. No Alarm annunciation, event only
BXHH	binary output	Binary status High-High	True, when X-value > High-High limit No Alarm annunciation, event only
BXL	binary output	Binary status Low	True, when X-value < Low limit No Alarm annunciation, event only
BXLL	binary output	Binary status Low-Low	True, when X-value < Low-Low limit No Alarm annunciation, event only
FB	binary input	Force blocked mode	Logic input: alarm action is blocked as long as input signal is true.
FBHH	binary input	Force blocked mode for alarm High-High	Logic input: alarm HH action is blocked as long as input signal is true.
FBL	binary input	Force blocked mode for alarm Low-Low.	Logic input: alarm LL action is blocked as long as input signal is true
FDH	binary input	Force disable transition high.	Permissive to start when false and prevents element to be started when true.
FDL	binary input	Force disable transition low.	Prevents element to be stopped.
FQ	binary input	Force totalizing	
FSH	binary input	Force safeguarding high	Shutdown – Signal overrules operator inputs (forcing the template Y-output high). After signal returns to normal, template will react to actual terminal status again. Signal is subject to blocking .
FSL	binary input	Force safeguarding low	Shutdown – Signal overrules operator inputs (forcing the template Y-output low). After signal returns to normal, template will react to actual terminal status again. Signal is subject to blocking.
FT	binary input	Force track mode	Track signal: XT-value
FU	binary input	Force suppression mode.	Logic input: alarm action and alarm annunciation is suppressed as long as input signal is true.
FUHH	binary input	Force suppression mode for alarm High-High.	Logic input: alarm HH action and annunciation is suppressed as long as input true.

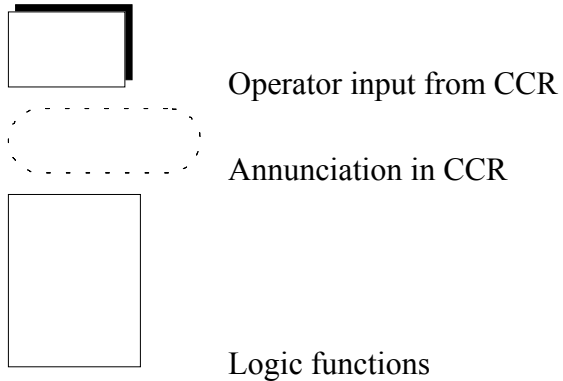
Terminal Code	Signal Type	Terminal Name	Supplementary description
FULL	binary input	Force suppression mode for alarm Low-Low.	Logic input: alarm LL action and annunciation is suppressed as long as input true.
FUWH	binary input	Force suppression mode for alarm WH	Logic input: alarm WH action and annunciation is suppressed as long as input true.
FUWL	binary input	Force suppression mode for alarm WL	Logic input: alarm WL action and annunciation is suppressed as long as input true
LA	binary input	Lock auto mode.	Locks the control function to auto mode, overruling the operator. After signal disappears, template keeps in auto mode.
LI	binary input	Lock internal set point mode.	Locks the logic to internal mode, overruling the operator. After signal disappears the logic keeps in internal set point operation mode.
LM	binary input	Lock manual mode.	Locks the logic to manual mode, overruling the operator. After signal disappears the logic keeps in manual mode.
LO	binary input	Lock outside operation mode.	Locks the logic to outside system operation mode, overruling the operator. After signal disappears the logic keeps in outside system operation mode.
LSH	binary input	Lock safeguarding high.	Shutdown - signal overrules operator inputs (locking the template to manual mode with Y-output to high -open valve-). Input is subject to blocking .
LSL	binary input	Lock safeguarding low .	Shutdown - signal overrules operator inputs (locking the template to manual mode with Y-output to low -stop motor-). Input is subject to blocking.
LX	binary input	Lock external set point mode.	Locks the logic function to external mode, overruling the operator. After signal disappears template keeps in external set point operation mode.
PFCT	Float point value	Factor used for calculation of flow	
PKF	Float point value	K-factor used for calculations of flow.	Defines the pressure drop across the orifice plates.

Terminal Code	Signal Type	Terminal Name	Supplementary description
PMOD	Integer value	Define formula to be used for flow calculation.	
RX	binary input	Reset latched output	
RXQ	binary input	Reset external totalizer	Logic signal to reset
SP1	binary input	Set priority 1	Set duty (prio.1) mode
SP2	binary input	Set priority 2	Set standby (prio.2) mode
WH	binary output	Warning alarm – High.	True, when X-value >WH limit
WL	binary output	Warning alarm – Low	True, when X-value <WL limit
WV	binary output	Warning deviation	
X	DI / AI	External function input	Binary or analogue input signal from process
X1-X4	DI / AI	External function input 1 to 4	Binary or analogue input signal from process
XE	binary input	Function <u>e</u> xternally enabled .	Electrical available used for electr. Equipment only
XEQ	binary input	External enable totalizing	Input to logic enable/disable totalizing
XF	binary input	External fault	Loop failure-i.e. input card broken.
XG	analogue input	Position read as measured value	Position read as measured value Logical deviations.
XGH	binary input	Position high feedback	Signal from MCC (running) or limit switch high.
XGL	binary input	Position low feedback	Signal from MCC (stopped) or limit switch low.
XOH	binary input (pulsed)	External outside set high	From process to control element. I.e. valve/ damper- in <u>outside mode</u> . Set high signal (positive edge) to open valve.
XOL	binary input (pulsed)	External outside set low	From process to control element. I.e. valve/ damper in <u>outside mode</u> . Set low signal (positive edge) to close valve.
XH	binary input	External set high	From process to control element. I.e. valve/ damper- in <u>auto mode</u> . Set high signal (open valve) only
XL	binary input	External set low	From process to control element. I.e. valve/ damper in <u>auto mode</u> . Set low signal (close valve) only

Terminal Code	Signal Type	Terminal Name	Supplementary description
XP1H	binary input (pulsed)	External priority 1 set high.	From logic or process to control element. I.e. motor- first priority in auto mode. Set high signal (start motor) only
XP1L	binary input (pulsed)	External priority 1 set low	From logic or process to control element. I.e. motor- first priority in auto mode. Set low signal (stop motor) only
XP2H	binary input (pulsed)	External priority 2 set high.	From logic or process to control element. I.e. motor-second priority in auto mode. Set high signal (start motor) only
XP2L	binary input (pulsed)	External priority set 1 low	From logic or process to control element. I.e. motor- second priority in auto mode. Set low signal (stop motor) only
XR	analogue input	External set point value	Used in external – auto – mode
XT	analogue input	Tracking value	Used in tracking mode
Y	binary output	Normal function output	Output status, which can be used in downstream logic
YF	binary output	Output function failed.	For use in downstream logic
YH	binary output (pulsed)	Pulsed normal function output high.	Output pulse to start big motors, which are operated with pulsed start/stop signals
YL	binary output (pulsed)	Pulsed normal function output low.	Output pulse to stop big motors, which are operated with pulsed start/stop signals
YR	analogue output	Reference set point value.	Set point to slave controller
YX	analogue output	Measured value output	

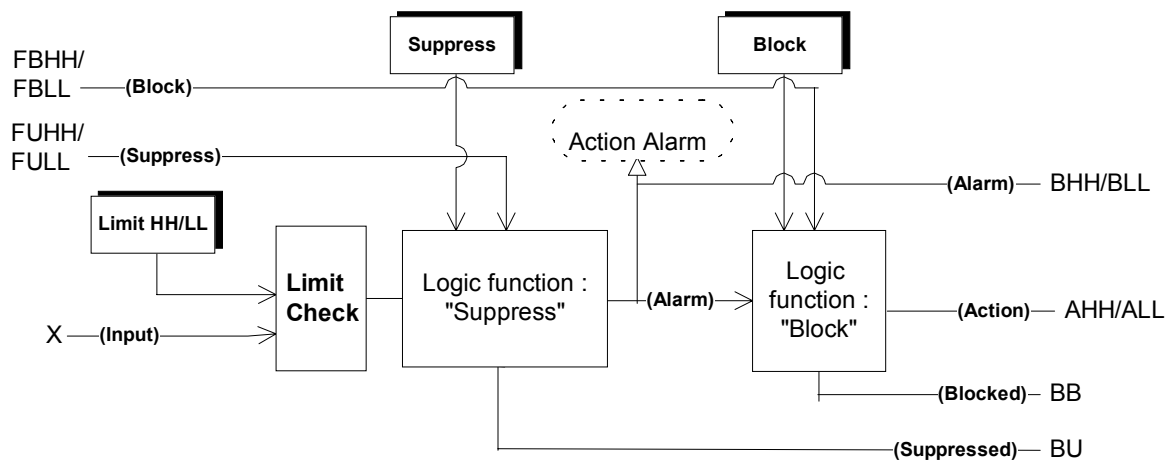
A.3 Block schematic representation of functions

A.3.1 Notation

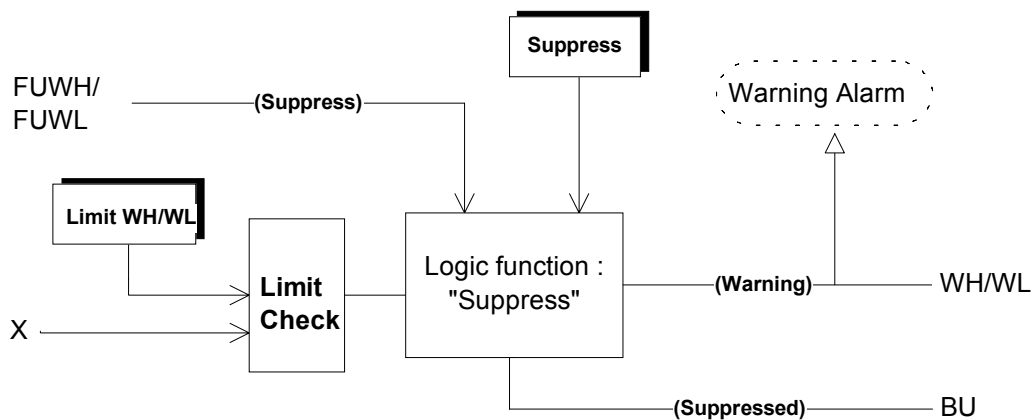


A.3.2 The notation of “Block and suppress” related to alarm function.

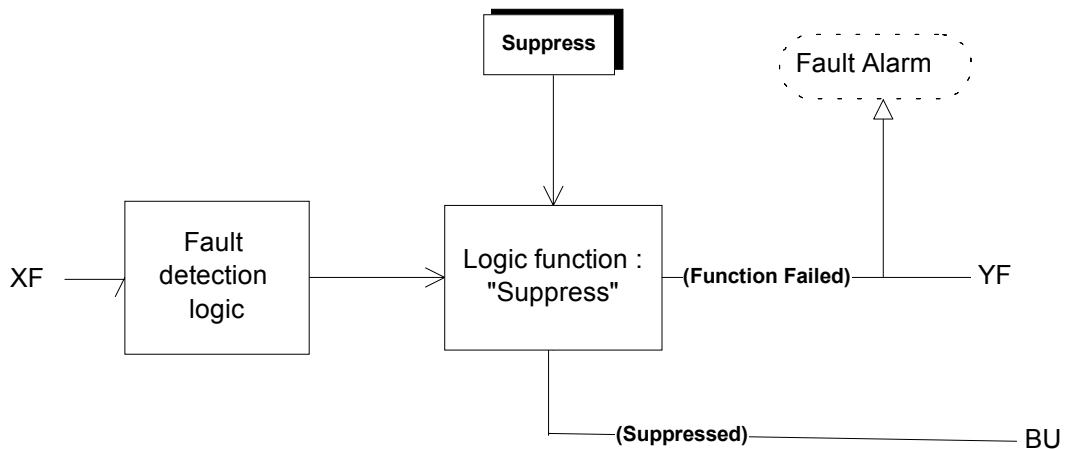
A.3.2.1 Action Alarm



A.3.2.2 Warning Alarm

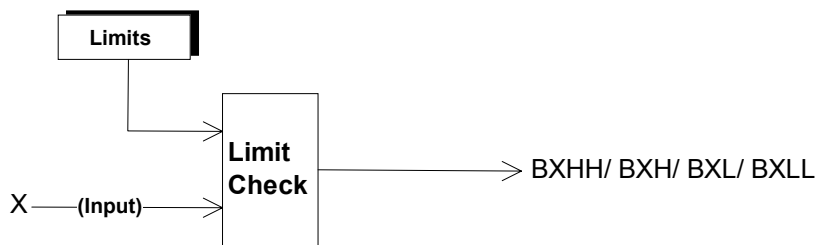


A.3.2.3 Fault Alarm



A.3.3 The notation of event functions

A.3.3.1 Event



Block

LSH/LSL

B

SA
SM
SO

LA
LM
LO

Auto/Manual/ Outside Ctrl.Mode state

Note 1

Operator Pos. select

Select manual mode

(Manual)

(Auto)

(Auto Input)

Select autol mode

Note 3

XH/XL

(Outside)

XOH/L

(Outside input)

Select outside mode

OR-Logic

Logic function : "Disable"

(Set H/L)

(Set low)

Note 2

FDH/FDL

B

(Force Disable)

Control Logic High/Low (position state)

Logic function: Force Safeguarding

Y

Note 1: Applicable for SBE and SBV
Note 2: Only applicable for SBE
Note 3: Ref. figure A for motors (SBE)

FSL/FSH

B

(Force Safeguarding)

FU

(Suppress)

XE

Suppress

Fault Alarm

XGH/XGL

(Position)

Compare Output vs. position feedback

Or Logic

Logic function : "Suppress"

(Action fault)

YF

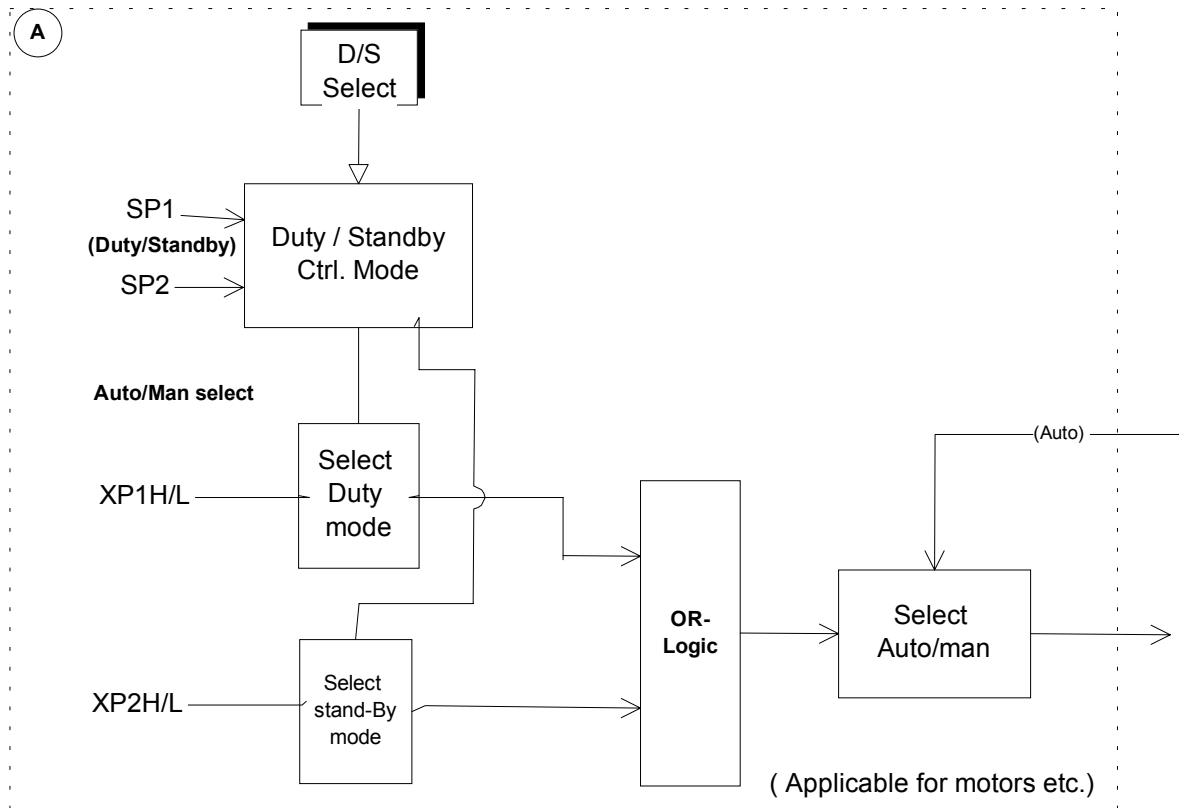
(Suppressed)

BU

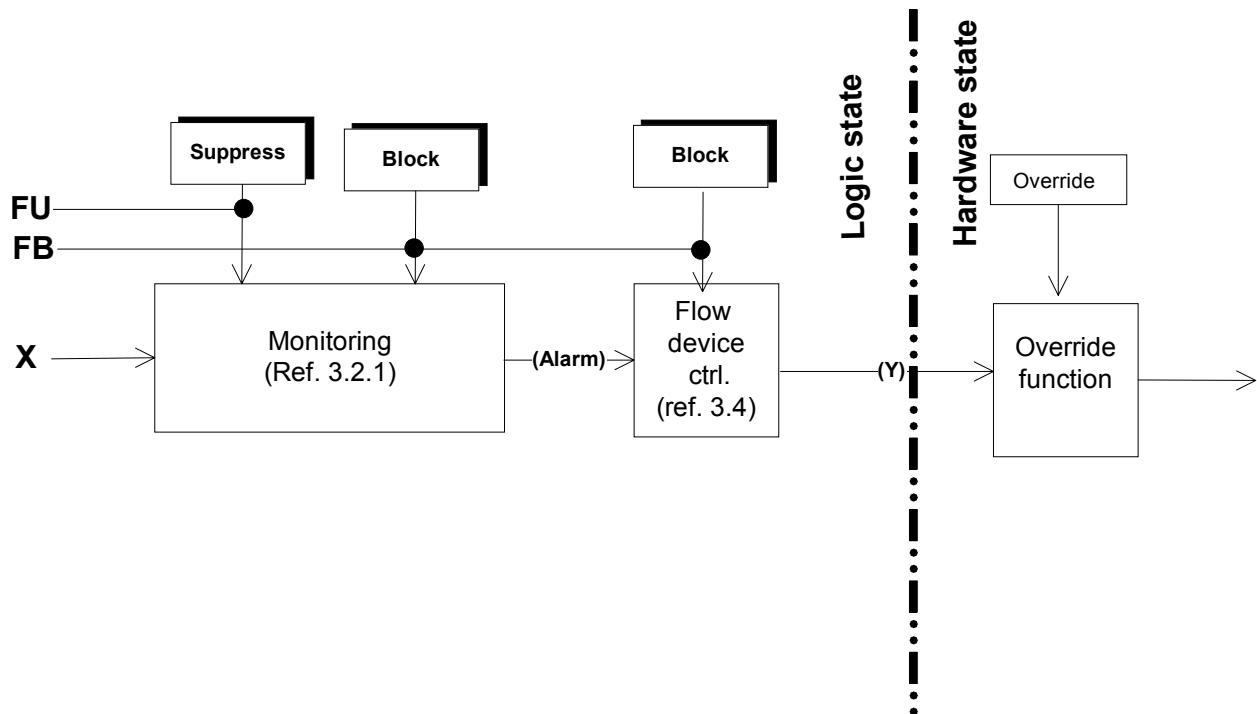
(Position Confirmed)

BCH/BCL

Duty / Standby selector logic principals for motors



A.3.5 Override



A.4 Function templates

A.4.1 Introduction

Function templates shall contain all necessary functions concerning an object with its interfaces towards the process, other function templates or logic and operator station. An object is considered to be a physical instrument or device with its related instrumentation for either measuring process variables or manipulating the state of the process.

All function templates in this specification are thus related to one object (one function symbol on the SCD). It is a requirement for a function template that it covers a complete function that can be represented by one symbol with its in- and out-puts to process, operator station and other logic. The interconnections between the function templates shall be recognisable within the automation system. Thus, a function template can be said to represent an object as defined above, on the SCD.

The SCDs represent a graphical documentation of the application software. The SCDs are the interface for process related users (process engineers, operators, etc.) and more instrumentation related users (instrument engineers, automation engineers, etc.).

The SCDs are a precise specification for the control system application and should be available on a magnetic medium. To generate the control system from the SCDs reduce possible errors, manually interpreting verbal specifications into control applications in software. An automatic generation of the control system to a certain degree (from an ideal point of view - 100%) will improve the efficiency and reduce the cost dramatically.

Additionally the SCDs can serve as a fault finding and debugging tool. The unified way of configuring with function templates, which are clearly defined before start of application configuration assures consistency in operation, alarm handling and indication of variables on the operator stations over the whole plant. All alarm handling features shall reside within the function templates. It shall have a function oriented approach towards the operator. The operator interface shall contribute to enable the operator to operate the process with a minimum number of shutdowns and hazardous situations and further achieve an increased optimisation of the process.

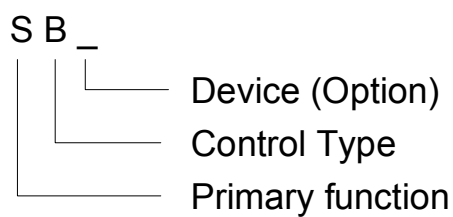
A.4.2 Function template name convention

Function templates shall be given a name (abbreviation) compound by minimum three-characters, identifying the main function of the software item.

The name syntax should be:

<Primary function> [by means of <Control type>] of <Device>

Example:



Letter	1.Character (Primary function)	2.Character (Control Type)	Succeeding characters (Device (optional use if required))
A		Analogue (Automatic Function)	
B		Binary (Automatic Function)	
C	Continuos Control		
D			
E			Electrically motor / heaters
F			
G			
H			
I			
J			
K	Sequencing		
L	Latching		
M	Monitoring		
N			
O			
P			
Q	Totalize		
R			
S	Switching Control	Step (Automatic Function)	
T			
U			
Letter	1.Character (Primary function)	2.Character (Control Type)	Succeeding characters (Device (optional use if required))
V			Valve / dampers
W			
X			
Y	Mathematical functions		
Z			
#			User defined

A.4.2.1 Primary function

- S - Switching Control
- C - Continuos Control
- L - Latching
- K - Sequencing
- Y - Mathematical functions
- Q - Totalize
- M - Monitoring

A.4.2.2 Control Type

- A - Analogue (Automatic Function)
- B - Binary (Automatic Function)
- S - Step (Automatic Function)

A.4.2.3 Device (optional use if required):

- E - Electrically motor / heaters (MCC)
- V - Valve / dampers
- # - User defined

A.4.2.4 Legend for naming function templates used in this annex.

Primary Function	Control Type	Device	Description
S	B	E	Switching control by means of a binary control action of El. power Devices.
C	B		Continuos control by means of a binary control action of El. power Devices.
S	B	V	Switching control by means of a binary control action of H/P power Devices (e.g. Valves)
C	A		Continuos control by means analogue control action
C	S		Continuos control by means step control action
M	A		Monitoring of Analogue Process Value
M	B		Monitoring of Binary Process Value
Q	A		Totallizing of Analogue Process Value
Y	A		Calculation of Analogue Process Value
L	B		Latching of Binary signal. I.e. PSD level block

A.4.3 Process variable Monitoring and Display

A.4.3.1 MB - Monitoring of Binary (Digital) Process Variables

A.4.3.1.1 Purpose

Function template intended for automatic monitoring (alarming), display and storage of binary process variable.

A.4.3.1.2 Requirements

The template includes alarm suppression and blocking functions. Additionally there shall be the possibility to adjust to input signals "Normal energised/Normal de energised" via a parameter. The type of annunciation as well as the alarm priority assigned shall be incorporated according to system vendor standards.

A.4.3.1.3 Function Template Schematic

<u>Inputs</u>	MB		<u>Outputs</u>
Normal function input	X	Y	Normal function output
External fault	XF	YF	Alarm Function failed
Reset latched output	RX		
<u>Operator Station:</u>			<u>Operator Station:</u>
Blocking on			Blocked status
Blocking off			Suppressed status
Suppression on			Alarm annunciation
Suppression off			
<u>Logic:</u>			<u>Logic:</u>
Force block mode	FB	BB	Status Blocked mode
Force suppression mode	FU	BU	Status suppressed mode
		BX	Status function input

Parameters:

Reference to vendor documentation

A.4.3.2 MA - Monitoring of Analogue Process Variables.**A.4.3.2.1 Purpose**

Function template for calculation, display (indication), automatic monitoring (alarming) and storage of process variable or control variable. The template comprises handling of field instrument and signaling faults.

A.4.3.2.2 Requirements

The template includes suppress and blocking functions. Suppression from operator station includes all alarm and fault outputs, whilst by logic it is possible to suppress individual alarm outputs. Faults cannot be suppressed by logic input. All limit checking and alarm annunciation resides within the template.

The parameter-values for the warning levels shall be adjustable from the operator-station. Hysteresis will be defined in % of maximum range and common for all limits given by parameter inputs. Additional status outputs shall be provided for limit checking without alarm annunciation (Event-handling).

Features for square-root extraction with a factor multiplied (measurements of flow by means of an orifice plate) and features for smoothing (low pass filtering) of the analogue input signal are not included. These shall be realised in auxiliary function template and only be used where applicable.

A separate function template (QA) will handle totalizing. Trending will be defined on HMI level.

A.4.3.2.3 Function Template Schematic

<u>Inputs</u>	MA		<u>Outputs</u>
Normal function input External fault	X XF	Y YF	Normal Function output Function failed
<u>Operator Station:</u> Block HH on Block HH of Block LL on Block LL off Suppression on Suppression off			<u>Operator Station:</u> Blocked states Suppression states Alarm annunciation Alarms, warnings and faults
<u>Logic:</u> Force block alarm HH Force block alarm LL Force suppress alarm HH Force suppress alarm WH Force suppress alarm WL Force suppress alarm LL	FBHH FBLL FUHH FUWH FUWL FULL	AHH BHH WH WL ALL BLL BBHH BBLL BU BB BXHH BXH BXL BXLL	<u>Logic:</u> Action alarm HH Status alarm HH Warning alarm High Warning alarm Low Action alarm LL Status alarm LL Action alarm HH is blocked Action alarm LL is blocked Block suppression mode Status Blocked mode Binary status HH (event) Binary status H (event) Binary status L (event) Binary status LL (event)

Parameters:

Reference to vendor documentation

A.4.4 Flow element Monitoring and Binary Control

A.4.4.1 SBE - Controls of Motors (Electrical Equipment)

A.4.4.1.1 Purpose

Function template for binary (on/off) control of a measured process variable by means of changing flow of medium (electricity, heat or fluid).

The function template shall be applied for all binary control of flow elements such as motors, pumps, heaters, fans etc.

A.4.4.1.2 Requirements – Control options

The function template can be configured to operate with several modes according to the type of application. These modes are fixed during run-time, but selected when structuring the control logic and thus called control options. The configured mode of the flow element is defining the principles of operation and is not depending on the actual state of the process the flow element is serving.

The control options allow for operation in both manual mode and auto mode. These operational modes are sub-modes to the selected configured option and may further be changed during run-time.

The control options can be defined by a parameter within the template or for some automation systems also defined as different template within a family of SBE - template. The following control options shall be made available:

Option 1: Outside Automation System Controlled (CCR indication only)

Flow element (motor) is locally controlled. Status will generally be indicated based on feedback signal (running -position high-) from the MCC. If the actual control output to the flow element is wired through the automation system based on inputs from a outside (local) control function, but no operator control is allowed due to operational reasons, this option shall be used. The flow element will not be operable from the HMI system. This shall be reflected by the indication on the operator stations.

Option 2: Manual Operation only (from HMI in CCR)

Flow element is manually switched to high or low flow (On/Off) by the operator in the CCR. The flow element will additionally be subject to safeguarding (shutdown) or interlock functions overruling the operator input. These are acting through the SMB template by means of the input terminals on the function template.

Option 3: Manual Operation + Automatic Control

The flow element is automatically operated by means of external input commands. External used in this context means that the binary control signal is generated outside the loop, in software or hardware.

This configuration allows for operation in both manual and automatic mode. When switched to automatic by the operator the external inputs (X-terminals) will maneuver the flow element. When switched to manual mode, the last output position will be maintained until operator's input (i.e. when it was running it keeps running).

To use minimum amount of terminals a stand-alone SBE function template is always considered to be in priority 1 (default value). The function template allows for automatic operation by means of control inputs (XP1H/XP1L-pulsed inputs- used as set priority 1 to High / set priority 1 to Low, Y output will be following if in auto and priority 1).

Option 4: Duty/Standby operation

Intended for automatic supervision of flow machines operating in parallel to increase the system availability. The operator shall be able to select priority function. One flow machine will be assigned duty (priority 1) and will thus normally be in operation. The other one is assigned standby (priority 2) and will automatically be put in operation if duty fails. Both flow machines will have to be selected auto to obtain automatic duty/standby function. Duty generates start command to standby if:

- Duty in auto mode and running and priority 1 and
- (Fails to operate (YF = true) or
- (Safeguarding mode and not blocked) or
- (Not enabled (XE = false) and not suppressed)

Standby starts if:

- Standby in auto mode and not running and
- Priority 2 selected and
- Transition to high not disabled (Start permission)

Automatic duty/standby function will be obtained by system vendor standards and is thus not further specified. This function should however preferable reside within the function template.

A.4.4.1.3 General requirements:

Disable transition facilities shall be provided within the function template to prevent manual and automatic binary control. Suppressing and blocking possibilities shall also be include.

Coincidence status on requested safeguarding actions when blocking / suppression is true shall be implemented. The symbols used on VDUs shall always show true position / status of the motor.

A.4.4.1.4 Function Template Schematic

<u>Inputs</u>	SBE		<u>Outputs</u>
Pos. High feedback (MCC)	XGH	Y	Normal function output
External fault	XF	YF	Alarm Function failed
Function externally enabled (MCC)	XE	YH	Pulsed normal function output High
External priority 1 Set High	XP1H	YL	Pulsed normal function output Low
External priority 1 Set Low	XP1L	BCH	Output position High Confirmed
External priority 2 Set High	XP2H	BCL	Output position Low Confirmed
External priority 2 Set Low	XP2L		
External outside set High	XOH		
External outside set Low	XOL		
<u>Operator Station:</u>			<u>Operator Station:</u>
Select Auto mode			Fault annunciation
Select Man. mode			Status ON/OFF
Select outside			Auto / manual / Outside
Select On (high)			Status Blocked
Select off (low)			Status Suppressed
Blocking on			Status Disabled
Blocking off			Status Safeguard
Suppression on			Coincidence state
Suppression off			
<u>Logic:</u>			<u>Logic:</u>
Lock safeguarding Low	LSL	BA	Status Auto/Man mode
Force Safeguarding Low	FSL	BO	Status Outside mode
Force Disable transition High	FDH	BP1	Status Priority 1
Force Disable transition Low	FDL	BP2	Status Priority 2
Force suppression mode	FU	BS	Status Safeguarding mode
Force block mode	FB	BB	Status Blocked mode
Lock Auto mode	LA	BU	Status suppressed mode
Lock Manual mode	LM	BP1F	Priority 1 faulty
Lock Outside operation mode	LO	BP2F	Priority 2 faulty
Set priority 1 – Duty	SP1		
Set priority 2 – Standby	SP2		

Parameters: Reference to vendor documentation

A.4.4.2 SBV - Control of Valves (Pneumatic/Hydraulic Equipment)

A.4.4.2.1 Purpose

Function template for binary (on/off) control of a flow element by means of changing flow of medium (heat or fluid).

The function template will be applied for binary control (open/close flow elements) such as valves, dampers etc.

A.4.4.2.2 Requirements - Control options

The function template can be configured to operate with several options according to the type of application. These options are fixed during run-time, but selected when structuring the control logic and thus called control options. The configured option of the flow element is defining the principles of operation and is not depending on the actual state of the process the flow element is serving.

The configured option allows for operation in both manual mode and auto mode. These operational modes are sub-modes to the selected configured mode and may further be changed during run-time.

The control options can be defined by a parameter within the template or for some automation systems also defined as different template within a family of SBV-template. The following modes shall be made available:

Option 1: Outside Automation System Controlled (CCR indication only)

Flow element (valve) is locally controlled. Status will generally be indicated based on feedback from limit-switches ("No limit-switches" feedback configuration mode 1, cannot be applied in this case!). See next page.

If the actual control output to the flow element is wired through the automation system based on inputs from a outside (local) control function, but no operator control is allowed due to operational reasons, this option shall also be used. The flow element will not be operable from the VDUs. This shall be reflected in the indication on the operator stations.

Option 2: Manual Operation only (from VDU in CCR)

The operator in CCR manually switches flow element to high or low flow (Open/Close). The flow element will additionally be subject to safeguarding (shutdown) or interlock functions overruling operators input. These are acting through the SBV template by means of the input terminals on the function template.

Option 3: Manual Operation + Automatic Control.

The flow element is automatically operated by means of external input commands. External used in this context means that the binary control signal is generated outside the function template, in software or hardware. This configuration allows for operation in both manual and automatic mode. When switched to automatic by the operator the external inputs (X-terminals) will maneuver the flow element. When switched to manual mode, the last output position will be latched until operators input (i.e. when it was running, it keeps running). The function template allows for automatic operation by means of control inputs (XH/XL-pulsed inputs- used as set to High / set to Low, Y output will be following if in auto mode)

Duty/standby configurations for valves are not used. But there is another configuration mode for the SBV-function template, which is the feedback limit-switch constellation. A parameter shall define the four possible constellations:

Feedback option 1: No limit-switches

The position of the element (valve/damper) is derived from the output of the function template and shown on the operator station. (for this mode the confirmed outputs are not relevant)

Feedback option 2: Position high limit-switch feedback only

The position of the element (valve/damper) is taken from the high limit switch only (i.e. if not open, it is assumed to be closed)

Feedback option 3: Position low limit-switch feedback only

As in 2, relying on the low switch (i.e. if not closed, it is assumed to be open)

Feedback option 4: Position high and low limit switches feedback

The position of the element is calculated out of the position of both limit switches. End positions as well as “moving” status can be shown on the operator stations.

A.4.4.2.3 General Requirements

Feedback from the valve/damper is monitored according to the feedback limit-switch constellation and compared to the output state (Y) of the element.

If mismatch is detected, a fault alarm shall be generated. An additional alarm delay function has to be incorporated to allow for a certain delay in change of state. Disable transition facilities shall be provided within the function template to prevent manual and automatic binary control.

Suppressing and blocking possibilities shall be also implemented into the template. Coincidence status on requested safeguarding actions when blocking / suppression is true shall be implemented. The symbols used on VDUs shall always show true position / status of the valve.

A.4.4.2.4 Function Template Schematic

<u>Inputs</u>	SBV		<u>Outputs</u>
Position High feedback	XGH	Y	Normal function output
Position Low feedback	XGL	YF	Alarm Function failed
External fault	XF	BCH	Output Position High Confirmed
External set high	XH	BCL	Output Position Low Confirmed
External set low	XL		
External outside set high	XOH		
External outside set low	XOL		
<u>Operator Station:</u>			<u>Operator Station:</u>
Select Auto mode			Fault annunciation
Select Man. mode			Status Open/Closed
Select outside			Auto / manual / Outside
Select Open (high)			Status Blocked
Select Closed (low)			Status Suppressed
Blocking on			Status Disabled
Blocking off			Status Safeguard
Suppression on			Coincidence state
Suppression off			
<u>Logic:</u>			<u>Logic:</u>
Lock Safeguarding H	LSH	BA	Status Auto/Man mode
Lock safeguarding L	LSL	BO	Status Outside mode
Force Safeguarding H	FSH	BS	Status Safeguarding mode
Force Safeguarding L	FSL	BB	Status Blocked mode
Force Disable transition H	FDH	BU	Status suppressed mode
Force Disable transition L	FDL		
Force suppress mode	FU		
Force block mode	FB		
Lock Auto mode	LA		
Lock Manual mode	LM		
Lock Outside operation mode	LO		

Parameters: Reference to vendor documentation

A.4.4.3 CB - Binary Control (Analogue Input - Binary Output)

A.4.4.3.1 Purpose

Function template for binary (on/off) control of a measured analogue process variable by means of changing flow of medium (electricity, heat or fluid).

The function template shall be applied for all binary control of flow elements such as motors, pumps, heaters, fans etc.

A.4.4.3.2 Requirements - Control options

The function template can be configured to operate with several options according to the type of application. These options are fixed during run-time, but selected when structuring the control logic and thus called control options. The configured option of the flow element is defining the principles of operation and is not depending on the actual state of the process the flow element is serving.

The control options allow for operation in both manual mode and auto mode. These operational modes are sub-modes to the selected configured mode and may further be changed during run-time. The control options can be defined by a parameter within the template or for some automation systems also defined as different template within a family of CB - template. The following control options shall be made available:

Option 1: Manual Operation only (from VDU in CCR)

Flow element is manually switched to high or low flow by the operator. The flow element will additionally be subject to safeguarding (shutdown) or interlock functions overruling the operator input. These are acting through the CB - template by means of the input terminals on the function template.

Option 2: Manual Operation + Automatic Control

The flow element is automatically operated by means of external input commands. External used in this context means that the analogue value is read and checked against the parameterised limit value. If the input value is higher than the high limit value, the output is set to one. There is a hysteresis defined, which prevents flickering output setting when the input value decreases beneath the limit. It is valid vice versa for the low limit. When switched to automatic by the operator the external inputs (X-terminals) will maneuver the flow element. When switched to manual mode, the last output position will be latched until operators input (i.e. when high, it will keep output high).

A.4.4.3.3 General Requirements

Disable transition facilities shall be provided within the function template to prevent manual and automatic binary control. Suppressing and blocking possibilities including coincidence status generation shall be also implemented.

A.4.4.3.4 Function Template Schematic

<u>Inputs</u>	CB		<u>Outputs</u>
Normal Function input	X	Y	Normal function output
Position High feedback	XGH	YF	Alarm Function failed
Position Low feedback	XGL	BCH	Output Position High Confirmed
External fault	XF	BCL	Output Position Low Confirmed
Function externally	XE		
Enabled (MCC)			
<u>Operator Station:</u>			<u>Operator Station:</u>
Select Auto mode			Fault annunciation
Select Man. mode			Status ON/OFF
Select On (high)			Auto / manual
Select off (low)			Status Blocked
Blocking on			Status Suppressed
Blocking off			Status Disabled
Suppression on			Status Safeguard
Suppression off			Coincidence state
<u>Logic:</u>			<u>Logic:</u>
Lock Safeguarding H	LSH	BA	Status Auto/Man mode
Lock safeguarding L	LSL	BS	Status Safeguarding mode
Force Safeguarding H	FSH	BB	Status Blocked mode
Force Safeguarding L	FSL	BU	Status suppressed mode
Force Disable transition H	FDH	BXH	Binary Status High
Force Disable transition L	FDL	BXL	Binary Status Low
Force suppression mode	FU	WH	Warning alarm high
Force blocked mode	FB	WL	Warning alarm low
Lock Auto mode	LA		
Lock Manual mode	LM		

Parameters:

Reference to vendor documentation

A.4.5 Modulating control

A.4.5.1 CA - Modulating Control (PID Controller)

A.4.5.1.1 Purpose

Function template for modulating control. Vendor standard PID controller template shall be used. The following features shall be provided. If not included, building a macro containing these additional features to the vendor standards shall be included.

A.4.5.1.2 Requirements

The controller can be operated in either manual, automatic internal or external mode. The operational modes appear eligible on the operator station. The controller can be forced to different modes by logic inputs.

Signal conditioning such as square-root extraction and smoothing (low pass filter) of analogue signal shall not be included into this template. These functions shall be used if applicable only and thus be realised in auxiliary function template. The CA template generates a fault alarm (monitoring of the analogue variable, feedback supervision), a coincidence alarm and a deviation warning. The deviation is calculated by subtracting the measured value from the set point. It is monitored and a warning will be enunciated on the operator station, if the deviation is outside working area.

Controller output

Function output will normally be within the range of 0-100 %. However, other output ranges may be applied for cascading via parameters.

The controller can be switched to output tracking mode by input FT. The output value Y will then be clamped to the input XT, output tracking value.

Set point

The set point shall be either internal or external. Another controller or other values generate external set point (XR) is used when operated in cascade mode and the set point. External may additionally be used for automatic setting of set point for automatic restart purposes. The operator gives internal set point.

The internal set point shall be clamped to the measured value in manual mode to assure a bumpless transfer from manual to automatic mode (set point tracking whilst in manual mode). The last set point used in auto mode is stored and displayed as a reference set point. The reference set point is shown on the operator station only and may be changed in manual mode by operating the set point value.

When switched to auto by the operator, the operator can manually adjust the set point to accomplish a bumpless transfer to the decided reference set point. When forced to auto by external logic, the set point shall automatically by step-by-step changed back to the original reference set point, if the measured process value has changed. The rise of the ramp is defined by an input parameter.

External/internal set point mode appears eligible on the operator station. The controller can be locked to external mode as well as to internal mode.

Other required features

A possibility to differ in between direct acting (increasing control deviation to give an increasing output) and indirect acting (increasing measured value to give an decreasing output) has to be provided. Fail-to-open and fail-to-closed functions are to be obtained.

It shall further be possible to adjust the PID controller parameters such that the controller acts either as a P controller, as a PI controller or with a PID algorithm. The controller parameters shall be indicated on the operator station and easily be changeable. If operable from operator station, they ought to be keyword protected. A feedback from the controller valve position low (XGL) can be monitored and compared with the Output State. If mismatch is detected, a fault alarm shall be generated.

However, to allow for a certain delay in change of state a parameter must be applied to adjust delay time. The function template shall also provide blocking and suppression facilities with the necessary additional features (coincidence status).

A.4.5.1.3 Function Template Schematic

<u>Inputs</u>	CA		<u>Outputs</u>
Normal function input	X	Y	Normal function output
External fault	XF	YF	Function failed
External Set point value	XR	YR	Reference Set point value
Tracking value	XT	YX	Measured value output (X)
Position low feedback	XGL		
<u>Operator Station:</u>			<u>Operator Station:</u>
Select Auto mode			Alarm/Fault Annunciation
Select Man. mode			Status Low- Closed
Select Internal			Auto / manual
Select External			Internal / External
Set Setpoint			Status Blocked
Set Output			Status Suppressed
Blocking on			Status Track mode
Blocking off			Status Safeguard
Suppression on			Coincidence state
Suppression off			
<u>Logic:</u>			<u>Logic:</u>
Lock Safeguarding H	LSH	WV	Warning Deviation
Lock safeguarding L	LSL	BA	Status Auto/Man mode
Force Safeguarding H	FSH	BX	Status External/Internal mode
Force Safeguarding L	FSL	BS	Status Safeguarding mode
Force Track mode	FT	BB	Status Blocked mode
Force suppression mode	FU	BU	Status suppressed mode
Force blocked mode	FB	BT	Status Tracking mode
Lock Auto mode	LA	WH	Warning Alarm High
Lock Manual mode	LM	WL	Warning Alarm Low
Lock External set-point mode	LX		
Lock Internal set-point mode	LI		

Parameters:

Reference to vendor documentation

A.4.5.2 CS - Step Control Template

A.4.5.2.1 Purpose

Function template for typical control and monitoring of choke valves. The choke valves are operated by either pulsed or steady output signals. One output for opening and one for closing the valve.

A.4.5.2.2 Requirements

The function template can be operated in either manual, auto mode. In manual mode the operator can maneuver the valve step by step to either open or closed position. Alternatively the operator can enter a set point for position (internal mode) and switch to auto mode. The valve will then automatically travel to set point position. Finally the function template can be operated in external mode, utilising the input terminal XR for external set point.

Disable transition facilities shall be provided within the function template to prevent manual and automatic sequencing binary control, as well as automatic closed loop (modulating) control actions.

Maximum allowed deviation between set point and position feedback is given by parameter input. If outside limits, a warning shall be generated.

Position feedback from flow element (XGL) will be compared with the position read ($XG < 1\%$) and initiate a function failed alarm if mismatch is detected.

Function failed alarm (fault alarm) shall be announced on the operator station.

Function failed status shall further be made available on the output terminal YF.

The following actions will be taken:

- Generate fault alarm and set output YF
- Switch to manual mode if in auto mode
- Position retained
- Externally generated faults may be connected to the template. These will only be enunciated.
- Safeguarding, blocking and inhibiting functions shall be incorporated into the template as for SBE, SB and CA.

A.4.5.2.3 Function Template Schematic

<u>Inputs</u>	CS		<u>Outputs</u>
Position Read as measured value	XG	YH	Pulsed normal function output high
External fault	XF	YL	Pulsed normal function output high low
External Set point value	XR	YF	Function failed
Position low feedback	XGL	BCL	Output Position Low Confirmed
		BG	Position status of position
<u>Operator Station:</u>			<u>Operator Station:</u>
Select Auto mode			Alarm/Fault Annunciation
Select Man. mode			Status Low- Closed
Select Internal			Auto / manual
Select External			Internal / External
Set Step Open			Status Blocked
Set Step Close			Status Suppressed
Set Step point			Status Safeguard
Blocking on			Status Moving
Blocking off			Coincidence state
Suppression on			
Suppression off			
<u>Logic:</u>			<u>Logic:</u>
Lock safeguarding L	LSL	WV	Warning Deviation
Force Disable transition H	FDH	BA	Status Auto/Man mode
Force suppression mode	FU	BX	Status External/Internal mode
Force blocked mode	FB	BS	Status Safeguarding mode
Lock Auto mode	LA	BB	Status Blocked mode
Lock Manual mode	LM	BU	Status suppressed mode
Lock External set point mode	LX		
Lock Internal set point mode	LI		

Parameters: Reference to vendor documentation

A.4.6 Co-ordination Function Template

A.4.6.1 QA - Totalizer Template

A.4.6.1.1 Purpose

Function template for accumulation of process values based on time intervals.

A.4.6.1.2 Requirements

A scale factor is determined by comparison of engineering units for function input and outputs, and shall be routed into the template via an input parameter.

Overflow of counter shall result in function failed (YF).

The automatic monitoring comprises limit checking on HH action alarms as well as H warnings and a status high without any alarm/warning annunciation.

Totalizing on/off

The totalizing function can be started and stopped by the operator. The totalizing can be enabled and disabled from logic by means of the input XEQ. If disabled or stopped the output value will be frozen until started again and XEQ is set. When input FQ is set from logic, the totalizer is forced to count unless X (Analogue variable) lower than 0, XEQ = false, or external fault is set (XF = 1).

The totalizer can be reset by the operator as well as from logic input, but only as long as the function template is enabled.

A.4.6.1.3 Function Template Schematic

<u>Inputs</u>	QA		<u>Outputs</u>
Normal function input	X	Y1	Previous total
External fault	XF	Y2	Current total
External enabling	XEQ	YF	Function failed
totalizing			
Reset external totalizing	RXQ		
<u>Operator Station:</u>			<u>Operator Station:</u>
Set Totalizer on			Blocked states
Set Totalizer off			Suppression states
Reset Totalizer			Alarm annunciation
Block HH on			Alarms, warnings and faults
Block HH off			On / Off
Suppression on			
Suppression off			
<u>Logic:</u>			<u>Logic:</u>
Force Totalizing	FQ	AHH	Action alarm HH
Force block mode alarm	FBHH	BHH	Status alarm HH
HH			
Force suppression mode	FUHH	WH	Warning alarm H
alarm HH			
Force suppression mode	FUWH	BBHH	Action alarm HH is blocked
alarm WH			
		BU	Status suppressed mode
		BXH	Binary status H (event)

Parameters: Reference to vendor documentation

A.4.6.2 YA - Process Input Calculation Template

A.4.6.2.1 Purpose

Function template for execution of simple signal as well as control variable processing.

A.4.6.2.2 Requirements

The template shall comprise the following features:

- Ratio calculation

The ratio between two analogue values is calculated and multiplied with a constant parameter.

Algorithm :

If (X2 = 0) then YF := 1 ; Divide by zero. else Y := (X1 / X2) * PFCT ; Calculate ratio. end
--

- Flow calculation based on density

Actual volumetric flow (m³/h) of gas or liquid is calculated based on density.

Algorithm :

Y = PFCT * SQRT(X1 / X2)

Where :

PFCT = Measuring constant given by the pressure

X1 = Diff. pressure transmitter signal (Bar).

X2 = Density transmitter signal (kg/m³).

- Flow calculation based on pressure (Bara) and temperature

Actual volumetric flow (m³/h) of gas or liquid is calculated based on temperature and absolute pressure.

Algorithm :

$$Y = PFCT * \text{SQRT}((X1 * (X3 + 273.15)) / (X2 + 1.01325) * MW)$$

Where :

PFCT = Measuring constant given by the pressure drop across the actual orifice plate.

X1 = Diff. pressure transmitter signal (Bar).

X3 = Temperature (Celsius).

X2 = Pressure (Barg).

MW = molweight entered by operator.

Note: Temperature is converted to Kelvin and pressure is converted to Bara within the block. Input to be given in degrees.

- Flow calculation based on pressure, temperature and density

Standardised flow (Sm³/h) of gas or liquid is calculated based on temperature, pressure and density.

Algorithm :

$$Y = PFCT * \text{SQRT}(X1 / X2) * (X3 + 1.01325) / (X4 + 273.15)$$

Where :

PFCT = Measuring constant given by the pressure the actual orifice plate

X1 = Diff. pressure transmitter signal (bar)

X2 = Density transmitter signal (kg/m³)

X3 = Pressure transmitter signal (barg)

X4 = Temperature transmitter signal (cels)

- Flow calculation based on pressure and temperature
Standardised flow (Sm^3/h) of gas or liquid is calculated based on temperature and pressure.

Algorithm :

When more than one calculation are based on the same pressure and temperature, these calculations can be done with help of one common compensation block. To obtain this feature, parameterize $\text{PKF}=0$.

$$Y = \text{PFCT} * \text{SQRT}((X2+1.01325)/((X3+273.15)*\text{MW}))$$

Where :

PFCT = Factor compensating for design temperature and design pressure of the orifice plate

X2 = Pressure transmitter signal (barg)

X3 = Temperature transmitter signal (cels)

MW = Molweight entered by operator.

When only one calculation is based on the temperature and pressure; parameterize $\text{PKF} > 0$.

$$Y_A = \text{PKF} * \text{SQRT}(X1)$$

$$Y_B = \text{PFCT} * \text{SQRT}((X2+1.01325)/((X3+273.15)*\text{MW}))$$

$$Y = Y_A * Y_B$$

Where :

PKF = Measuring constant given by the pressure drop across the actual orifice plate.

X1 = Diff. pressure transmitter signal (Bar).

PFCT= Factor compensating for design temperature and design pressure of the orifice plate

X2 = Pressure transmitter signal (barg)

X3 = Temperature transmitter signal (cels)

MW = Molweight entered by operator.

- Iterative flow calculation based on temperature and density. Standardised flow (Sm^3/h) of gas or liquid is calculated iterative based on temperature and density.

Algorithm :

$$Y = \text{PFCT} * C * \text{SQRT}(X1/X2)$$

Where :

PFCT = Factor compensating for design temperature and design pressure of the orifice plate

$$C = e^{(-a*dT - 0.8*a^2*dT^2)}$$

With :

$$dT = \text{TEMP} - 15$$

$$a = 613.9723 / DS$$

$$DS = X2 / C$$

X1 = Diff. pressure transmitter signal (bar)

X2 = Density transmitter signal (kg/m^3)

The calculation is done iterative. When calculation limits:

$$| DS - (DS_{\text{old value}}) | < 0.05$$

and

$$| C - (C_{\text{old value}}) | < 10^{(-5)}$$

The different constellations shall be preferably achieved during implementation in configuration modes.

The formulas shall be defined according to specific project requirements.

The way of calculation and selection of configuration mode is dependent on the automation system used.

Inputs

Factor used for calculation
K-factor used for
calculation
Define formula for
Calculation

X1
X2
X3
X4

Molecular weight indication

PFCT
PKF
PMOD

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A.4.7 Process Shutdown templates

A.4.7.1 LB – PSD shutdown level template

A.4.7.1.1 General

Function template for safeguarding shutdown functions requiring latching. One LB function template shall be used per shutdown level. The shutdown levels form an overview over the whole shutdown system. They are build up in a hierarchy of levels. The LB will be the interface to the HMI and also supervise the shutdown performance per level. All cause and effect elements will have the possibility to interface the LB.

A.4.7.1.2 Normal function input (Primary Safeguarding)

If the automatic Safeguarding actions (input X) initiated by single cause results in a release of several succeeding levels, the primary shutdown level is the first shutdown released. The Primary Safeguarding will be latched and will thus require a reset interaction by the operator.

A.4.7.1.3 External Safeguarding

An External Safeguarding (input XS) is a shutdown released from a higher shutdown level. External Safeguarding may be chained to form a timed sequence or logic condition of succeeding shutdown actions. External Safeguarding will not be latched and will thus not require a separate reset interaction by the operator.

A.4.7.1.4 Blocking

The function template shall provide the possibility to block all inputs from other shutdown levels as well as to all other shutdown levels from the operator station. Using two independent operations should do this. These blocking facilities shall not affect the process inputs/outputs. Blocking of Primary Safeguard may be shown on the LB. Blocking on effect elements is shown on the LB.

A.4.7.1.5 Monitoring

When a shutdown is performed correctly, only the shutdown level status (from LB) should be reported and logged in addition to the alarm coming from the shutdown initiator (Primary Safeguard). However, if not all defined shutdown actions are performed due to equipment failure or blocked mode on shutdown actions, separate level associated alarms for coincidence and fault should be generated.

A.4.7.1.6 Function Template Schematic

<u>Inputs</u>	LB	<u>Outputs</u>
Normal function input External safeguarding Reset safeguarding	X XS RX	Y YX Normal function output Output external
<u>Operator Station:</u> Set safeguard Reset safeguard Blocking on XS Blocking off XS Blocking on YX Blocking off YX		<u>Operator Station:</u> Level released Level external released Common fault Common coincidence Common blocked on normal function input. (safeguarding) Level blocked inputs Level blocked outputs
<u>Parameters:</u> Shutdown level		

Parameters:
Reference to vendor documentation

A.4.8 Auxiliary Function Template

A.4.8.1 Required Auxiliary Function Template

Dependent on the design it has shown to be helpful and sensible to have special function template for the ESD and F&G systems. These templates shall include all necessary interfaces to the mimic/matrix of the ESD system, but shall basically be based on the standard template as previously outlined.

There shall be card-monitoring possibilities provided, which shall be implemented using the built in standards of the automation system.

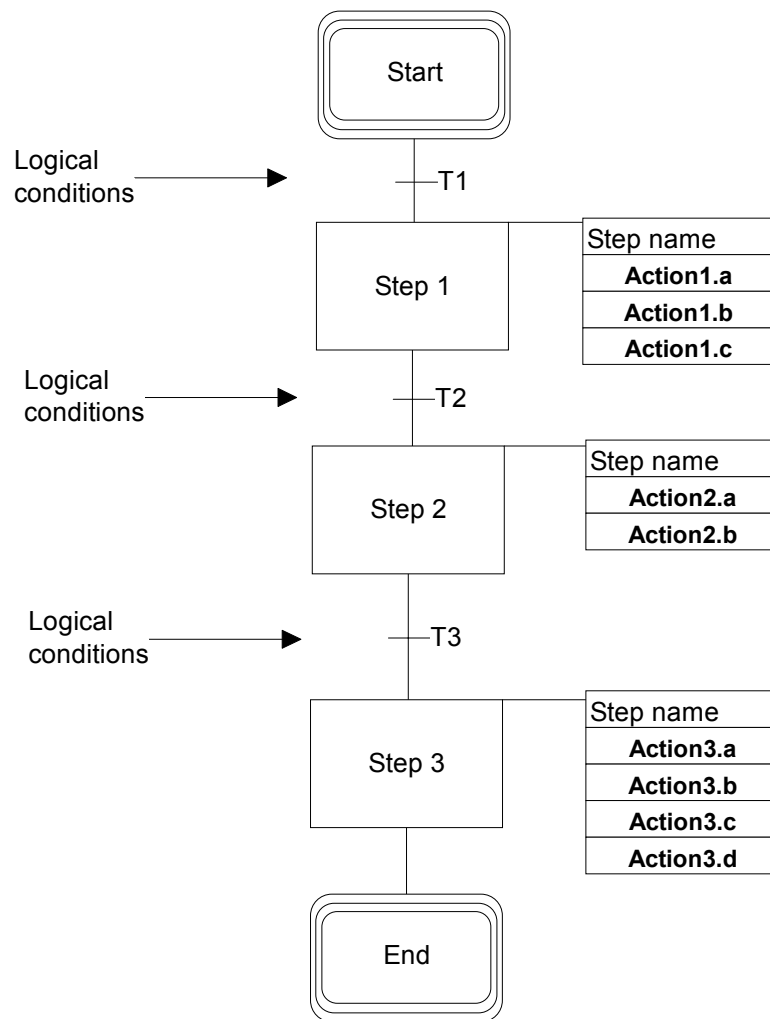
For the sub sea functions there may also be an extra set of function template, which incorporate the special sub sea control system interfaces.

A.4.9 Sequence logic

Sequence logic should be specified according to IEC 61131-3. The graphical language - Sequential Function Chart (SCF) should be utilised. Sequence oriented tasks should be formulated using steps and transitions. The steps represent actions (to SCD functions) and transition conditions that must be fulfilled before moving to the next step.

Features of the Sequential Function Chart shall include:

- Formulation of steps and conditions for SCD
- Parallel sequences and alternative sequence selection (priority can be specified).
- Feedback paths allowable.



The sequence logic may be specified in SCD drawing or a separate document. There shall be implemented references between SCD functions and sequence logic.

ANNEX B - SCD DRAWING STANDARD (NORMATIVE)

B.1 Introduction

The SCD is in general a simplified version of the P&ID's where all the piping details have been excluded and where functional templates and their logical connections have been included. A consequence of this is that the process is presented on a considerable fewer sheets. This gives a better overview of the process.

It is recommended to design the layout of the SCD independently and in parallel to the P&ID.

The information on the SCD is in general divided in four categories:

- Equipment
- Measuring Instruments
- Functions
- Flow paths

The symbols used to present the equipment are mainly based on ISO3511 and NS1710. In addition some new symbols are introduced in the standard to reflect the extended information provided by the SCDs.

B.2 Content of scd's

B.2.1 Equipment

B.2.1.1 Plant Equipment

Plant equipment is defined as equipment used to process, transport or store process fluids: gas, liquids or solids. Such equipment includes:

- Tanks, pressurized vessels, columns
- Flow machines: fans, pumps, compressors, ejectors, turbines, conveyors and weight feeders
- Mixers
- Heat exchangers
- Filters
- Hydrocyclones, reactors or other special process equipment
- Complex or non-electrical drives.

Construction details or internals may be shown only where essential for the understanding of associated instruments and control. The equipment should be tagged.

B.2.1.2 Electrical Equipment

Electrical equipment shall, as a general rule be included on the SCD's. A symbol with references to the electrical system shall always be used as interface between system function and electrical actuators. All process inline electrical equipment shall be included on the SCD. Electrical equipment normally included on the SCD's are:

- Electrical heaters
- Electrical-chemical equipment
- Generators
- Motors with extensive instrumentation

Examples of equipment, which normally will not be shown on the SCD's are:

- Electrical motors directly connected to mechanical equipment forming an entity (for examples standard motor/pump configuration)
- Local emergency push buttons when these are provided as a standard feature.

Individual electrical consumers may require additional features associated with the electrical switchboard or starter circuitry. Additional electrical equipment may be inserted between the switchboard reference symbol and the consumer. The same reference symbol shall be used to give references to such.

Typical additional equipment is:

- Transformers (normally only included if instrumentation is involved)
- Frequency converters (normally involves control)

B.2.1.3 Valves

Valves shall be included on the SCD's according to the list below:

- Remotely controlled valves with actuator (incl. On/off valves and control valves)
- Local self-actuated control valves or valves controlled from local controllers
- Pressure safety valves
- Check valves and flow restriction orifices where essential for understanding system operation

B.2.2 Measuring Instruments

All measuring instruments with input to the control system, or to local controllers shall be shown on the SCD.

Instruments connected to dedicated control systems with separate operator station shall be included where essential for understanding the system.

B.2.2.1 Functions

B.2.2.2 Control Functions

The SCD shall include all Control functions and their interrelation. Interrelation in form of exchange of status's, measuring variables, interlocking and suppression. Both functions controlled by the SAS and in any package-supplied control system shall be identified to give a total understanding for the operation. These functions are represented with different symbols as specified later in this annex.

All control functions including locally mounted controllers shall be shown. For locally mounted controllers may tag number however be omitted

B.2.2.3 Shutdown Functions

All shutdown functions within PCS and PSD shall be implemented on the SCDs. Shutdown functions within the PCS and non-latched shutdown functions within PSD shall be implemented as logical connections between the relevant output and inputs on the applicable control function blocks. Latched shutdown functions within PSD shall be implemented as logical connections between the relevant output and the shutdown function template, ref. SCD - Functional standard. Shutdown functions from the external systems like HIPPS, F&G and ESD shall be identified by the triangle reference symbol which gives references to the external system and logical connected to the relevant output and inputs on the applicable control function blocks.

B.2.3 Flow paths

B.2.3.1 Process Flow

Flow paths (including recycle lines) which are required for understanding of system operation for normal operation, start-up and shutdown shall be included.

B.2.3.2 Signals

The following signals shall be shown on the SCD:

- signals between functions blocks and field instruments/flowelements
- signals interconnecting function templates
- signals between electrical equipment and function templates
- Signals between local control panels and function templates
- signals from/to shutdown reference triangles
- signals from/to sequence reference flags

The signal path shown on the SCD's shall in general only reflect the functional relations.

Signal lines may only be omitted if it is described in the SCD-legend or in a typical.

B.2.4 Information not shown on the SCD's

- Minor flow paths as pipes and ducts not essential for understanding of the system
- Pipes with valves etc. for maintenance purpose
- Pipe tagging
- Local instruments without connection to any control function
- Fire and gas detection and fire fighting equipment (but may however be shown on special printouts suited for these purposes)
- General utility functions as heat-tracing etc.

B.2.4.1 Black Box representation

To ease the readability of the SCD's the following recommendation shall be adhered to:

- Functions, which are not required for the general understanding of the process/system interactions, may be omitted or described in a short text with reference to a lower level SCD where the function may be fully shown. An example is the mechanical part of a compressor.
- Pure logic functions of some complexity may on the SCD be shown as a black box including textual description of the function. Details of the internals may be included on a more detailed level SCD.

B.2.5 Parallel Equipment

Where parallel, identical, complex equipment shall be shown, only one set may be fully drawn. The other sets may be shown as boxes with reference to the fully drawn set.

Interdependency between parallel functions, may be indicated by showing the interconnected function templates with terminal codes inside the box. Where required to ease the understanding, connections may be drawn inside the borders of the box. An example is presentation of wells.

B.3 Layout

B.3.1 Layout

Proper layout of the SCD's is a key factor to obtain readability. Experience shows that the SCD's have a tendency to include information to an extent which makes the readability suffer. Only general guidelines are introduced in this section.

B.3.2 The extent of information on SCD's

Primarily the process shall be divided in functional standalone sections on each SCD. Natural process splits shall be considered to minimise the number of interfaces.

As a guideline for readability of the SCD the number of objects may be used. The process may be sectionalised to provide a maximum number of objects requiring function templates (transmitters, valves, motors, etc.). The maximum number should be 30-40 if the functions are dominated of control, 50-60 if the functions are dominated of monitoring.

B.3.3 Location of information on the SCD's

Different type of information has to be allocated:

- References to associated SCD's should be located on the outermost right or left areas
- Shutdown applications shall be located on the upper section of the SCD sheet.
- The process and associated function templates shall be located in the remaining part

B.3.4 Direction of flow

The main flow should normally be from left to right in the diagram. This statement is applicable for both process flow and for flow of information. However, control signal may by nature be contrary to this and violations of the statement will occur.

B.3.5 Page connectors

References to and from succeeding and preceding SCD sheets shall be included both for process flow and signals. The references represent the connecting links and all transfer of process medium or signals between SCD's shall be supported by the page connector symbol.

Page connector symbols may include both the process and the signal flow. The direction of flow for the two types may be reversed. Such cases should be limited to include signals having a direct and significant influence on the flow. An example would be a signal for stop or trip of a pump upstream the process section shown on the SCD where the signals originate.

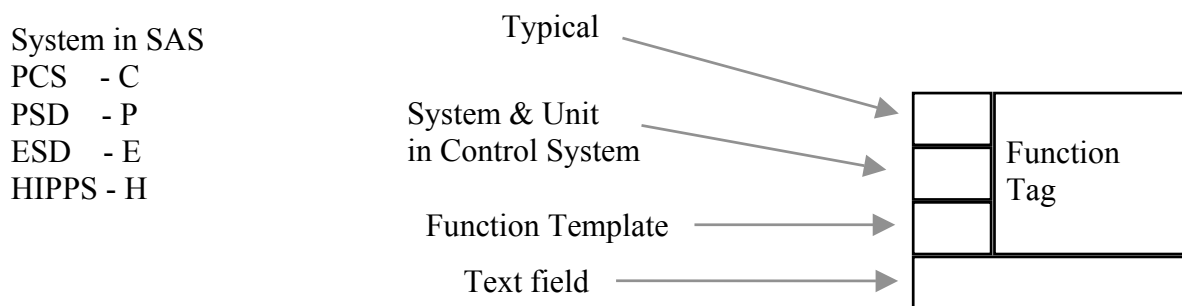
B.4 Symbols

The symbols used on the SCD shall in general adhere to the symbols used on the P&ID's, ref. ISO 3511. However, modifications and additions to both the symbols itself and the range of symbols defined in the P&ID legend are required to reflect the extended information provided by the SCD's. To enable use of extended functions the following SCD symbols are introduced:

- Function templates
- Logic and arithmetic functions
- Signal Lines
- Instruments
- Reference symbols

B.4.1 Function Template symbol

Function template shall be used for all tagged functions related to instrumentation and control.



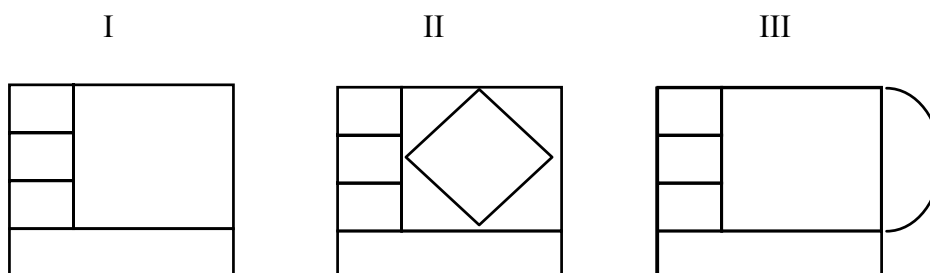
The left-hand three rows column is dedicated for:

- Typical (internal control option/variant for specific template)
- System and Unit in SAS
- Function Template (Annex A)

The text field is dedicated for additional information to the reader of the SCD.

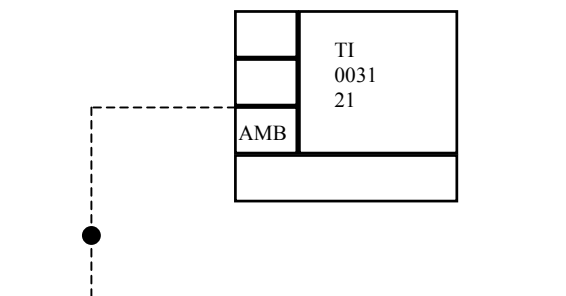
The symbol represents the complete control function covered by the function template, ref. SCD Function Standard. The control function can be completely integrated in SAS (as shown in above example) or can be integrated in stand-alone packages.

The symbol shall be altered to show the degree of integration:

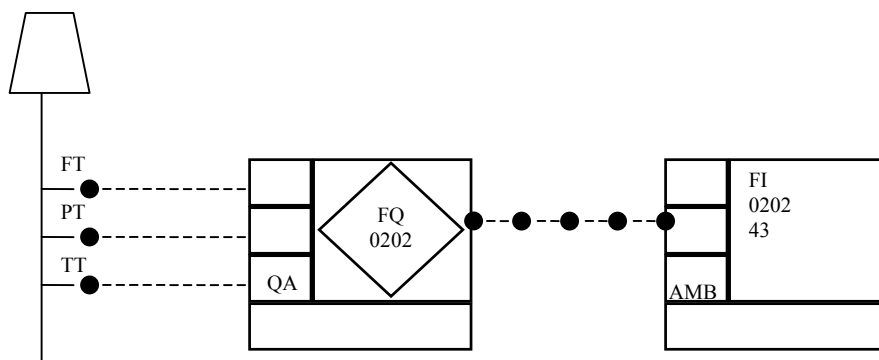


I	Control function and HMI fully integrated in the main control system.
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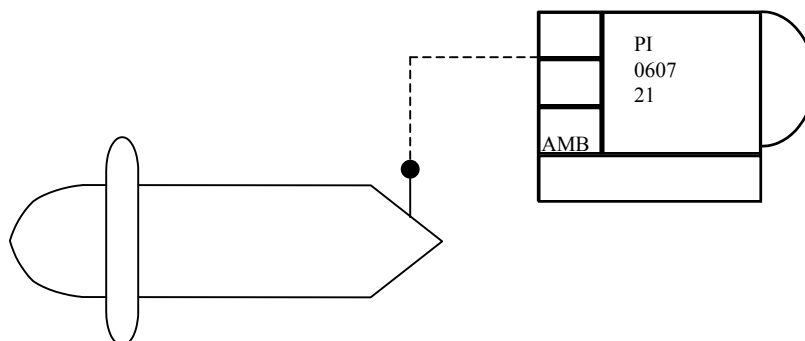
II	HMI function integrated in the main control system. Outside control function not shown separately
III	Outside control function. Interface to the main control system shown separately if applicable. Symbol I should then be used.



I. Control function and HMI fully integrated in the main control system.



II. HMI function integrated in the main control system.



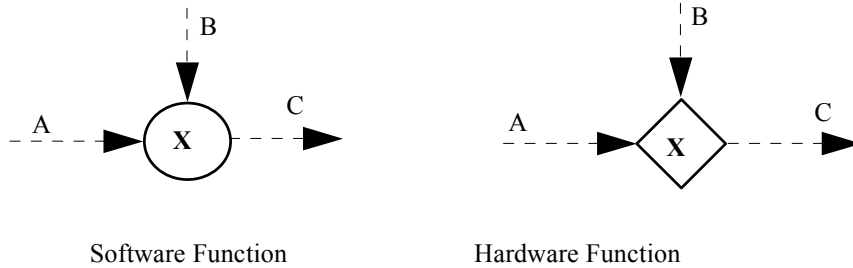
III. Outside control function.

B.4.2 Symbols for logic and arithmetic functions

As a general rule, positive logic shall be used on the SCDs.

Symbols for arithmetic and logic functions are unique for the SCD method.

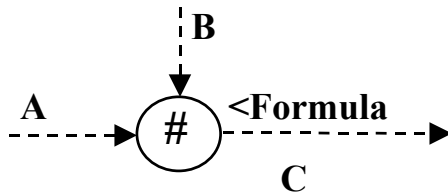
The symbols for combination of multiple input signals can be shown differencing between software and hardware realisation:



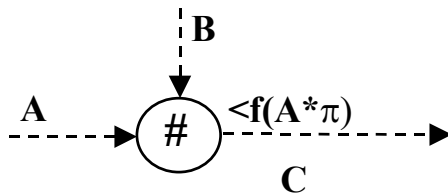
The x symbol is defining the function according to the following table:

x	Function
O	Logic "OR" ($A \text{ or } B = C$)
&	Logic "AND" ($A \text{ and } B = C$)
H	High Selector ($C = \text{the higher of } A \text{ and } B$)
L	Low Selector ($C = \text{the lower of } A \text{ and } B$)
>	Comparator High ($C = 1$ when $B > A$, otherwise $C = 0$)
<	Comparator Low ($C = 1$ when $B < A$, otherwise $C = 0$)
+	Arithmetic Plus ($A + B = C$)
-	Arithmetic Minus ($A - B = C$)
*	Arithmetic Multiply ($A * B = C$)
/	Arithmetic Division ($A / B = C$)
M	Memory element (S=set, R=reset)
I	Inverter (NOT $A = C$)
S	Split of signal
#	Optional

By use of “Optional” the formula should be written at the output signal line.



Example:

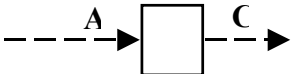
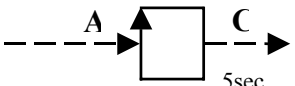
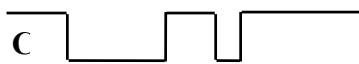
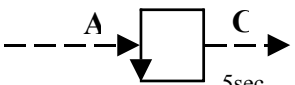
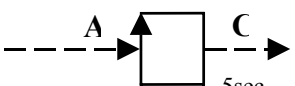
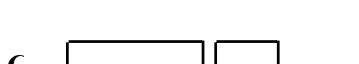
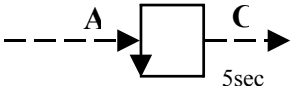


To avoid ambiguities regarding hardware/software interpretation and system unit allocation of signals the following rules shall be strictly adhered to:

- Signals from field devices shall always be routed directly to a function template.
- A hardware signal split is defined to be a field device and such an exception, where a field device is connected to a field device.

In special cases output from a hardware signal split can be routed to a local instrument.

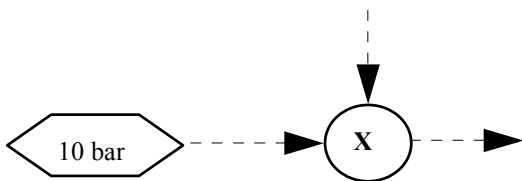
The logic elements for single signal operation are defined in the table below.

Description	Symbol	Logic
		
Inverter		
Timer (delay on rising edge)		
Timer (delay on falling edge)		
Pulse generator (pos. pulse on false - true)		
Pulse generator (pos. pulse on true - false)		

All symbols shall maintain the orientation of the symbol regardless of the relative signal line orientation.

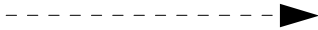
B.4.3 Parameter Labels

To implement process parameters, numbers and logical operands the symbol shown below should be used.



B.4.4 Signal line

The general symbol for signal line is

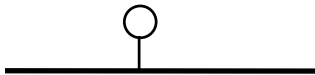


Arrow shall be included to indicate the direction of information flow.

Whenever multiple usage of a signal is required, the signal split symbol shall be used.

Signal lines for electrical signal/power, hydraulic signal/ power, pneumatic signal power and digital communication link shall be identical to symbols defined in the P&ID legend.

B.4.5 Instruments



The instruments shall be drawn with small circles without tag identification on SCD where the instrument tag may be derived from the associated function template. This is a deviation from ISP3511. The reason for the deviation is that the same information is shown in the function template.

No tag number shall be provided at this point unless where the process variable cannot be derived from the function code shown in the function template. The identification letters dedicated for the measured variable shall in that case be given adjacent to the instrument symbol.



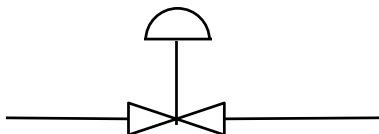
B.4.6 Mechanical equipment

The symbols for the equipment shall be identical to symbols defined in the P&ID legend. Only the basic symbol shall be used. Auxiliary equipment not required to fulfill the intention of the SCD shall be omitted.

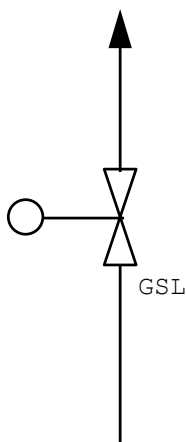
B.4.7 Valves

B.4.7.1 On/Off Valves

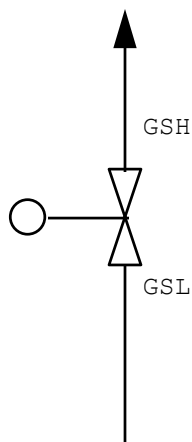
The on/off valves shall be drawn as a simple valve. The actuator shall be drawn with a small circle without tag identification letters. This is a deviation from ISO 3511. The reason for the deviation is that the same information is shown in the function template.

B.4.7.2 Modulating control valves**B.4.7.3 Limitswitches**

For indication of limitswitches shall GSL and GSH be used. GSL indicates a limitswitch for closed position. GSH indicate a limitswitch for open position. GSL should be located downstream the valve. GSH upstream the valve.



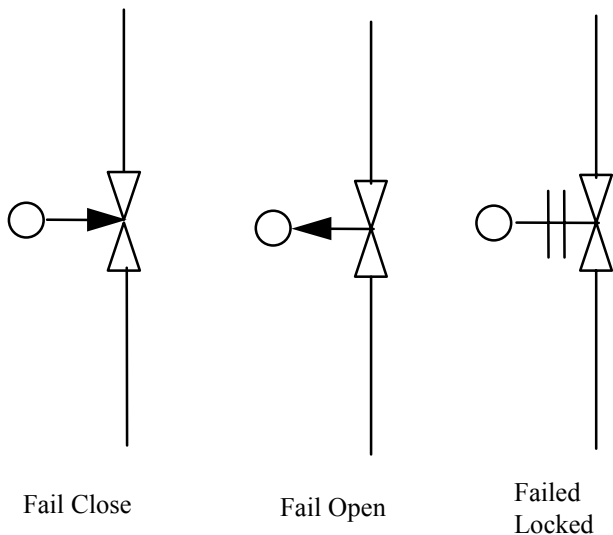
Hand Valve
w/ limitswitch for closed
position



Hand Valve
w/ limitswitch for open and closed
position

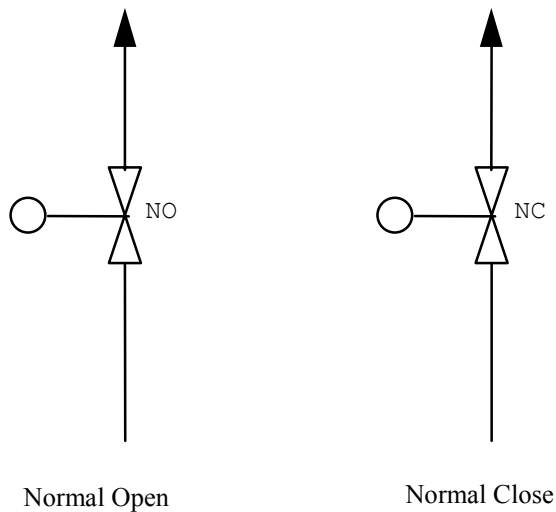
B.4.7.4 Fail Safe

Fail Safe should be shown on the SCD according to the figure below.



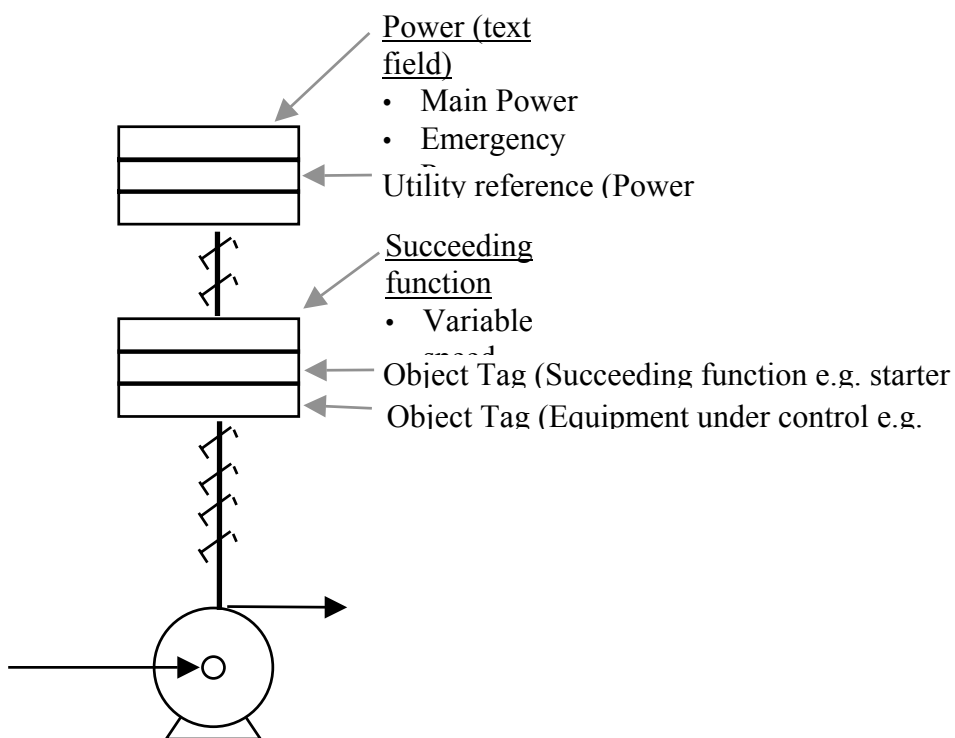
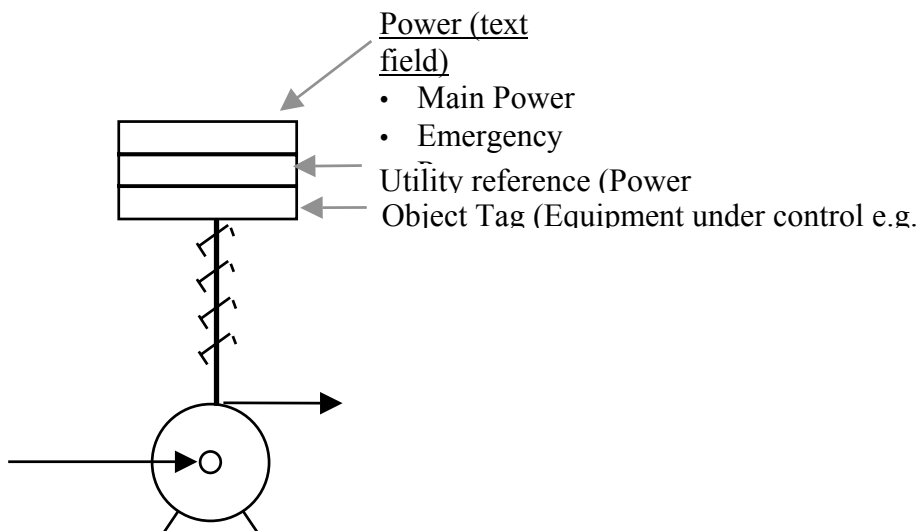
B.4.7.5 Normal Open / Normal Close

Normal Open / Normal Close may be shown on the SCD. If shown it shall be shown according to the figure below.



B.4.8 Electrical equipment

For electrical devices, the SCD shall provide references to the electrical equipment which hold signal interface to the control system.



B.4.9 Reference Symbols**B.4.9.1 Page Connectors**

Page Connectors to and from succeeding and preceding SCD sheets shall be included both for process and signal flow lines. The page connectors represent the connecting links and all transfer of process medium or signals between SCD's shall be supported by the reference symbol.

Drawing reference for process connections



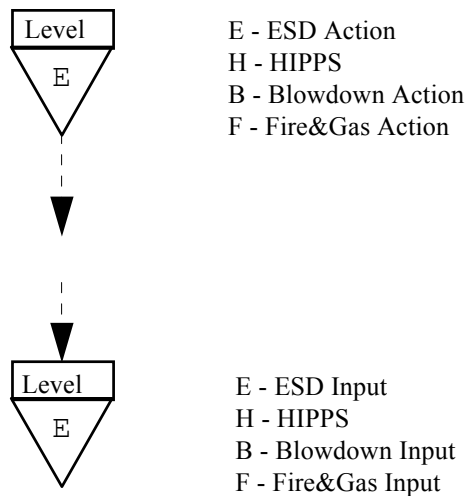
Drawing reference for instrument signals

The description shall give a unique reference

Drawing reference description

**B.4.9.2 ESD/HIPPS/Blowdown/F&G Reference Triangle**

References to and from the ESD, HIPPS, Blowdown and Fire & Gas shall be included on the SCD. The ESD, HIPPS, Blowdown and Fire & Gas can, but will normally not be included on the SCD's.



B.5 Tagging

All function templates on SCD shall be tagged.

The tag shall identify the function of the template and shall have a sequence number.

The project standards for tagging shall be used. Such standard will normally be in accordance with generally accepted standards like NS 1438 / ISO 3511.

The same tag identification shall be used for identical functions on P&ID, SCD and HMI.

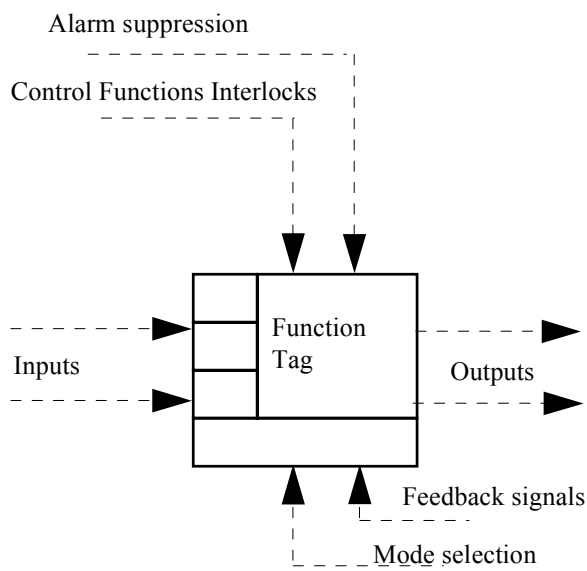
In cases where the equipment shall be tagged e.g. tagging of electrical equipment should object tagging be used.

B.6 Terminal codes

Each function template has defined input and output signals. Input denoted with X is acting on the output Y and/or on operator presentation. The blocks contain necessary monitoring functions to ensure that the most frequent faults regarding to the field object are detected and reported.

Each signal interconnecting two functions, use terminal codes for identification.

The most frequent used terminal codes are shown in the table below. For complete overview of terminal codes ref. annex A; Functional Standard



The inputs shall be located to the left of the function template.

The outputs shall be located to the right of the function template.

The feedback signals shall be located at the bottom of the function template.

The control function interlocks and the alarm suppressions should be located of the top of the function template.

The mode selection should be located at the bottom of the function template.

ANNEX C - PROJECT EXECUTION GUIDELINES (INFORMATIVE)

C.1 Engineering

C.1.1 Objectives

The SCD Approach represents an overall methodology in order to achieve the following main objectives during the engineering phase:

- Improved quality
- Improved standardisation
- Improved safety
- Improved productivity
- Improved process understanding

C.1.1.1 Quality

Operation & control requirements are defined by a single document forming the basis for verification activities as well as implementation and testing.

- Verification of control strategies defined by other disciplines. (process, mechanical, HVAC etc.)
- Verification of control strategies defined by package suppliers.
- Verification of control system implementation. (Factory Acceptance Test)
- Validate operation & control strategies with client/operations.
- Third-party verifications related authority requirements.

C.1.1.2 Standardisation

Improved standardisation will be accomplished on a control system level as well as on an application level.

Control system level:

- Common functionality in terms of function templates.
- Common documentation, independent of control system supplier.
- Common terminology used for identical control functions, independent of control system supplier.

Application level:

- Common control strategies for all systems.
- Common control strategies for packages.

C.1.1.3 Safety

Process safeguarding functions are shown in connection with process control functions defining the requirements for independent process safeguarding functions in addition to the process control functions

Process related emergency shutdown functions are also shown in connection with the process safeguarding and control functions enabling an enhanced understanding of the plant safety requirements.

C.1.1.4 Productivity

The previous objectives will obviously result in an improvement of the productivity.

- Improved standardisation resulting in simpler implementation.
- Improved quality resulting in less changes during design, test and commissioning of the control system.

Efficient communication between all parties will improve the productivity for the control engineers.

The functions are defined in an unambiguous manner making the internal disciplines work more efficient as additional documents and meetings can be reduced.

Improved communication with third parties regarding operation & control. The SCDs forms the basis for interface discussions. Design changes may be documented by SCD mark-ups, e.g. attached to minutes of meetings.

The amount of interchangeable documents and subsequently the number of dependencies between the involved parties can be reduced.

- Common document for design, test, commissioning and operation.
- Common document for all disciplines.
- Common document for all package suppliers.

The SCD Approach will enable the control engineer to develop the operation & control requirements in parallel with the process design and will thus support concurrent engineering.

Field proven solutions may also be copied from previous projects independent of control system supplier.

The SCD Development can be split in two main activities.

- Basic Design
- Application Design

The Basic Design will normally only be applicable for a first time implementation of the SCD standard or in order to facilitate new operational requirements.

The Application Design contains the development of the actual SCDs within a specific project.

C.2 Implementation

C.2.1 Objectives

The following main objectives can be defined for the implementation phase:

- Unambiguous input to implementation
- Improved standardisation
- Improved productivity

C.2.1.1 Unambiguous input

Unambiguous definition of functional requirements is of vital importance for the implementation phase. Discussions related interpretation of functional requirements as well as possible re-work is avoided.

The information, which is not relevant for the control system, has been removed making the implementation effort simpler.

A structured design based on standard templates and basic logic functions may be directly translated into application logic providing a simple link between functional requirements and the actual implementation.

C.2.1.2 Standardisation

A well defined and widely recognized standard will provide a basis for development of corresponding supplier standards.

The need to develop project specific typical (function blocks) will be significantly reduced. Function blocks based on a general standard may thus be used independent of specific project requirements.

Applications may further be re-used from one project to another.

C.2.1.3 Productivity

The previous objectives will also impact the productivity.

- Unambiguous input to the implementation providing a basis for efficient programming as well as reduced probability for modifications.
- Improved standardisation resulting in extensive reuse of proven solutions.

A well defined basis for programming will also require less use of system specialists for application programming. The programming effort will mainly consist of translating functional templates and connectivity, rather than software development as such.

However, the ultimate objective in order to improve the overall productivity is to facilitate automatic configuration of the safety and automation system, based on SCDs, eliminating manual programming.

C.2.2 Documentation

The initial implementation of the SCD standard should be based on a joint effort between the involved parties in order to achieve an optimized use of supplier standard functionality to accomplish the project control strategy.

The implementation model is defined by the Basic Function Design.

The high-level supplier documentation should provide a bridge to the SCDs in order to enable non-system experts understanding supplier documentation.

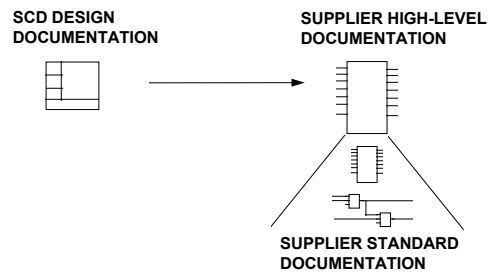


Figure 8, SAS Supplier Interface

Even if a one-to-one mapping of templates should be the ultimate target, a one-to-many strategy should be adopted if required. System constraints in terms of logic restrictions, CPU load, parameters etc. may call for an optimisation. A one-to-many approach implies that one specific template results in variants depending on control options or parameter selections. The number of variants should be kept to an absolute minimum. The functionality implemented should also be kept within the range of the original template.

C.2.3 Verification

The SCDs should form the basis for the verification activities.

Internal application tests as well as Factory Acceptance Test, should be based on SCDs.

C.3 Commissioning

C.3.1 Objectives

The System Control Diagrams will be used throughout the commissioning phase. The SCDs handed over to commissioning must reflect as “programmed status”. The use of SCDs can be related to the following activities:

- Commissioning procedures
- Commissioning runs

C.3.1.1 Commissioning procedures

The SCDs forms the basis for the commissioning procedures related the Safety and Automation System.

The procedures should cover activities not already covered by the SCDs. The SCDs will thus be included as a part of the commissioning documentation as such.

The SCDs will typically provide the following information to be covered by the procedures.

- Blocking of Interlocks during commissioning.
- Suppression of alarms.

C.3.1.2 Commissioning runs

The SCDs must be kept updated throughout the commissioning phase.

Commissioning of the Safety and Automation System will mainly be based on the SCDs.

The SCDs will thus be a “live” document subject to yellow-lining, mark-ups, comments etc.

C.4 Operation

The development of the System Control Diagram as such was initiated in order to provide a functional description of the logic contained in the Safety and Automation System for operational personnel, not familiar with the supplier logic standard.

C.4.1 Objectives

The main objectives by using SCDs in the operational phase can be related to the following:

- Safety analysis
- Production control
- Modifications

C.4.1.1 Safety Analysis

The SCDs defines process safeguarding functions in connection with the process control strategies. Effects of critical process conditions may thus be evaluated by means of the SCDs. “What if “ scenarios as well as post event analysis may be carried out.

Process effects related safeguarding systems documented by means of cause & effects may also be evaluated.

Effects resulting from faulty instrumentation or a manual blocking of a safeguarding function will be documented and may be encountered for by means of the SCDs.

The SCDs should form the basis for approval of workpermits affecting the Safety and Automation System.

C.4.1.2 Production Control

The SCD representation is closely allied to the operator interface displayed on the VDUs in the control room. The SCDs will thus provide an unambiguous documentation of the SAS functionality for the operators with an apparent relationship to the actual operator interface.

The daily use of the SCDs in the control center will be related to “trouble-shooting”. The SCDs will enable the operator to resolve operational problems without involving additional system specialists.

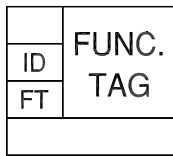
Most control systems provide e.g. well defined information on mode of operation for a selected control object. However, if the control object is interlocked by an external cause, the source of the interlock is often not properly documented.

By providing the operators with enhanced possibilities to resolve operational problems, the requirements for reduced manning will be met.

C.5 Modifications

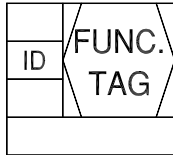
The SCDs will also be used in connection with modifications to the Safety and Automation System. The methodology applicable for modifications during the operational phase will be similar to the engineering methodology for application design, implementation and verification.

- Multidiscipline design.
- Input to implementation.
- Basis for verification and testing.

ANNEX D – SCD LEGEND (NORMATIVE)**Function Block Symbols**

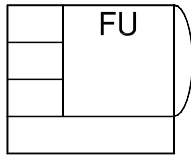
Standard SAS control function:

Function fully implemented with standard SAS function template for logic as well as HMI.



Non – Standard control function:

Logic control function implemented as non – SAS software, but with a standard SAS HMI.



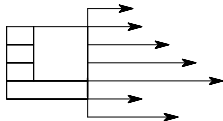
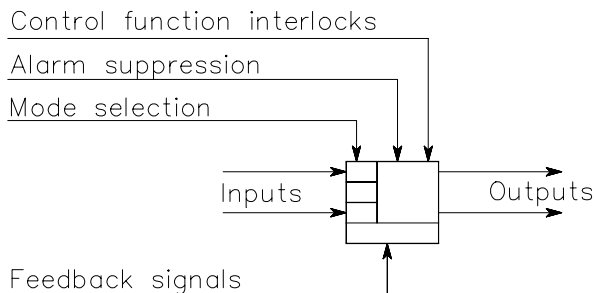
Local control function:

Logic control function implemented as non – SAS software and with no SAS HMI.

FT: SAS function template name

ID: SAS unit identification

Operator info: Identification of the controlled object (valve, motor, heater) as it appears to the operator (on VDU alarm lists etc.) or other convenient operator info.

Function template terminals

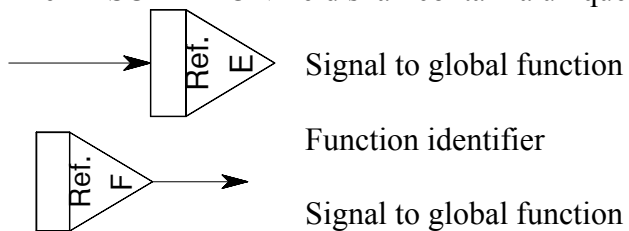
Extension of function block symbols if more terminal points are required.

Reference symbols

DESCRIPTION	
DRWG.NO.	DRAWING REFERENCE FOR PROCESS CONNECTION

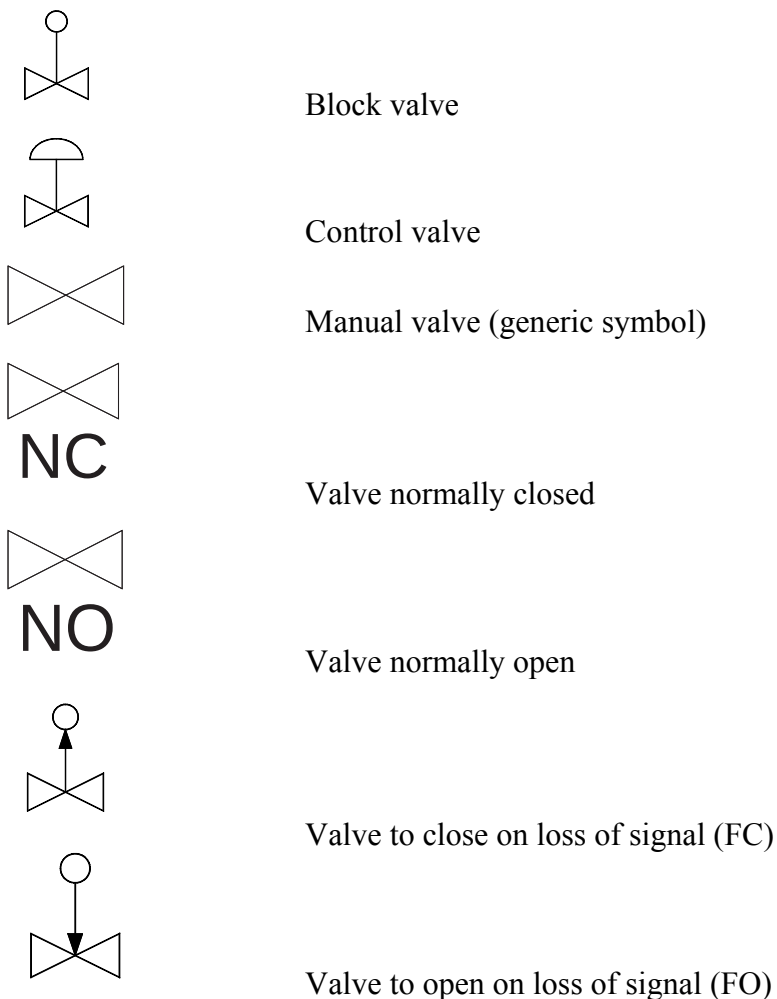
DESCRIPTION	
DRWG.NO.	DRAWING REFERENCE FO RINSTURMENT SIGNALS
	R = Unique signal reference identifying the signal connection

The DESCRIPTION field shall contain a unique signal reference.



Ref: Reference to shutdown level.

Equipment symbols





Valve to be locked on loss of signal (FL)



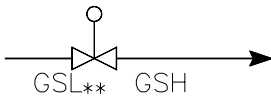
Valve to maintain position on loss of signal (FI)



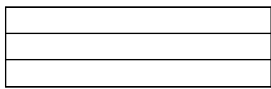
Transmitter



Safety relief element



Low (GSL) and High (GSH) limit switch indicator

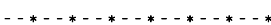


Power (text field)
Object tag (power)
Object tag (controlled equipment)

Instrument signals



General signal, e.g. logic software signal within a node or hardwired signal from transmitter to SAS. Can also be used for bus signals and serial lines.



Data communication link, i.e. bus or serial line. The signal line reflects the logic end points of the signal, and not the actual bus topology.

Constant values

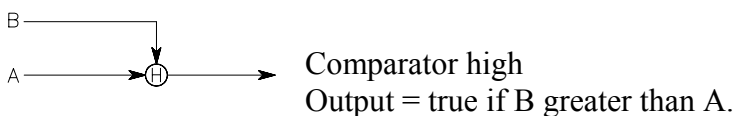
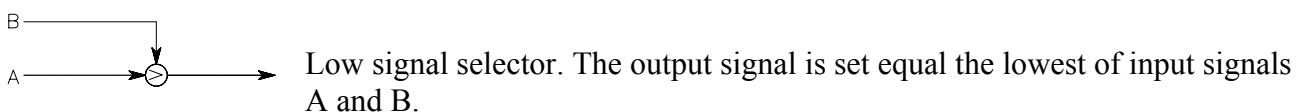
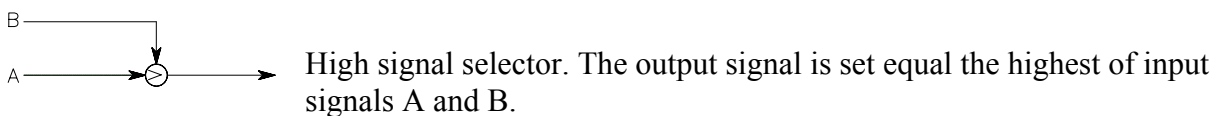
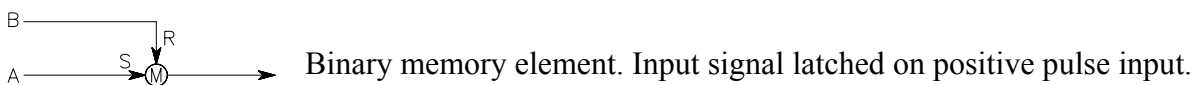
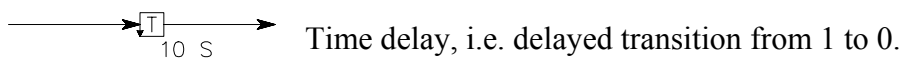
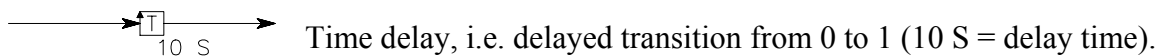
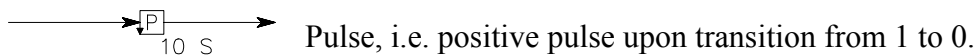
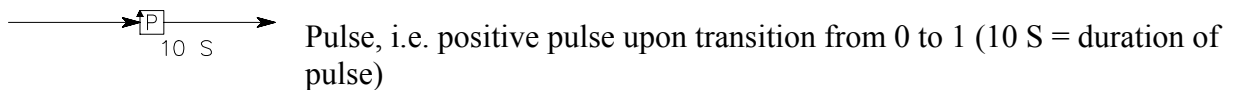
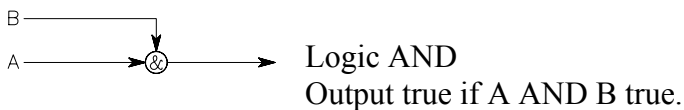
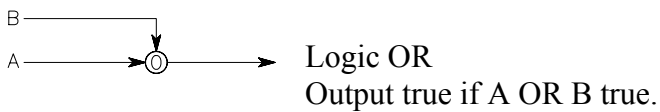
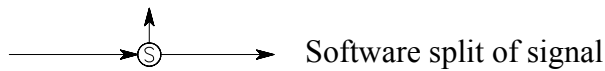
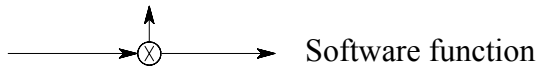
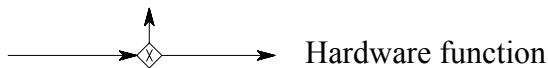
Constant values used as parameters to logical/arithmetic elements (e.g. timers, pulses). To be shown as a signal into the actual element.



Value of parameter, e.g. 25

Unit of parameter, e.g. deg. C

Logic and arithmetic symbols



 B
A →  →

Comparator low
Output = true if B less than A.

 B
A →  →

Arithmetic plus.
Output = $A + B$

 B
A →  →

Arithmetic minus
Output = $B - A$

 B
A →  →

Arithmetic multiply.
Output = $B * A$.

 B
A →  →

Arithmetic division.
Output = B / A

 B
A →  (formula) →

Optional