

System control diagram

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Foreword

The NORSOK standards are developed by the Norwegian petroleum industry to ensure adequate safety, value adding and cost effectiveness for petroleum industry developments and operations. Furthermore, NORSOK standards are as far as possible intended to replace oil company specifications and serve as references in the authorities' regulations.

The NORSOK standards are normally based on recognised international standards, adding the provisions deemed necessary to fill the broad needs of the Norwegian petroleum industry. Where relevant, NORSOK standards will be used to provide the Norwegian industry input to the international standardisation process. Subject to development and publication of international standards, the relevant NORSOK standard will be withdrawn.

The NORSOK standards are developed according to the consensus principle generally applicable standards work and according to established procedures defined in NORSOK A-001.

The NORSOK standards are prepared and published with support by The Norwegian Oil Industry Association (OLF) and Federation of Norwegian Manufacturing Industries (TBL).

NORSOK standards are administered and published by Standards Norway.

Annex A, B, D and F is normative. Annex C, E and G 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 fulfill 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).

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 and guidelines which, through reference in this text, constitute provisions and guidelines 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 and guidelines of the standards referenced below.

NORSOK I-002	Safety and Automation Systems (SAS)
NORSOK L-003	Piping details
NORSOK Z-002	Code Manual
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 Definitions

3.1.2

shall

verbal form used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted, unless accepted by all involved parties

3.1.3

should

verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required

3.1.4

may

verbal form used to indicate a course of action permissible within the limits of the standard

3.1.5

can

verbal form used for statements of possibility and capability, whether material, physical or casual.

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. Warning alarm: Alarm without blocking facilities intended for abnormal conditions enabling operator intervention in order to prevent further escalation. Fault alarm: Alarm associated to fault or failure in the instrument and/or control device.
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 normalization 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.
Commands	Manipulation affecting the mode of the function template. 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. 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.
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. Outside: Flow element operated from a field device. I.e. local panel. Manual: Flow element manually controlled by the operator from the CCR. 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. 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). Suppress: The intention of suppress is to disable the faulty state of an object. For input objects like MA and MB templates it disables fault- and abnormal state alarm annunciation as well as related safeguarding actions. For output objects like SBE and SBV templates suppress disables fault alarm annunciation and feedback conflict. 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. Disabled: Function not available for external control commands. Safeguarding commands will not be affected in disabled mode.
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 is a mismatch.
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.
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.

A functional description of the process objectives should follow the SCD.

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.

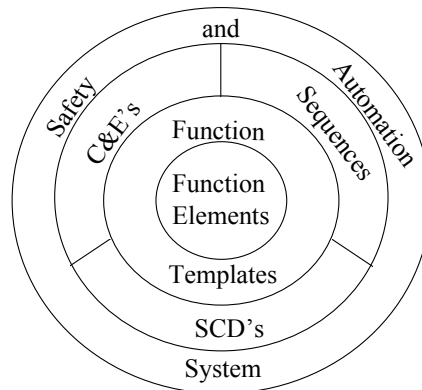


Figure 1 – SCD Framework

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.

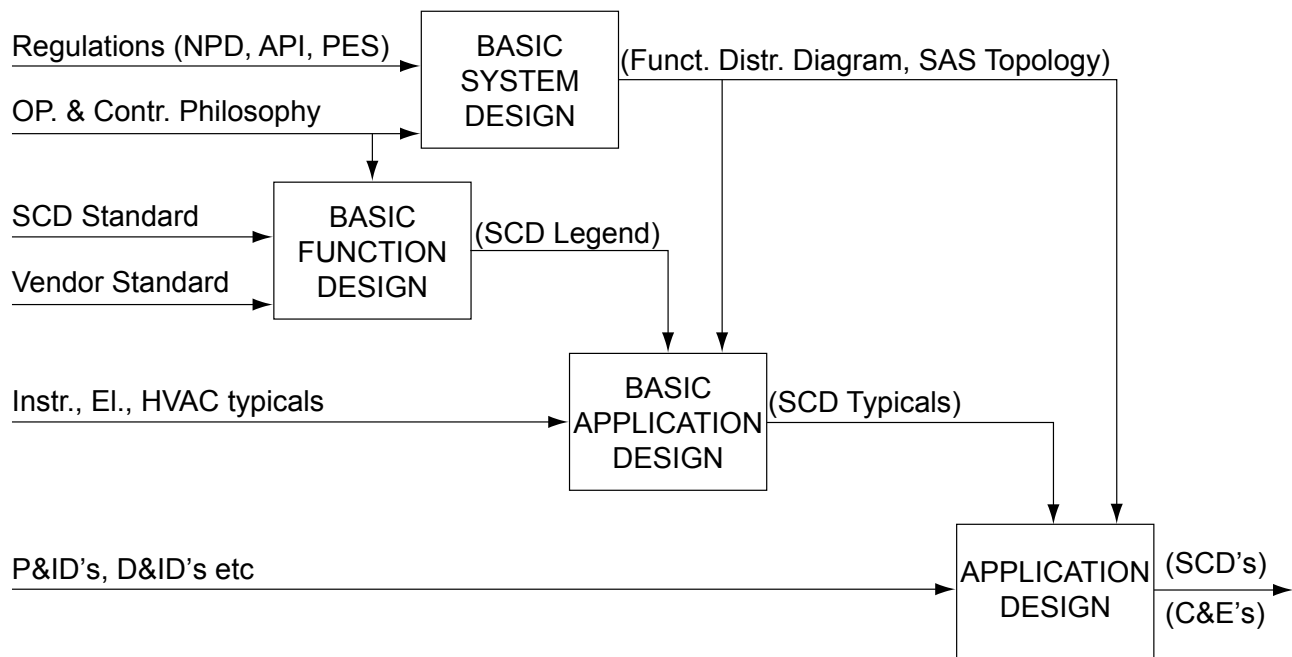


Figure 2 – Basic design

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.

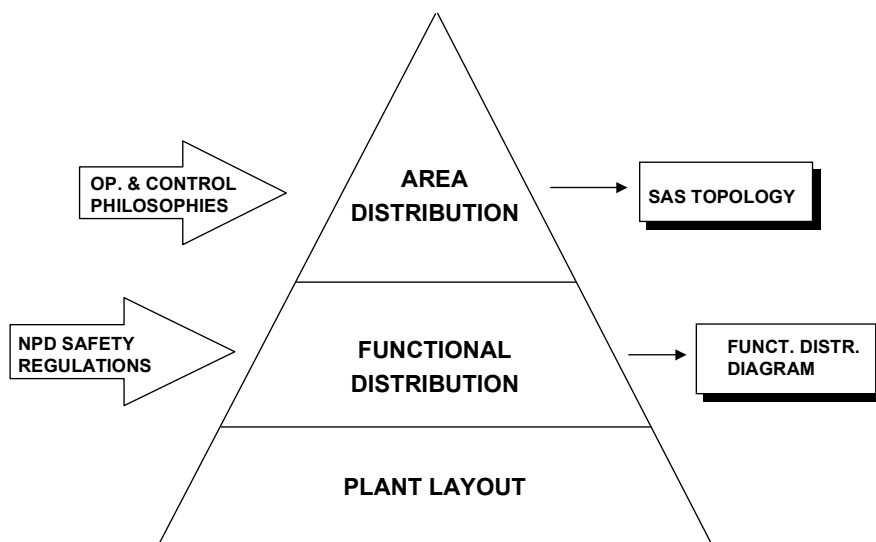


Figure 3 – Basic system design

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.

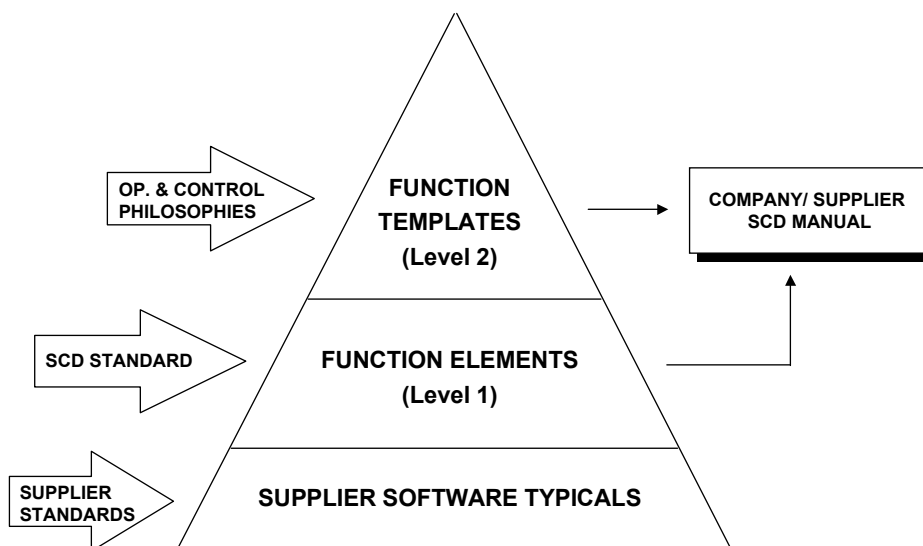


Figure 4 – Basic function design

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

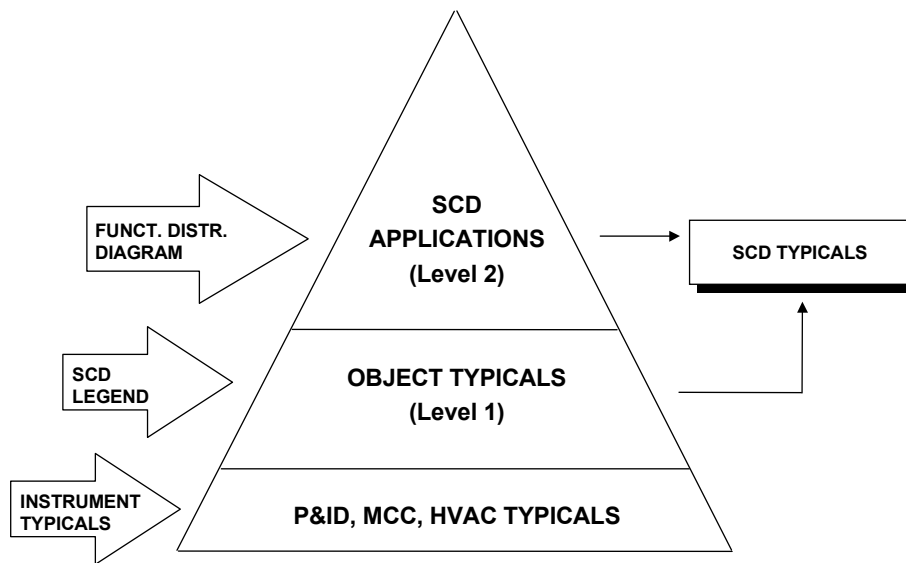


Figure 5 – Basic application design, application typical

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

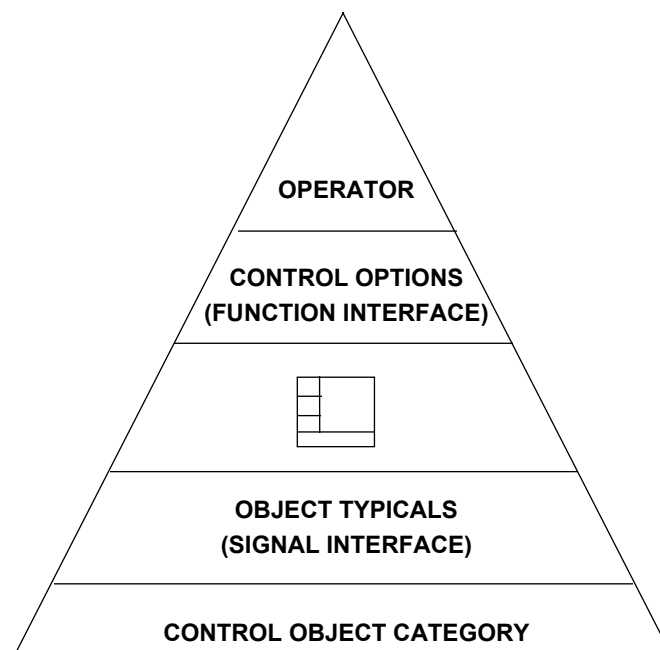


Figure 6 – Object typical

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.

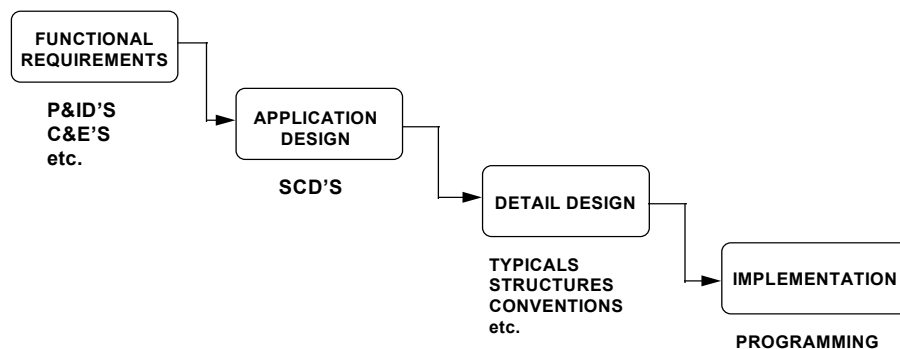


Figure 7 – Object typical

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

- Establish process schematic and identify all control objects.
- Describe the Process and Control Objectives.
- 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 (Normative) SCD Function standard

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)	

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). Could be used as 1.letter on a pin not in accordance with this standard. Note! Some SAS systems may not support this special character.

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	Output of valve 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.
BU	binary output	Status suppressed mode	Any 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.
FBLL	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	Totalizing as long as true

Terminal Code	Signal Type	Terminal Name	Supplementary description
FSH	binary input	Force safeguarding high	Shutdown – Signal overrides 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 overrides 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.
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 annunciation is suppressed as long as input true. This output should normally not be used for downstream logic.
FUWL	binary input	Force suppression mode for alarm WL	Logic input: alarm WL annunciation is suppressed as long as input true. This output should normally not be used for downstream logic.
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 overrides operator inputs (locking the template to manual mode with Y-output to high -open valve-). Input is subject to blocking .After signals disappear the template remains in manual mode and the output high.
LSL	binary input	Lock safeguarding low .	Shutdown - signal overrides operator inputs (locking the template to manual mode with Y-output to low -stop motor-). Input is subject to blocking. After signals disappear the template remains in manual mode and the output low.
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	Factor compensating for design temperature and design pressure of the orifice.

Terminal Code	Signal Type	Terminal Name	Supplementary description
PKF	Float point value	K-factor used for calculations of flow.	Measuring constant given by the pressure drop across the orifice plates.
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. Equipm. 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
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 (Y1, Y2)	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 normal function	Output pulse to stop big motors, which are

	(pulsed)	output low.	operated with pulsed start/stop signals
--	----------	-------------	---

Terminal Code	Signal Type	Terminal Name	Supplementary description
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

For a precise specification and better visualization of the control function behavior please refer to Annex F. This Annex have been developed within a project performed by Sintef electronics and Cybernetics on behave of the Norsok SCD committee where the objective have been to define the behavior of the Norsok control functions in an unambiguous manner.

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:

S B _

```

graph LR
    SB[S B _] --- P[Primary function]
    SB --- CT[Control Type]
    SB --- DO[Device Option]
  
```

Device (Option)
Control Type
Primary function

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			
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		Continuous 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		Continuous control by means analogue control action
C	S		Continuous 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
S	B		Switching Binary Signal for Shutdown

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

Parameters:

Reference to vendor documentation

A.4.4 Flow element monitoring and binary control

A.4.4.1 SB – Single Binary signal for shutdown

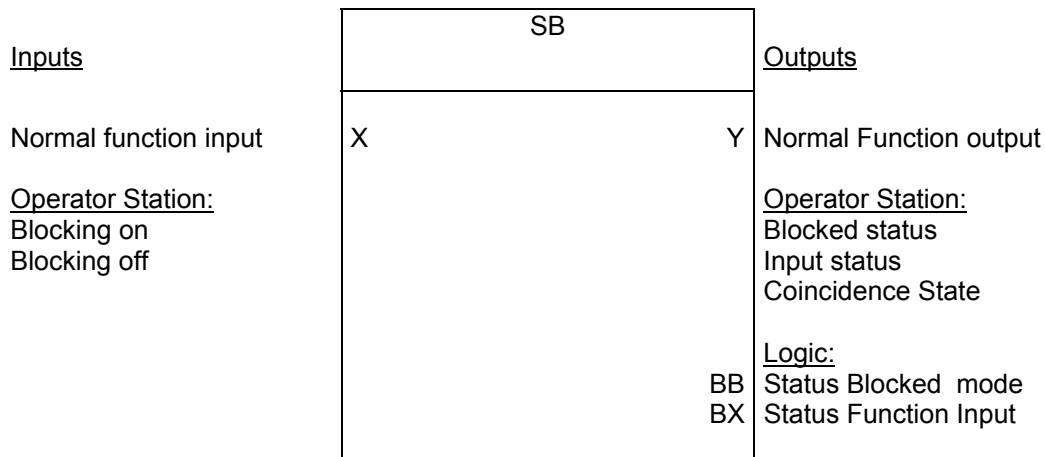
A.4.4.1.1 Purpose

Function Template for single binary shutdown of equipment. It is used to enable local manual control of an shutdown signal which has its main control template in a remote node or system.

A.4.4.1.2 Requirements

The template includes blocking function of the output from the operator station.

A.4.4.1.3 Function Template Schematic



Parameters:

Reference to vendor documentation

A.4.4.2 SBE – Controls of electrical equipment (Motors)

A.4.4.2.1 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.4.4.2.2 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 SBE 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 confirmed Y=1 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.4.4.2.3 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 is true shall be implemented. The symbols used on VDUs shall always show true position / status of the motor.

A.4.4.2.4 Function template schematic

<u>Inputs</u>	SBE	<u>Outputs</u>
Pos High feedb. (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 Pri 1 set high	XP1H	YL Pulsed normal function output low
External Pri 1 set low	XP1L	
External Pri 2 set high	XP2H	
External Pri 2 set low	XP2L	
External outside set high	XOH	BCH Output Position High Confirmed
External outside set low	XOL	BCL Output Position Low Confirmed
<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 L	LSL	BA Status Auto/Man mode
Force Safeguarding L	FSL	BO Status Outside mode
Force Disable transition H	FDH	BS Status Safeguarding mode
Force Disable transition L	FDL	BB Status Blocked mode
Force suppress mode	FU	BU Status suppressed mode
Force block mode	FB	BP1 Status priority 1
Lock Auto mode	LA	BP2 Status priority 2
Lock Manual mode	LM	BP1F Priority 1 faulty
Lock Outside operation mode	LO	BP2F Priority 2 faulty
Set priority 1 (Duty)		
Set priority 2 (Standby)		

Parameters: Reference to vendor documentation

A.4.4.3 SBV – Control of Pneumatic/Hydraulic equipment (Valves)**A.4.4.3.1 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.4.4.3.2 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 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.4.4.3.3 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 feedback timeout function has to be incorporated to allow for a certain delay in change of state. The timeout time should be available as an parameter. 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.4.4.3.4 Function template schematic

<u>Inputs</u>	SBV	<u>Outputs</u>
Position High feedback	XGH	Y
Position Low feedback	XGL	YF
External fault	XF	BCH
External set high	XH	BCL
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.4.4.4 CB – Binary control (Analogue input – Binary output)

A.4.4.4.1 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.4.4.4.2 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.4.4.4.3 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.4.4.4.4 Function template schematic

<u>Inputs</u>	CB	<u>Outputs</u>
Normal Function input	X	Y
Position High feedback	XGH	YF
Position Low feedback	XGL	BCH
External fault	XF	BCL
Function externally Enabled (MCC)	XE	
<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
Lock safeguarding L	LSL	BS
Force Safeguarding H	FSH	BB
Force Safeguarding L	FSL	BU
Force Disable transition H	FDH	BXH
Force Disable transition L	FDL	BXL
Force suppression mode	FU	WH
Force blocked mode	FB	WL
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 reverse 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
External fault	XF	YF
External Set point value	XR	YR
Tracking value	XT	YX
Position low feedback	XGL	Measured value output (X)
<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
Lock safeguarding L	LSL	BA
Force Safeguarding H	FSH	BX
Force Safeguarding L	FSL	BS
Force Track mode	FT	BB
Force suppression mode	FU	BU
Force blocked mode	FB	BT
Lock Auto mode	LA	WH
Lock Manual mode	LM	WL
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.
- If the safeguarding signals are reset before the valve is reached its closed position the valve should freeze in the current position and manual mode.

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> Select Auto mode Select Man. mode Select Internal Select External Set Step Open Set Step Close Set Step point Blocking on Blocking off Suppression on Suppression off			<u>Operator Station:</u> Alarm/Fault Annunciation Status Low- Closed Auto / manual Internal / External Status Blocked Status Suppressed Status Safeguard Status Moving Coincidence state
<u>Logic:</u> Lock safeguarding L Force Disable transition H Force suppression mode Force blocked mode Lock Auto mode Lock Manual mode Lock External set point mode Lock Internal set point mode	LSL FDH FU FB LA LM LX LI	WV BA BX BS BB BU	<u>Logic:</u> Warning Deviation Status Auto/Man mode Status External/Internal mode Status Safeguarding mode Status Blocked mode Status suppressed mode

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 totalizing	XEQ	YF Function failed
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 HH	FBHH	BHH Status alarm HH
Force suppression mode alarm HH	FUHH	WH Warning alarm H
Force suppression mode alarm WH	FUWH	BBHH Action alarm HH is blocked
		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 (m^3/h) of gas or liquid is calculated based on density.

```
Algorithm :      Y = PFCT * SQRT(X1 / X2)
                  Where:
                  PFCT = Measuring constant given by the pressure drop across
                  the actual orifice plate
                  X1 = Diff. pressure transmitter signal (Bar).
                  X2 = Density transmitter signal ( $\text{kg}/\text{m}^3$ ).
```

- Flow calculation based on pressure (Bara) and temperature

Actual volumetric flow (m^3/h) of gas or liquid is calculated based on temperature and absolute pressure.

```
Algorithm :      Y = PFCT * 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 (Sm^3/h) of gas or liquid is calculated based on temperature, pressure and density.

```
Algorithm :      Y=PFCT*SQRT(X1/X2)*(X3+1.01325)/(X4+273.15)
                  Where :
                  PFCT = Factor compensating for design temperature and design
                  pressure drop across the actual orifice plate
                  X1 = Diff. pressure transmitter signal (bar)
                  X2 = Density transmitter signal ( $\text{kg}/\text{m}^3$ )
                  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 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 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

$$(-a*dT - 0.8*a^2*dT^2)$$

$$C = e$$

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.

A.4.6.2.3 Function template schematic

<u>Inputs</u>	YA	<u>Outputs</u>
External function input 1 External function input 2 External function input 3 External function input 4	X1 X2 X3 X4	Y Normal function output YF Alarm - Function failed
<u>Operator Station:</u> Molecular weight input		<u>Operator Station:</u> Molecular weight indication
<u>Parameters:</u> Factor used for calculation K-factor used for calculation Define formula for Calculation	PFCT PKF PMOD	

Parameters:
 Reference to vendor documentation

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			<u>Operator Station:</u> Level released Level external released
Blocking on XS Blocking off XS Blocking on YX			Common fault Common coincidence Common blocked on normal function input. (safeguarding) Level blocked inputs Level blocked outputs
Blocking off YX			
<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.

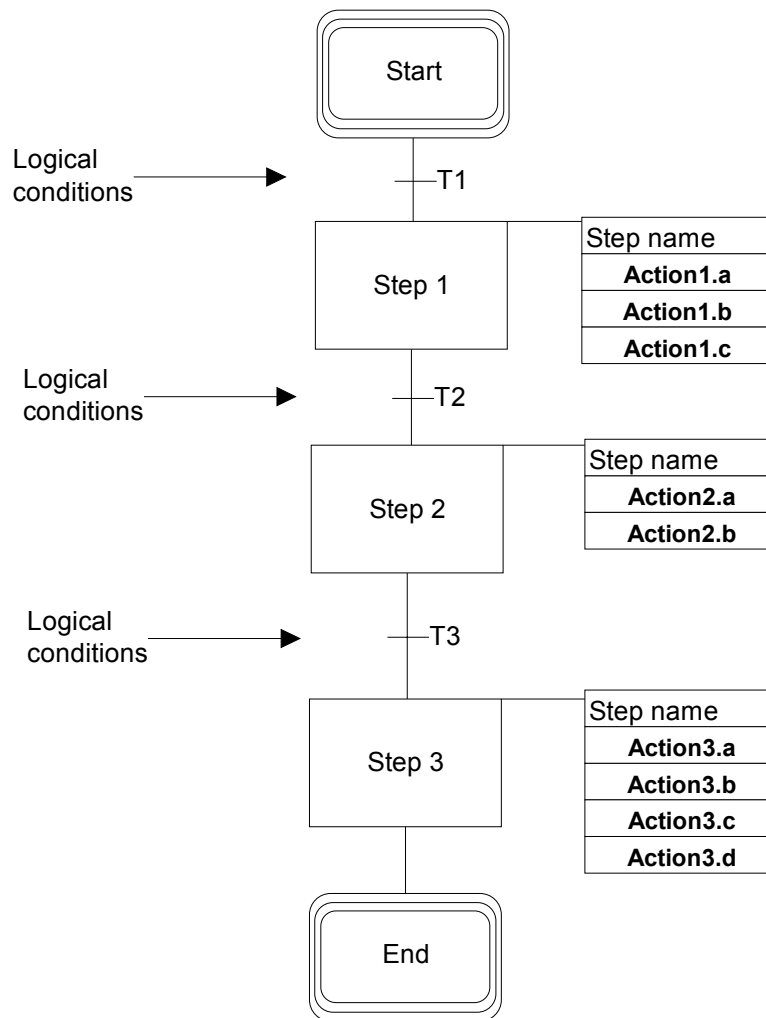
For the sub sea functions there may also be an extra set of function template, which incorporate the special sub sea control system interfaces.

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.
- Failure modes



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 (Normative) SCD Drawing standard

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 templates and field instruments/flowelements
- signals interconnecting function templates and other logical elements
- 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 extend 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 dominates 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

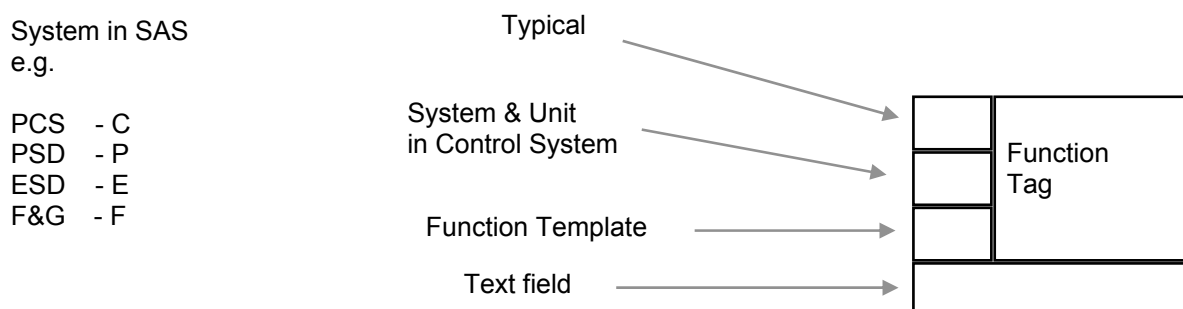
The symbols used on the SCD shall in general adhere to the symbols used on the P&ID's, ref. ISO 3511. However, modifications and additions to both the symbols itself and the range of symbols defined in the P&ID legend are required to reflect the extended information provided by the SCD's.

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.



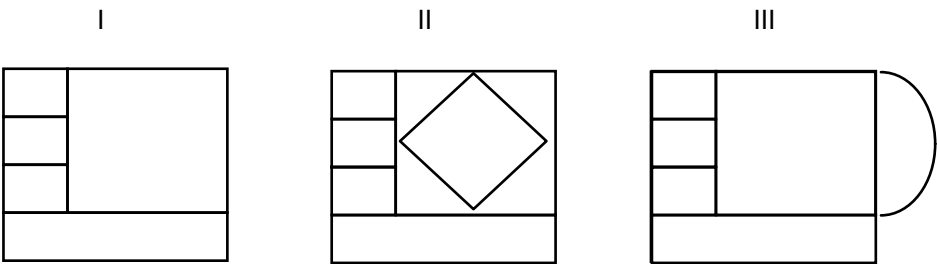
The left-hand three rows column is dedicated for:

- 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.

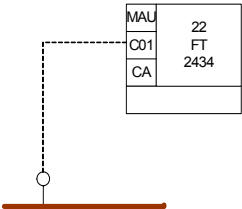
The symbol represents the complete control function covered by the function template, ref. SCD Function Standard. The control function can be completely integrated in SAS (as shown in above example) or can be integrated in stand-alone packages.

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

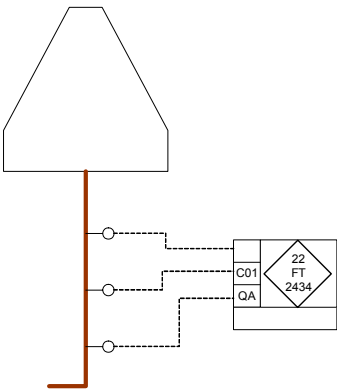


I	Control function and HMI fully integrated in the main control system.
II	HMI function integrated in the main control system. Outside control function not shown separately
III	Outside control function. Interface to the main control system shown separately if applicable. Symbol I should then be used.

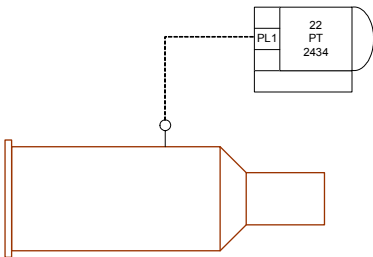
I. Control function and HMI fully integrated in the main control system.



II. HMI function integrated in the main control system.



III. Outside control function.



If function template field in the Function Template symbol (type: Integration level II) is filled out this object is represented in main control system with a full version of the standard template. If the field is only filled out

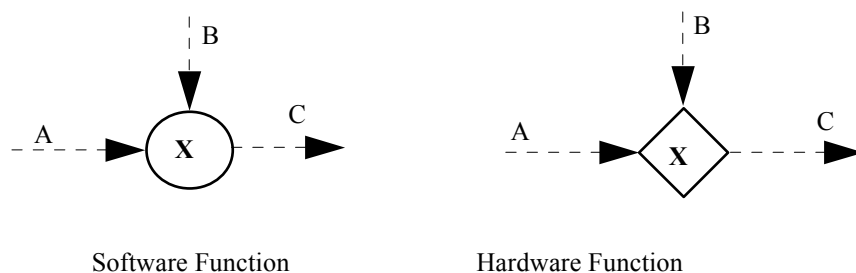
with an ' - ' (Minus sign) it is not represented with a standard template. The typical field can then be used for identifying a typical HMI. A HMI not defined in this standard but in the specific project.

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.

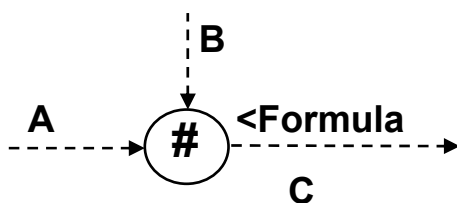
The symbols for combination of multiple input signals can be shown differencing between software and hardware realisation:



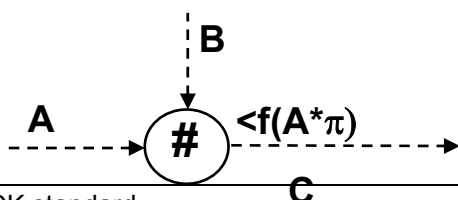
The x symbol is defining the function according to the following table:

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 ($C = 1 \text{ when } B > A, \text{ otherwise } C = 0$)
<	Comparator Low ($C = 1 \text{ when } B < A, \text{ otherwise } C = 0$)
+	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)
S	Split of signal
#	Optional

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



Example:

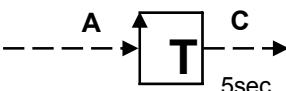
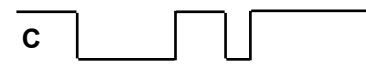
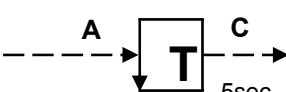
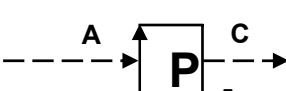
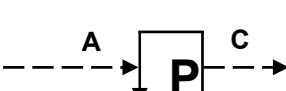


To avoid ambiguities regarding hardware/software interpretation and system unit allocation of signals the following rules shall be strictly adhered to:

- 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.

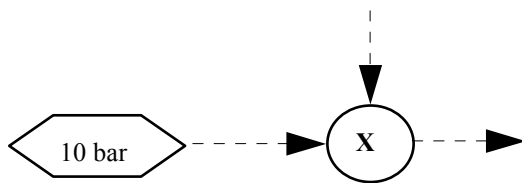
The logic elements for single signal operation are defined in the table below.

Description	Symbol	Logic Diagram
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.

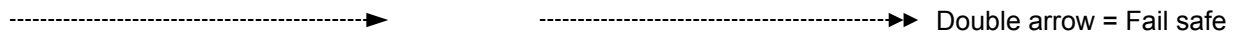
B.4.3 Parameter labels

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



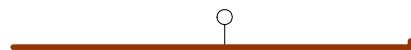
B.4.4 Signal line

The general symbol for signal line is



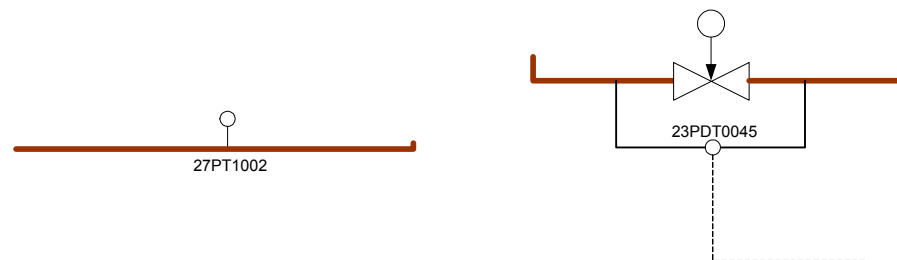
Arrow shall be included to indicate the direction of information flow. Whenever multiple usage of a signal is required, the signal split symbol shall be used. Signal lines for electrical signal/power, hydraulic signal/power, pneumatic signal power and digital communication link shall be identical to 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 close to the instrument symbol.



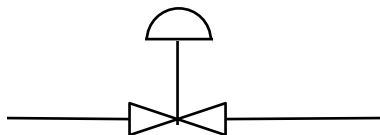
B.4.6 Mechanical equipment

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.

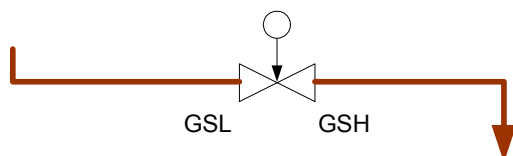
B.4.7 Valves

B.4.7.1 On/Off valves

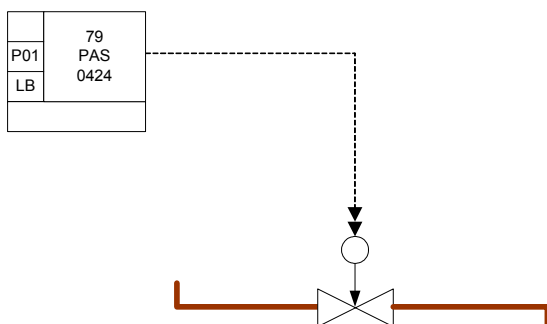
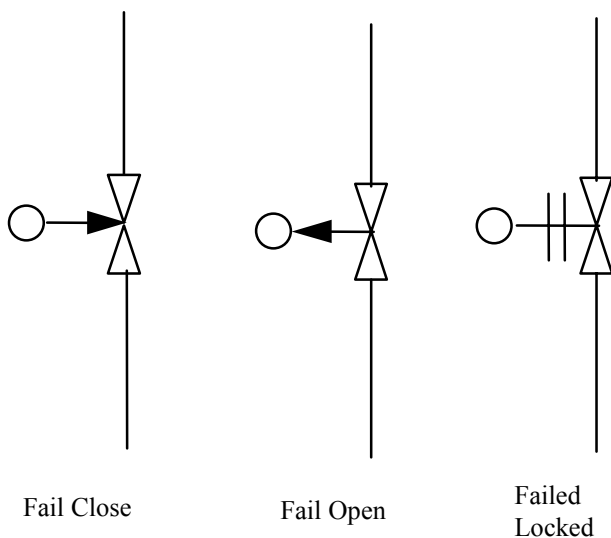
The on/off valves shall be drawn as a simple valve. The actuator shall be drawn with a small circle without tag identification letters. This is a deviation from ISO 3511. The reason for the deviation is that the same information is shown in the function template.

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.

**B.4.7.4 Fail safe**

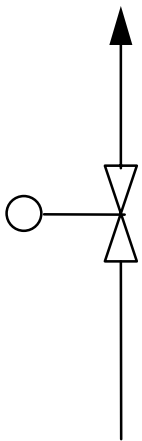
Fail safe on loss of electrical signal should be shown on the SCD according to the figure below.



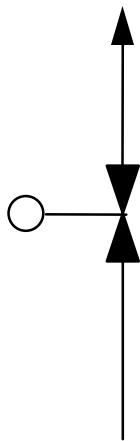
Double arrow may be used to indicate normally energised circuits.

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.



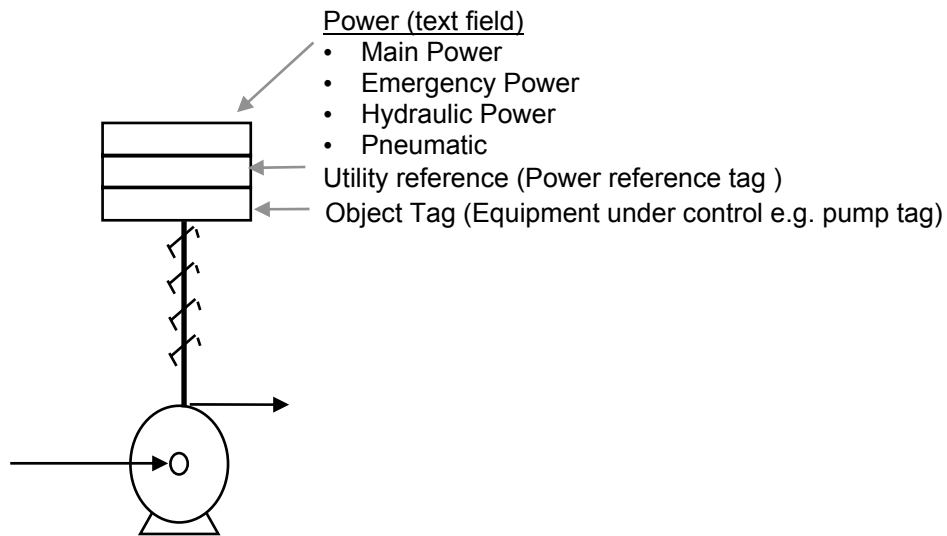
Normal Open



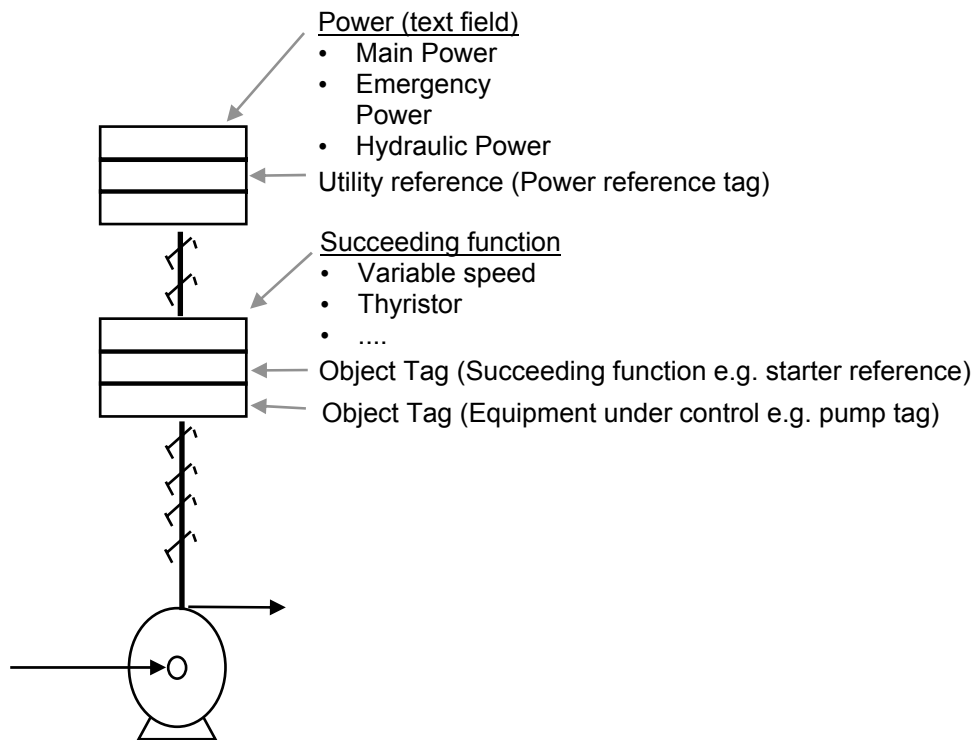
Normal Close

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.



Feedback signal are not normally shown.



Note: Feedback signals are in general not shown on the SCD.

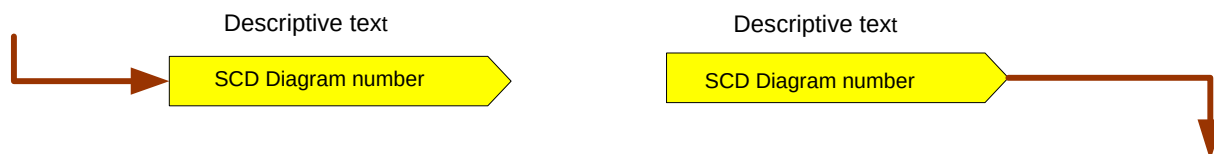
|

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



The reference shall identify the drawing where the line continues/originates. In addition there shall be a descriptive text making the line recognizable from the one sheet to the other.

Drawing reference for instrument signals

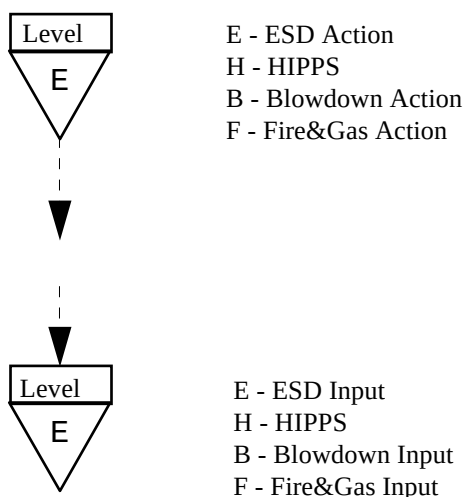


The first reference shall contain a unique 3-digit number (or more if required), the second reference shall identify the drawing where the line continues/originates.

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.

(Reference letters included as examples only.)



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.

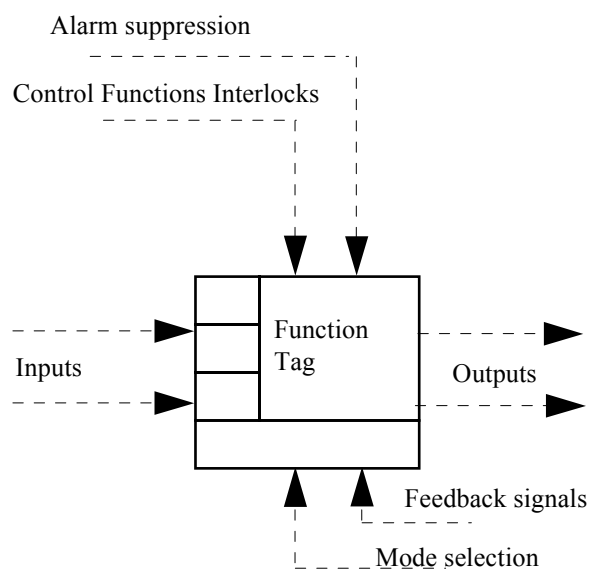
In cases where the equipment shall be tagged e.g. tagging of electrical equipment should object tagging be used.

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 at the top of the function template.

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

Annex C

(Informative)

Project execution guidelines

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.

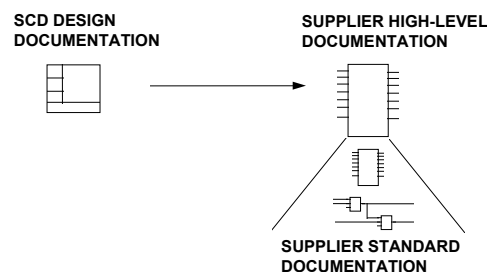


Figure C.1 - SAS Supplier interface

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.

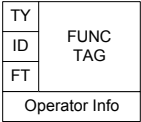
C.5 Modifications

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.

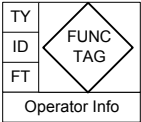
- Multidiscipline design.
- Input to implementation.
- Basis for verification and testing.

Annex D
(Normative)
SCD Legend

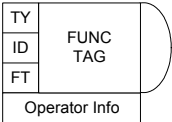
Function Block Symbols



Standard SAS control function:
Function fully implemented in the main control system for logic as well as HMI.



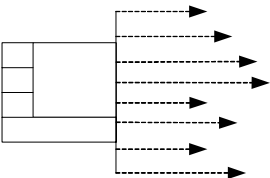
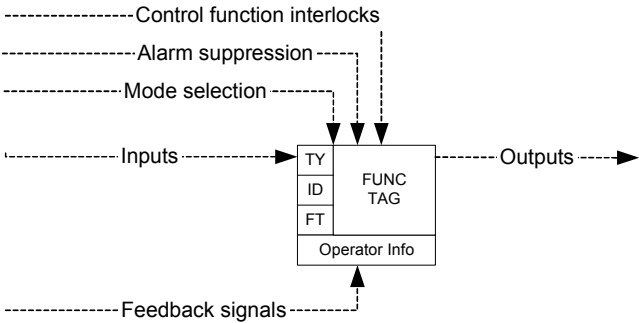
Non – Standard control function:
Logic control function implemented outside main control system –, but with the HMI function integrated in the main system.



Local control function:
Logic control and HMI function implemented outside main control system. Any information interface to the main system to be shown separately.

FT: SAS function template name
ID: SAS unit identification
TY: SAS function typical implementation
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

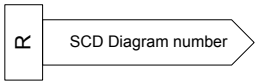


Extension of function block symbols if more terminal points are required.

Reference symbols



Drawing reference for process connection



Drawing reference for instrument signals
R = Unique signal reference identifying the signal connection

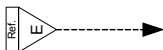


Sequence reference flag. Reference to sequence. Normally reference to a step in applicable sequence. I.e step 01

Function identifier for safety system interface.



Signal to global safety function - Ref: Reference to shutdown level.
E – Identifier of safety system
ref. Chapter B.4.9.2



Signal from global safety function - Ref: Reference to shutdown level.
E – Identifier of safety system
ref. Chapter B.4.9.2

Descriptive text

SCD Diagram number

Equipment symbols



Block valve



Control valve



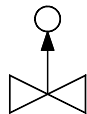
Manual valve (generic symbol)



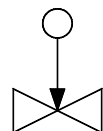
Valve normally closed



Valve normally open



Valve to open on loss of electrical signal (FO)



Valve to close on loss of electrical signal (FC)



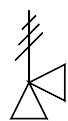
Valve to be locked on loss of signal (FL)



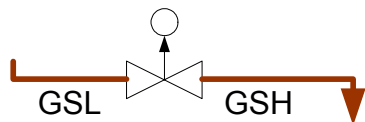
Valve will fail indeterminate on loss of signal (FI)



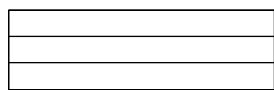
Transmitter



Safety relief element

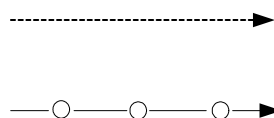


Low (GSL) and High (GSH) limit switch indicator

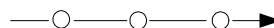


Power (text field)
Object tag (power)
Object tag (controlled equipment)

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.



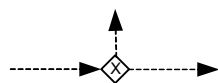
Constant values

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

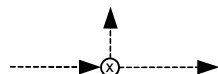


Value of parameter, e.g. 25
Unit of parameter, e.g. deg. C

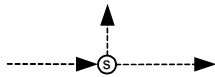
Logic and arithmetic symbols



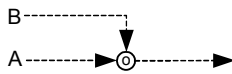
Hardware function



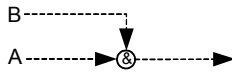
Software function



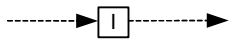
Software split of signal



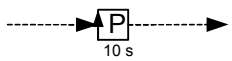
Logic OR
Output true if A OR B true.



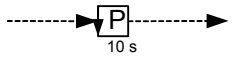
Logic AND
Output true if A AND B true.



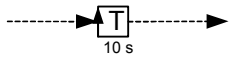
Inverter



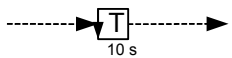
Pulse, i.e. positive pulse upon transition from 0 to 1 (10 S = duration of pulse)



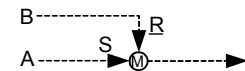
Pulse, i.e. positive pulse upon transition from 1 to 0.



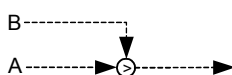
Time delay, i.e. delayed transition from 0 to 1 (10 S = delay time).



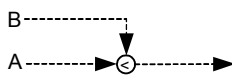
Time delay, i.e. delayed transition from 1 to 0.



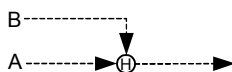
Binary memory element. Input signal latched on positive pulse input. Underline the dominant state. I.e. R = Reset dominant



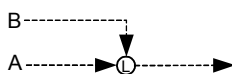
Comparator high
Output = true if B greater than A.



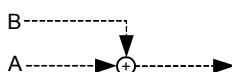
Comparator low
Output = true if B less than A



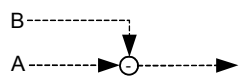
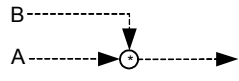
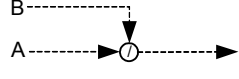
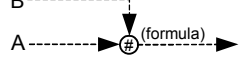
High signal selector. The output signal is set equal the highest of input signals A and B.



Low signal selector. The output signal is set equal the lowest of input signals A and B.



Arithmetic plus.
Output = A + B

	Arithmetic minus Output = A – B	
	Arithmetic multiply. Output = A * B.	
	Arithmetic division. Output = A / B	
	Optional	

Annex E (Informative) SCD Application guidelines

E.1 Purpose

This annex is ment to be a guideline for projects using this NORSOK standard for SCD development. It provides the reader with a number of practical examples of expressing monitoring and control functions on SCDs. The examples are extracted from actual SCDs from several projects. Any project should specify necessary application typical in addition to the typical defined in this annex, based on the same principles. The application typical used for the project should be implemented on the project SCD legend.

This guideline covers both basic functional elements as well as comprehensive application typical.

E.2 Tagging

All function templates shall be tagged. The same tag identification *should* be used for identical functions on P&ID, SCD and HMI.

The project standards for tagging should be used. Reference is also made to NORSOK standard Z-DP-002, Coding System.

All tagging in this document is for exemplification only. All tagging of the function templates is from examples from different projects.

Symbols for logic and arithmetic functions are not tagged.

E.3 Application typical

This chapter will give a selection of a various application typical. Only a few selected inputs and outputs for the function templates will be used in the examples.

E.3.1 Process measurements

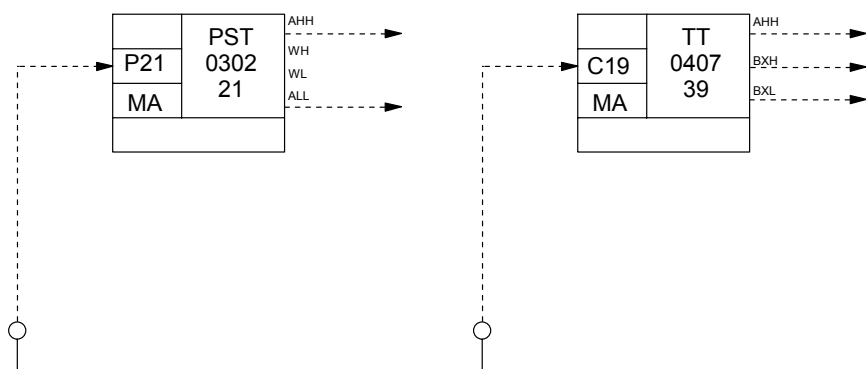
E.3.1.1 Analogue measurements

For monitoring and display of analogue process variables, the MA-template shall be used. The template comprises functions for action and warning alarm as well as loop fault annunciation. Additionally the template handles limit-checking for status outputs (events) without any alarm annunciation.

Applicable alarm handling attributes (AHH, WH, WL, ALL) and status/event handling attributes (BXHH, BXH, BXL, BXLL) shall be identified on the SCD:

All alarm, warning and event limits need to be specified within the SAS system.

Warning alarms with no signal outputs (no actions), shall only be presented on the VDU and in the alarm/event lists.

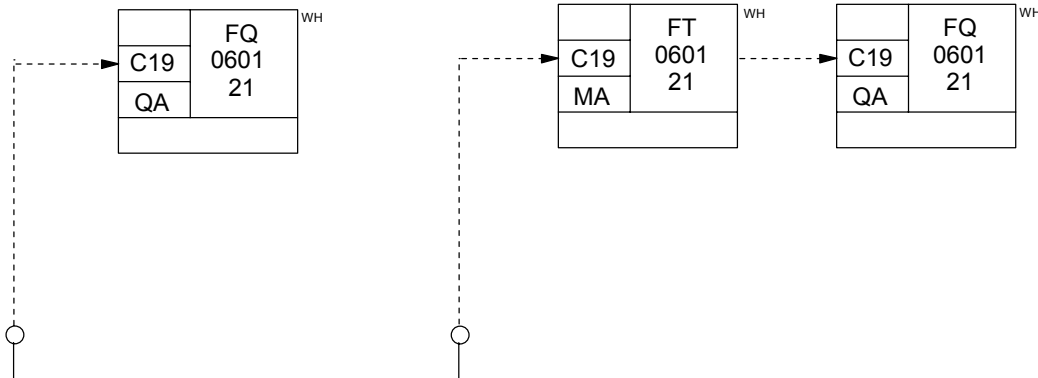


E.3.1.2 Totalization

Totalization of flow is handled by a separate function template, the QA template. The template calculates the *accumulated* flow over a final interval in time by integrating the measured instantaneous flow. The *accumulated* flow calculation can be started, stopped or reset either from the OS or by logic input.

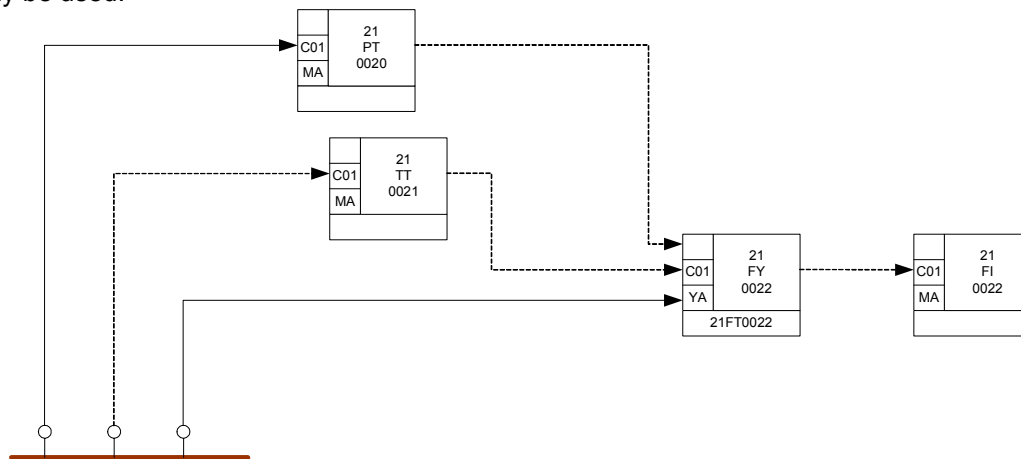
The calculated *accumulated* flow is monitored and compared to HH action and H warning alarms and a HH status (event) output without alarm annunciation. Applicable alarms and events shall be shown on the SCD's.

The analogue value can be connected directly to the x input on the QA template, a MA *template should* only be used either in series or parallel when indication *of the present measured flow* on the operator station is necessary.



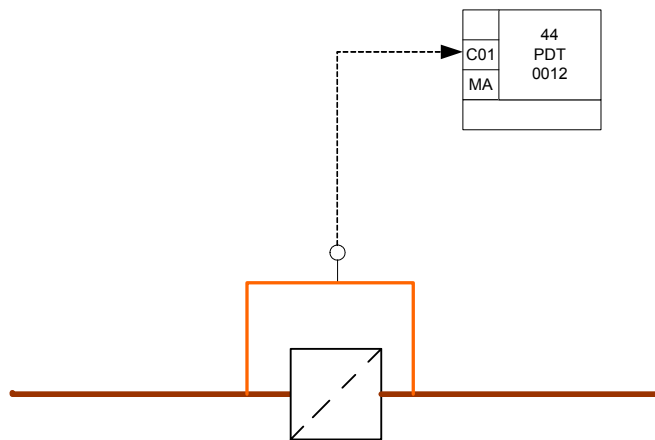
E.3.1.3 Compensation of measured flow

For accurate volumetric flow calculations, the measured flow must be compensated for pressure and temperature. For calculation of standardized flow, the measurement additionally have to be density compensated. Type of function template is not specified by the NORSOK standard, a vendor specific template may be used.



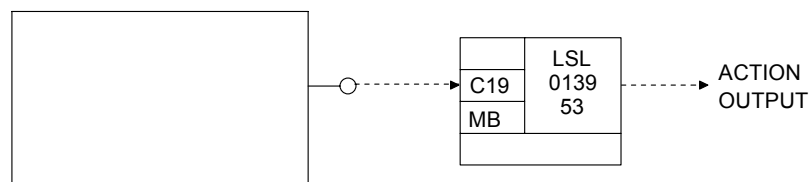
E.3.1.4 Differential pressure measurement

For measuring of differential pressure in the process, it *may* be indicated on the SCD from where and to where the measurement is performed, with simple lines, i.e. across a filter in the process line, as shown in the figure:

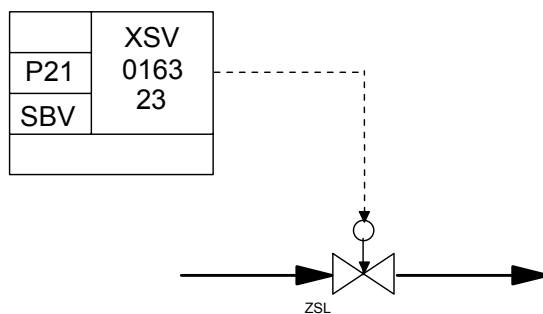


E.3.1.5 Binary measurements

The MB-template shall be utilised for monitoring and display of binary process variables or digital inputs. The MB-template comprises functions for operator alarming and action initiation:

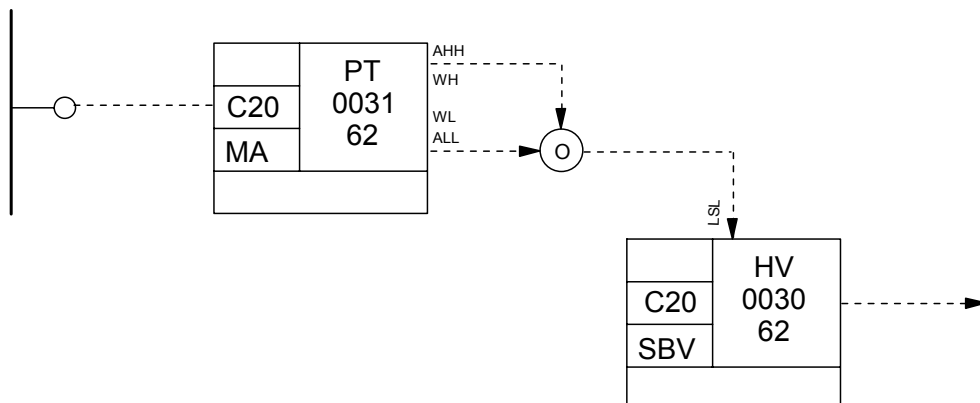


Digital inputs not initiating any actions or alarms shall only be used as input to function templates operating the actual controlled object. E.g. for XSV's, a ZSL limit switch shall give input to the position low input (XGL) of the SBV. A mismatch between the position low input and the normal function output (Y) of the SBV will then generate a fault alarm and switch the valve to manual mode if in auto. The valve position will be maintained. The feedback signal from the limit switch *should* not be shown on the SCD:

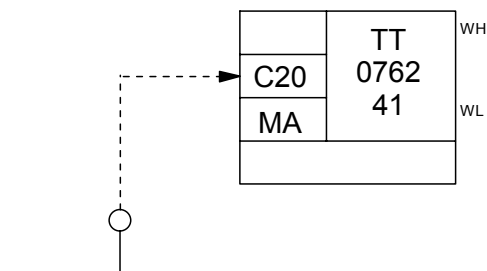


E.3.1.6 Action and warning alarms

Action alarms are alarms initiating automatic interlocking actions in addition to alarm annunciation in CCR. The interlock shall be performed independently of the mode (auto/manual) of the interlocked object:

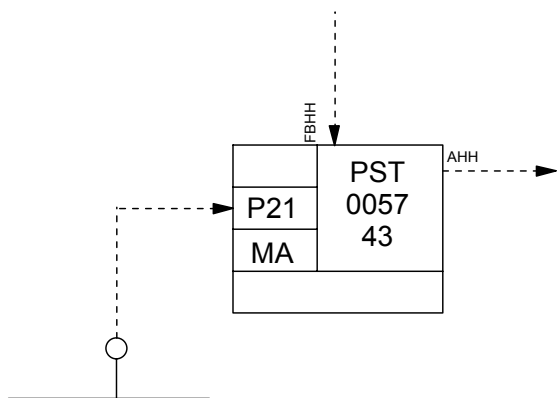


Warning alarms are alarms warning the operator about an undesired process upset. A warning alarm enables the operator to perform corrective actions, but no automatic action is initiated. The alarm annunciation in CCR requires acknowledgement by the operator:



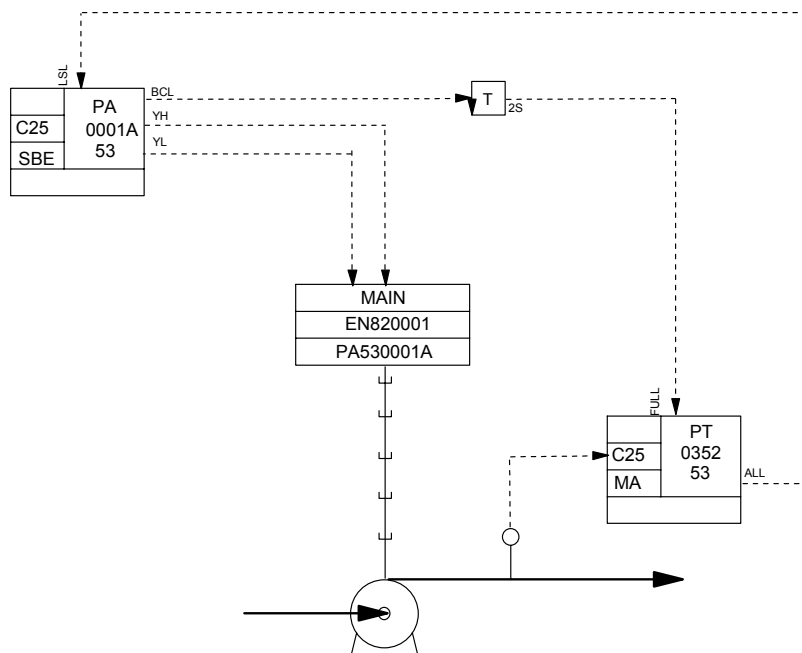
E.3.1.7 Action blocking

Action alarms may be blocked from initiating the actual interlocking action, but still give alarm annunciation. Blocking from the OS blocks all action outputs while single action outputs may be blocked by external logic:



E.3.1.8 Alarm suppression

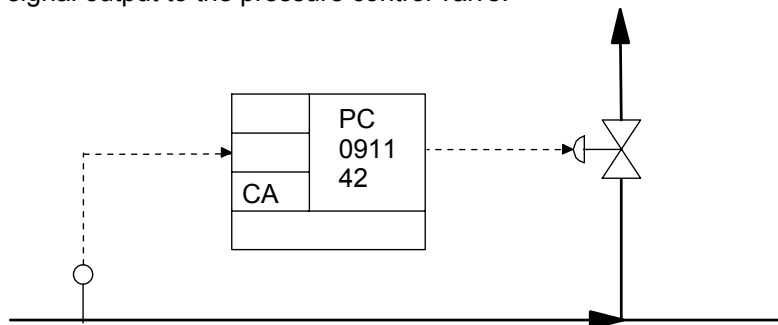
Action alarms as well as alarm annunciation may be suppressed. Suppression from the OS suppresses all interlocking action outputs, alarm and fault annunciation. Single alarms may be suppressed by external logic:



E.3.2 Process control

E.3.2.1 Modulating control

The example shows a typical control loop with an analogue pressure measurement to SAS and an analogue signal output to the pressure control valve:

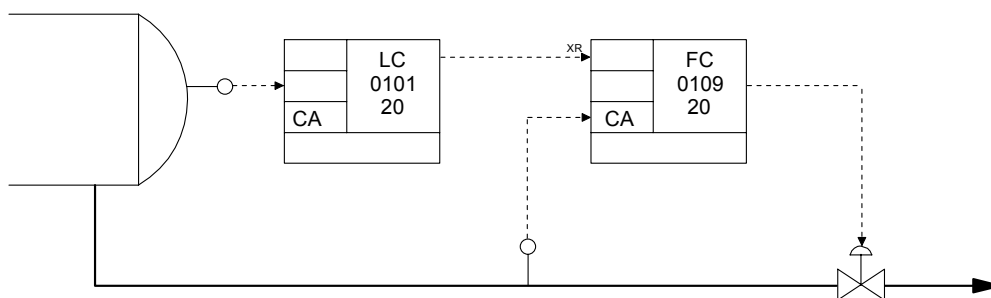


The controller can be operated in either manual, automatic internal or external mode. When operated in automatic mode, the controller can be either direct acting (increased measured input gives increased output) or reverse acting (increased measured input gives decreasing output). It *should* be possible to differ between direct acting and indirect acting, by parameter-setting within the CA template. In internal mode, the set point is selected by the operator. In external mode, the set point input from logical function is used. It shall 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.

Properties for definition of fail-open or fail-close function for the valve should be available within the function template CA.

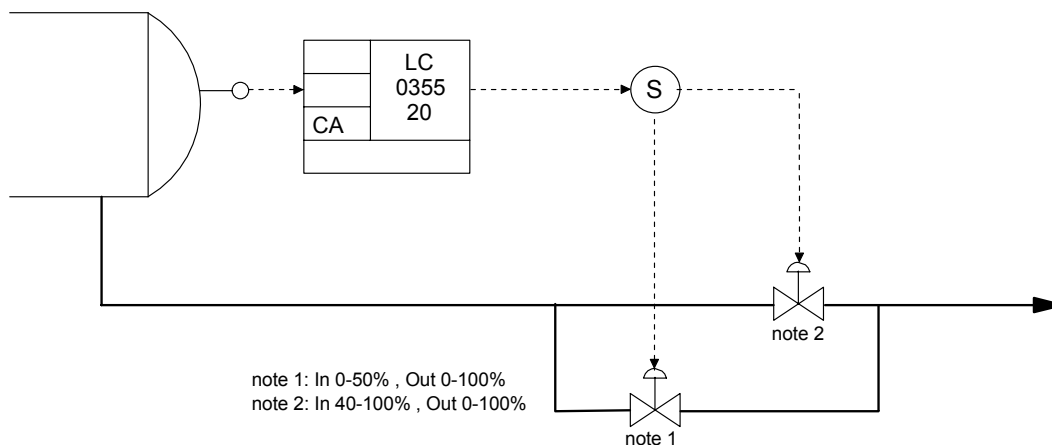
E.3.2.2 Cascade control

For controllers in a cascade coupling, the secondary loop controller uses the output of the primary loop controller as its set point. The output range for the primary controller *should be* the same as the input range for secondary controller:



E.3.2.3 Split range control

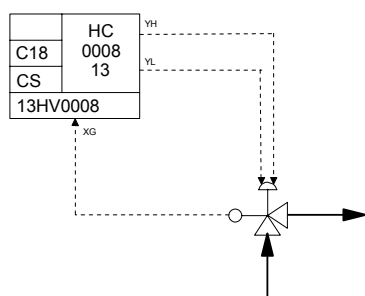
Split range control *should* be in software. The controller output is calculated in the CA template as for standard closed loop control and connected to the positioners in the split range arrangement. The positioners then have to be software calibrated for split range control.



E.3.2.4 Control of choke valves

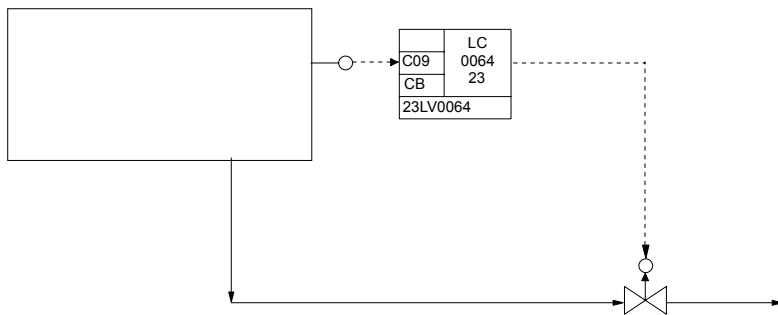
Choke valve control shall be implemented using the CS-template, Step Control Template. The choke valves are operated by either pulsed or steady output signals. One output for opening and one for closing the valve.

The most typical operation of choke valves is by manual stepwise opening or closing from the OS. The CS-template also comprises facilities for automatic control (operator defined set point) or external control (set point defined by external logic). The valve position feedback shall give input to the PCS system:



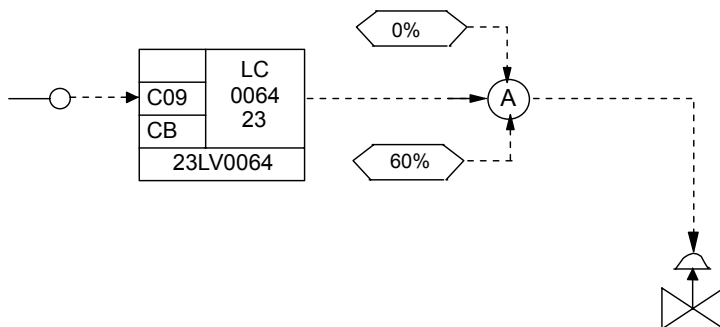
E.3.2.5 Binary control

For binary (on/off) control of flow elements such as valves, pumps and heaters, based on an analogue process measurement, the function template CB, Binary Control (Analogue Input - Binary Output) *may* be used:

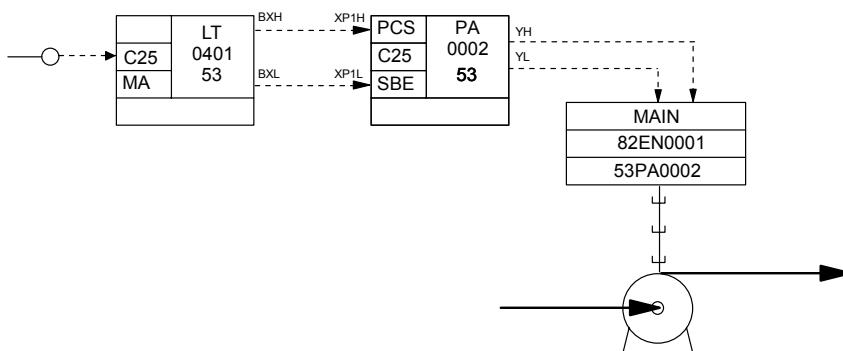


The example above shows level control using the CB-template to switch between open and closed valve position, depending on the level in the tank. In this case the object name on the OS is the valve tag LV230064, and is therefore written in the text field.

On/off control is also performed with a modulating control valve, switching between to specified values, e.g. between 0 and 60% as shown in the example below:



For special applications, an combination of MA (analogue measurement) and SBV/SBE may be utilized, an example is shown below.



The third example shows level control by on/off pump control, implemented with a SBE-template. For this application, the motor control need two outputs, one to start the motor (YH) and one to stop the motor (YL), which are not available on the CB-template:

E.3.2.6 Control of on/off valves, BSV/ESV/XSV/HV

For control of on/off valves the function template SBV - Switching control of valve, is used.

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

The function template can be configured to operate with several options according to the type of application. The following options shall be available, Outside Automation System Controlled (CCR indication only), Manual Operation only (from VDU in CCR) and Manual Operation + Automatic Control.

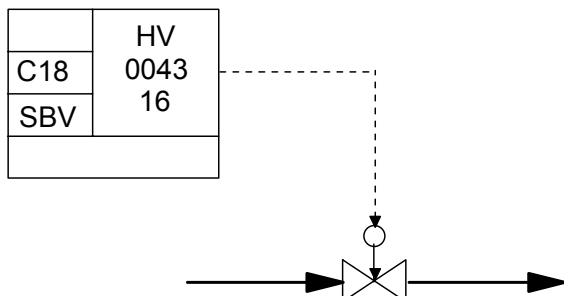
The SBV-template will have four possible feedback constellations:

No limit-switch feedback, position high limit-switch feedback only, position low limit-switch feedback only or position high and low switches feedback.

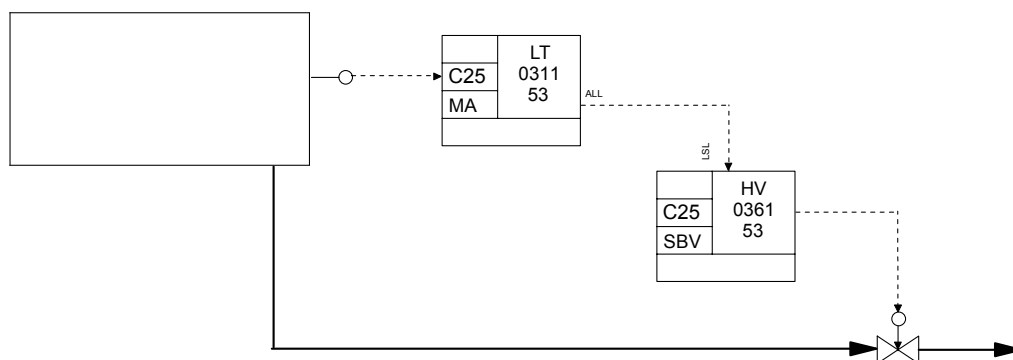
The limit-switch feedbacks to the SBV function template will not be shown explicitly on the SCD, but only indicated on the SCD with ZSL and ZSH below the flow element.

E.3.2.6.1 HV-valves

The figure below shows a manual operated HV-valve with no limit-switch feedback:

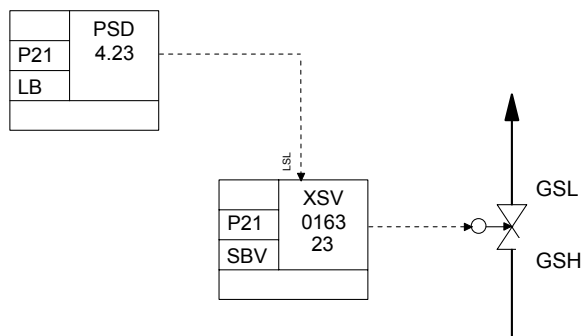


The example below shows a shutdown implemented in the PCS system, i.e. a shutdown not required by API RP 14C (ISO 10418). The valve is closed on activation of LSL independently of state and control mode prior to activation of the LSL-signal. When the level turns back to normal, the valve must be set back manually to the initial position:



E.3.2.6.2 XSV valves

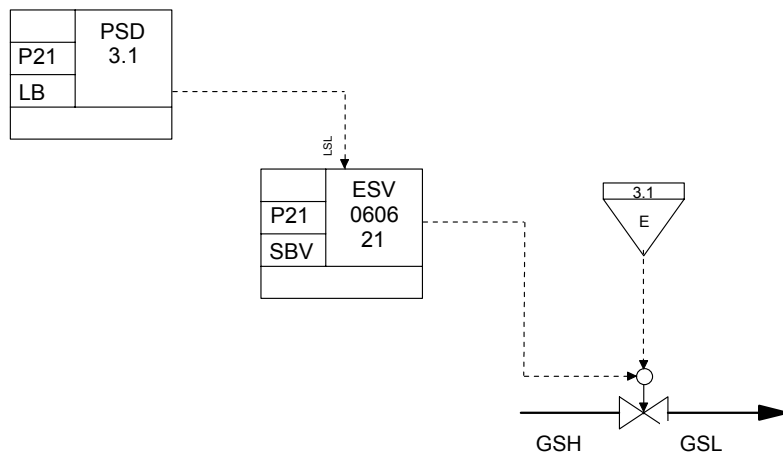
XSV-valves are operated from PSD. In general, XSV's could have closed limit switches wired to PSD. XSV valves can also have both closed (GSL) and open (GSH) limit switches.



E.3.2.6.3 EV valves for sectionalisation

EV-valves for sectionalisation are operated with separate solenoids from ESD and PSD. ESV's may have both open and closed limit switches for feedback wired to PSD.

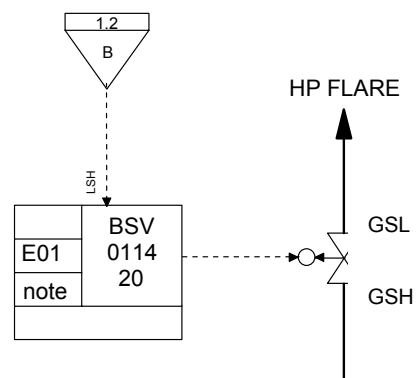
After an activation from ESD the ESV's must be reset in the field (except for subsea EV-valves). This reset function is not shown on the SCD:



The ESD shutdown group will not be documented on the SCD and is only represented with the triangular E-symbol.

E.3.2.6.4 BSV valves for blowdown

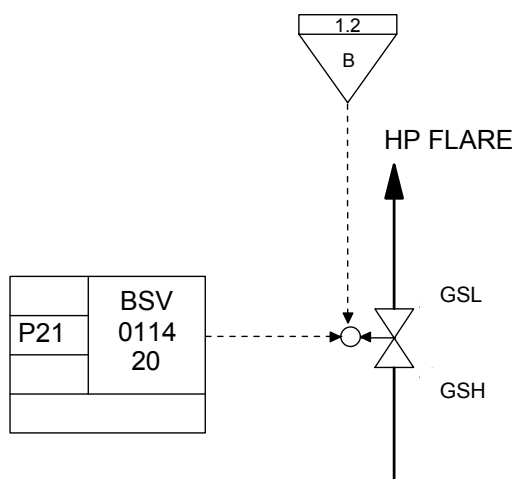
Blowdown BSV's *should be shutdown from* ESD only. The blowdown BSV's *can* have limit switches for both open and closed position feedback wired to ESD. There is no field reset for these blowdown valves:



note: function templates for BSV valve for sectionalisation or blowdown are not specified by NORSOK standard. Vendor specific templates to be used.

The shutdown group is only represented with the triangular B-symbol. The function template that represents the BSV in the ESD node *should be explicitly shown* on the SCD.

For blowdown BSV that shall be possible to operate from PSD or PCS, e.g. for depressurisation of compressors, a separate solenoid for PSD or PCS is needed, as shown below:

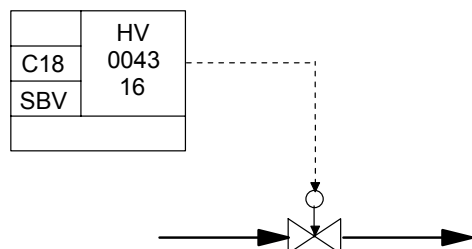


The function template that represents the BSV in the ESD node shall not be shown on the SCD. Open and close manually from CCR *should be either from PSD or PCS*. The valve *may have* both limit switches wired to PSD or PCS.

E.3.2.6.5 Failure actions for BSV/ESV/XSV/HV

E.3.2.6.5.1 Fail close

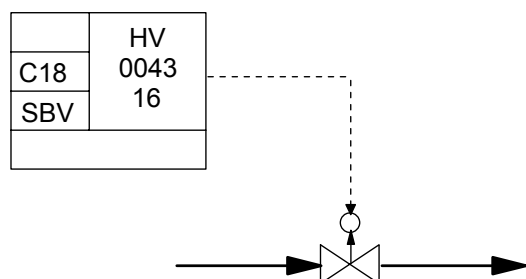
For fail close on loss of signal for on/off valves, the valve will close when the electrical signal is lost. The valve is expecting a low signal (0 V DC) for closing of the valve.



E.3.2.6.5.2 Fail open

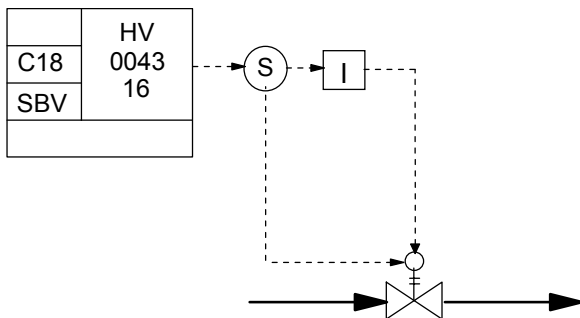
For fail open on loss of signal for on/off valves, the valve will open when the electrical signal is lost. The valve is expecting a low signal (0 V DC) for opening of the valve.

Properties for definition of fail-open or fail-close function for the valve should be available within the function template SBV.



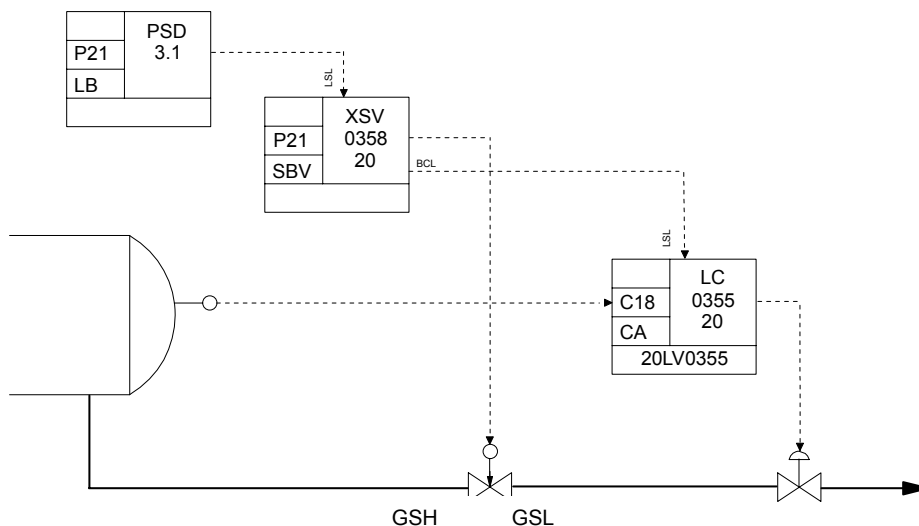
E.3.2.6.5.3 Fail maintain

For fail maintain on loss of signal for on/off valves, the valve maintain in its position when the electrical signal is lost. A fail maintain valve is a double acting valve, *consisting* of two solenoid valves, one for opening and one for closing of the valve. The output from the SBV function template is split in two signals. The signal to the closing solenoid valve is inverted, as shown in the drawing below.



E.3.2.6.6 ESV/XSV/HV and control valve interaction

Control valves located downstream ESV/XSV/HV's *should* be closed subsequent to closure of the ESV/XSV/HV. For ESV's, XSV's, and HV's if in another node than the control valve, the position confirmed low (BCL) output *should* be sent over the bus to the actual PCS node.



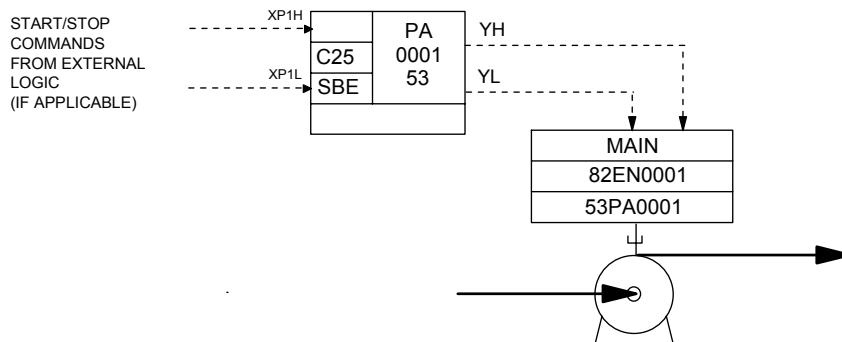
E.3.2.6.7 Electrical equipment control

For control of electrical equipment, such as motors, pumps, heaters, fans etc., the function template SBE shall be used.

The function template can be configured to operate with several options according to the type of application. The following options shall be available, Outside Automation System Controlled (CCR indication only), Manual Operation only (from VDU in CCR), Manual Operation + Automatic Control and Duty/Standby Operation.

E.3.2.6.7.1 Low-voltage motors/heaters with on/off control

Low-voltage (LV) motors/heaters with manual start/stop from the OS and eventually automatic start/stop from external logic *should* basically be shown as follows:



All motor control is performed from PCS. The signal interface from PCS to the MCC may be via a communication link, i.e. a PROFIBUS link. The typical signal interface between PCS and MCC for low-voltage motors are a start (YH) and stop (YL) signals in addition to available and running feedback signals. Available and Running feedback signals are not shown explicitly on the SCD, but will be a part of the standardized MCC interface for the project, other interface may also be defined by the project. The standard MCC interface should be specified on the project SCD Legend.

LV motors may also be controlled by one common hardwired start/stop signal, in addition to available and running feedback signals.

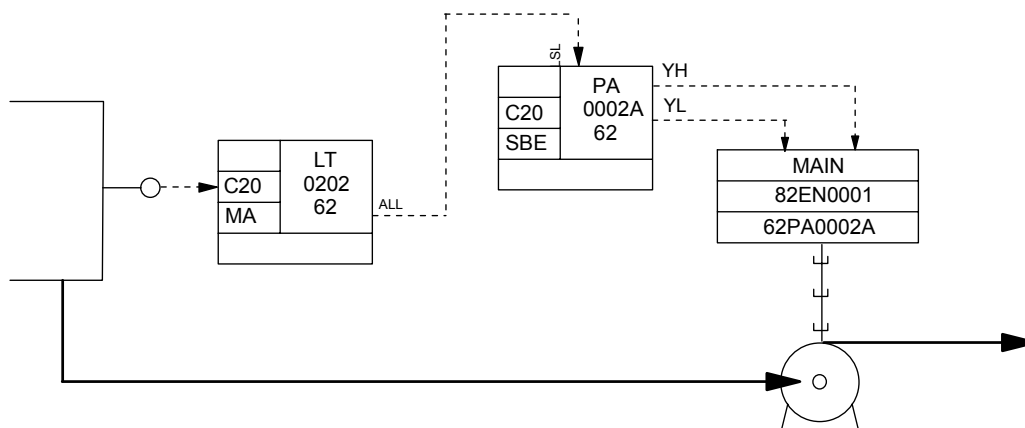
The interface between SAS and MCC may be shown as a data communication link or as hardwired signals.

Additionally the motors may have trip signals from PSD (API shutdowns), separate package logic or load shedding trip from the electrical system. This shall be shown explicitly on the SCD.

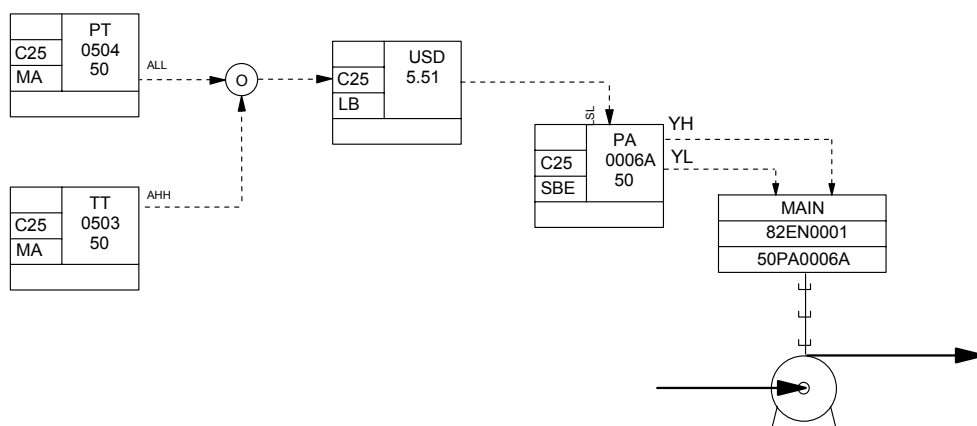
Heaters are equal to motors.

E.3.2.6.7.2 Motors/heaters with manual on/off control and PCS interlock

In addition to normal control from PCS, motors/heaters may be interlocked by a single PCS trip or by a PCS shutdown group. Single PCS interlock:



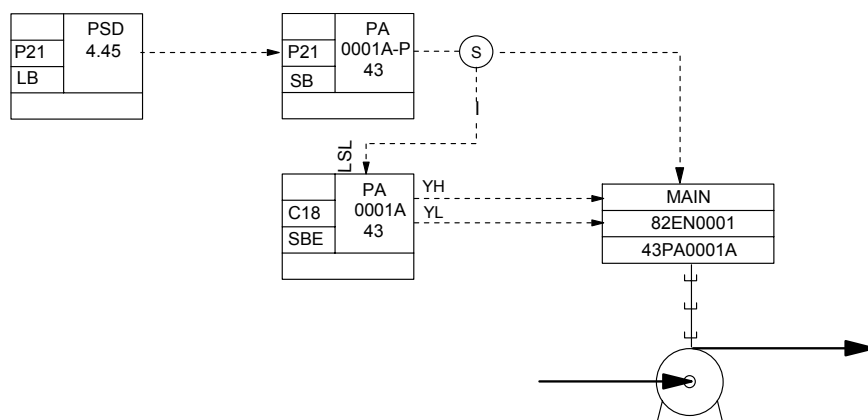
PCS shutdown groups for equipment protection (USD = Unit ShutDown) shall be implemented using the same function template as for PSD shutdowns, namely the LB-template:



Shutdown by interlock from PCS is only acceptable when the shutdown is for pure protection of equipment not in hydrocarbon service, i.e. shutdowns not required by API RP 14C (ISO 10418).

E.3.2.6.7.3 Motor/heater with manual on/off control and PSD interlock

Safeguarding interlocks required by API RP 14C must be implemented in the PSD system. The SCD representation *should* be as follows:

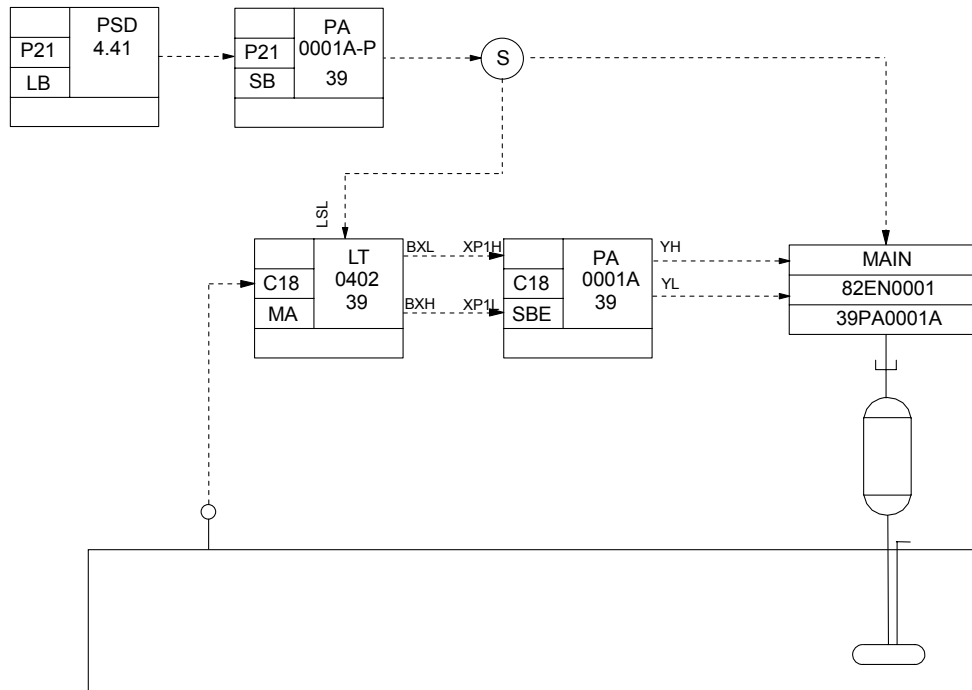


Upon shutdown activation the hardwired output Y signal from the single shutdown signal function template SB to the trip-relay in the motors circuit breaker is deenergised, thus electrically isolating the motor.

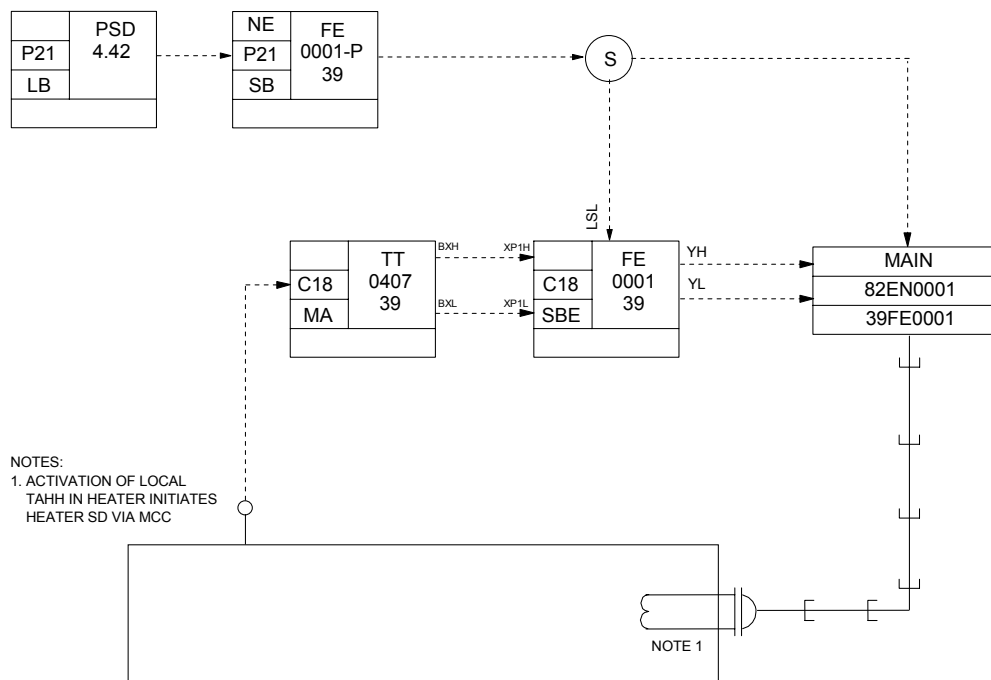
When the motor is shutdown from PSD. The output signal Y is sent by bus to PCS. This will shutdown the pump from PCS also, and addition suppress alarms from PCS.

E.3.2.6.7.4 Motor/heater with automatic on/off control and PSD interlock

Pumps with on/off control based on an analogue process measurement and safeguarding interlock from PSD *should* typically be shown as follows:

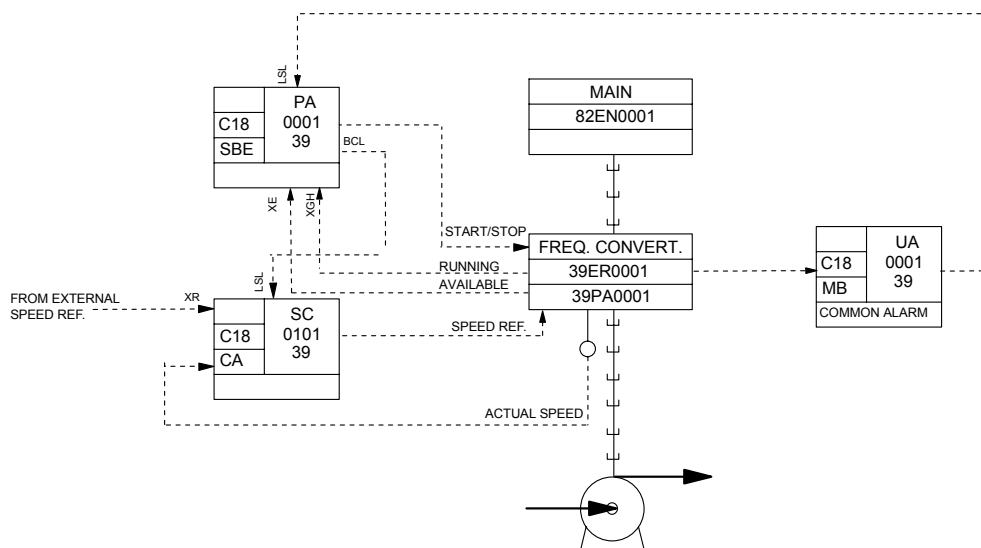


Electrical heaters *should* be shown similarly, but with an additional note about the local termistor for TAAH protection:



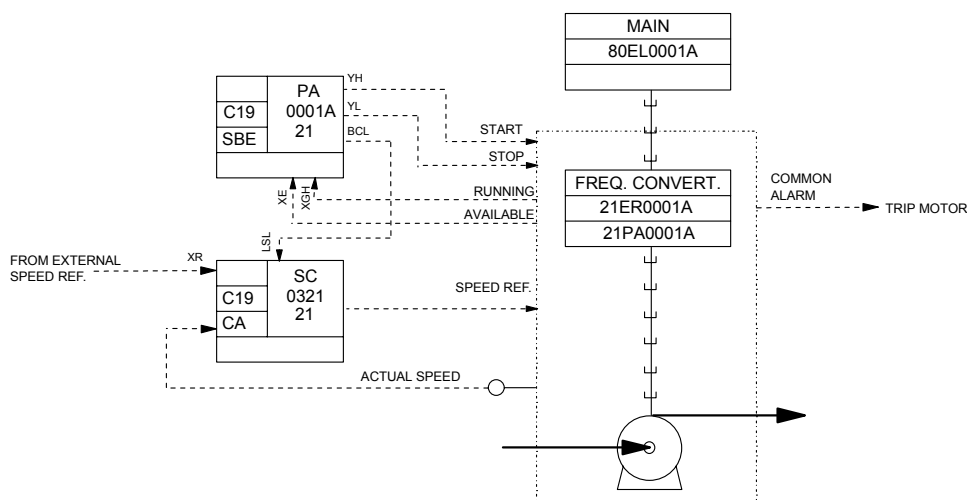
E.3.2.6.7.5 Low voltage motors with modulating control

For variable speed low-voltage motors, an variable speed drive is interfaced from PCS, for the speed control. The CA-template is used to calculate the speed reference input to the variable speed drive. Motor control functions like start/stop and mode selection is handled by the SBE-template.



E.3.2.6.7.6 High voltage motors with modulating control

For variable speed high-voltage motors, different types of frequency converters may be used. The detailed signal interface towards the frequency converter may vary for the different types of converters as well as the specific application. A typical example:

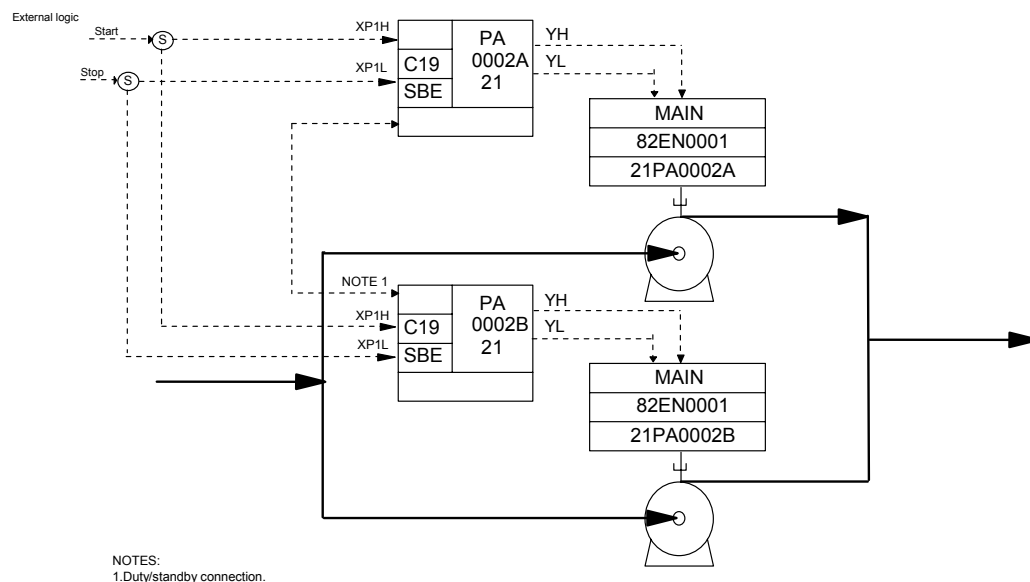


E.3.2.6.7.7 2 x Duty / Standby configuration

Norwegian : Drift / Klar or Drift / Beredskap

For duty/standby configurations with 2 controlled objects, e.g. 2 x 100% pumps, the objects need to be connected to each other, according to specific vendor solution.

The operator shall be able to select the priority function. One flow machine 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.



The flow machines can be either started/stopped manual or automatic from external logic.

If relevant inputs for priority 1 and priority 2 may be used from external logic, XP1H/XP1L and XP2H/XP2L. As an example this can be used for level control of a tank, if the level is reaching a specified level 1 (BXH), pump with priority 1 is started (XP1H). If the level does not start to decrease, but increases instead, pump with priority 2 (XP2H) can start at level 2 (BXHH). Both pumps may run until the level reaches an acceptable low level (BXL).

When operating in duty/standby mode, both SBE templates must assigned auto mode, else the duty/standby configuration will not function.

E.3.2.6.7.8 3 X Duty / Standby configuration

For three objects in duty/standby, the normal configuration will be to have two objects in duty and the third in auto and standby. If only one object shall be running at the time, the second object must be in auto and standby while the third must be set in manual.

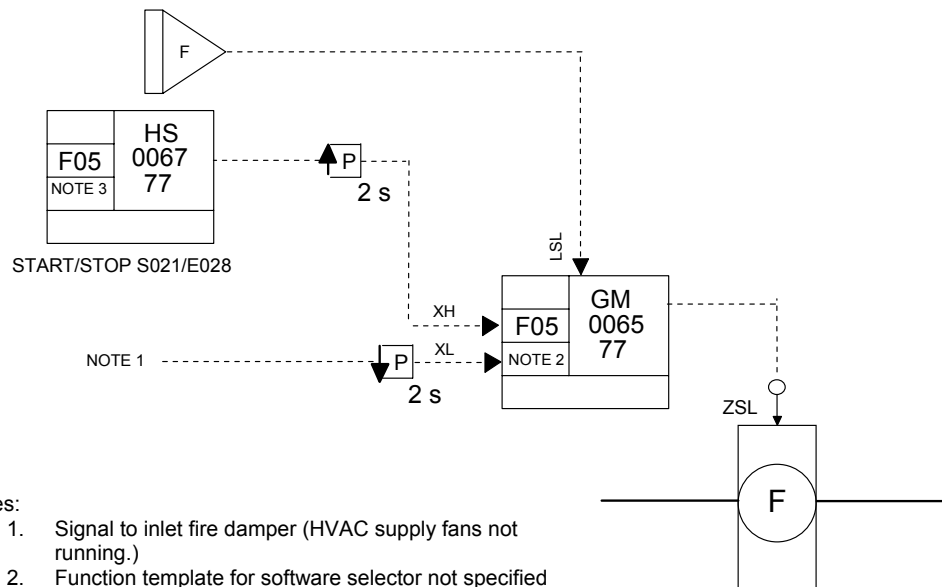
E.3.2.7 HVAC

HVAC control is either performed from the F&G or the PCS system.

E.3.2.7.1 Control of HVAC dampers

All fire dampers can be manually operated from the OS. When the operator initiates start of a HVAC system, the relevant fire dampers will be opened.

In case of a fire or gas detection in a HVAC systems intake, the relevant fire dampers will be shut down from F&G.



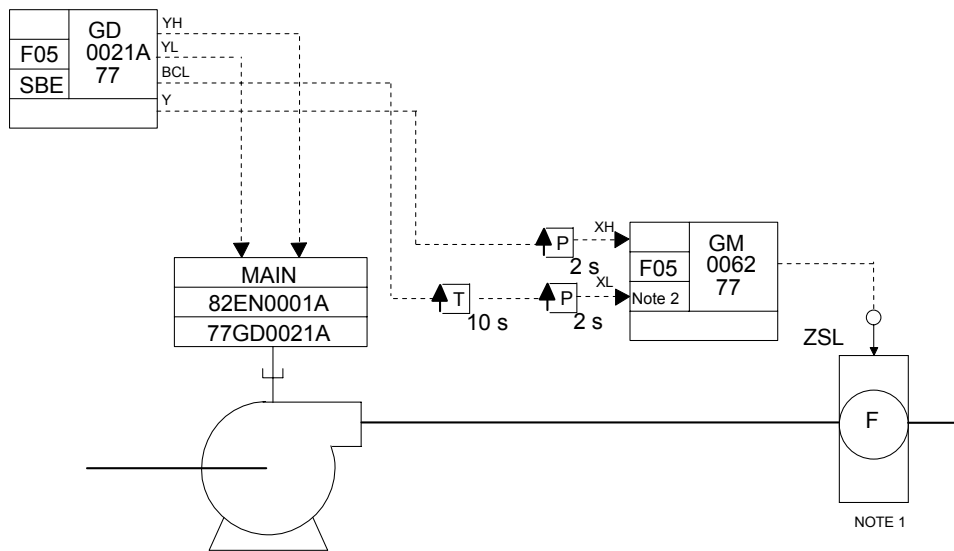
Notes:

1. Signal to inlet fire damper (HVAC supply fans not running.)
2. Function template for software selector not specified by NORSOK Standard. SBV may be used.
3. Start / stop software pushbutton.

Fire dampers are generally equipped with closed limit switches wired to F&G. The limit switches shall be indicated on the SCD's.

A fire damper can in some cases have a combined functionality. In addition to work as a fire damper, it can also have the functionality as a shutoff damper.

The relevant fire dampers will be closed in case of a fire, but also when the HVAC system is not running.

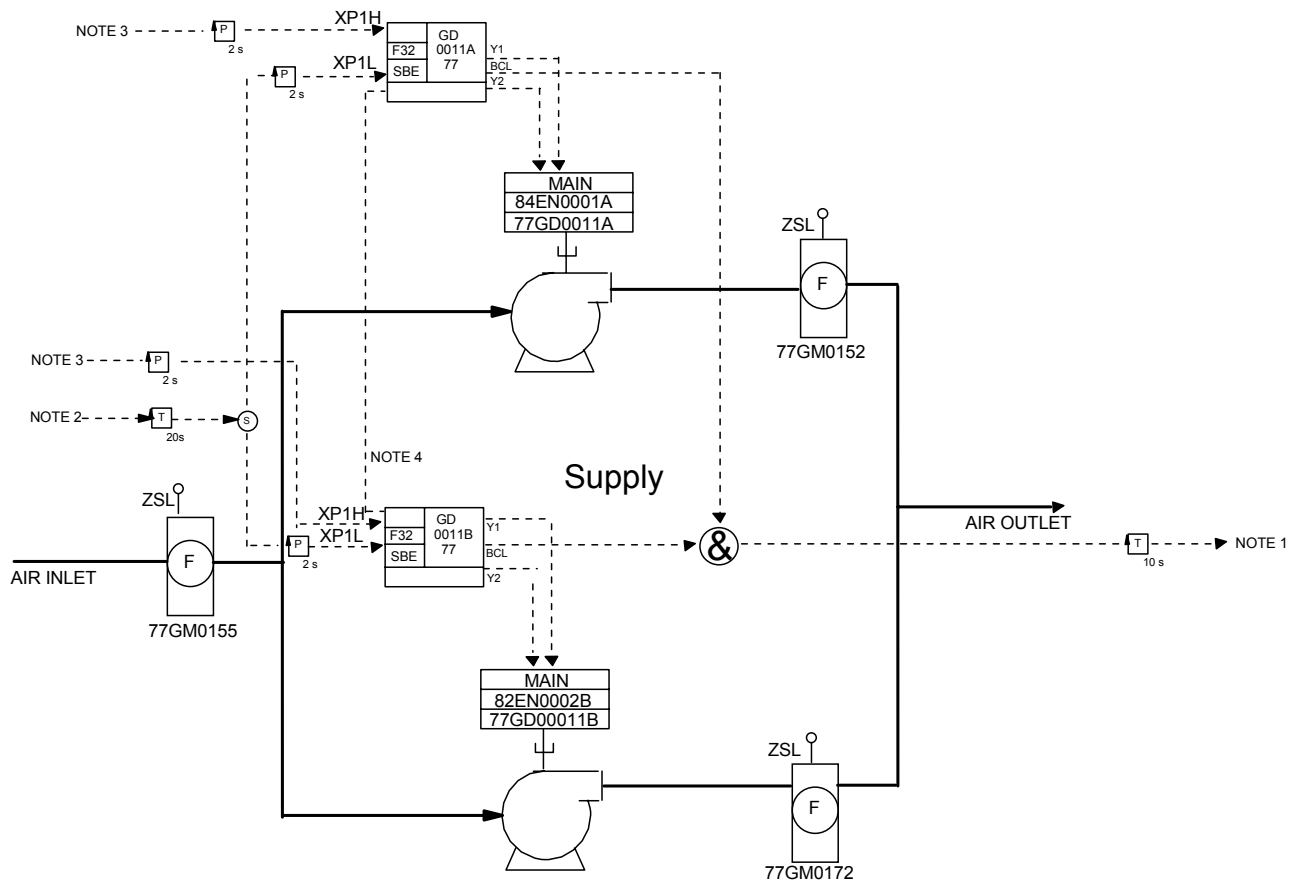


Note 1: Firedamper work as a shutoff damper controlled by F&G system (F05).

E.3.2.7.2 Control of HVAC fans

Start of HVAC fans *will normally* be manually initiated from the OS. Start of a HVAC system *should* activate the actual supply and extract fans. No fan will be permitted to start if not both inlet and outlet fire/shutoff dampers are confirmed open. In addition to manual stop initiated from the OS a HVAC fan will be stopped from the logic if either inlet or outlet fire dampers should close. In case of a fire or gas detection in a HVAC systems intake, the relevant fans will be shut down from F&G.

To avoid over- or under pressure, supply and extract fans for the HVAC system *should* be interlocked. If extract fan stops the supply fan *should* be stopped, and vice versa.



Note 1. SIGNAL TO EXTRACT FANS (SUPPLY FANS NOT RUNNING)

Note 2. SIGNAL FROM EXTRACT FANS (EXTRACT FANS NOT RUNNING)

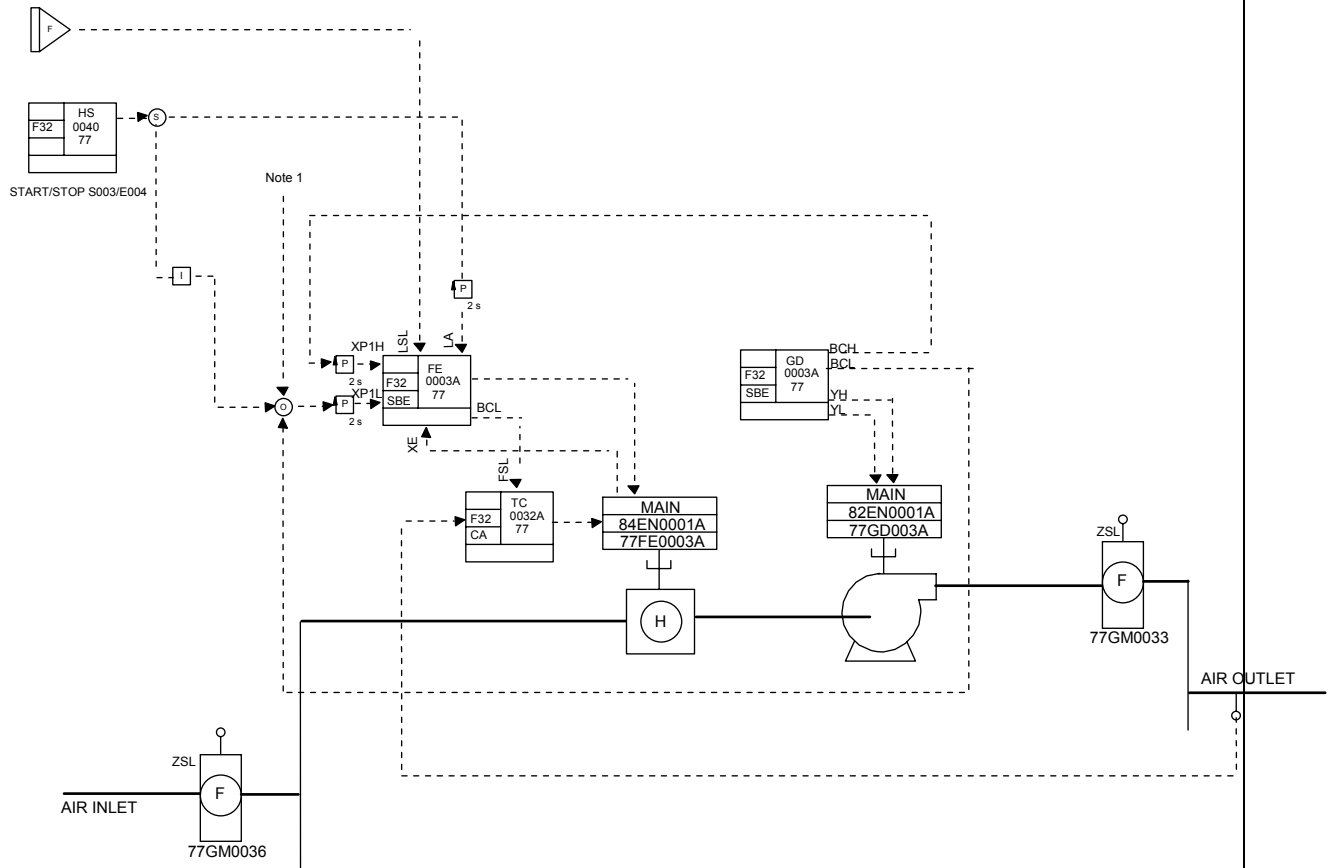
Note 3. SIGNAL IF INLET FIRE DAMPER IS OPEN AND START IS ENABLED

Note 4. DUTY/STANDBY CONNECTION

E.3.2.7.3 Control of HVAC heaters

For HVAC heaters with modulating control thyristor control *may* be used. When the HVAC supply fan is confirmed running then the heater will start. The effect of the heater is controlled by measuring the air outlet temperature. These measurements are used as an input to the controller (TIC).

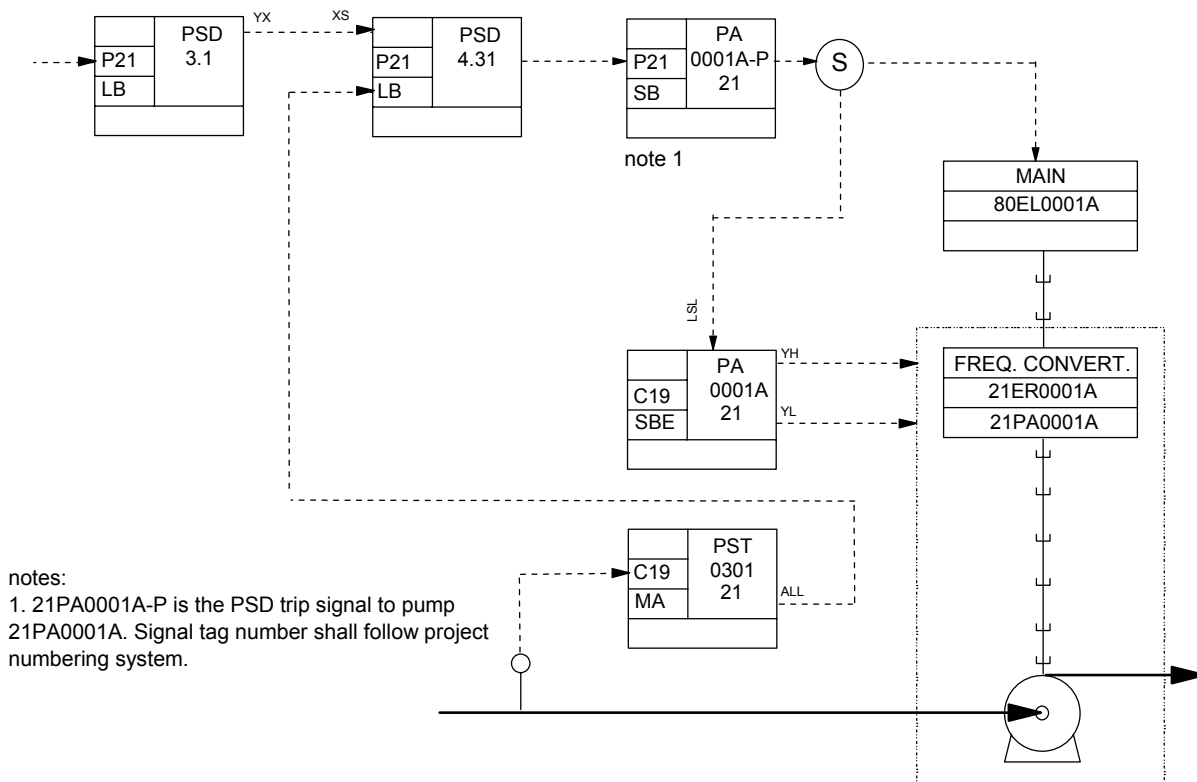
The heater will stop if the HVAC system or fan is stopped or if either inlet- or outlet fire dampers should close. In case of a fire or gas detection, the relevant heater will be shut down from F&G.



E.3.2.8 Shutdown

E.3.2.8.1 PSD shutdown groups

The highest level shutdown group activated by some unwanted process condition is latched and be reset from the OS. Shutdown groups activated directly by the first shutdown group shall not be latched. E.g. when the condition releasing PSD 3.1 no longer is present, the 3.1 group may be reset. In effect then, PSD 4.31 is reset as well:

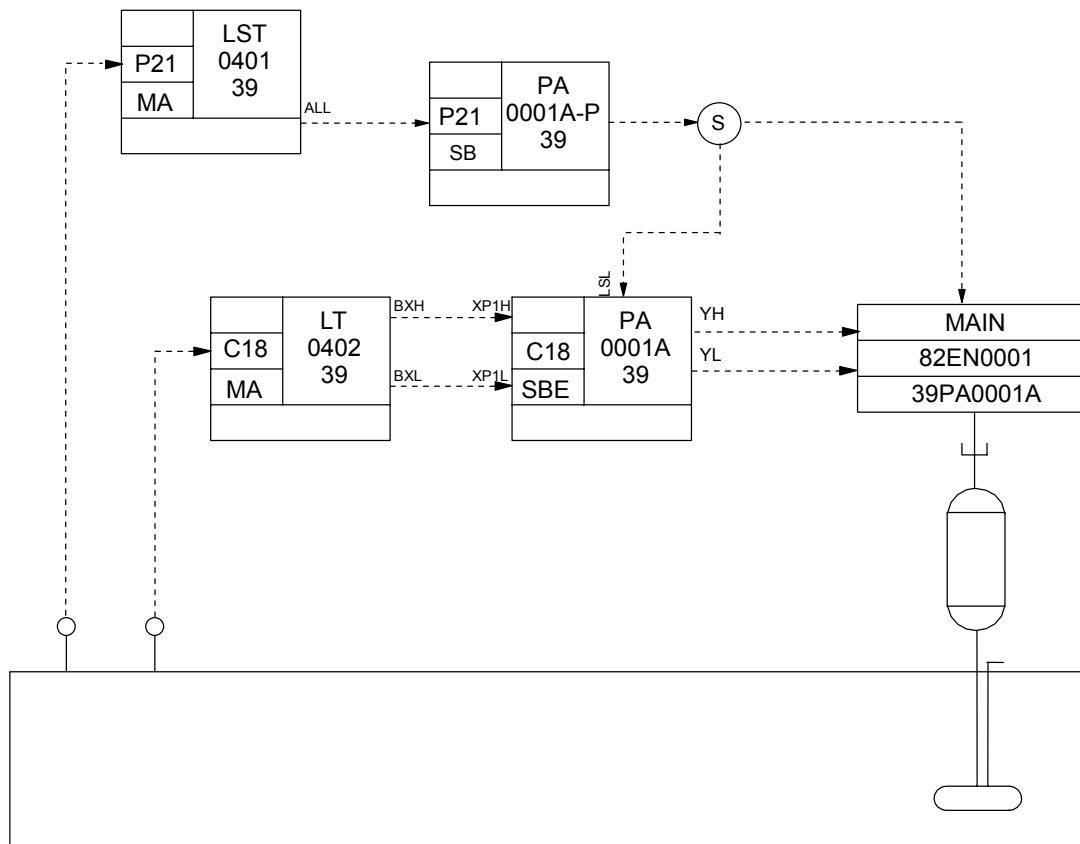


Causes initiating shutdown levels shall be implemented via a MA or a MB block. With these function templates, the operator can see the status of the signal on the OS and has the possibility to block the signal. In case of a trip, the event initiating the PSD will be shown in the alarm list.

If the effects of a shutdown level are placed in a PSD node, the signals shall be connected to either a single shutdown signal function template SB or a SBV. These function templates have blocking possibilities and status indication on the OS, but are not shown in the alarm list.

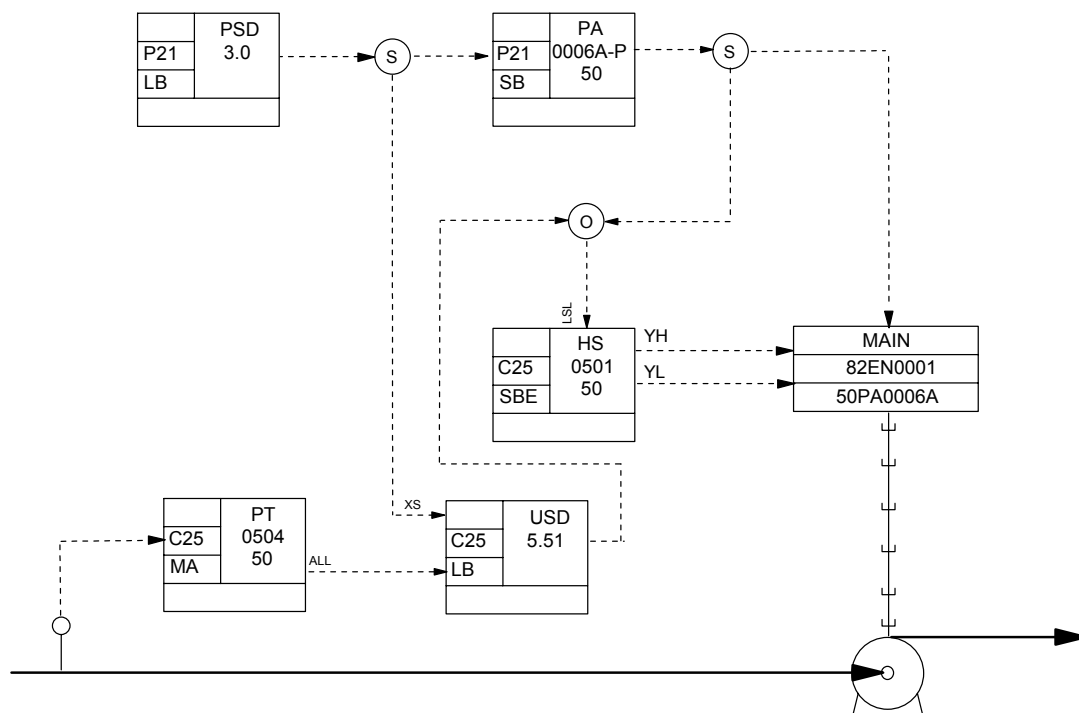
E.3.2.8.2 Single PSD shutdown

When a process measurement to the PSD system shall initiate a shutdown action not part of a shutdown group, the SCD implementation *should* be as indicated:



E.3.2.8.3 Shutdown from PCS

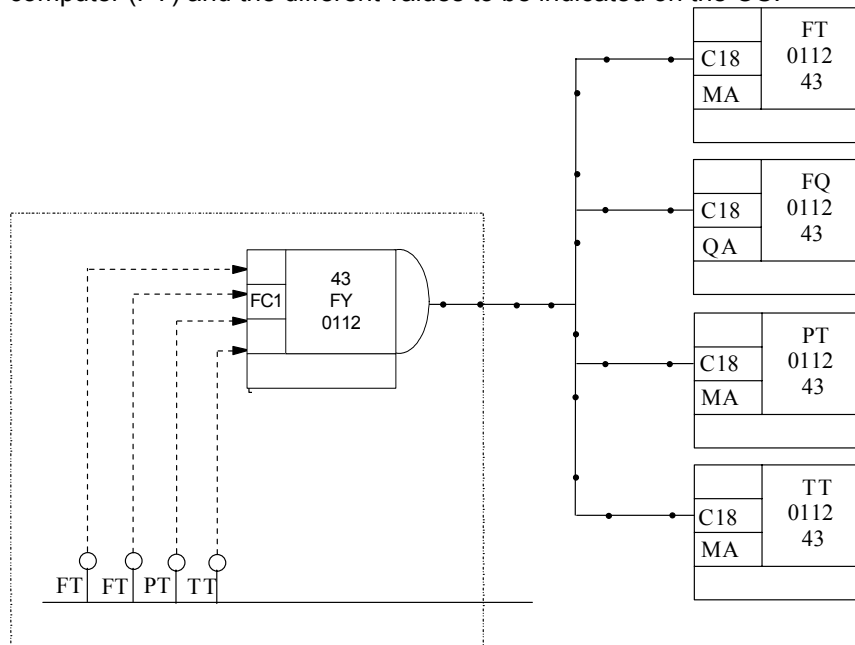
Shutdown not required by API RP 14C (ISO10418) may be performed from PCS, either by a single shutdown initiator or by a PCS shutdown group. An example of a PCS shutdown group is shown below:



E.3.2.9 Interface to external systems

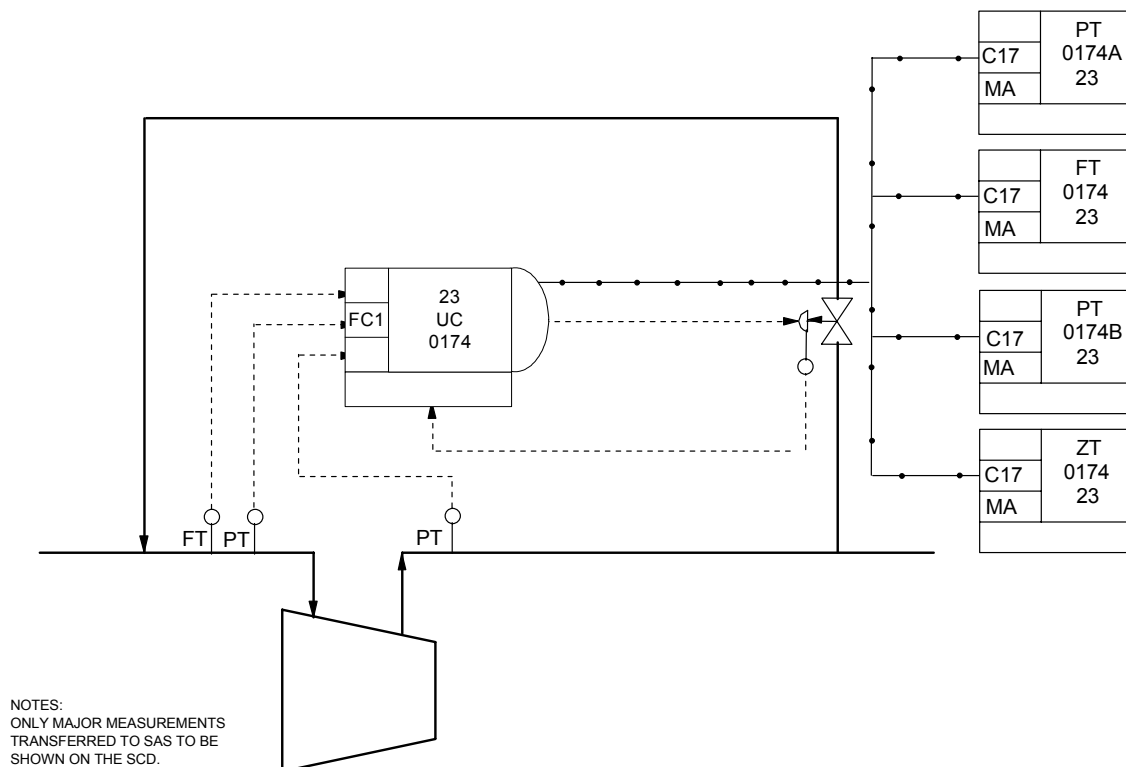
E.3.2.9.1 Typical metering station interface

A typical metering station will be supplied with an interface to a common metering computer. For this example, the calculated values to be indicated on the OS is transferred from the metering computer (FC1) to SAS via a serial link, although the interface may as well be hardwired signals. The SCD's *should* show the type of measurements (FT, PT etc.) input to the metering station, the calculation function in the metering computer (FY) and the different values to be indicated on the OS.



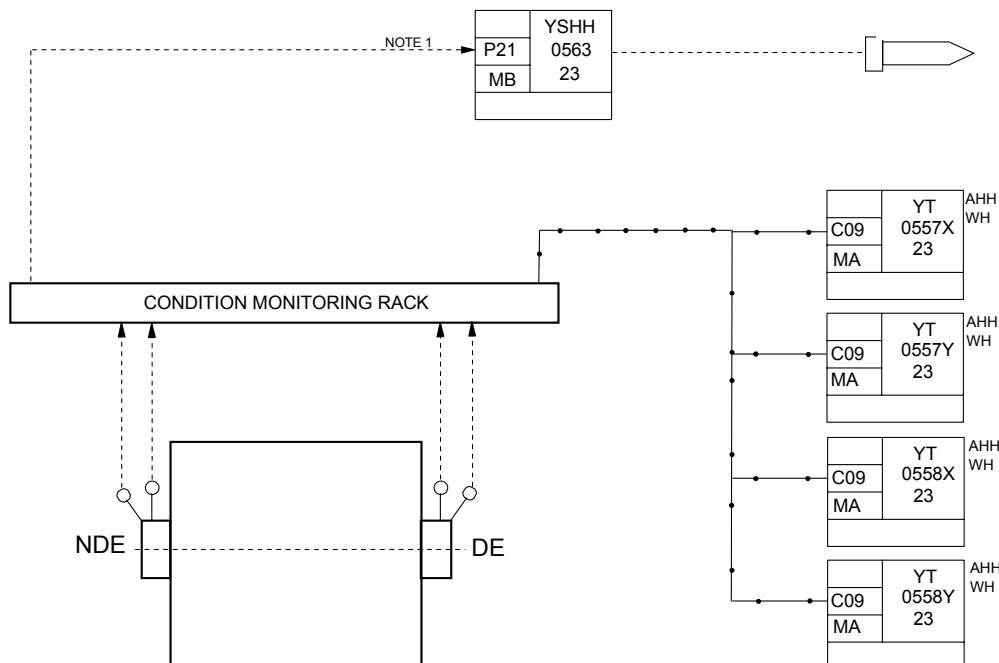
E.3.2.10 Anti-surge control

Anti-surge control may be implemented in the SAS system or in a stand-alone system with interface to SAS.



E.3.2.11 Condition monitoring

The hardwired signal interface for the common shutdown (YSHH) signal from the vibration monitoring system *should* be shown on the SCD's. The measured values from the vibration probes may be indicated with a serial link interface from the vibration monitoring system.



Both analogue values and binary status signals may be transferred via the serial link from the condition monitoring system to the SAS system.

E.3.2.11.1 Typical analogue values transferred to SAS system

Measured vibration signal
Alarm limits

If alarm limits are not transferred to the SAS system, the limits need to be configured in both systems, and may cause variations in the two systems. When transferring alarm limits from the condition monitoring system to the SAS system, the alarm limits will be automatic updated in the SAS system, if the alarm limits are re-configured in the condition monitoring system.

E.3.2.11.2 Typical binary status signals transferred to SAS system

Alarm 1
Alarm 2
Channel not OK
Channel in bypass mode

Another possibility is to give a TRIP MULTIPLY command from the SAS system to the condition monitoring system (typical Bently Nevada solution). This command will multiply the alarm limits with a specified factor, to increase the trip limits, to avoid to trip the rotating equipment during special situations, i.e. start-up of equipment.

E.3.2.12 Parallel functions

For parallel functions, two different approaches may be taken, depending on the application. One approach is to create a detailed SCD for one of the parallel functions and then document the rest of the parallel functions in separate SCD's showing tables of tag numbers for the parallel functions not shown in the detailed SCD's. Typical applications where this approach may be used is for subsea production lines and gas lift lines.

An alternative approach is to document each of the parallel functions in detailed SCD's. This approach *should* typically be used for parallel process sections like the gas export trains, the glycol regeneration unit and the air compressors and for equipment protection SCD's like the oil export pumps.

Annex F (Normative) SCD Control function templates behaviour

F.1 Introduction

This annex is based on a project performed by Sintef Electronics and Cybernetics and its project report STF72F99309.

Note: Chapter 7.11 is added by the Norsok SCD committee into this annex.

F.2 Objective

Purpose of the project has been:

- Define the behavior of the NORSOK control functions in an unambiguous manner
- Test the feasibility of the method for description of SCD behavior proposed by SINTEF.

F.3 Contents of this Annex

- Chapter **F.4 Definition of some NORSOK SCD concepts**" contains the most important SCD concepts used throughout the annex. This information may be used as input to the "System Control Diagrams" document.
- Chapter **F.5 Method for description of behaviour (Control function state charts)**" describes the main ideas behind the method of visualization used in this document.
- Chapter **F.6 Description of behavior in various modes**" describes the various modes of the SCD templates. Each of these modes can be viewed as a "component" mode and used in one or many of the SCD templates.
- Chapter **F.7 Definition of the NORSOK control function behaviour**" describes the behavior of the NORSOK SCD templates. This chapter is based on the template information found in "Annex A: SCD Function Standard", Revision 1.1, November 1999.
- Chapter **F.8 Description of control function elements**" defines the behavior of a few control function elements. Defining the behaviour of all control function elements has not been part of this project. However, one has still been defined, and is documented in chapter.

F.4 Definition of some NORSOK SCD concepts

This chapter lists and defines some important SCD concepts used throughout this annex.

F.4.1 SCD Control function template

The SCD control function templates define control functions that are frequently used in offshore process control systems. The template definition contains a maximum definition of input/output ports and control function elements to be contained in a control function of this type.

F.4.2 SCD Control function

The SCD Control function is an instance of an SCD Control Function Template. This instance may include all the functionality (ports and control function elements) defined in the SCD standard for the particular template, or only a subset of the functionality.

F.4.3 Control function element

A Control Function Element performs elementary (basic) control function operations on process information. This could be a PID controller or a limit check with the purpose to give an alarm.

F.4.4 Process ports (Input and output)

Process Ports convey information that reflects a *state or condition in the outer process*. Examples of information conveyed by a process input port are a measurement value from a process or the state of a limit switch on valve. An external set point to a PID controller is also process information and is therefore conveyed by a process input port. Process Output ports convey information that has some kind of physical interpretation. An example is a valve position. The information can be set out to the process via the control

system's I/O system, or it can be used by another control function. An example of the latter is control functions in cascade.

F.4.5 Logic ports (Input and output)

Logic Input Ports convey information that is used to *control the internal behaviour of the control function*. The information may come from other control functions (such as a control function used to set or reset a process shut-down level). The information conveyed by Logic Output Ports reflect the internal states of the control function.

F.4.6 Operator station ports (Input and output)

The *operator communicates* with a control function through operator station (OS) ports. This can be parameters to the control functions (e.g. set point values) or control information such as block alarms, enable etc.

OS Output Ports convey information that is useful to the operator, such as alarms, warnings and information about particular internal states in the control function (suppression, blocking etc.).

F.4.7 State and mode

States are elements of a Mode. A mode is a collection of states with transitions between the states. If a state contains other states, it may be called a *super-state*. States that do NOT contain other states, may be called *elementary states*. Within a mode, a system is in one and only one of the elementary states. Example of a Mode is Auto Manual Mode. Elementary states are Auto, Manual, Locked Auto, Locked Manual. There are no super-states in Auto Manual Mode.

F.5 Method for description of behaviour (Control function state charts)

The idea behind defining and visualising the behaviour of control functions in terms of modified state charts originates from SINTEF, department of Automatic Control. A project for POSC/Caesar on representation of the information in SCD control functions in terms of POSC/Caesar terminology had revealed the need for a more precise specification and better visualisation of the control function behaviour.

F.5.1 Basic idea

An SCD control function (template) basically has two types of behaviour.

1. One is *the flow and processing of process information*. For example a measurement and set point into a PID controller and the calculation of the resulting control output.
2. Processing of *Control (logic) information (discrete events and commands)* conveyed by the logic inputs and also commands via operator inputs. The processing of this information determines how the template is to react as a result of these events.

One can say that the results of the logic information processing determines how the process information is to flow between the control function elements within the template and to some extent how the process information is to be processed.

A natural consequence of recognising these two types of behaviour, is that one can use different methods in order to describe them. This has been done and the basis for the methods are:

- The logic (processing of internal control information) has been visualised based on *state charts* (explained below)
- The flow process information has been visualised using *electrical* metaphors (signal paths, switches etc.)

The method proposed attempts to clearly distinguish in visualisation between the processing of process information and logic control information through a control function. It attempts to combine the strengths of state charts and logic diagrams (signal or information flow from left to right). In "normal" state chart formalism, the actions performed when entering a state would be described within the state chart. In the formalism developed here, the actions are modelled in terms of electrical symbols. The method has been named "Control Function State Charts". In the following, the method is explained using an example, and starting by explaining the state chart as the basis, and adding the modifications gradually to finally end up with the method for visualising the behaviour of SCD control functions.

F.5.2 State charts

The logic of a control function is quite complex viewed in the number of inputs/outputs and possible combinations of these. However, an analysis reveals that the much of this behaviour is highly parallel. (e.g. Auto/Manual vs. Alarm Suppression). This property makes the logic of the control functions well suited for modelling by state charts.

State charts have the ability to model:

- Parallel state diagrams in which states from other state machines may enter as conditions in other. (This is in the literature referred to as "orthogonality")
- "Depth" in state machines. That is that a group of states can be aggregated into a more abstract super state. A typical example are enable and disable (super-) states which again have states within them.

A good reference for further reading on state charts is:

Harel, David, *State Charts: A visual Formalism for Complex Systems*. North-Holland, Science of Computer Programming 8 (1987) pp231-274.

An example of one state chart follows in Figure F.1.

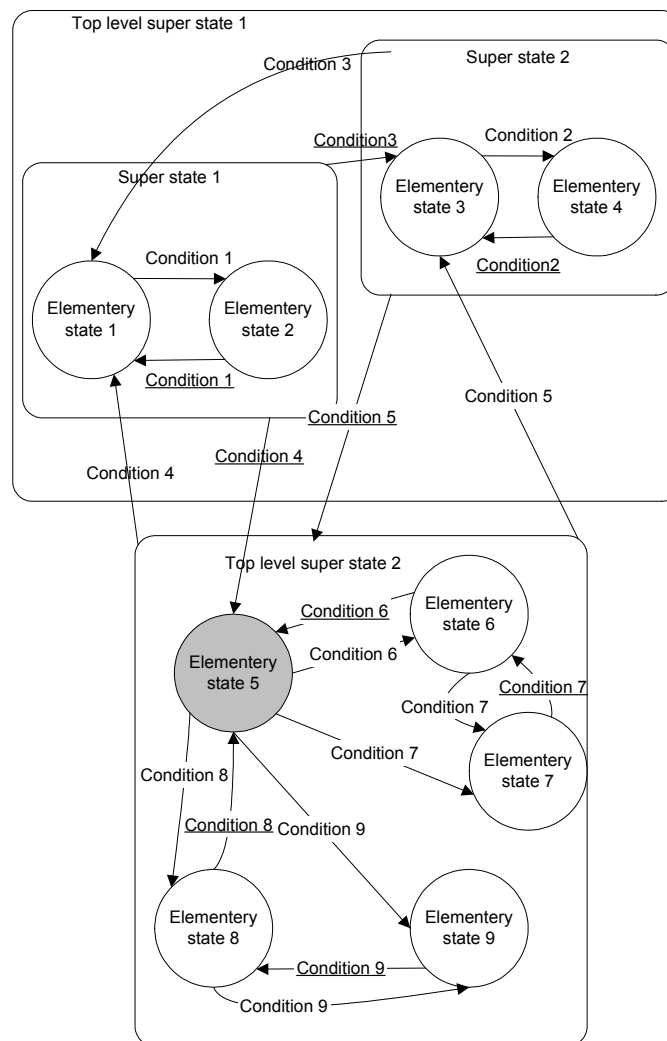


Figure F.1 – Example state chart, with two top level super-states and super-states and elementary states within them

F.5.2.1 States

Figure F.1 shows a state chart with two top level super-states which are indicated with the outer rounded rectangles. The super-states have been named "Top level super state 1" and "Top level super state 2". Within "Top level super state 1" there is another level of super-states, "Super state 1" and "Super state 2". The circles indicate elementary states. The elementary states are the bottom level of states. No states are contained within these. The function can be exactly one of the elementary states at any time.

The purpose of a super-state is to handle behaviour (or conditions) that are common for a group of elementary states. Attaching the state transition to the rim of the super-state means that this state transition is valid for all of the states within the super-state. See the Condition 5 signal gives a state transition to the Top level super state 1. It is attached to the rim of the "Top level super state 2" super-state. However, a state transition from a group of states must end up in a single elementary state. Within "Top level super state 1", "Elementary state 3" is the initial state. In the same way, when Condition 5 disappears, the system will return from either of the states within "Top level super state 1" to "Top level super state 2", with "Elementary state 5" as the initial state. Elementary state 5 is also indicated to be the initial state of the whole state machine.

F.5.2.2 Condition for transition

The condition for transition between states is mostly determined by the values (true or false) on the logic input ports, however operator input is often also a cause for state transition (e.g. Auto Manual selection). One can not intuitively see the role of the input ports from the state chart in Figure F.1. Therefore a modified state chart has been made, where the input ports used by the state charts are "listed" with arrows on the left side of the state chart, see Figure F.2. In the same figure, the output ports and OS output ports whose values are set by the state chart are included on the right side.

Referring to Figure F.2, "Condition 1" means a true value on "Logic input Condition 1", which is a logic input port. "Condition 1" means a false value on the same port. (Sometimes a state from a parallel state chart may enter as a condition for transition in a different state chart. However, this should be the exception rather than the rule in a system with a nature suited for decomposition into parallel behaviour.)

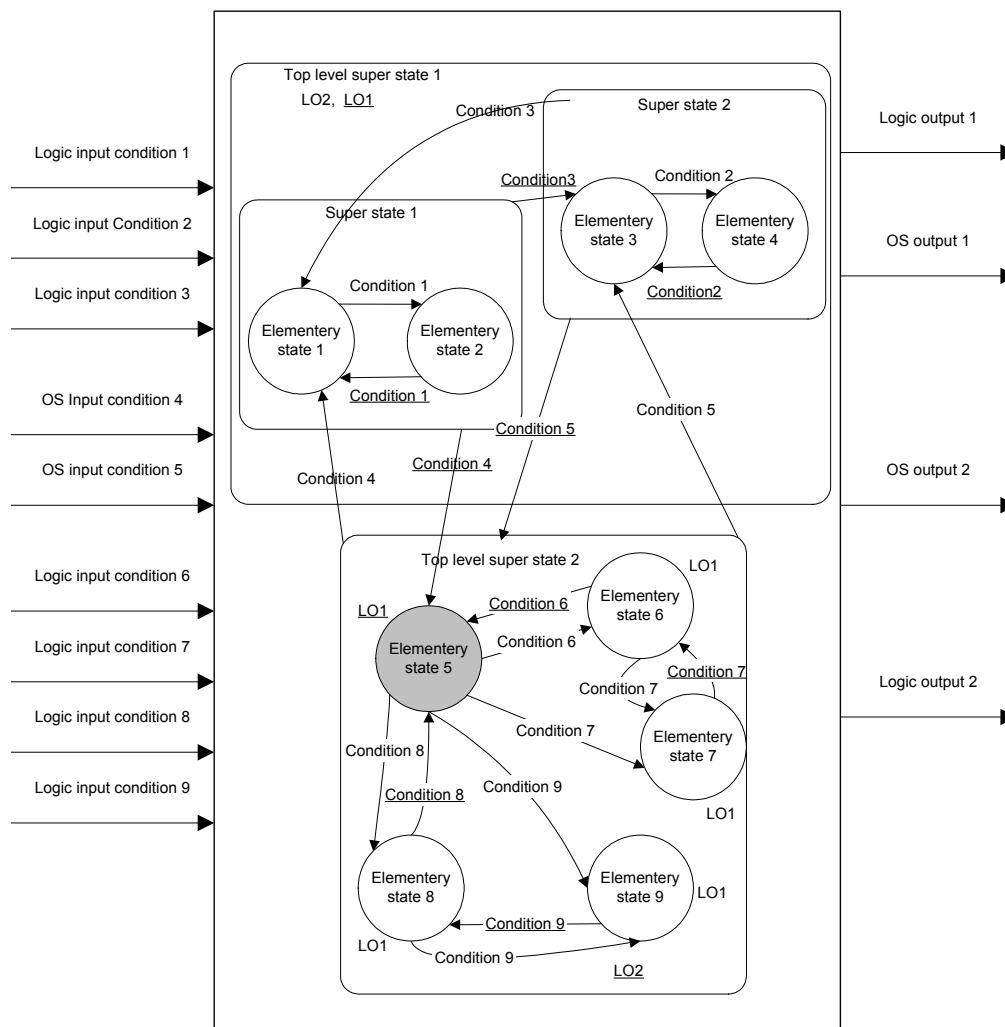


Figure F.2 – Example state chart including the logic input ports and OS input ports used (left), state-chart and logic output ports and OS ports (right) set by the state chart. Condition are build up by combining the inputs

F.5.2.3 Logic output ports

The state chart often needs to inform the outer world about its state. This is done by setting a value on a logic output port. The state machine in figure F.2 uses the "Logic output 1" and the "Logic output 2" output ports as well as information to the OS to tell the outside world about its inner state. The values set out on "Logic output 1" and "Logic output 2" are determined as part of being in a state in the state chart. As one can see from Figure F.2, a LO1 (underlined) is placed in the "Top level super state 1" and next to the "Elementary state 5" state, indicating that a "false" value will be set out on the "Logic output 1" port in this case. For all other states "Logic output 1" is set to true, indicated by a LO1 (no underline) next to these states. Similarly, "Logic output 2" is false (LO2) in the superstate "Top level super state 2", but true (LO2) in the "Top level super state 1" super state.

The state is also often reported to the operator station, as indicated by OS output ports Figure F.2. This may be more complex information than simply a true or false value, therefore the setting of the values of these outputs have not been included in the state chart.

F.5.3 Modelling of the processing of process information

Figure F.1 illustrates how the system reacts to the states of various events and illustrates the additional information that has been added to the state chart in order to give a more complete picture of the handling of logic information. However, the processing of process information remains to be shown. As stated earlier, the consequence of changing states is that process information is processed differently. Figure F.3 shows the state chart again stripped of information about the logic input and output ports, but with the flow and processing of process information included. The numbers indicating the position of the switches below the state chart in Figure F.3 are cross-referenced to numbers within the states of the state chart above. For instance, when the system is in "Elementary state 1"(1), the switch will be in position 1 and a control value calculated by the PID controller is set out on the controller output Y. If the system is in "Elementary state 6" state (6), the switch turns position 6 and a Safeguarding High Value is set out on the controller output Y.

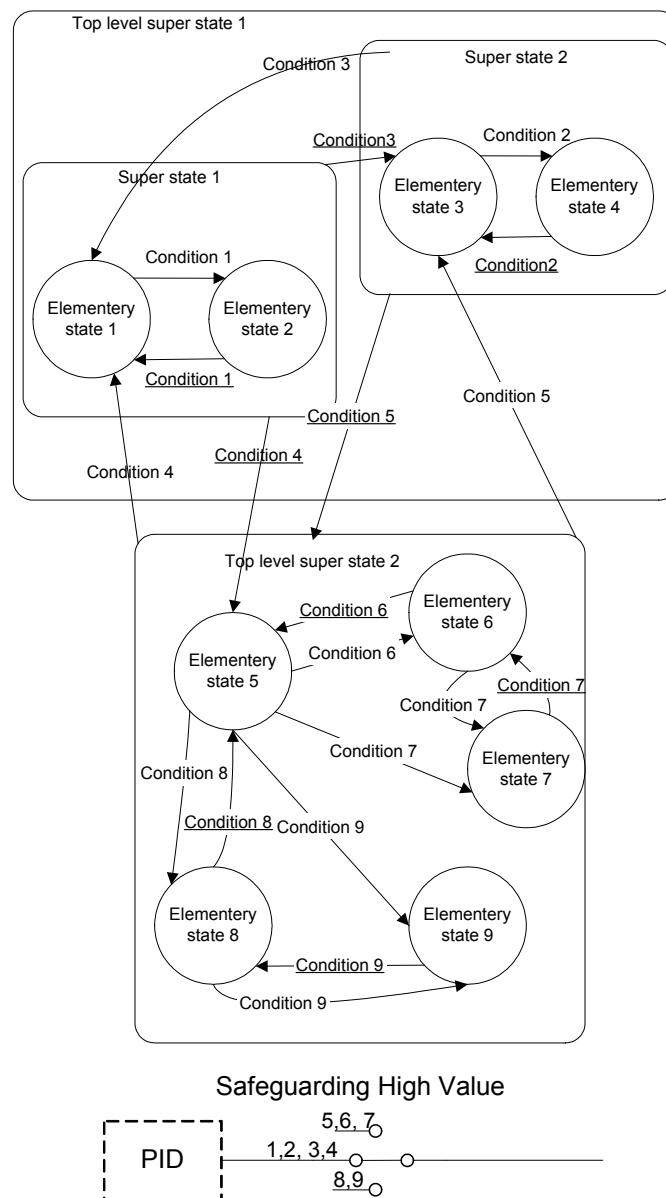


Figure F.3 – the value for the output Y of being in a certain elementary state are shown using electrical metapores

F.5.4 Parallel state charts

Figure F.3 illustrates the state chart of one single mode and how different values are set out on the output Y. But as mentioned before, an SCD control function consists of a number of (parallel) state charts, see for instance Figure F.22.

Parallel state charts are separated with dotted lines. The actions following the elementary states of a state chart take place between these dotted lines, and the actions of a state are cross-referenced by numbers, as stated previously.

As one can see from Figure F.22 (or any of the succeeding figures) several of the state charts may influence the same output, for example Y.

The order left to right of the state charts indicates the priority of the state charts vs. the output.

Given flow from the left to right of process information, the right-most state chart will have the highest priority with regards to setting the value of the output. Safeguarding as an example has the highest priority in setting the output value Y in the CA template. If there is No Safeguarding, or Safeguarding is blocked, the position of the switch means that the Safeguarding state chart "leaves the control" over the value set out on Y to a state chart to the left.

F.5.5 Symbols used for modelling control functions using state charts

An overview of the symbols used when modelling control function behaviour using state charts is given in Figure F.4.

F.5.5.1 How ports are handled

The names of process input ports appear outside the border on the left side the template, and process output ports to the right. These names are defined in the SCD standard.
Logic input ports and output ports have been omitted in the figures defining the template behaviour. For logic input and output ports, refer to the figures specifying each mode, Figure F.5 to Figure F.13.

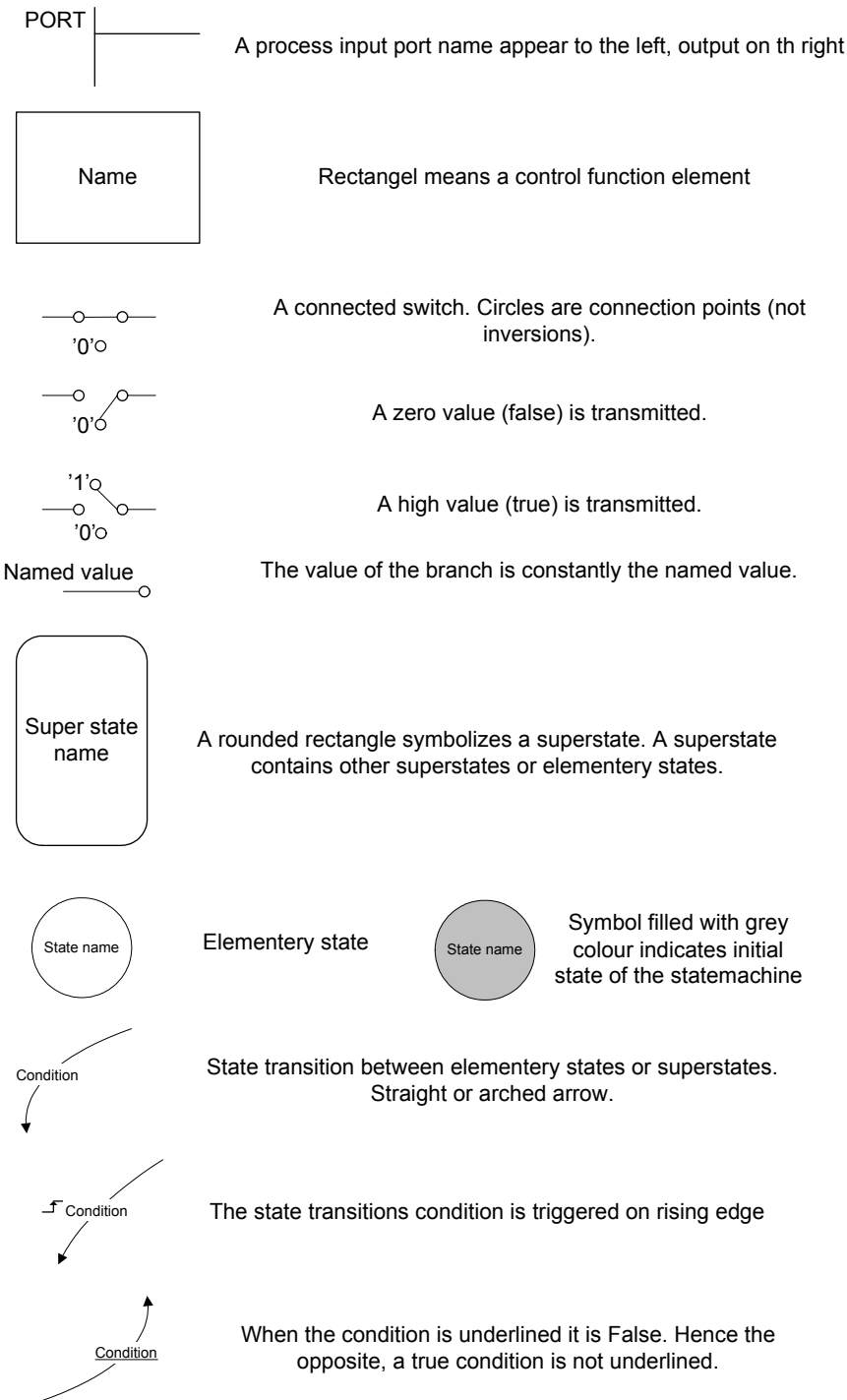


Figure F.4 – Overview of symbols used when modelling control functions using state charts

F.6 Description of behaviour in various modes

This chapter contains descriptions of the NORSOK control function modes, their superstates and elementary states and on the conditions for changing between states. A change of state is most frequently caused by the input information entered through the Logic Controller Input Ports, OS Controller Input Ports. However a state change may in some cases also occur as a consequence of a state change in a different mode.

Different templates may contain the same Modes and Mode Selection functions (conditions for switching between states). However, the actions performed by a template as a consequence of the state change is highly different, and described in chapter F.7.

This chapter describes each individual mode. It starts by describing the Auto Manual Mode. This is a complex mode. Later and simpler modes may be easier to understand for readers not familiar with this kind of modelling.

F.6.1 Auto-manual mode

There are 4 states in Auto Manual Mode, Auto, Manual, Lock Auto and Lock Manual respectively, see Figure F.5. One can give order to switch between Auto and Manual states from the operator station. Lock Auto is entered as the Lock Auto port gives a "true" signal. True in this case means on a positive edge, indicated as $\uparrow$ LA in the figure below.

F.6.1.1 The influence of safeguarding mode on auto manual mode

The states Locked Safeguarding High or Low in Safeguarding Mode (see Figure F.13) always cause the Auto Manual Mode to enter Manual. This is indicated as an open arrow in Figure F.5 with Locked Safeguarding High (LSHS) and Low (LSLS) states being the condition for transition. The names of the safeguarding states have been abbreviated due to limited space. The abbreviations are shown in the table below.

Abbreviation used in Figure F.5	Safeguarding State, see Figure F.13
NOSS	No Safeguarding state
LSLS	Locked Safeguarding Low state
LSHS	Locked Safeguarding High state
BSS	Blocked Safeguarding state

A state transition to Auto or Locked Auto state is only possible if safeguarding is not active, which means that the control function only can be in No Safeguarding or Blocked Safeguarding. Also, a transition to Locked Manual is only possible in No Safeguarding or Blocked Safeguarding.

F.6.1.2 The influence of outside mode on auto manual mode

If Outside Mode is present in a control function, Outside state causes the Auto Manual Mode to enter Manual state. Therefore Outside state is a condition for transition into the Manual state.

Auto Manual Mode

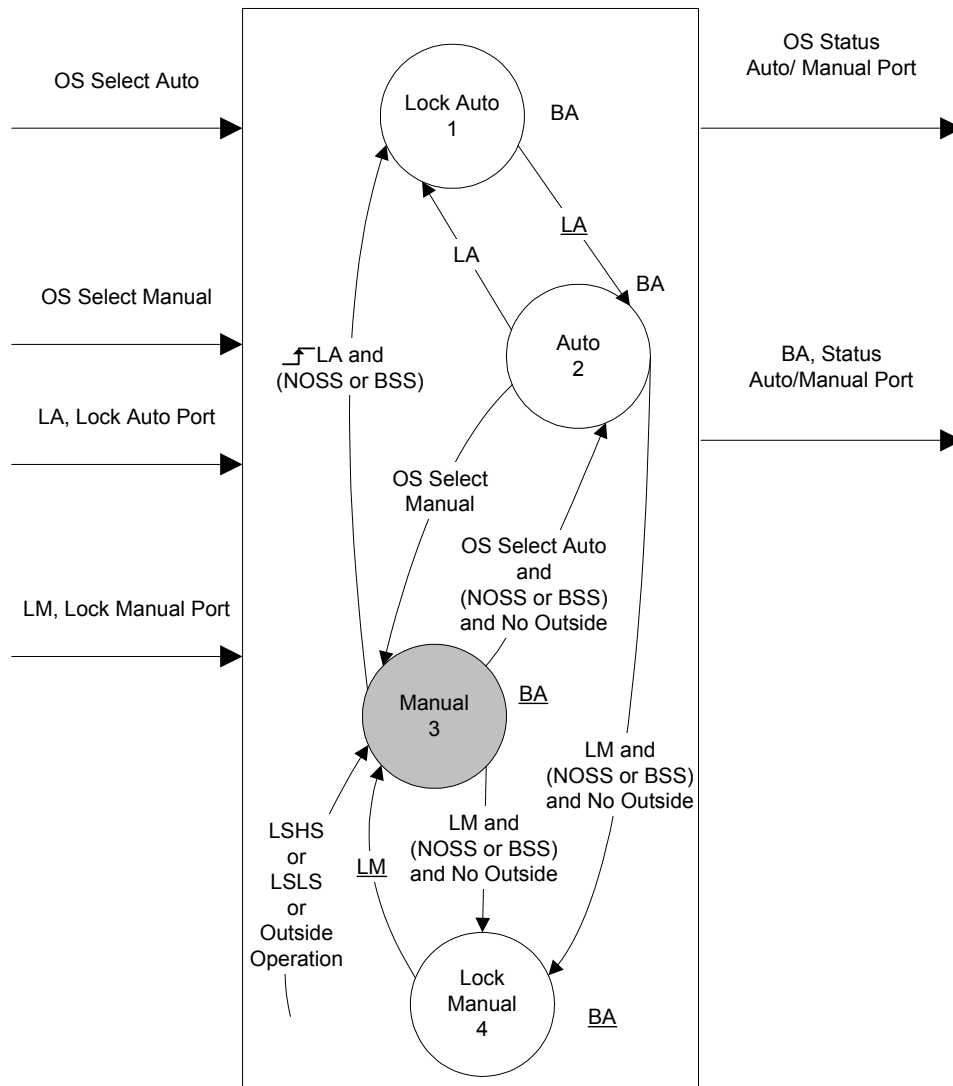


Figure F.5 – States and state transitions of Auto manual mode

F.6.2 Block alarm mode

This state machine is used to determine blocking of actions following alarms. Announcement of the alarm is still made. Blocking can be selected either from OS or via the logic input ports, in this case the Force Block port, FB.

Block Mode

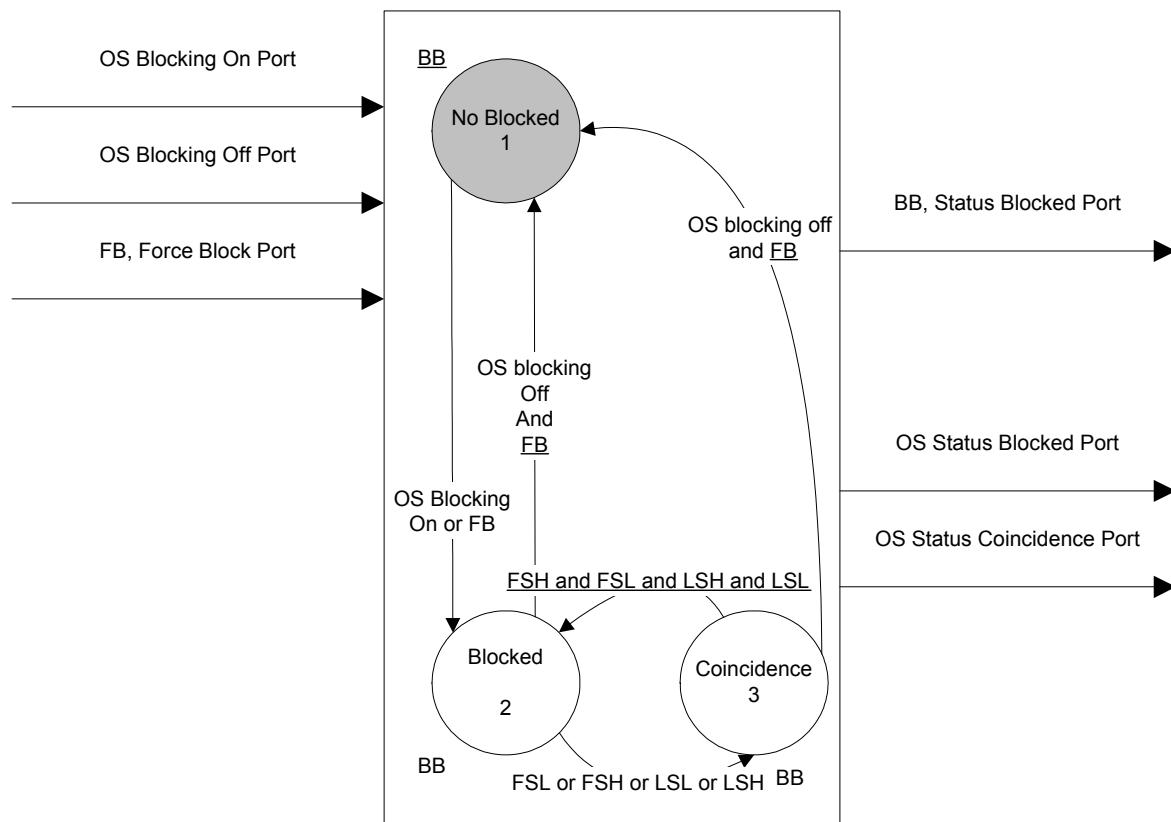


Figure F.6 – State and state transitions for Block mode

Block Alarm Mode is used to block both HH and LL alarms. However, only HH or only LL alarms can be blocked by using Block Alarm HH Mode or Block Alarm LL Mode, respectively. These modes are described in the following.

F.6.2.1 Block alarm HH mode

Similar to Block alarm mode, only that this mode only blocks actions following HH alarms.

Block Alarm HH Mode

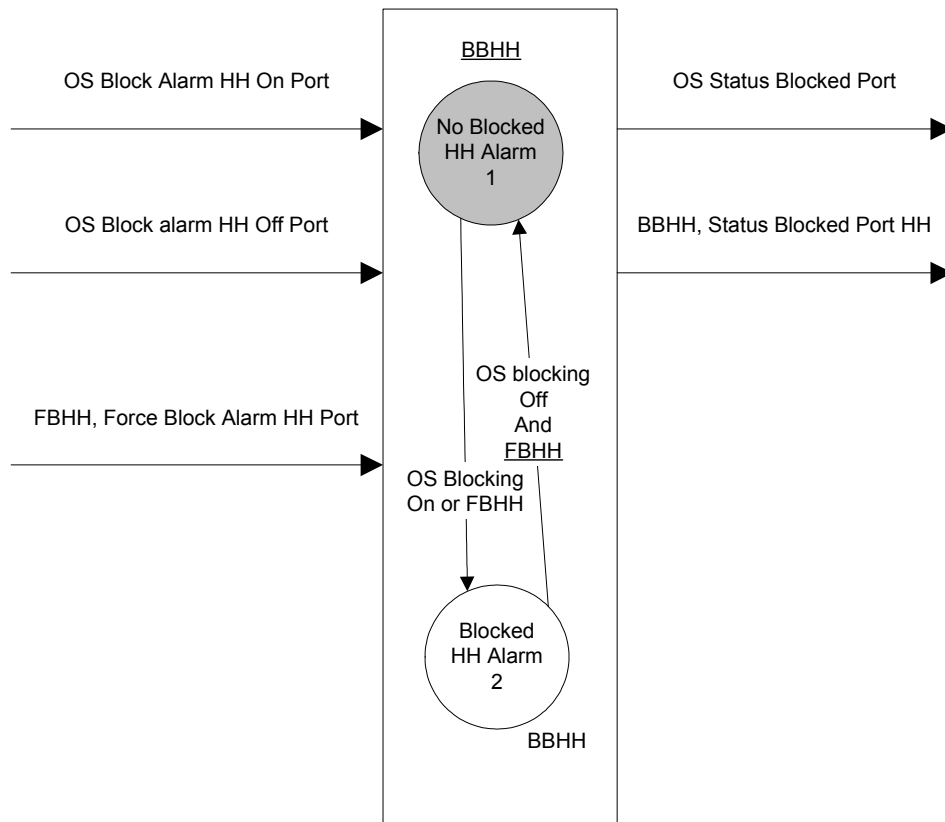


Figure F.7 – The states and state transitions of Block alarm HH mode

F.6.2.2 Block alarm LL mode

Similar to Block Alarm Mode, only that this mode only blocks LL Alarms. The LL alarms can be blocked from the OS, or from the logic input port FBLL.

Block Alarm LL Mode

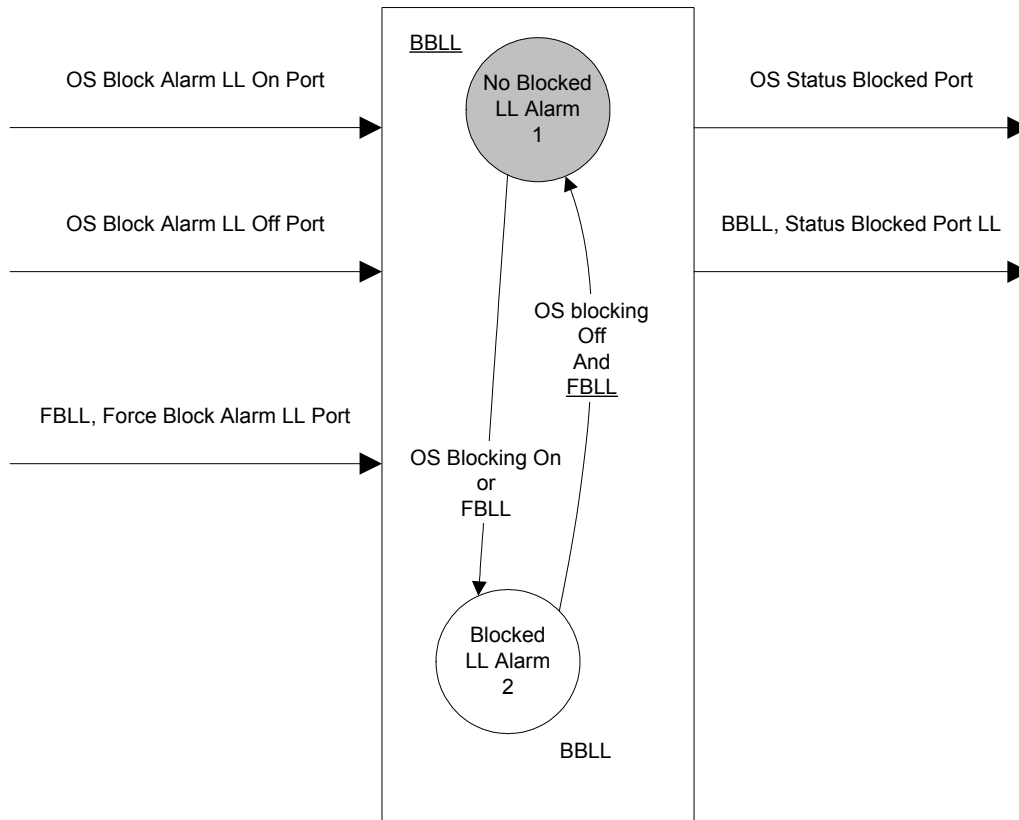


Figure F.8 – States and state transitions of blocked alarm LL mode

F.6.3 Disable Transition mode

Disable mode is used to prevent the output to go to a high or low state next time this demand is made. If the output is already in low state, and a disable low (FDL) is requested, the output will remain in low (Low Disable Low state in the figure below). But when high position is confirmed (BDH) the Disable Low state is entered, and the output will remain in high state even if the input goes low as long as the FDL is true and there is no safeguarding.

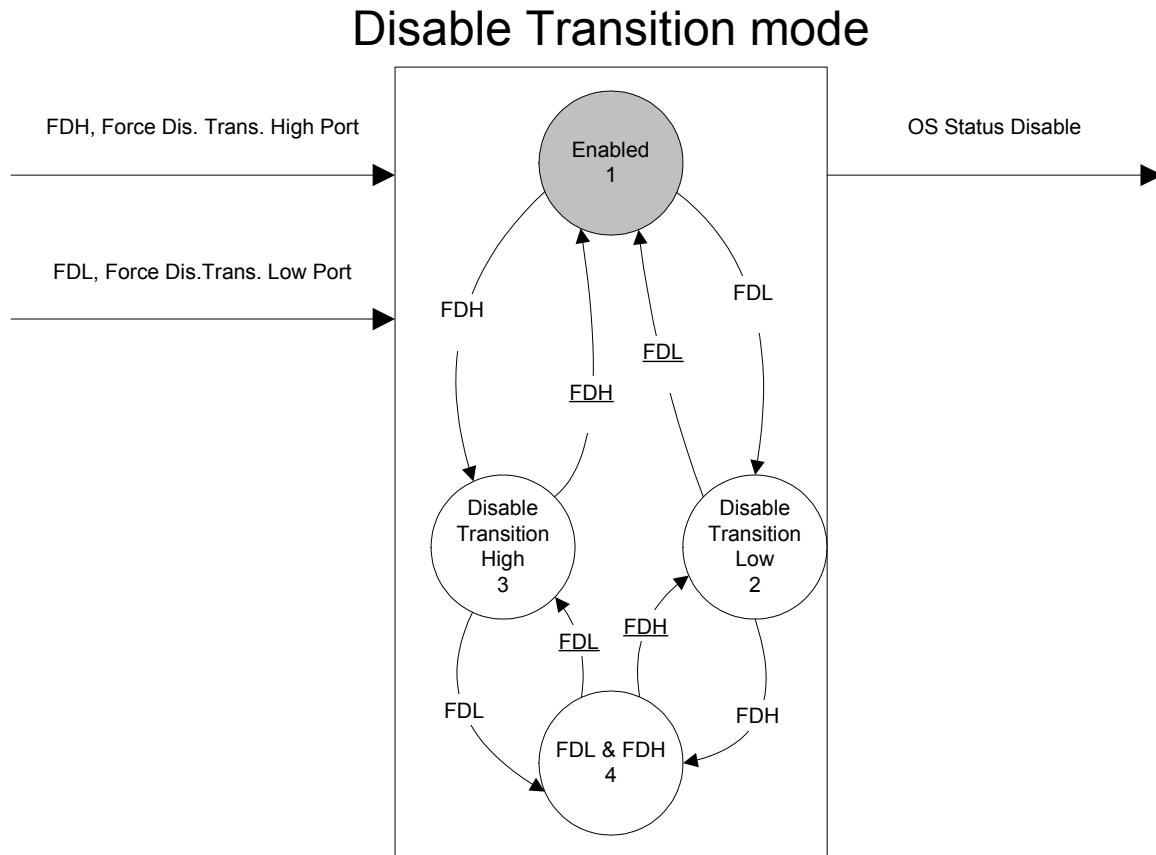


Figure F.9 – States and state transitions of Disable transition

F.6.3.1 The influence of safeguarding mode on disable mode

Some of the states in Safeguarding mode come in as conditions for transition in the Disable Mode state chart, see for instance. Chapter F.7.5.

If safeguarding Low state is entered while in Disable low state (output Y in "high"), the output will be brought to Low by Safeguarding, and the Disable mode goes back to Enabled. But since a Force Disable Low is still demanded, the state transition to the Low Disable Transition Low State occurs. This state is kept until the Locked Safeguarding Low State is exited. If Safeguarding low state is entered while a Force Disable Low is requested, the disable mode will remain in Low Disable Transition Low State until the Safeguarding Low disappears and the output can be brought to a high position again.

F.6.4 Duty standby mode

For some critical applications one may have two parallel motors, where the one with its priority 1 input port set to true is in duty state. The other is in standby state and has its priority 2 input set. This gives a possibility to change which engine is the duty and which is the standby engine at run time.

Note that a duty and standby states express the role of the engines in a parallel configuration. It does not indicate which of them is running. There are different ports for start and stop signals for the Duty and the Standby engines. Both engines receive the same signals, but depending on their role (Duty or Standby state) action is taken or not taken. This configuration allows for a reconfiguration during run-time. That is, the motors may change Duty/Standby roles.

This is explained further in chapter F.7.3 NORSOK Motor control template, SBE.

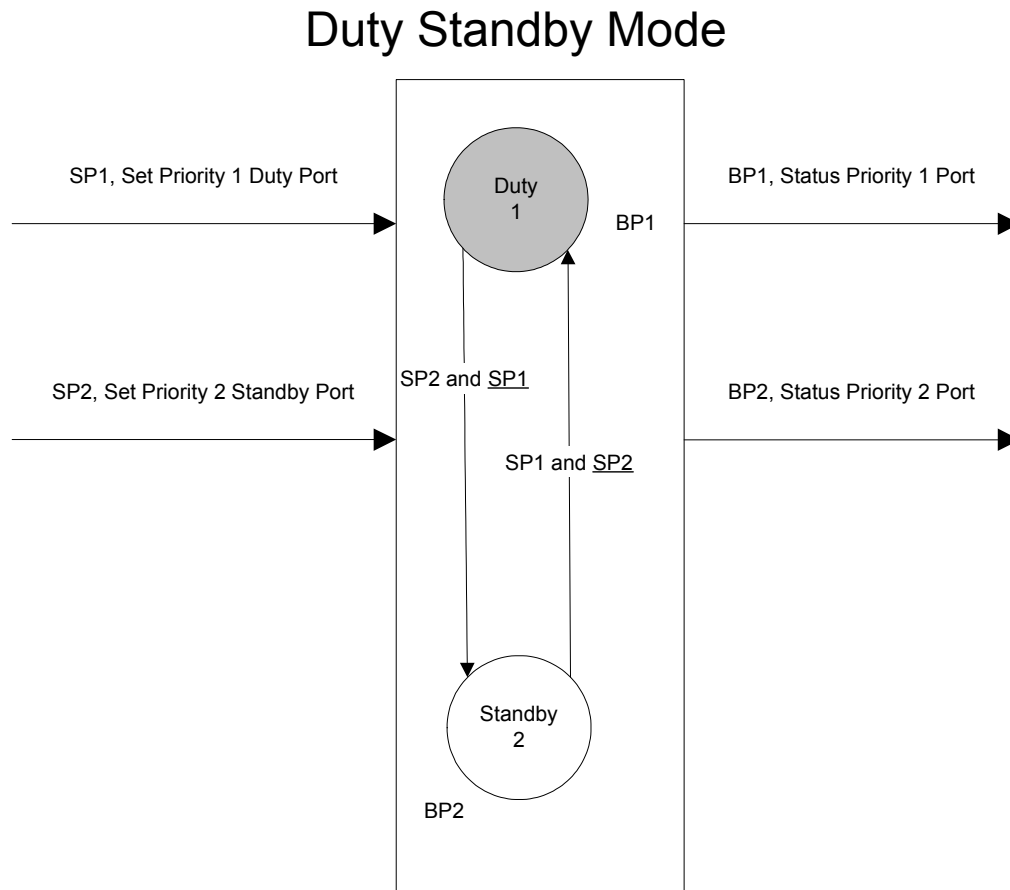


Figure F.10 – Duty standby mode and conditions for transition between states

F.6.5 Internal external mode

Internal External Mode controls whether a set point is to be taken from an external port or from an internal value set by the operator on the operator station. See for instance chapter F.7.6.

The locking functionality will prevent the operator from determining if the set point is to be taken internally or from an external port.

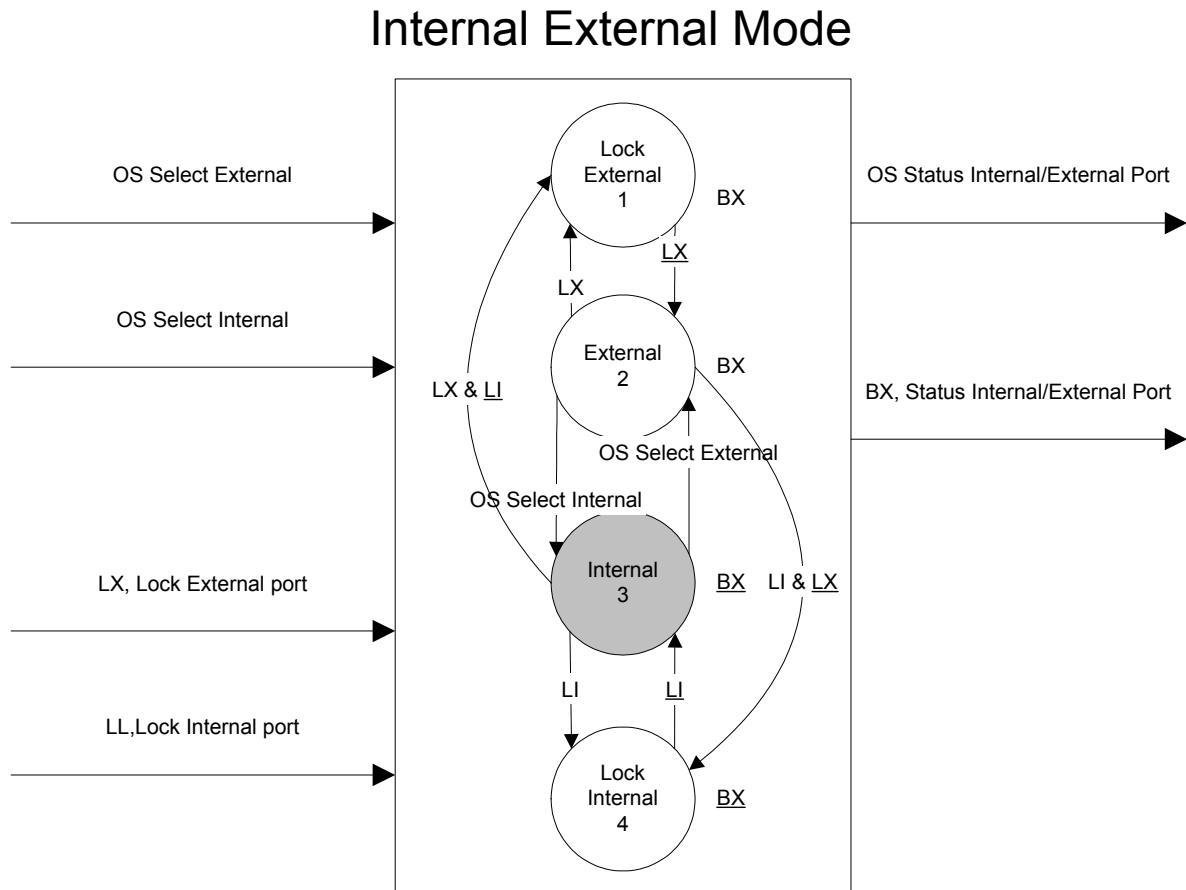


Figure F.11 – Internal External mode controls where a set-point is to be taken from an port (externally) or from an internal parameter set by operator

F.6.6 Outside operation mode

When in Outside Operation state, a valve or engine is controlled (started/stopped, opened/closed) from a local panel. The central control system can only observe (and if desired display) what happens, but not control the engine or valve. When in No Outside Operation state the valve or engine is controlled by the central control system.

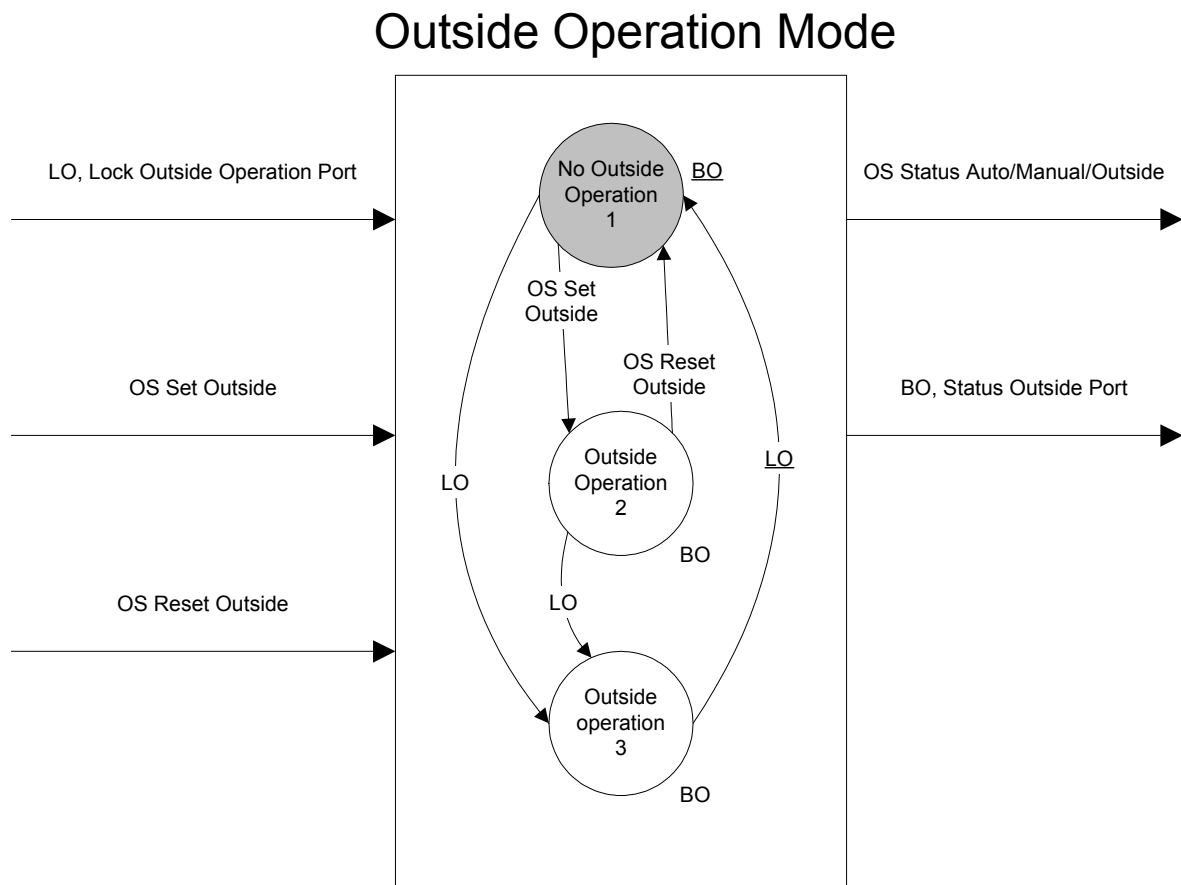


Figure F.12 – Outside operation mode. When in outside operation state, the valve or engine is controlled from a local panel, and not from the central control room

F.6.7 Safeguarding mode

Safeguarding mode is controlled by process shut down functionality of the plant, see LB in Figure F.31.

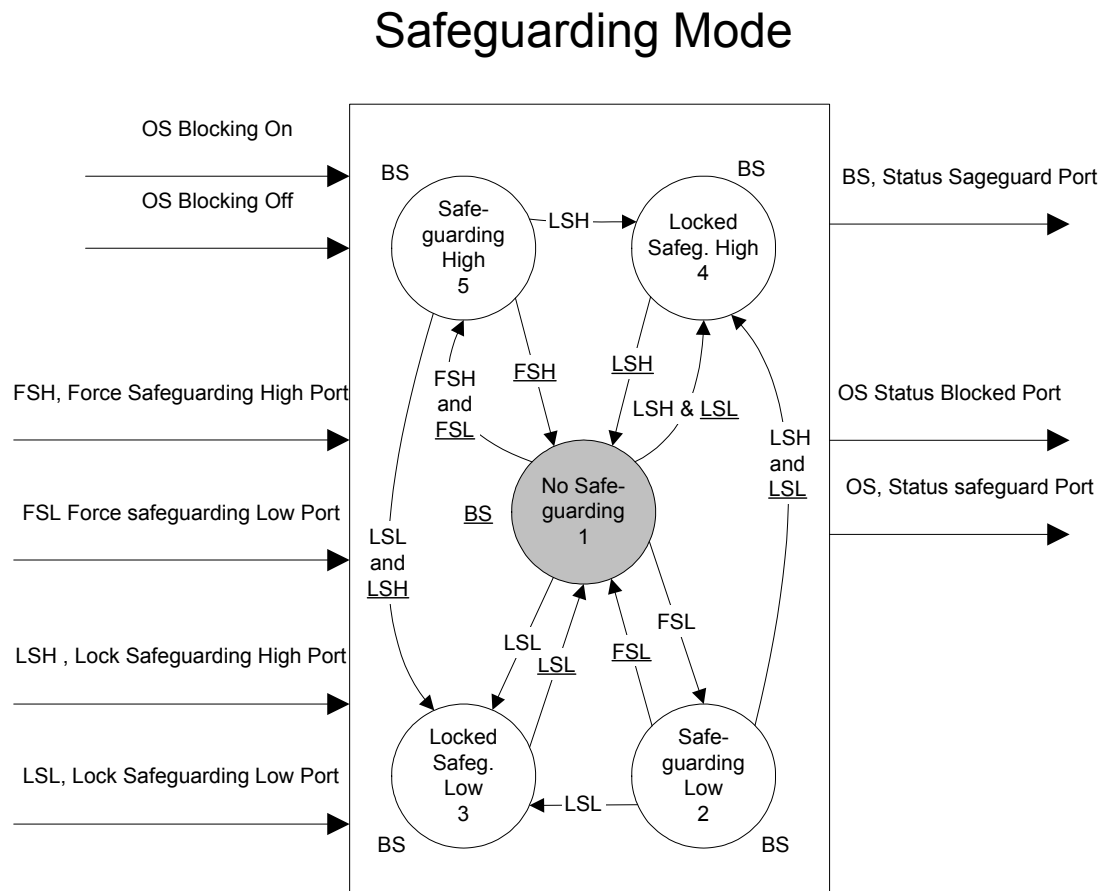


Figure F.13 – Force block mode and safeguarding mode

F.6.8 Suppress alarm mode

This mode is used to control suppression of alarm announcement and alarm actions. The mode is controlled both from the logic (FU) and from the operator station (OS).

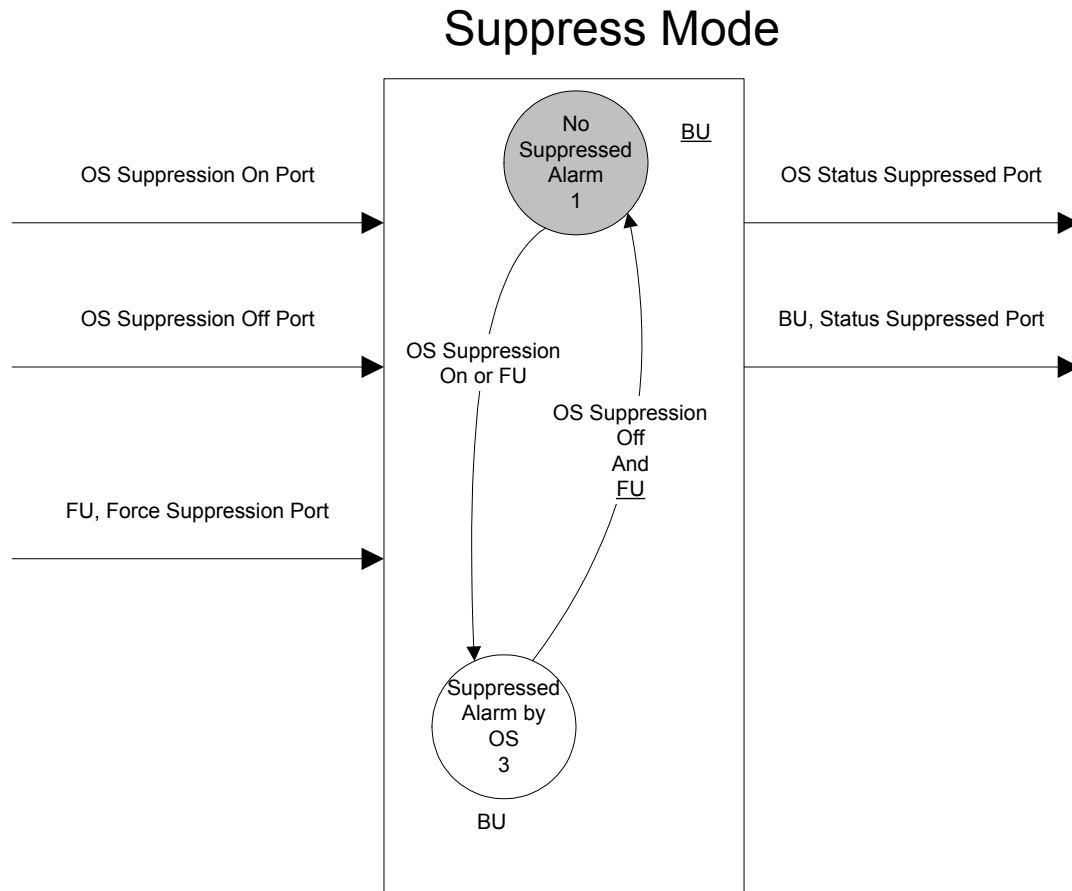


Figure F.14 – The states and state transitions in suppress output signal alarm mode. Controls the suppression of alarm announcement and output signal actions (MB)

F.6.8.1 Suppress alarm HH mode

As for Suppress Alarm Mode, only this mode controls the suppression of alarms and alarm actions following HH alarms. If in one of the suppression states, the logic output BU is true.

Suppress Alarm HH Mode

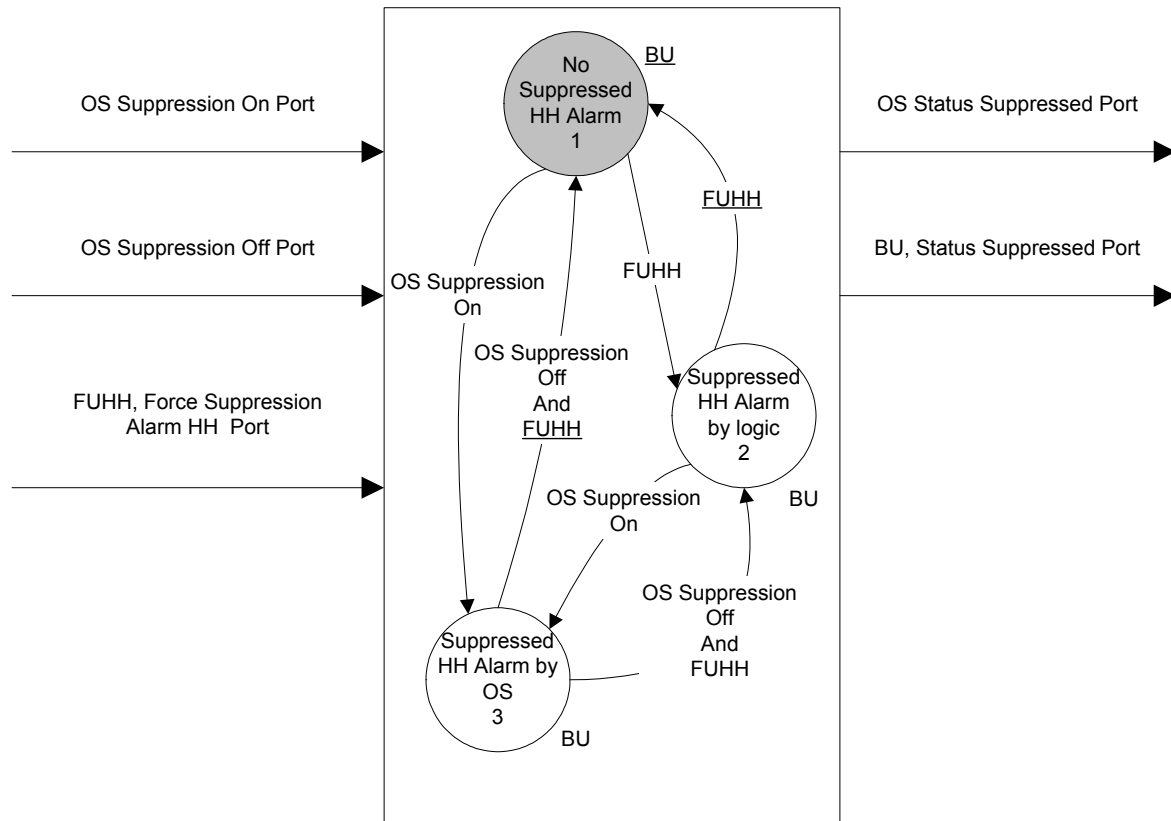


Figure F.15 – The states and conditions for state transition of suppress alarm HH

F.6.8.2 Suppress alarm LL mode

Similar to Suppress Alarm HH Mode.

Suppress Alarm LL Mode

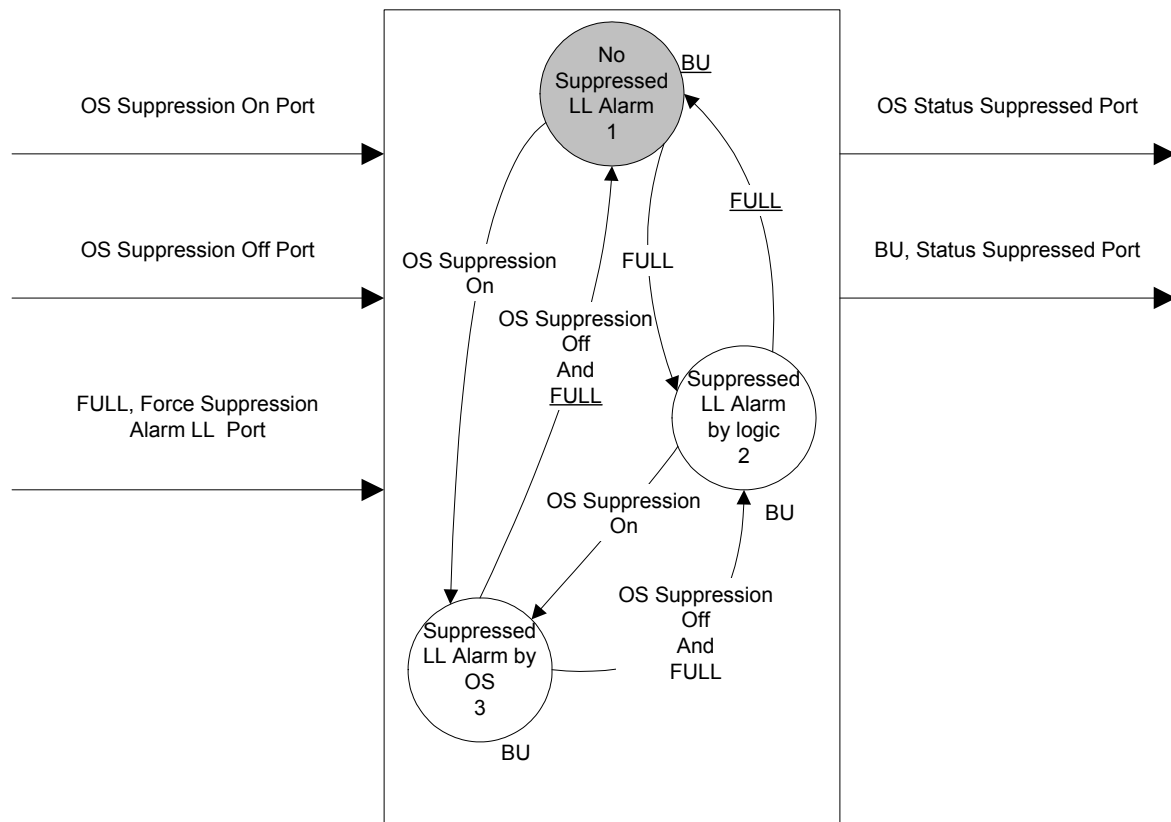


Figure F.16 – The states and conditions for state transition of suppress alarm LL

F.6.8.3 Suppress alarm WH mode

This mode is used to control the suppression of the announcement of a warning high alarm. A warning alarm normally does not have any alarm action, only announcement.

Suppress Alarm WH Mode

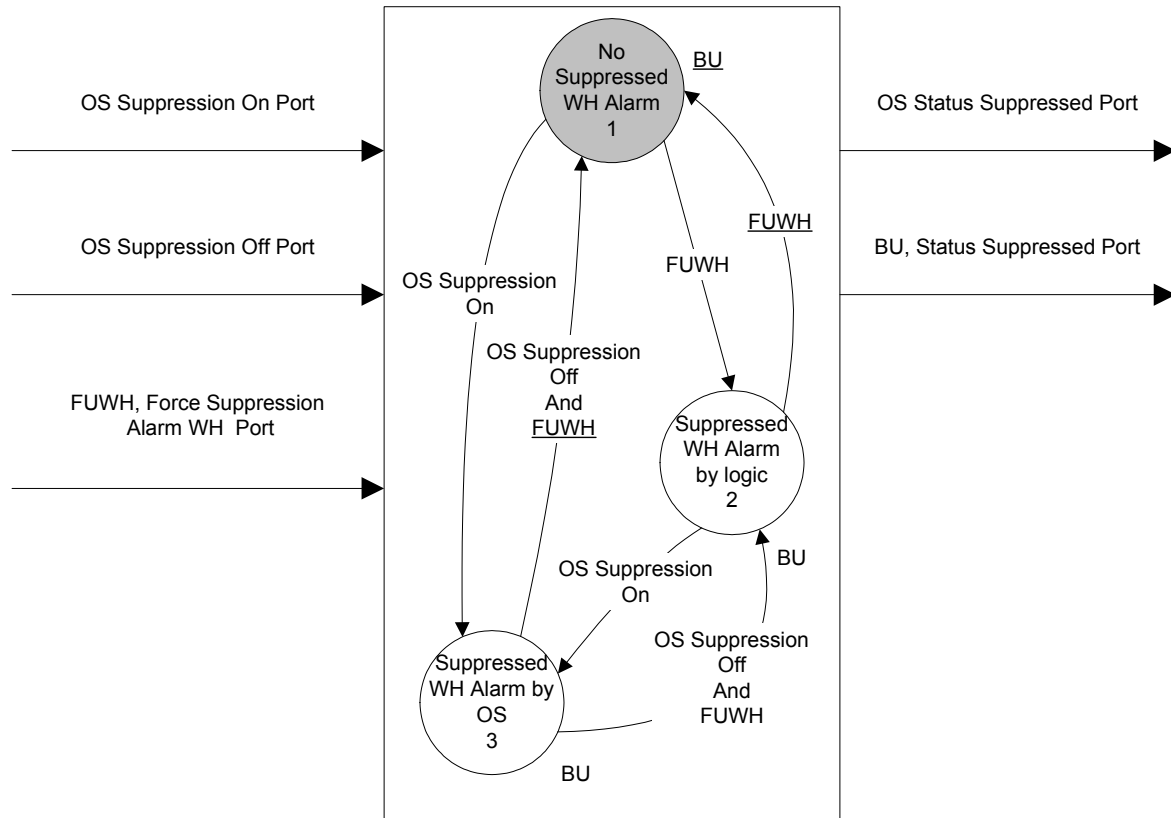


Figure F.17 – The states and conditions for state transition of suppress alarm WH

F.6.8.4 Suppress alarm WL mode

The Suppress Alarm WL Mode suppresses the announcement of WL alarms. Warning alarms normally do not have any actions, only announcement.

Suppress Alarm WL Mode

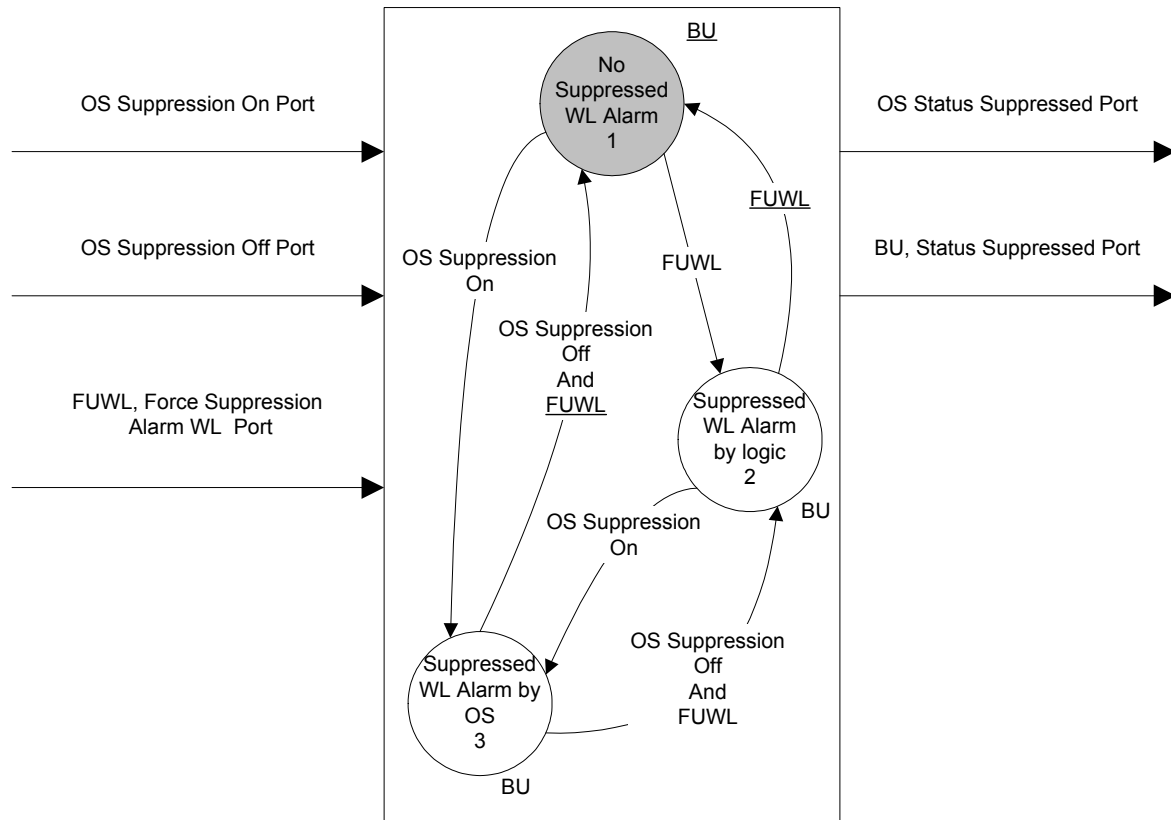


Figure F.18 – The states and conditions for state transition of suppress alarm WL

F.6.9 Suppress fault mode

Suppress Fault Mode is used to control whether or not fault states are set out on the external fault port, YF. The mode also controls whether or not fault announcement on the operator station is to be made.

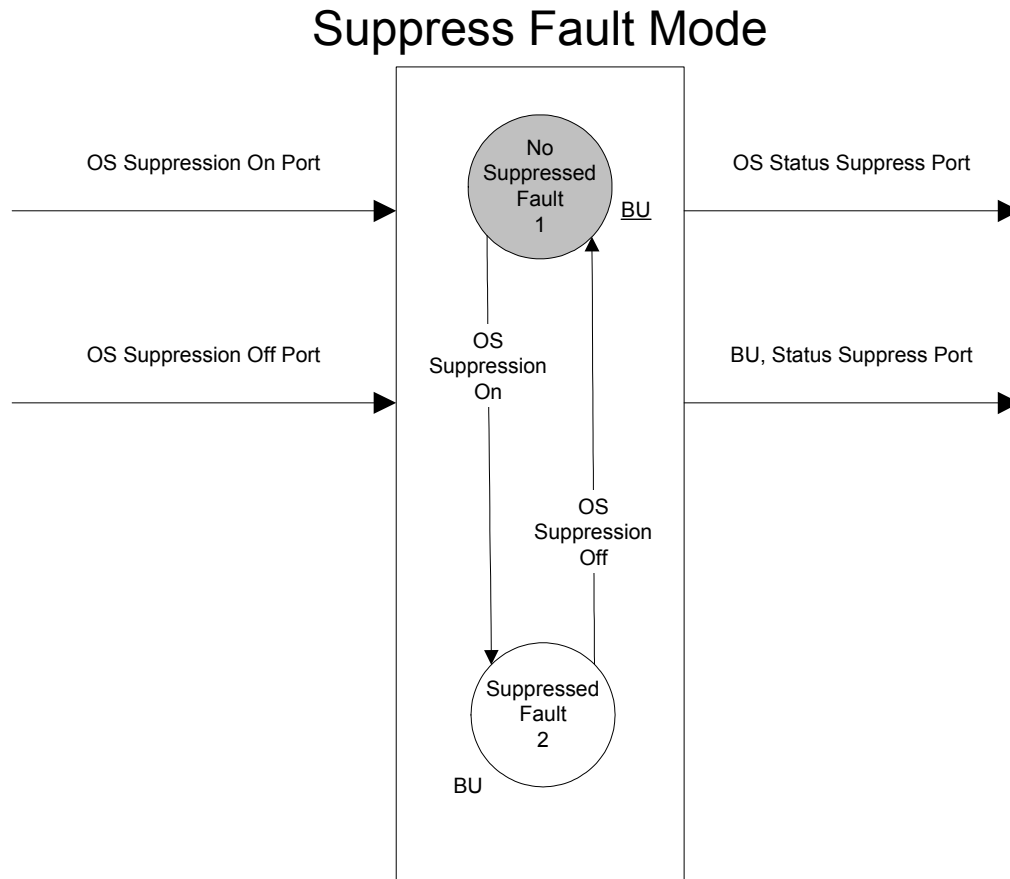


Figure F.19 – The states and conditions for state transition of suppress fault mode

F.6.10 Totalizer mode

This section describes the states within the Totalizer Mode, and the conditions for changing between the states. Totalizing can be enabled or disabled depending on the state of the signal on the port XEQ. When XEQ goes false (low) Totalizing Disabled state is entered. When XEQ goes true (high) Totalizing Enabled is entered, with Totalizing Off as the initial state. Totalizing Enabled is therefore a super-state.

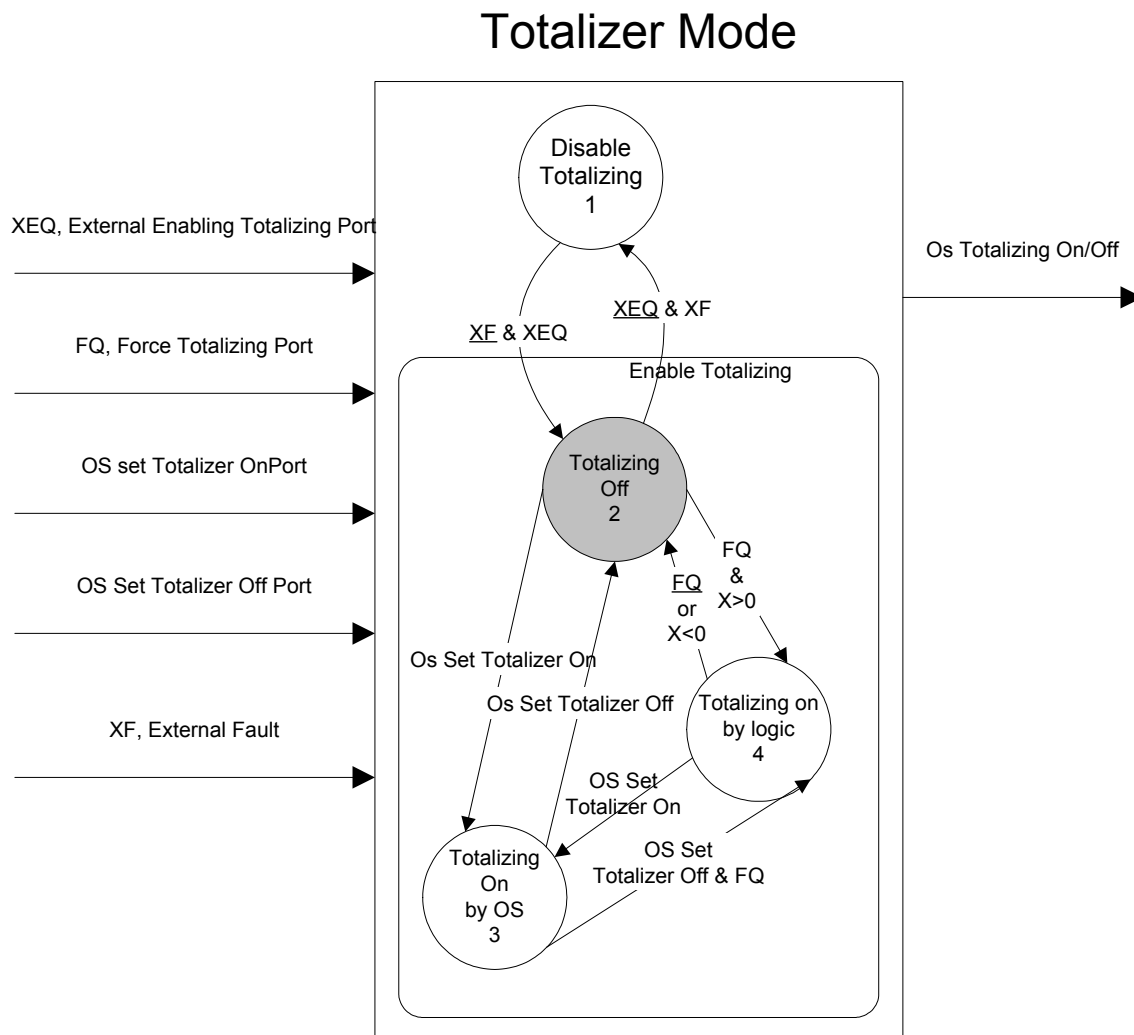


Figure F.20 – The states and conditions for state transition of Totalizer mode

F.6.11 Track mode

Track mode controls whether or not the output of a CA (PID controller) is to follow a track which is given on an input port. Track mode is controlled only by the logic.

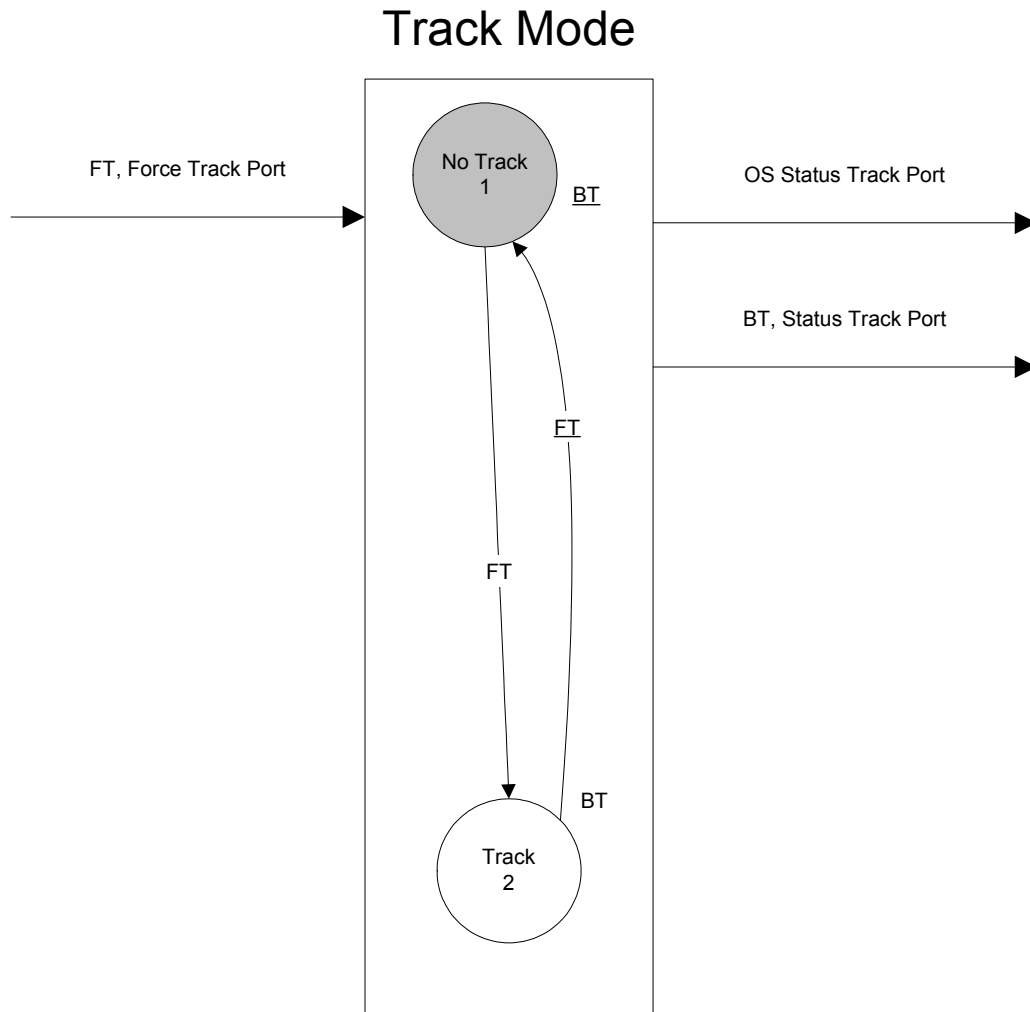


Figure F.21 – The states and conditions for state transition of Track Mode

F.7 Definition of the NORSOK control function behaviour

This chapter will contain description of the behaviour of the NORSOK control functions. The behaviour will be defined using the behaviour building blocks defined F.5.5.

F.7.1 NORSOK Monitoring of binary process variable template, MB

The MB template monitors an binary variable, X. The variable X is always reflected on status output BX.

Explanation of the control functions (rectangles) follows:

"Set Value & Sign Status": This function will change the output Y to high when X goes high (positive edge). Y is maintained in high until the function receives a reset signal (positive edge) on RX. Y can then go high again on the next positive edge on X.

Here the Block Mode is used to block the output Y (but not the announcement of a high state to the OS). A fault on YF is generated when the input signal XF goes high or the function it self is can.

MB, Monitoring of Binary Process Variables

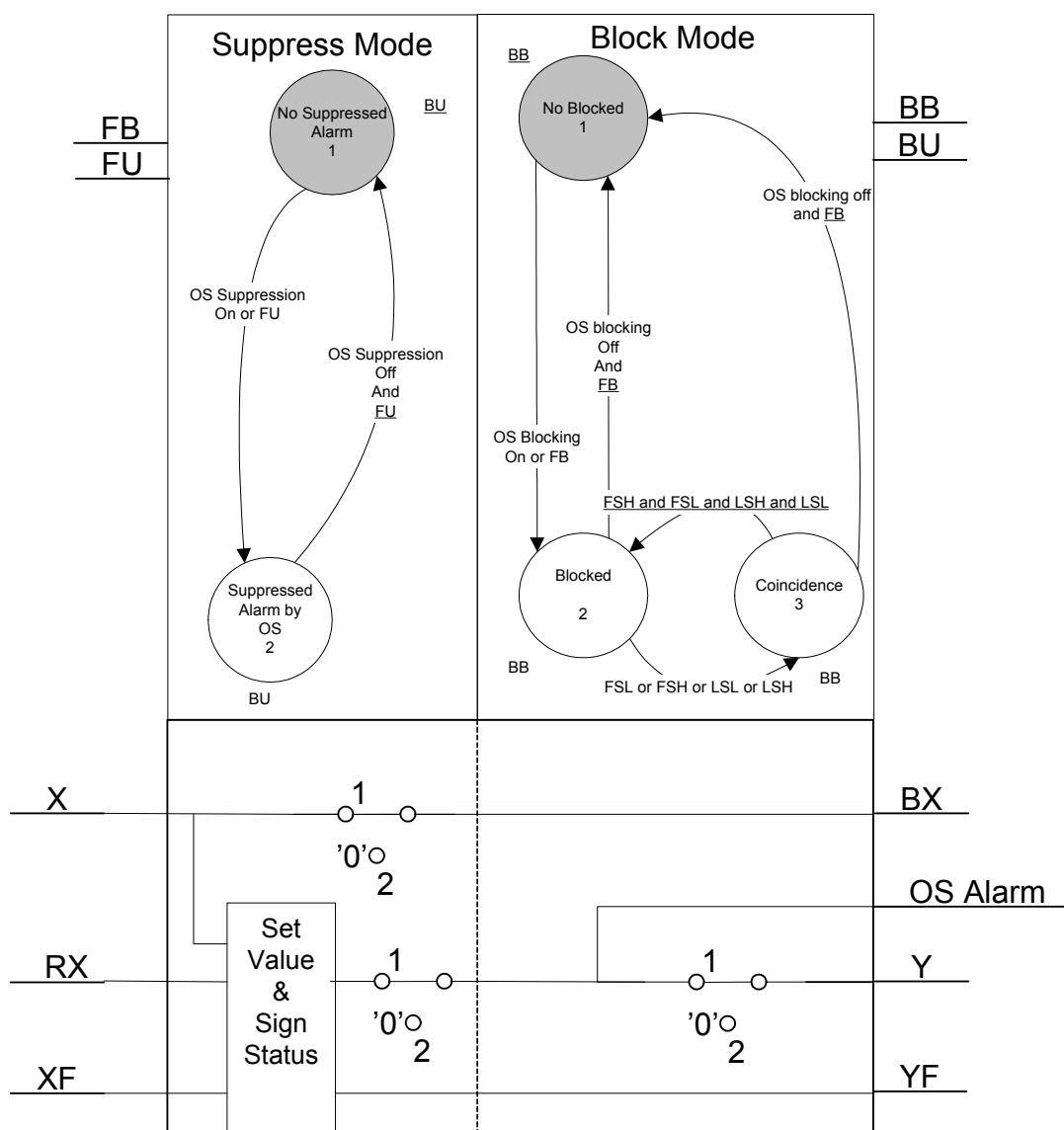


Figure F.22 – MB Behaviour

F.7.2 NORSOK Monitoring of analogue process variable template, MA

The MA template monitors an analogue variable, X. The variable X is always set out on the output Y, but warnings or alarms are generated if the value exceeds upper or lower warning or alarm limits.

Explanation of the control functions (rectangles) follows:

"Limit Check & Sign Status": This function compares the analogue input value X with upper and lower alarm and warning limits and generates alarms/warnings if the limits are exceeded. It also compares the analogue input value X with event limits and generates events if the limits are exceeded. The event limits are possibly different than the alarm and warning limits. The events can not be suppressed/blocked.

A fault on YF is generated when the input signal X fails.

MA, Monitoring of Analogue Process Variables

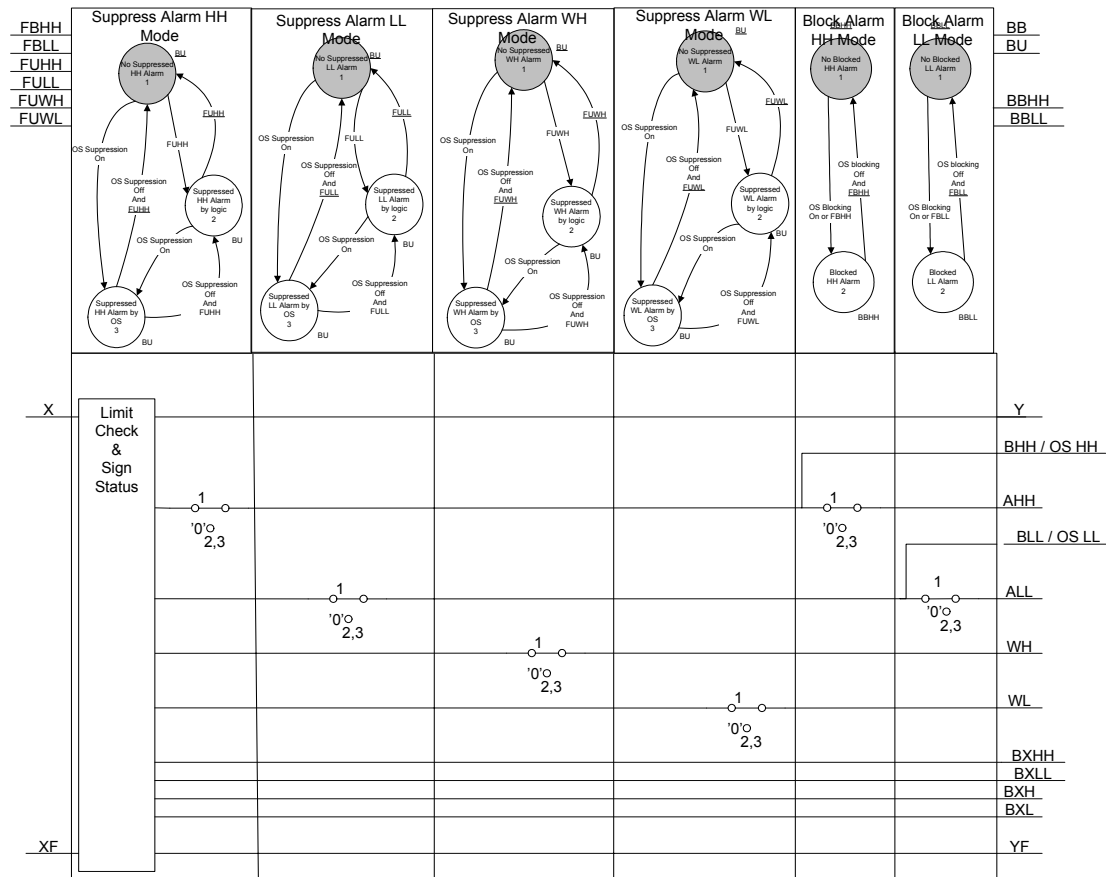


Figure F.23 - MA Behaviour

F.7.3 NORSOK Motor control template, SBE

Figure F.24 reflects the behaviour of the Motor Control Template, SBE. The figure illustrates a "full" configuration for one motor with a second motor in parallel (with its own control function based on an SBE template). This is called a duty standby configuration. In addition, control can be taken at a panel locally on the motor (outside operation), or given from the OS to the local control panel.

Control of a single motor

This is done selecting duty (setting the SP1 to true permanently), and using the XP1H/XP1L inputs to control the motor in the auto states. The motor can be controlled by one signal Y or two signal YH and YL.

Single motor in Manual Mode (No Auto permitted)

As for control of a single motor, but Auto and Locked Auto States can no longer be selected, XP1H/XP1L are no longer used, the motor can only be started from the OS.

Outside operation ONLY

In this configuration mode no control actions can be taken from the central control system. The central control system only reads the XGH value, and displays the state of the motor (On or Off) on the operator station.

Explanation of the control functions (rectangles) follows:

"Motor sig gen & status" : This function serves several tasks. It compares the actual output to the feedback status from the valve and gives the BCL / BCH status out. It generates the status Coincidence if Block and safeguarding is present at the same time. It generates failure status YF if an external or internal fault is reported. It also reports the priority that the motor has BP1/BP2 and the combined status of fault and priority BP1F/BP2F.

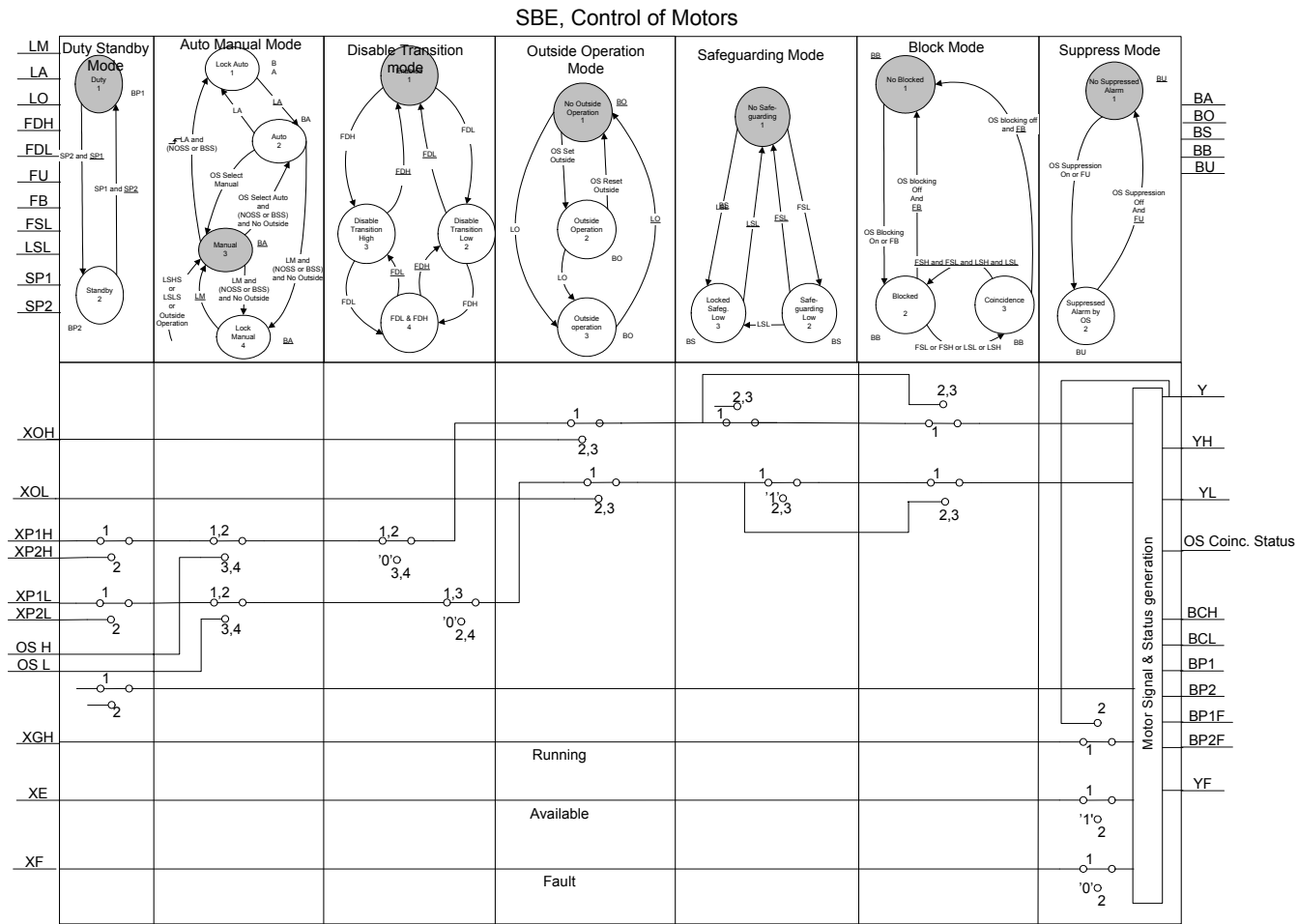


Figure F-24 - SBE Behaviour

F.7.4 NORSOK Valve control template, SBV

The SBV template describes the control of valves. There is one output, Y, which conveys an open/close (high/low) command to the valve actuator.

Explanation of the control functions (rectangles) follows:

“Valve sig gen & status”: This functions serves several tasks. It compares the actual output to the feedback status from the valve and gives the BCL / BCH status out. It generates the status Coincidence if Block and safeguarding is present at the same time. It also generates failure status YF if a external or internal fault is reported.

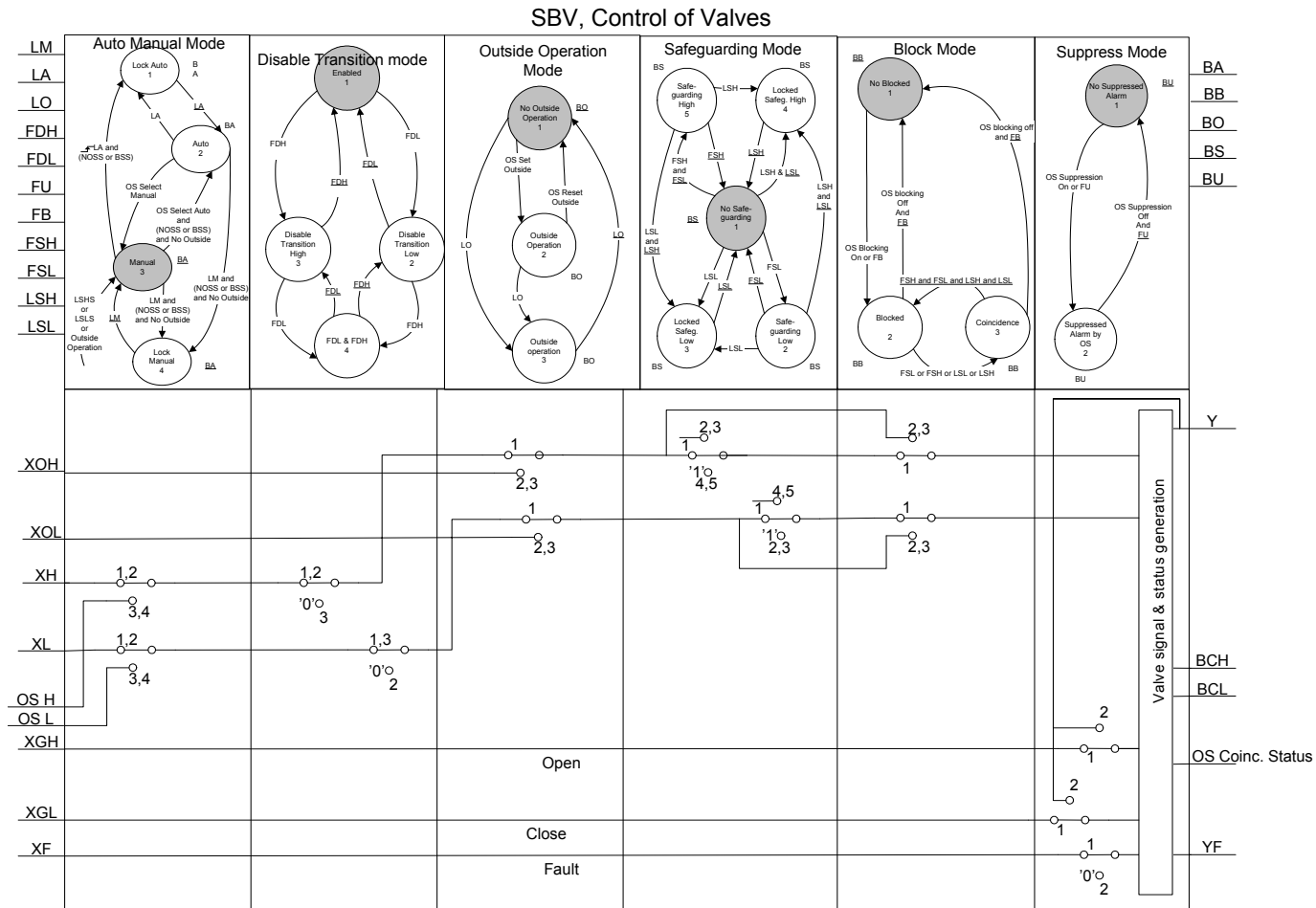


Figure f.25 – SBV Behaviour

F.7.5 NORSOK Binary control template, CB

Explanation of the control functions (rectangles) follows:

“0/1 gen”: On/off (open/close) control based on an analogue measurement value. When the analogue measurement value X reaches a high or low threshold the output is switched on or off. An operator warning is generated whenever the output Y changes state. In manual mode the operator select open or close.

“Status signal gen”: This functions serves several tasks. It compares the actual output to the feedback status from the valve and gives the BCL / BCH status out. It generates the status Coincidence if Block and safeguarding is present at the same time. It generates failure status YF if a external or internal fault is reported. It also generates WH/WL signal based on comparison between a a set of alarm limits and the analogue input value.

CB, Binary Control

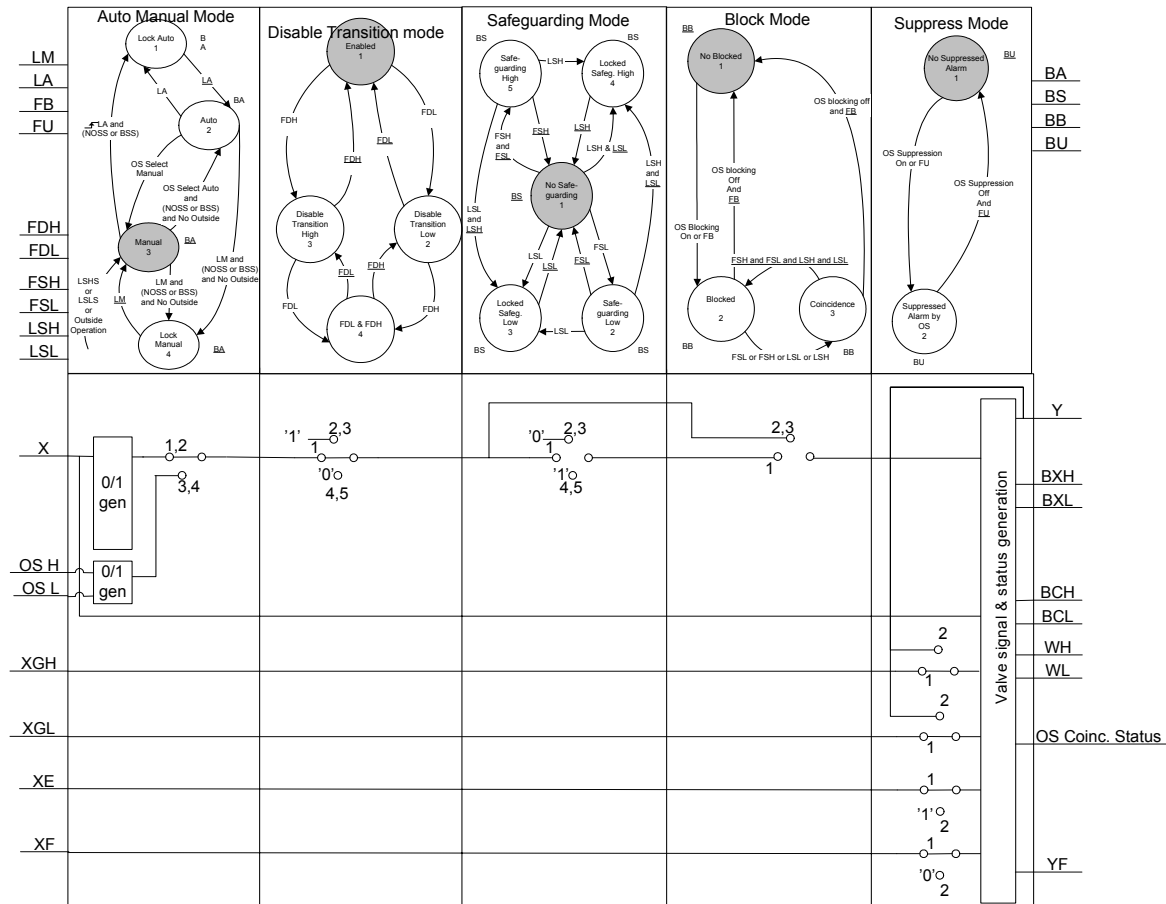


Figure F.26 – Model of CB Behaviour

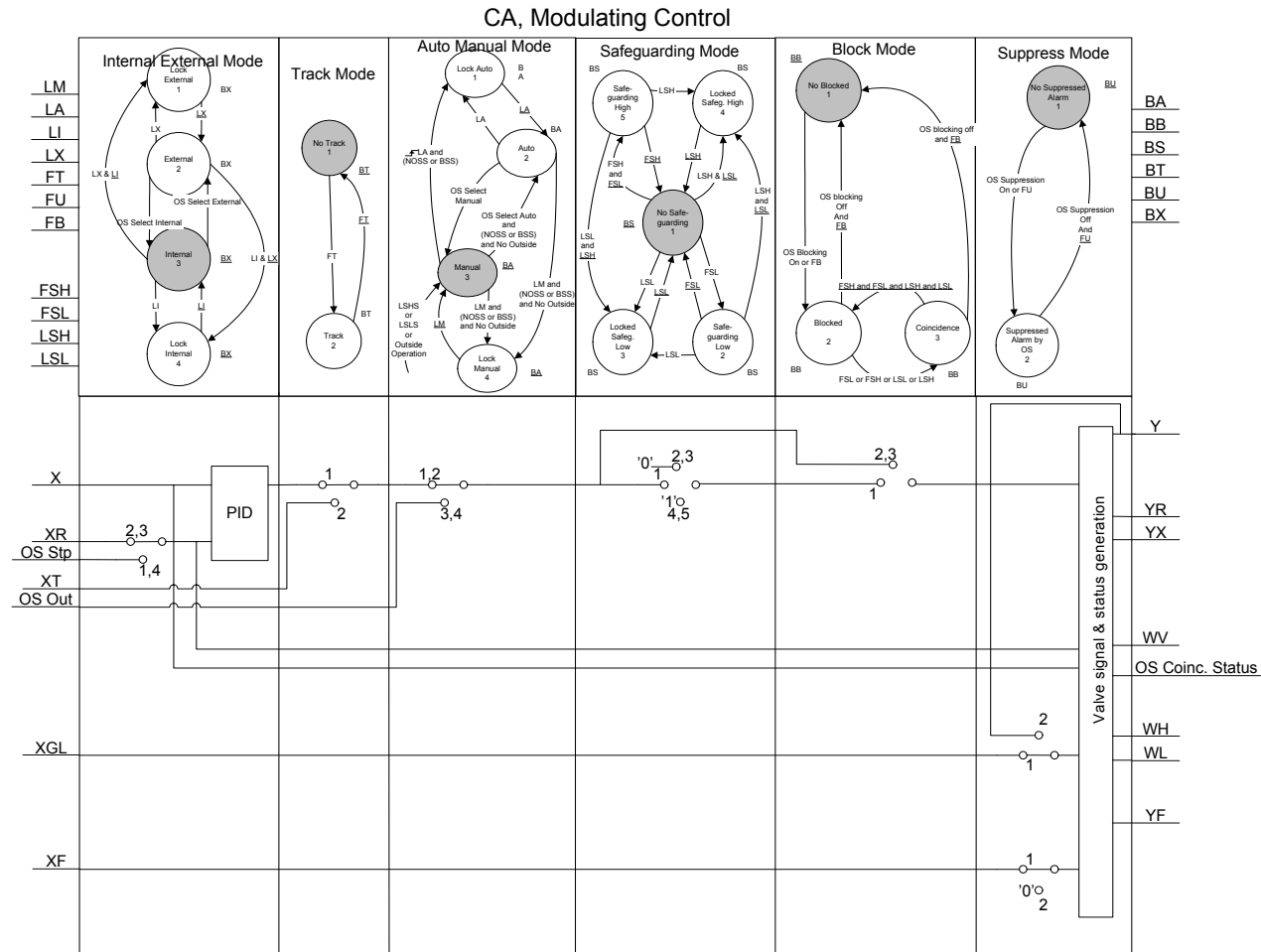
F.7.6 NORSOK Modulating control template, CA

The CA template is a PID controller with necessary logic in order to choose set point, set in Auto or Manual, Safeguarding functionality etc. Starting from the left, the set point can be chosen either as an external value, or an internal value set from the OS. When in Track state, the output will follow the input port XT. Auto Manual model controls whether or not the output value is to be taken from a manually set value on the OS or from the PID controller (or XT if in Track state also). However, placing Safeguarding Mode closer to the output Y means that Safeguarding may override any of the state charts to the left of Safeguarding Mode.

Explanation of the control functions (rectangles) follows:

“PID”: This is the Proportional, Integral and/or Derivate function that forms the main function of a PID controller.

“Status signal gen” : This functions serves several tasks. It compares the actual output to the setpoint and gives an alarm WV to the operator if the deviation exceeds a preset limit. It generates the status Coincidence if Block and safeguarding is present at the same time. It generates failure status YF if a external or internal fault is reported. It also generates WH/WL signal based on comparison between a set of alarm limits and the analogue input value.



F.7.7 NORSOK Step control template, CS

The Step Control Template is used for sub-sea choke control and monitoring. Stepping the position up and down controls a choke. In auto, the new position is given by an external source (XR), and the control system controls the stepping up or down. In manual mode, single step commands for opening and closing is given by the operator. If in Lock Safeguarding Low state, the "Step to Low" function will step the valve down to a closed position.

Explanation of the control functions (rectangles) follows:

"Out sig gen & Status": This functions serves several tasks. It generates the step signal onto the outputs YH/YL. It compares the actual output to the setpoint and gives an alarm WV to the operator if the deviation exceeds a preset limit. It generates the status Coincidence if Block and safeguarding is present at the same time. It generates failure status YF if a external or internal fault is reported. It compares the actual output to the feedback status from the valve and gives the BCL status out. It also generates WH/WL signal based on comparison between a set of alarm limits and the analogue input value.

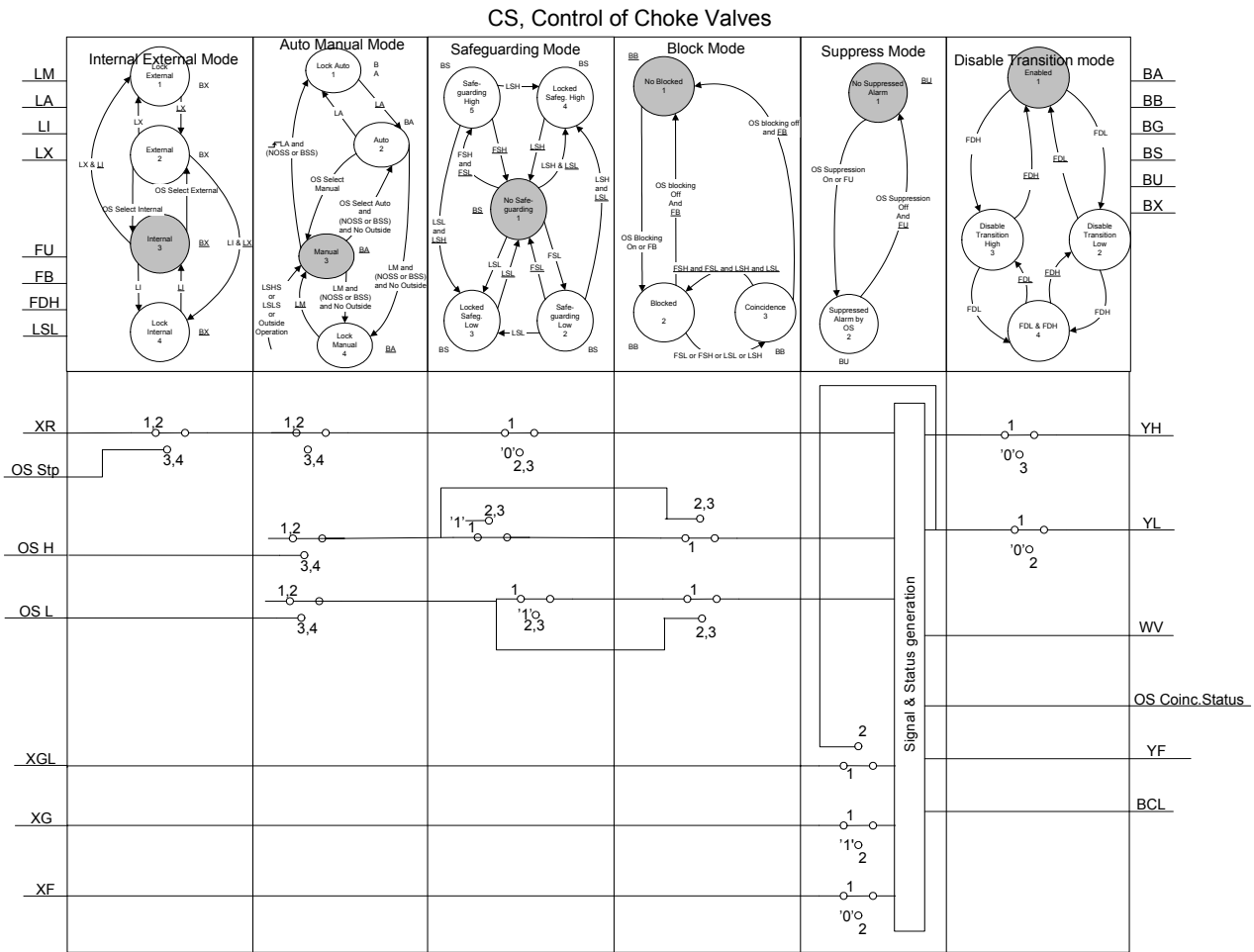


Figure F.28 – Model of CS behaviour

F.7.8 NORSOK Totalizer template, QA

The Totalizer Template performs an integration of the input value (Normal Function Input) and sets the value out on the output port.

There are various ways to control the integration mechanism (Totalizer function). The Totalizing function must be enabled from logic external to the template. Once enabled, the Totalizing function can be switched on and off. The integration mechanism can also be reset to start from zero again.

Explanation of the control functions (rectangles) follows:

“Totalizing & Limit check”: This functions serves several tasks. It performs the main totalizing function. It generates failure status YF if a external or internal fault is reported. It also generates WH/AHH signal based on comparison between a set of alarm limits and the analogue input value.

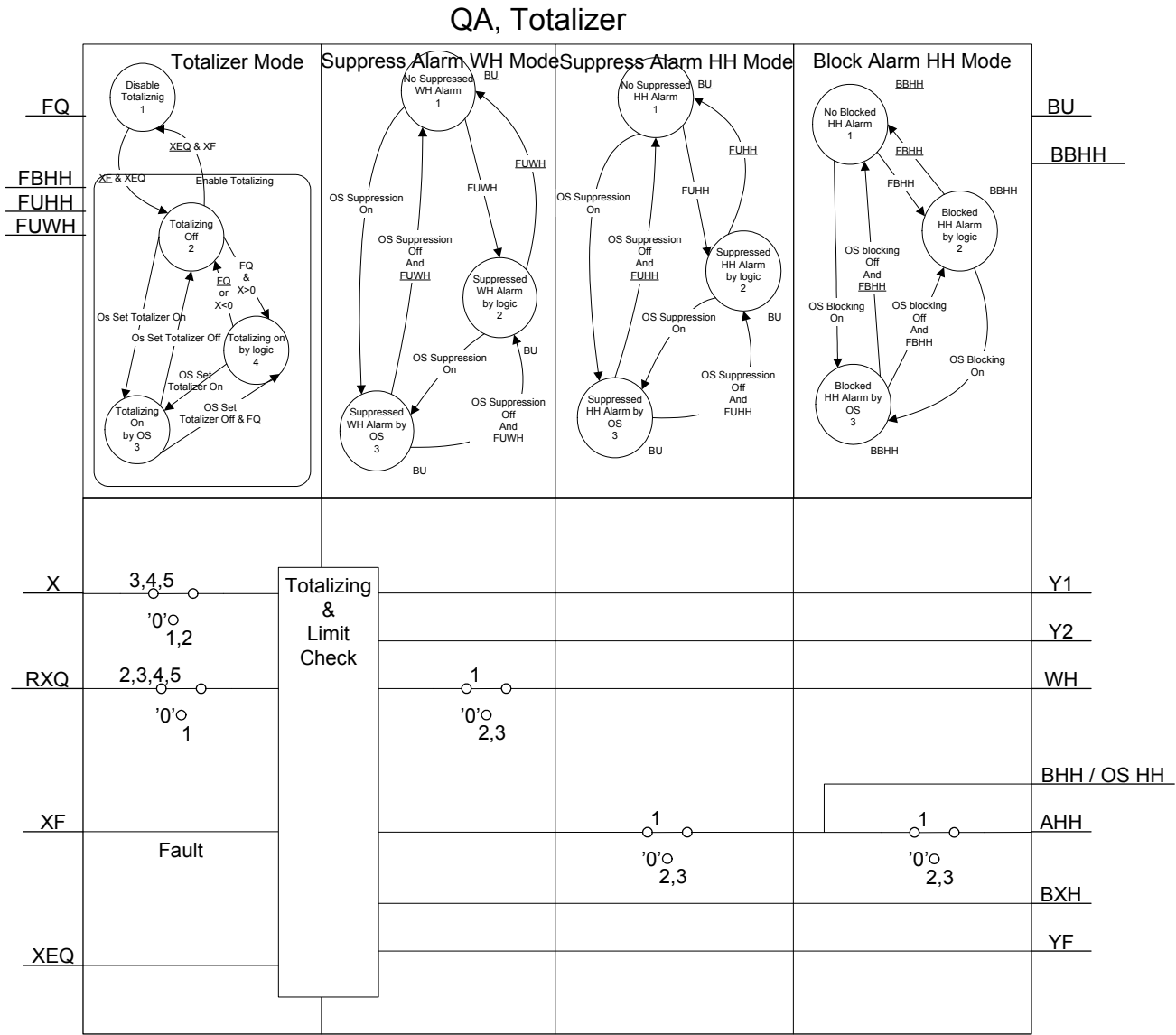


Figure F.29 – Model of QA behaviour

F.7.9 NORSOK Process input calculation template, YA

The YA template is a function for calculation of various process variables. The Process Calculation function may be one out of a set of functions for calculation of ratio between two inputs, flow calculation based on density, pressure and/or temperature.

Explanation of the control functions (rectangles) follows:

“Process Calculation”: This function performs the main Calculation function

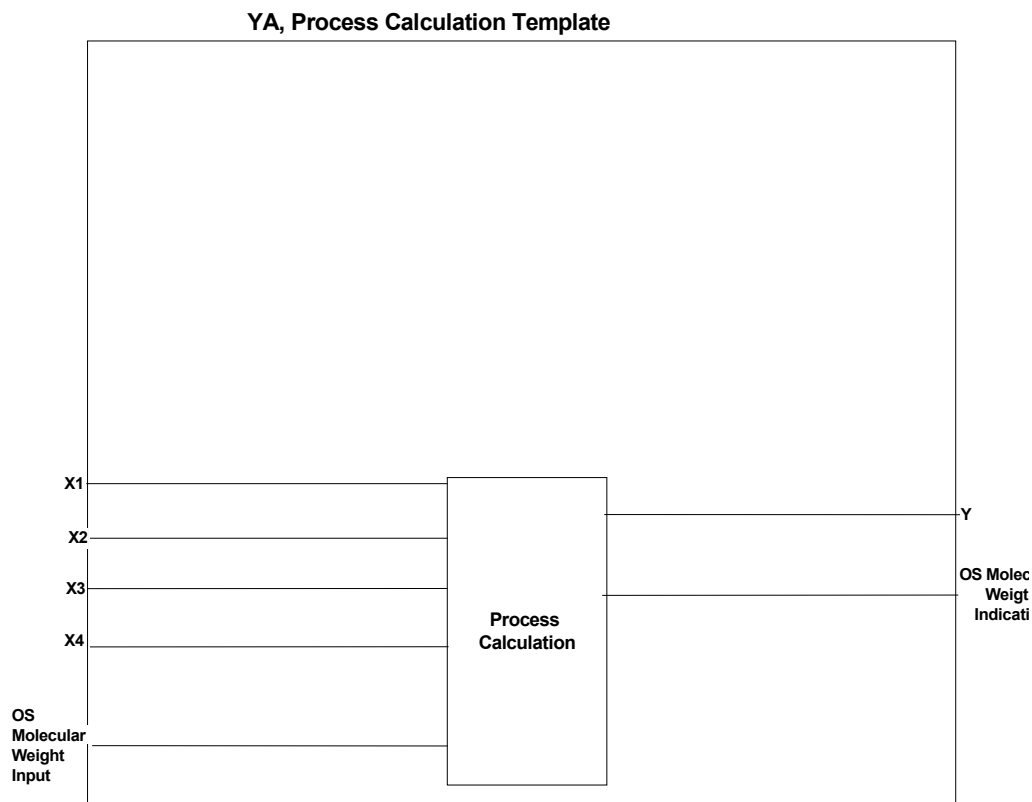


Figure F.30 – The YA process calculation template contains a single control function element

F.7.10 NORSOK Process shut-down template, LB

The LB template controls the setting and resetting of PSD actions.

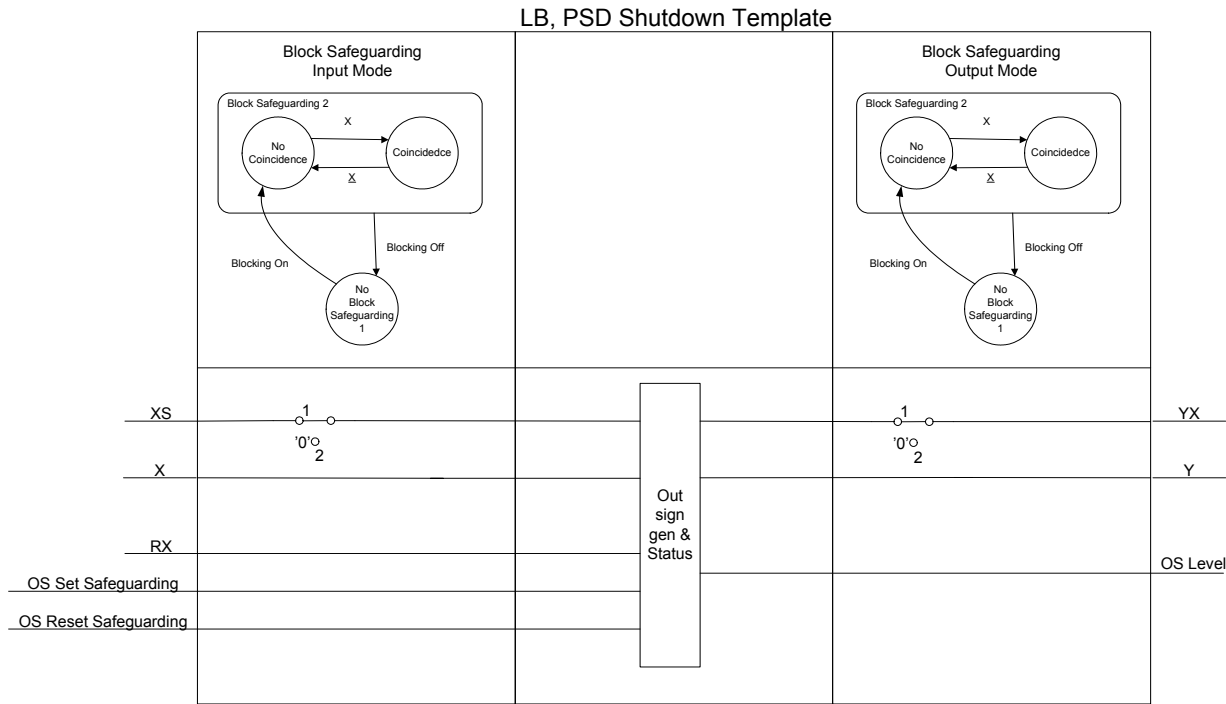


Fig. 31 - Model of LB behavior

Figure F.31 – Model of LB behaviour

F.7.11 NORSOK Single binary signal for shutdown, SB

Note: This chapter is an addendum to the Sintef report done by the Norsok SCD committee.

Template used for a single signal from a shutdown node (or a process node) not controlling the equipment that shall be shut down. The output signal Y is equal to input signal X unless the signal is blocked by the operator.

SB, Single Binary Signal for Shutdown

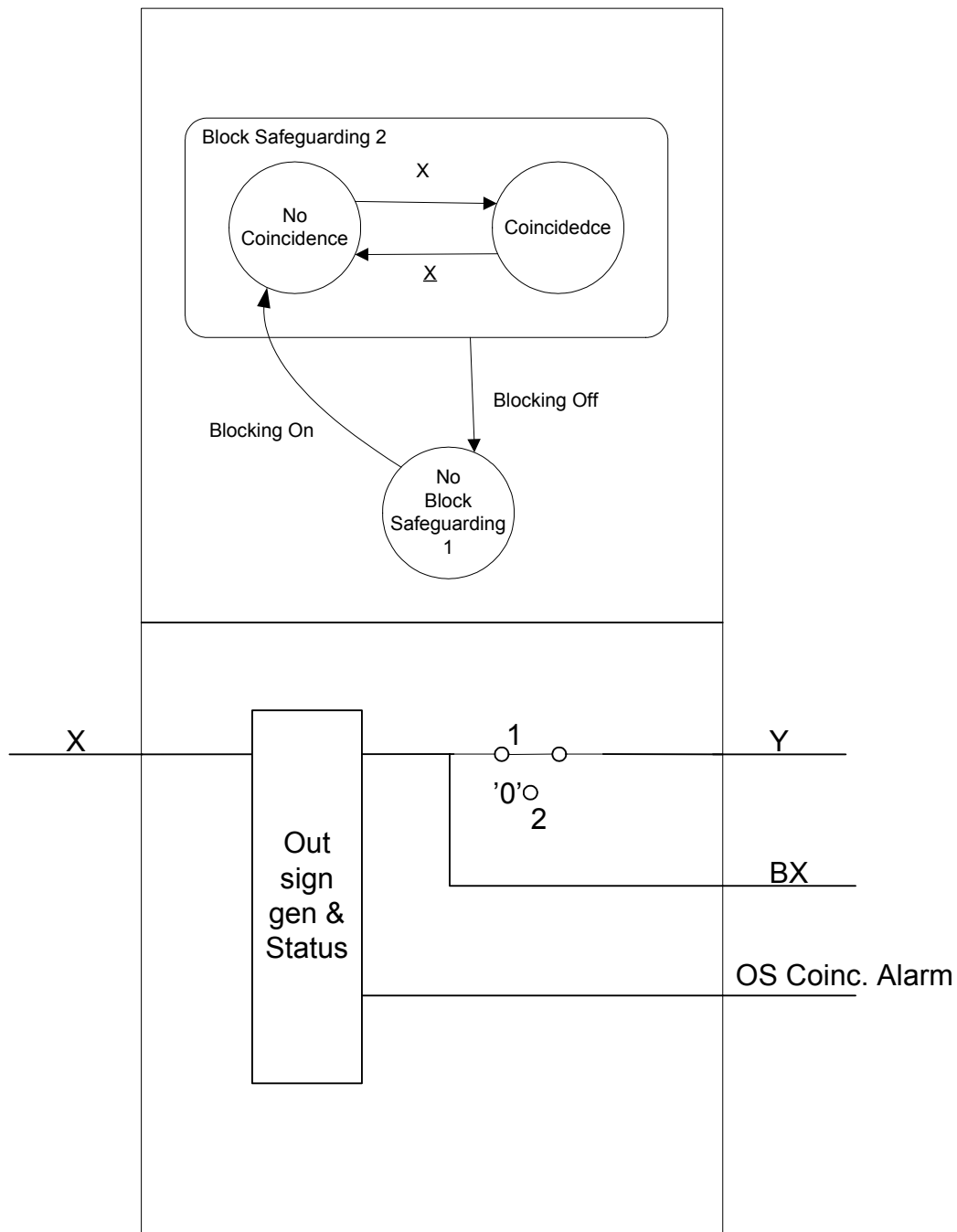


Figure F.32 – SB, control function behaviour

F.8 Description of control function elements

The control function elements are the rectangular boxes in the figures of chapter F.7. These "boxes" also have a behaviour. Describing this behaviour has generally not been the scope of this project, also the definition of the behaviour of many of them must be left up to the vendor. Many of these control functions would typically have sequential behaviour, however one that we have come across in this project is best described with a state chart.

F.8.1 Confirm position

Confirm Position is a control function element, but its behaviour can be described best with a state chart. The following figure describes the Confirm Position control function when there are both low and high limit switches present.

A new figure should be drawn for the cases where one has only one limit switch (low or high).

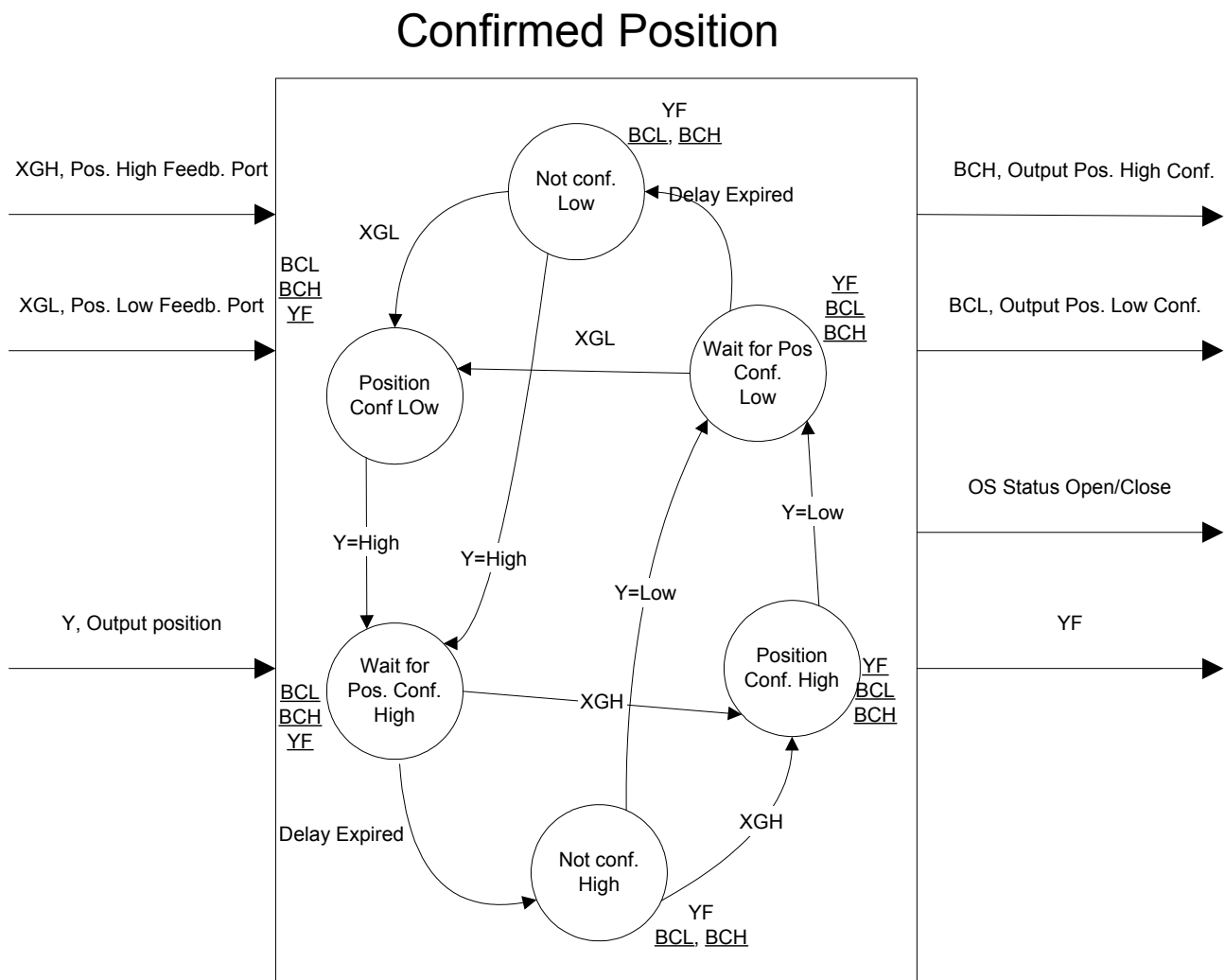


Figure F.33 – the states and conditions for state transition of confirmed position control function

F.9 Future discussion

This annex is a first version of a description of SCD control function behaviour by these types of figures and terminology. The new method of description introduced in this document will provide a good basis for future discussion and further definition of control function behaviour.

Annex G

(Informative)

SCD readers manual

G.1 What is an SCD?

A System Control Diagram (SCD) contains elements both from process/utility flow diagrams and control logic diagrams. It can be looked upon as the result of merging a control system software diagram with a simplified process/utility flow diagram.

SCD's are not necessarily complete with respect to equipment and process, as this is covered by P&ID's. However, SCD's are complete with respect to all control functions that are not implemented as control sequences.

SCD's can be used both to specify exactly how control functions shall be implemented, and to document how control functions have been implemented. Within its scope, an SCD can be made absolutely exact and identical to the control system software that is implemented in the SAS (Safety and Automation System).

The purpose of merging control information with process/utility flow information is to aid in understanding. SAS suppliers' logic documentation may appear difficult to non-specialists. On SCD's this type of information is shown graphically within a process control context, making it easier to grasp. Relations between operator functions, automatic control functions and equipment under control are immediately visualised in a single drawing.

While P&ID's and instrument loop drawings relate to physical equipment, SCD's are function oriented. SCD's identify the process control objects that are accessible to the operator, what the objects do and what the operator can do with the objects.

Standardised logical control system objects are represented on the SCD by a number of software function blocks with surrounding logic (see below). Function blocks in SAS are tagged, either with the tag of the physical object they represent, or with a non-physical control function tag. On SCD's this tagging is shown in exact detail.

G.2 Areas of use

In the early stages of a project SCD's are used for further developing the initial system control specification expressed on P&ID's and vendor package documentation. SCD's can be readily understood by process engineers, safety engineers, package vendors and other participants. Because of this, SCD's may be used as a basis for interdisciplinary discussions on SAS control logic functionality. Each discipline can use the SCD as verification of the SAS engineer's understanding of their requirements.

During detail engineering SCD's are primarily used for further communication between disciplines and for communication with Operations. SCD's define the full operator interface, by use of standard function blocks.

At the time of programming the SAS, the SCD's may be used as the detailed program specification. If the SAS supplier supports standard function blocks (which the major SAS suppliers in the Norwegian offshore industry do) the logic in SAS will be identical to the logic shown on the SCD's. SCD's can be made to an exact level of detail, such that the SAS programmer does not have to add anything during programming. Conversely, what is programmed will be visible in full detail on the SCD's.

The SCD's may be supplemented by a functional description to describe the background for the selected solutions and provide a description of the complete system under control to help and ease the understanding during programming, testing, commissioning and maintenance. Control sequence logic, vendor package document references and serial line information can be collected in the functional description.

Because of this potential for completeness, SCD's may be used as input to automatic SAS programming.

SCD's are SAS supplier independent. If based on standard function blocks, SCD's can in principle be made without knowing who the SAS supplier is. Re-use of control system solutions becomes possible.

Provided the SCD's are kept updated during commissioning and subsequent modification work, they can function both as educational tools for new personnel and as a tool for evaluating proposed changes and additions to the control system. SCD's can have this function during the whole lifetime of the plant.

G.3 The process part of SCDs

The process part of SCD's is simplified. As a main rule it contains about the same information as is visible to the operator on the screens, i.e. the equipment that is necessary for understanding the process.

G.4 The control part of SCDs

The control part comprises function blocks, simple logic elements and logic connections. Together these elements express control system functionality such as displaying the state of the process, running control loops, performing shutdowns and interfacing with the alarm system, control sequences and external systems.

Note that control sequence logic is not shown in detail on SCD's. However, the logical objects that such sequences operate on, are shown.

G.4.1 Function blocks

A function block is a configured package of defined logic functionality, with input terminals (receiving actions from other parts of the SAS logic or from the physical field interface) and output terminals (initiating actions toward other parts of the SAS logic or to the physical field interface). Function blocks are generally capable of being manipulated by the operator, via the SAS screens.

The general definition of any function block type is called a 'function block template', or just 'template'. A template is brought into practical use as a function block when a copy of the template is inserted into the SAS software configuration as a tagged object and given parameter values and logical connections (see below).

Any specific tagged function block resides in a given SAS node, ie. runs in a given machine on the control system network. The operator interface on the screen is independent of which node the function block resides in.

A template has the following standardised components:

- Ports for receiving information (input terminals)
- Ports for outputting information (output terminals)
- Two-way interfaces with the operator screen
- Interfaces with the alarm system
- Set of internal variables (parameters) that select functional options and govern dynamic behaviour
- Algorithm, which determines the total behaviour of the function block. This includes rules for generating values on output terminals as a function of values on input terminals, parameter values and operator actions on screen, as well as the rules governing the operator screen interface.

Templates have been defined for typical SAS functions, as input of analogue or digital process value, on/off valve control, analogue control loop, electrical motor control, etc.

G.4.2 Simple logic elements

Simple logic elements have input and output terminals that work in the same manner as for function blocks. However, simple logic elements are not tagged, and they are neither visible nor accessible to the operator.

Such elements perform elementary logic functions based on the states of the input terminals, and present the result on the output terminal.

Typical simple logic elements are logical AND, OR, logical inversion, analogue value multiplication, latches (memory elements), etc.

Any specific simple logic element resides in a given SAS node, in the same way as function blocks do.

G.4.3 Logic connections

Logic connections are conceptually similar to electrical connections: A logic connection states that the software has been configured such that the state or value of a source is continuously copied to a destination.

Possible sources are:

- The physical field interface for input signals to SAS
- An output terminal of a function block
- The output terminal of a simple logic element

Possible destinations are:

- The physical field interface for output signals from SAS
- An input terminal of a function block
- An input terminal of a simple logic element

Logic connections may be made between terminals on a single function block or between terminals on a simple logic element.

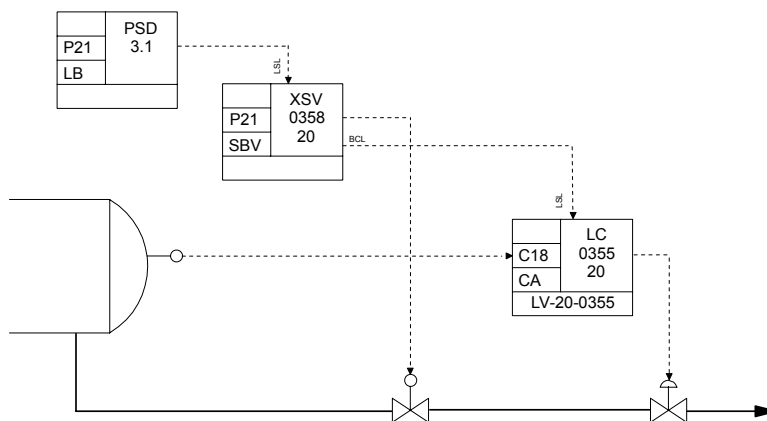
Logic connections from source to source or from destination to destination are illegal.

Logic connections may be made within a single SAS node or between different SAS nodes.

SCD's make no distinction between logical connections within a single SAS node and logical connections between different SAS nodes, other than identifying in which node the source and destination reside, respectively.

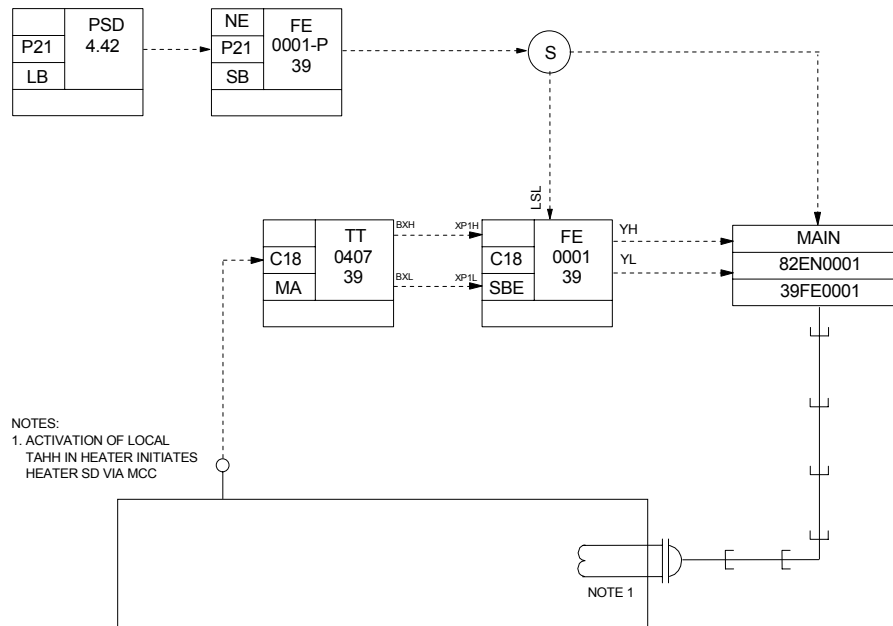
G.5 Examples

G.5.1 Level control



The CA block, (20LC0355) get the level measurement from the physical field interface for input signals to SAS, and the controller output goes to the physical field interface for output signals. The SBV block controls the block valve (20XSV0358) through the physical field interface for output signals. The SBV block gets a shutdown signal and output terminal of the LB block. The LB block represent PSD 3.1 and it shut down the SBV block (LSL = Lock Safeguarding Low). The last connection between the SBV block (output source) to the CA block (destination), is the logic that force the CA block to Lock Safeguarding Low (LSL) when the SBV block is in confirmed closed position (BCL)

G.5.2 Temperature control



The MA block represents the temperature coming from the physical field interface for input signals to SAS. The high event limit (BXH) on the MA block output terminal is connected to the start terminal (XP1H) on the SBE block. The low event will stop the SBE block. The SBE block is connected to the electrical starter through the physical field interface for output signals from SAS. The LB block is used for shutdown propose like in the previous example.

