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Foreword

NORSOK I-002:2021 was adopted as NORSOK Standard 2021-10-11.

NORSOK I-002:2021 supersedes NORSOK I-002 Rev. 2, May 2001.

NORSOK is an acronym for the competitive position of the Norwegian continental shelf and comprise petroleum industry standards in Norway. The collaboration initiative in 1993 between the authorities and the petroleum industry initiated the development of NORSOK standards.

Reducing the project execution time and developing and operating cost for petroleum installations on the Norwegian shelf was the target.

The intention for the Petroleum industry is to develop and use standards providing good technical and cost effective solutions to ensure that the petroleum resources are exploited and managed in the best possible way by the industry and the authorities. The industry will actively contribute to the development and use of international standards in the global market.

The NORSOK standards shall:

- bridge the gap based on experiences from the Norwegian continental shelf where the international standards are unsatisfactorily;
- replace oil company specifications where possible;
- be available as references for the authorities' regulations;
- be cost effective; and
- promote the Norwegian sector as an attractive area for investments and activities.

Developing new NORSOK standards and regular maintenance of existing standards shall contribute to maintain the competitiveness both nationally and internationally for the Norwegian petroleum industry.

The NORSOK standards are developed by experts from the Norwegian petroleum industry and approved according to the consensus principles as laid down by the guidelines given in NORSOK A-001 N directive.

The NORSOK standards are owned by the Norwegian Oil and Gas Association, the Federation of Norwegian Industries and the Norwegian Shipowners' Association. They are managed and published by Standards Norway.

Annex A and B are informative.

The 2021 edition has been completely rewritten to incorporate new principles for system design, the use of new technological concepts in industrial automation and control system solutions, best practice project execution models, and result of changes in the Norwegian petroleum authority regulations.

Introduction

Normative text contains the requirements of the standard. Informative text is only guidance to the reader. All text in foreword, introduction and notes is informative text. Note to entries in Clause 3 and annexes to the document may be either normative or informative.

The bibliography lists standards, norms, laws, regulations and other literature that may be relevant to the use of this document.

Industrial automation and control systems

1 Scope

This document covers functional and technical requirements for design of industrial automation and control systems (IACS) part of an oil & gas production and processing facility.

IACS is the collection of personnel, hardware and software that can affect or influence the safe, secure and reliable operation of industrial processes.

The IACS architecture described will enable a safe, secure and efficient management of hardware and software, flexible vertical integration of operational technology (OT) and information technology (IT) functions and low effort horizontal integration of control and monitoring functions between systems in the IACS domain.

This document revision seeks not to prevent use of near-future technology concepts that are emerging in the marketplace.

An introduction to functions and elements that form the IACS solution is described in Clause 5 and 6.

This document does not cover requirements for the following functions and topics, however, some requirements may apply based on company pre-acceptance:

- field devices for measuring of process and equipment conditions;
- field devices for control actuating;
- systems or equipment not under control by the central control room operator;
- company secure access solution;
- electrical cable and installation.

This document does not state performance requirements to specific control and monitoring functions that is executed by the IACS. Functional owner discipline standard should be referred to in this respect.

2 Normative references

The following referenced documents contain text which fully or in part is part of the requirements in this document. For dated references, only the edition cited applies. For undated references, the latest edition of the cited document applies (including amendments).

[NS-EN ISO 11064-5](#), *Ergonomic design of control centres — Part 5: Displays and controls*

[NS-EN ISO 13849](#), *Safety of machinery — Safety-related parts of control systems*

[NS-EN ISO/IEC 80079 \(all parts\)](#) — *Explosive atmospheres*

[NEK IEC 60079-1](#), *Explosive atmospheres – Part 1: Equipment protection by flameproof enclosures "d"*

[NEK IEC 60079-14](#), *Explosive atmospheres – Part 14: Electrical installations design, selection and erection*

[NEK IEC 60529](#), *Degrees of protection provided by enclosures (IP Code)*

NEK IEC 61131-3, *Programmable controllers – Part 3: Programming languages* [NEK IEC 61131-3](#)

NEK IEC 61499, *Function blocks (all parts)* [NEK IEC 61499](#)

[NEK IEC 61508](#), *Functional safety of electrical/electronic/programmable electronic safety-related systems*

[NEK IEC 61511](#), *Functional safety – Safety instrumented systems for the process industry sector*

[NEK IEC 61892-3:2019](#), *Mobile and fixed offshore units – Electrical installations –Part 3: Equipment*

[NEK IEC 62061](#), *Safety of machinery - Functional safety of safety-related electrical, electronic and programmable electronic control systems*

[NEK IEC 62443-3-2](#), *Security for industrial automation and control systems – Part 3-2: Security risk assessment for system design*

[NEK IEC 62682:2017](#), *Management of alarm systems for the process industries*

[NEK IEC 62890](#), *Industrial-process measurement, control and automation –Life-cycle-management for systems and components*

[NEK IEC PAS 63131](#), *System Control Diagram*

ANSI/ISA 101.01, *Human Machine Interfaces For Process Automation Systems*

DNVGL-OS-D101, *Marine and machinery systems and equipment*

NAMUR NE043, *Standardisation of the Signal Level for the Failure Information of Digital Transmitters*

NAMUR NE175, *NAMUR Open Architecture*

NAMUR NE178, *NAMUR Open Architecture – NOA Verification of request*

NOG 070:2020, *Norwegian Oil and Gas Association Application of IEC 61508 and IEC 61511 in the Norwegian Petroleum Industry*

3 Terms and definitions

In this document, the terms and definitions from the following IEC Electropedia (<http://www.electropedia.org>) subject areas apply in addition to the terms and definitions listed below.

151 Electrical and magnetic devices

171 Digital technology – Fundamental concepts

192 Dependability

351 Control technology

426 Equipment for explosive atmospheres

732 Computer network technology

741 Internet of Things

904 Environmental standardization for electrical and electronic products and systems

3.1

shall (requirement)

expression in the content of a document conveying objectively verifiable criteria to be fulfilled and from which no deviation is permitted if compliance with the document is to be claimed

Note 1 to entry: Requirements are expressed using the verbal forms specified in ISO/IEC Directives, Part 2 clause 7.2 Table 3.

3.2

should (recommendation)

expression in the content of a document conveying a suggested possible choice or course of action deemed to be particularly suitable without necessarily mentioning or excluding others

Note 1 to entry: Recommendations are expressed using the verbal forms specified in ISO/IEC Directives part 2 clause 7.3 Table 4.

Note 2 to entry: In the negative form, a recommendation is the expression that a suggested possible choice or course of action is not preferred but is not prohibited.

3.3

may (permission)

expression in the content of a document conveying consent or liberty (or opportunity) to do something

Note 1 to entry: Permissions are expressed using the verbal forms specified in ISO/IEC Directives Part2 clause 7.4 Table 5.

3.4

can (possibility and capability)

1: expression in the content of a document conveying expected or conceivable material, physical or causal outcome

2: expression in the content of a document conveying the ability, fitness or quality necessary to do or achieve a specified thing

Note 1 to entry: Possibility and capability is expressed using the verbal forms specified in ISO/IEC Directives Part 2 clause 7.5 Table 6.

3.5

alarm

audible and/or visible means of indicating to the operator an equipment malfunction, process deviation or abnormal condition requiring a timely response

[SOURCE: NEK IEC 62682:2014, 3.1.7]

3.6

active dual redundant

redundancy wherein two redundant items operate simultaneously

3.7

configurable I/O channel

input or output channel [\(3.22\)](#) with software or hardware configurable signal type definition enabling direct field cable termination

3.8

control node

functional unit in a system that executes the control application

EXAMPLE Controller, logic solver, programmable logic controller.

3.9**core layer**

core of a network infrastructure aggregating all data elements through a reliable connectivity to distribution layers ([3.23](#)) and/or *edge layers* ([3.12](#))

Note 1 to entry: Core layer has normally a high availability design allowing non-disrupting in-service upgrades.

3.10**data link**

means of connecting one networked device to another for the purpose of transmitting and receiving digital information

3.11**distribution layer**

policy-based connectivity and demarcation between the *edge layer* ([3.12](#)) and the core layer ([3.9](#))

Note 1 to entry: Distribution layer is normally used at large facilities with the need of policy control and isolation/demarcation points between different parts of the facility.

3.12**edge layer**

demarcation between the network infrastructure and the devices that leverage that infrastructure

Note 1 to entry: Edge layer normally enforces security, segmentation, QoS and policy trust enforcement.

3.13**engineering workstation**

human-machine interface ([3.20](#)) in a system where configuration, maintenance and diagnostic of system hardware and software are performed by a user

3.14**facility**

installation, plant and other equipment for production and processing of petroleum, and comprises also pipeline and cables unless otherwise specified

3.15**field device**

device connected directly to the industrial process or located in close proximity to the process

EXAMPLE Field instrument, final control element, field network switch.

3.16**field instrument**

functional unit containing sensors, and if required local human-machine interface, connected directly to the industrial process or located in close proximity to the process

EXAMPLE Pressure transmitter, flow meter.

3.17**fire detection area**

an area with uniform causes (e.g. type of fire or gas detection) and effects (e.g. emergency shutdown or firefighting) with basis in similar hazards and operating conditions

3.18

first-out alarm

alarm (3.5) determined (i.e., by first-out logic) to be the first, in a multiple-alarm scenario

[SOURCE: NEK IEC 62682:2014, 3.1.53]

3.19

green line

status confirming that temporary interlinked facilities are ready to start production after the monitoring circuit has verified that all equipment is in the correct status and that all safety instrumented functions are in operation

Note 1 to entry: Typically used between facility and shuttle tanker.

3.20

human-machine interface

HMI

functional unit used by the user to monitor and interact with the system and with the industrial process via the system

EXAMPLE Operator stations, critical action panels, engineering workstation.

3.21

industrial automation and control systems

IACS

collection of personnel, hardware, software, procedures and policies involved in the operation of the industrial process and that affect or influence its safe, secure and reliable operation

Note 1 to entry: The IACS can include components that are not installed at the asset owner's site.

Note 2 to entry: Annex A guides and illustrates further the functional aspects of IACS in the context of this document.

[SOURCE: NEK IEC 62443-4-1:2018, 3.1.20]

3.22

input/output channel

I/O channel

functional unit in an industrial control system that typically handles the transfer of data between *control nodes* (3.8) and hardwired *field devices* (3.153.15)

EXAMPLE Analogue input channel, analogue output channel, digital input channel, digital output channel, Profibus PA channel or ethernet channel.

3.23

input/output system

I/O system

equipment containing input/output channels

EXAMPLE Terminal blocks, galvanic isolators, output signal relays, common data network interface, common power supply, etc.

3.24

interoperability

interoperable

ability of two or more systems or components to exchange information and to use the information that has been exchanged

[SOURCE: NEK ISO/IEC/IEEE 24765:2017, 3.2089]

3.25**operator station**

human-machine interface in a system where the user monitors and interacts with the industrial process via the control system

3.26**portability**

the ease with which a system or component can be transferred from one hardware or software environment to another

[SOURCE: NEK ISO/IEC/IEEE 24765:2017, 3.2968]

3.27**protected area**

rooms that are located beyond hazardous areas and where the ventilation arrangement is such that gas cannot penetrate into the room

Note 1 to entry: This is typically rooms in accommodation area or utility areas located next to the accommodation area.

Note 2 to entry: None-explosion protected electrical equipment that is required to remain operational in abnormal situations should be located in the protected area.

3.28**redbox**

network device with a single network interface connected to a dual redundant network

3.29**safety and automation system****SAS**

human-machine interface for the central control room operator to control and monitor safety instrumented functions, production and processing functions, power distribution functions, ballast and bilge functions and marine system functions

3.30**SAS control class 1**

control and monitoring functions are fully integrated into SAS utilising project standard SAS software and hardware

Note 1 to entry: Systems and equipment under control are operated and monitored through SAS HMI.

3.31**SAS control class 2**

control and monitoring functions are partially integrated into SAS

Note 1 to entry: Non-SAS control nodes are either directly connected to SAS network or interfaced to other SAS equipment via data link.

Note 2 to entry: Systems and equipment under control are operated and monitored through SAS HMI following SAS HMI standard for uniform operation.

3.32

SAS control class 3

control and monitoring functions are not integrated in SAS

Note 1 to entry: Interface to SAS is not required, however supervisory control or monitoring from SAS HMI could be applied.

Note 2 to entry: Systems and equipment under control are operated and monitored through stand-alone HMI.

3.33

secure access solution

secure communication conduit between the facility *IACS* ([3.21](#)) and off premise IT solutions and a set of global services for use in *IACS* ([3.213.22](#))

EXAMPLE Examples of global services can be secure access, file transfer, backup, patch and anti-virus distribution.

3.34

shelve

temporary suppress an alarm, initiated by the operator, with engineering controls to unsuppress the *alarm* ([3.5](#))

[SOURCE: NEK IEC 62682:2014, 3.1.79]

3.35

standby dual redundant

redundancy wherein the second redundant item is activated only when the first active item is unavailable

3.36

supplier

organization that provides a product or a service

EXAMPLE Producer, distributor, retailer or vendor of a product or a service.

Note 1 to entry: A supplier can be internal or external to the organization.

Note 2 to entry: In a contractual situation a supplier is sometimes called "contractor".

[SOURCE: NS-EN ISO 9000:2015, 3.2.5]

3.37

suppress

annunciation of the [alarm](#) to the operator when the alarm is active

[SOURCE: NEK IEC 62682:2014, 3.1.84]

4 Abbreviations

For this document, the following abbreviations apply.

AC	alternating current
APC	advanced process control
APS	abandon platform shutdown
ATS	automatic transfer switch
BPCS	basic process control system
CC1	control class 1
CC2	control class 2

CC3	control class 3
CAP	critical action panel
CCR	central control room
CIP	common industrial protocol
CPF	communication profile families
CPU	central processing unit
DC	direct current
EDP	emergency depressurisation
ESD	emergency shutdown
F&G	fire and gas
FAU	field automation unit
HMI	human-machine interface
HSR	high-availability seamless redundancy
HVAC	heating, ventilation and air conditioning
I/O	input/output
IACS	industrial automation and control systems
IED	intelligent electronic device
IIoT	Industrial Internet of Things
IP	internet protocol / ingress protection (based on context)
IT	information technology
LCD	liquid-crystal display
LED	light emitting diode
LSD	large screen display
LTS	long term support
MRP	media redundancy protocol
NTP	network time protocol
OPC	open platform communications
OVF	open virtualization format
OT	operational technology
OVS	open virtualisation format
PCS	process control system
PDCS	power distribution control system
PRF	parallel redundancy protocol
PSD	process shutdown system
PTP	precision time protocol
QoS	quality of service
SAS	safety and automation system
SIF	safety instrumented function
SIL	safety integrity level
SIS	safety instrumented systems
SL-T	security level target
SPCS	subsea production control system
TCS	turbine control system
UA	Unified architecture
USD	unit shutdown
UTC	universal time coordinated
VLAN	virtual local access network
VPDS	vibration protection and diagnostic system

5 Introduction to methodology

5.1 Objectives

IACS comprises systems for instrumented safety, control and monitoring of facilities.

The main objectives for the IACS solution are:

- safeguarding of personnel, environment and asset;
- controlling, monitoring and operating the facility;
- enabling condition-based maintenance of facility systems and equipment.

The project's main design objectives of IACS are:

- enable value creation in operations by use of real-time automatic control functions to maximise production value and minimise production cost;
- enable value creation in operations by delivering quality information to company IT platform;
- minimising facility life cycle cost by enabling efficient low manning / unmanned operations;
- minimising life cycle cost by enabling efficient upgrading of IACS components;
- low risk project development by minimising project specific technical and communication interfaces;
- low risk project development through high degree of IACS standardisation;
- efficient project development by use of digital tools for automatic data exchange.

5.2 IACS functional hierarchy

The IACS functional hierarchy is based on NEK IEC 62264 functional hierarchy definition and can be as illustrated in [Figure 1](#).

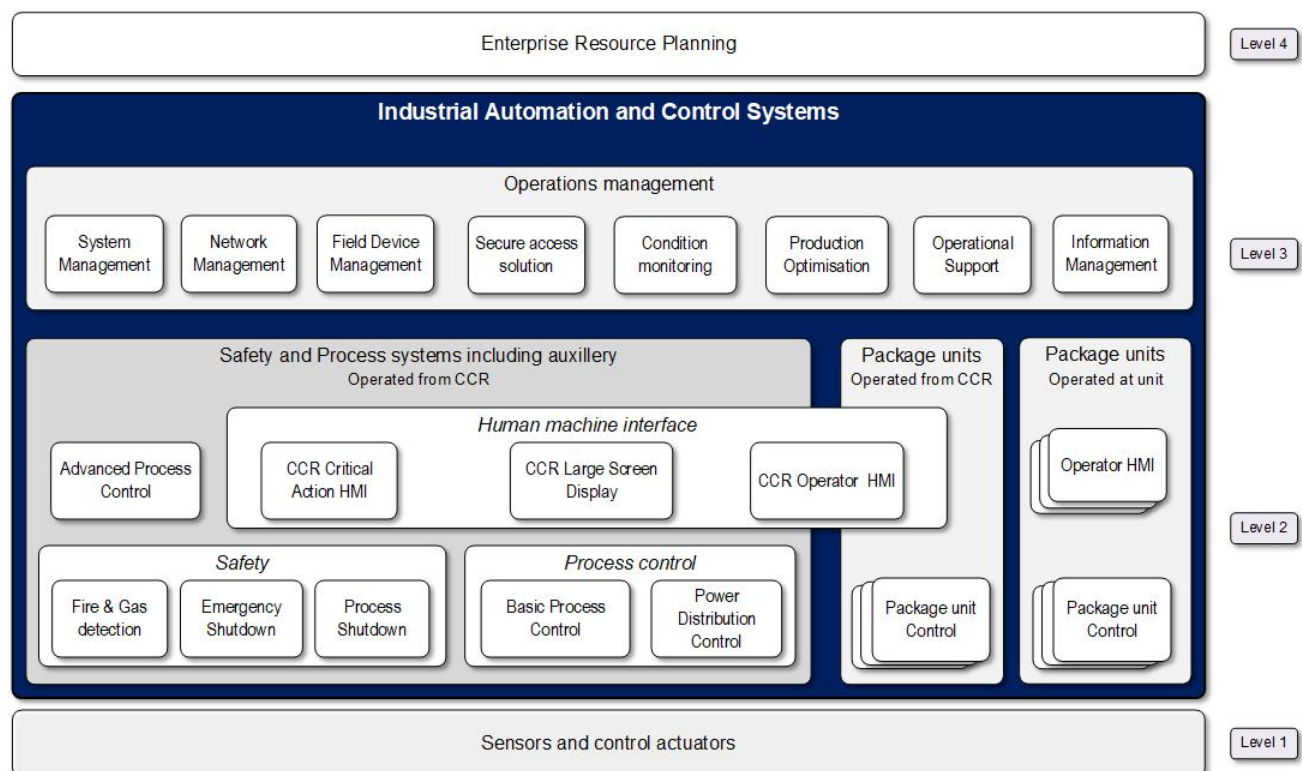


Figure 1 — Functional hierarchy

5.3 IACS basic elements

5.3.1 Introduction to basic elements

IACS consist of basic elements that together forms the realisation of the project solution. The main elements are described in the following sub-clauses.

5.3.2 Physical elements

Physical elements are material elements or assembly of such elements, e.g.:

- component (physical element that cannot be physically divided into smaller parts without losing its particular function);
- device (physical element intended to perform a required function);
- apparatus (device or assembly of devices which can be used as an independent unit for specific functions);
- equipment (single apparatus or set of devices or apparatuses, or the set of main devices of an installation, or all devices necessary to perform a specific task).

5.3.3 Functional elements

Functional elements are entities of hardware or software, or both, that defines a specific purpose, e.g.:

- functional unit (functional element capable of accomplishing a specified purpose);
- system (set of interrelated functional elements considered in a defined context as a whole and separated from their environment).

5.3.4 Hardware

Hardware is a device or assembly of devices used for information processing, e.g.:

- actuator (functional unit that generates the manipulated variable, required to drive the final controlling element);
- field instrument (functional unit containing sensor(s), and if required local HMI, connected directly to the industrial process or located in close proximity to the process);
- input/output channel (functional unit in a system that typically handles the transfer of data between control nodes and hardwired field devices);
- control node (functional unit in a system that executes the control application);
- human-machine interface (functional unit used by the user to monitor and interact with the system and with the industrial process via the system);
- computer (functional unit that can perform data processing);
- gateway (functional unit that connects two computer networks with different network architectures and protocols).

Hardware requires software to execute computer programs and to store and transmit data.

5.3.5 Software

Software is an assembly of programs, procedures, rules, documentation and data, pertaining to the operation of an information processing device or system, e.g.:

- firmware (software stored in a way that is functionally independent of main storage, usually in a read-only storage);
- operating system (software that controls the management and the execution of users' programs in a computer);
- software framework (platform for developing software applications);
- application software (software that is specific to the solution of a problem submitted by an end user);
- application (software designed to fulfil a particular purpose).

Software requires hardware to execute programs and to store and transmit data.

6 Functional systems in IACS

6.1 Safety and automation system

6.1.1 General

The SAS is the facility main system providing the human-machine interface for the central control room operator to control and monitor:

- safety instrumented functions;
- production and processing functions;
- power distribution functions;
- ballast and bilge functions;
- marine system functions.

6.1.2 Safety instrumented system

6.1.2.1 General

The safety instrumented functions (SIF) shall be implemented in safety instrumented system (SIS) and consist of sensor(s), control node(s) and final control element(s).

The SIS shall be functionally separated in the following independent systems:

- 1) emergency shutdown (ESD) system;
- 2) fire & gas (F&G) system;
- 3) process shutdown (PSD) system.

6.1.2.2 Emergency shutdown system

The ESD system shall execute safety related functions for protection of personnel, environment and asset, prevent escalation of an abnormal condition into a major hazardous event and limit the extent and duration of any such events that occur.

The ESD system shall:

- 1) monitor and detect facility hazards;
- 2) activate isolation and sectionalisation of process segments, including isolation of wells and pipeline/flowline risers;
- 3) activate emergency depressurisation;
- 4) activate ignition source isolation;
- 5) initiate automatic PSD actions;
- 6) initiate APS time delay function.

6.1.2.3 Fire and gas system

The F&G system shall detect fire or gas hazards and initiate required actions upon demand.

The F&G system shall:

- 1) monitor and detect fire and gas hazards;
- 2) initiate automatic ESD actions (if applicable);
- 3) alert personnel;
- 4) activate relevant fire-fighting system(s);
- 5) activate shutdown of heating, ventilation and air conditioning (HVAC) systems.

6.1.2.4 Process shutdown system

The PSD system shall detect and evaluate an abnormal process condition, initiate required process sectioning and equipment shutdown in order to control the situation and avoid escalation.

The PSD system shall:

- 1) monitor and detect process hazards;
- 2) activate process safety functions;
- 3) activate isolation of affected process unit or facility.

6.1.3 Process control system

6.1.3.1 General

The process control system (PCS) shall control and monitor the production process, mechanical and electrical equipment and utility systems part of the facility.

The PCS system shall as a minimum:

- 1) monitor the process and equipment;
- 2) execute automatic closed loop control;
- 3) execute automatic sequences;
- 4) execute manual operator command.

The PCS shall have automated functions for the following operational modes, i.e. there shall be no need for manual supervision or intervention from central control room (CCR):

- normal production, i.e. handle process disturbances and defined fault scenarios;
- start-up of the whole or parts of the facility where essential utilities are available, e.g. electrical power, instrument air, etc.;
- stop of the whole or parts of the facility to an operational safe and idle state.

The PCS functions shall not have a negative impact on SIS i.e. SIS ability to perform SIF.

6.1.3.2 Basic process control

The basic process control system (BPCS) shall control and monitor the main process systems, export and by-product handling systems, process support and utility systems and electrical power generation systems.

Supervisory control and monitoring of subsea production and processing systems shall be an integrated part of BPCS.

6.1.3.3 Power distribution control system

The power distribution control system (PDCS) shall control and monitor the electric power distribution network.

Power management functions shall be part of the PDCS.

6.1.3.4 Ballast and bilge control

The ballast and bilge control system shall control and monitor equipment for ballast and bilge operations.

6.1.3.5 Marine system control

The marine system control in SAS shall control and monitor marine equipment that are required operational during normal facility production.

6.1.4 Human machine interface system

The human-machine interface (HMI) system shall be designed with respect to operational needs, facility complexity and limitations in human perceptual and cognitive capabilities.

The HMI design shall enable the CCR operator primary tasks of facility monitoring and control.

The HMI design should minimise the impact of secondary tasks (e.g. display navigation within the HMI) that may distract the CCR operator from performing their primary tasks.

The HMI system shall support the following tasks in a safe, reliable and efficient manner:

- normal operations;
- abnormal/disturbance operations;
- emergency operations;
- start-up / shutdown operations;
- maintenance operations.

The HMI system shall be the main operator interface for:

- control and monitoring functions for SIS;
- control and monitoring functions for process control system;
- control and monitoring functions for SAS CC2 systems;
- functions for advanced process control.

The HMI system shall have integrated alarm system functionality for uniform handling of alarms in the control room.

The HMI system shall include a common system management interface to:

- hardware and software;
- data exchange to external systems.

If two or more operators have shared responsibility in the control room, the HMI system should include a large screen display (LSD) that is visible from all operator work desks without any obstructions in the line of sight.

If an LSD is to be present in the control room, it shall display necessary information for the control room operators to support joint situation awareness and interaction.

Critical action panel (CAP) shall be present in the CCR for activating and monitoring of the CAP functions.

Local control panels shall be present in the field when local operation is needed and shall have the information needed for executing commands and monitoring status in a safe and reliable manner.

6.2 Control systems other than SAS

6.2.1 Introduction

This clause covers functional description of some control systems that may be delivered as separate systems in a project. Level of integration between SAS and these control systems needs to be further defined.

6.2.2 High integrity protection system

High integrity protection system (HIPS) may be used as an instrumented protection system to compensate for lack of conventional mechanical protection to obtain an acceptable risk level.

NOTE IOGP Report 443 provides industry guidance in the provision, operation and maintenance of HIPS.

6.2.3 Gas turbine control system

The turbine control system (TCS) shall control and monitor the gas turbine.

The TCS shall include the following functions:

- monitor the turbine and accompanying auxiliary systems;
- execute core fuel and speed control;
- execute automatic sequences.

The TCS portion providing core fuel control shall be approved by the turbine manufacturer.