



Exploration & Production

GENERAL SPECIFICATION

SUBSEA SYSTEMS

GS SPS 019

Subsea production control system

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1. Scope

This document describes the requirements for the Subsea Production Control System (SPCS). Requirements and main equipment for three different subsea layouts are described.

This specification has to be considered in conjunction with other documents describing the total subsea system, interfacing equipment or more details regarding SPCS equipment. These documents will provide additional input to this specification.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

This specification and all other equipment specifications referenced herein are based on a set of industry standards identified below.

2.1 General

The Subsea Production Control System shall comply with all relevant statutory requirements and specifications.

All relevant ISO standards and EU directives shall be adhered to unless otherwise stated by COMPANY.

Standards

Reference	Title
NAS 1638	National Aerospace Standard: Cleanliness requirements of parts used in hydraulic systems
89/336-EEC	EMC Directive
ISO 3511	Process measurement control functions and instrumentation Symbolic representation
ISO 13628-6	Subsea Production Control System
ISO 9000-3	Quality management and quality assurance standards - Part 3: Guidelines for the application of ISO 9001 to the development, supply and maintenance of software

Professional Documents

Reference	Title
Not applicable	



Regulations

Reference	Title
Not applicable	

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

The Subsea Production Control System shall comply with the following COMPANY specifications.

Reference	Title
GS SPS 001	Design philosophy and requirements for Subsea Stations
GS SPS 020	Subsea Control Unit Functional Requirements
GS SPS 021	Subsea Mateable Electrical/Optical Connectors
GS SPS 022	Environmental testing of Subsea Electronics
GS SPS 023	Cleaning and Flushing of Hydraulic Systems

3. Abbreviations

BER	Bit Error Rate
CIV	Chemical Injection Valve
CITV	Chemical Injection Throttle Valve
DHSV	Down Hole Safety Valve
DIU	Downhole sensor Interface Unit
DV	Manifold 3-Way Directional Valve
ESD	Emergency ShutDown
ETU	Electronic Test Unit
FS	Full Scale
HP	Hydraulic High Pressure
HPU	Hydraulic Power Unit

HTC	Hydraulic Test Container
ICSS	Integrated Control and Safety System
LP	Hydraulic Low Pressure
MCM	Manifold Control Module
OS	Operator Station
PCV	Production Choke Valve
PIGV	Manifold Pigging Valve
PMV	Production Master Valve
PSD	Process ShutDown
PWV	Production Wing Valve
ROV	Remotely Operated Vehicle
RPC	Remote Power Controller
SCM	Subsea Control Module (Master Control Station)
SCU	Subsea Control Unit
SEM	Subsea Electronic Module
SPCS	Subsea Production Control System
SU	Service Umbilical
SPCU	Subsea Power and Communication Unit
UPS	Un-interruptable Power Supply
UTH	Umbilical Termination Head

4. System description

4.1 General

This specification comprises the services and main building blocks for Subsea Production Control Systems (SPCS). A detailed specification for all building blocks shall be written by CONTRACTOR. The building blocks might differ depending on development concept. Therefore several concepts have been established, in order to cover most probable building blocks for foreseeable future developments. These concepts are described in higher level documents, but may be summarised as follows:

- Concept 1: Templates with manifold
- Concept 2: Individual wells connected to manifold centre (cluster solution)
- Concept 3: Individual wells with discrete connection to production facility
- Concept 4: Single satellite tie-backs to existing infrastructure

5. Product requirements

5.1 General

The SPCS shall be of the electro-hydraulic type, with an optional optical fibre main communication system. Selection of hydraulic fluid and the use of open or closed control system are to be approved by COMPANY.

The SPCS shall interface the ICSS system of the production platform.

Level of redundancy throughout the system will influence cost and reliability, and must be analysed for all parts of the system, i.e.:

- Subsea Control Unit (SCU)
- Topside modems, umbilical lines and connectors
- Umbilicals
- Hydraulic lines and couplers
- Subsea Electronic Modules (SEM) - to be redundant
- Process Sensors - to be redundant
- Housekeeping Sensors
- Control Valve Solenoids
- Subsea hydraulics

Due consideration shall be given to:

- Production availability requirements
- Standardisation -use "off the shelf"- products, industrial standards
- Fabrication costs
- Operating costs
- Maintenance.

Subsea control systems shall be designed hydraulically and electrically fail-safe. All subsea valves related to safety functions shall return to safe position on loss of hydraulic pressure.

All subsea valves shall start valve operation less than 1 second after operator command is available to SPCU. Updating of subsea measurements shall be every second for all wells, but with configurable longer interval.

The choke position indication using step counts shall be accurate to < 1%.

The subsea hydraulic system shall be robust and designed and qualified to tolerate accidental contamination of seawater and particles. It shall be designed to avoid ingress or accumulation of such contamination. All components shall be qualified for operation in fluid contaminated with solid particles and seawater. Vulnerable parts with very low fluid consumption, as control valve pilot stages, shall be protected by dedicated filters separate to LP or HP filters.

The system shall be designed to operate on hydraulic fluid [NAS 1638](#) Class 12 for five years. The aspects to consider includes filter sizing, filter type and single components tolerance for contamination.

The design shall be such that trapped air as far as possible is avoided, and can be removed, either by design, flushing or venting prior to subsea installation.

All user interfaces, including both hardware and software, shall be agreed with COMPANY in all project phases.

All subsea components containing software shall have hardware/firmware facilitating downloading of new application software and configuration from topside. Complete or partial download of application program to SEMs shall be possible without interrupting normal operation. Complete information on software and hardware version shall be retrievable from the ETU.

Temperature ratings are to be according to [ISO 13628-6](#), extended ratings.

5.2 Reliability and availability

Reliability and availability (including mean time to repair) shall be calculated for the total subsea production system including topside equipment, X-Mas Tree equipment and umbilical terminations. Reliability figures for all components shall be documented and justified by calculations and/or tests.

5.3 Subsea Power and Communications Unit (SPCU)

The SPCU shall contain racks of modems and power units for transmission of signal and power to the SCM's via the subsea umbilical. Continuous monitoring of the umbilical line insulation with an override trip function shall be provided in the SPCU. Overriding the trip function shall not affect the monitoring. It is required to monitor insulation level on all lines from SPCU to SEM, including subsea distribution.

It shall be possible to connect an Electronic Test Unit to the SPCU without interrupting production from any well.

No single failure or associated repair work in the SPCU shall have greater consequence than loss of redundancy on power or communication to the subsea wells. The SPCU shall be designed for easy access to terminals to facilitate work and minimise risk of personnel injuries and errors during commissioning, start-up of new wells and maintenance.

5.3.1 Interface SPCU to ICSS and Production Unit

The SPCU shall have dual redundant power supplies, supplied with separate lines from UPS. Loss of one power supply from UPS shall not have any effect on SPCU functionality.

The SPCU will have interfaces to the SCU, UPS, and the umbilical via the platform cabling. The SPCU must handle communication to several masters, e.g. additional Smart Well SCU.

All communication protocols used between SCU and SPCU shall be standards that are widely used in industry.

The SPCU may provide parts of the functionality and function blocks described for SCU, i.e. provide "smart modems".

5.3.2 Communication SPCU-SEM

Communication between SPCU and the SEMs in the MCM and SCM shall be with high transmission data rate.

The communication channels from each modem shall be dual redundant, i.e. each SEM shall have dual redundant communication. To improve reliability and reduce complexity in connections, the modems shall transmit and receive on the same fibre.

5.4 Hydraulic Power Unit (HPU)

The HPU supplies hydraulic pressure and fluid to the subsea system through the umbilical. Two separate reservoirs and pump(s) for circulation/cleaning of fluid shall be implemented. When non-water based hydraulic fluid is used, a unit for removal of water must be included. The HPU shall include separate ESD valves in the High Pressure (HP) and the Low Pressure (LP) supply lines.

The HPU shall be controlled by ICSS.

CONTRACTOR shall establish the HPU performance requirements resulting from Hydraulic analysis.

Hydraulic fluid from HPU shall as a minimum satisfy cleanliness requirements of [NAS 1638](#) Class 6.

Safety valve setting shall not exceed design pressure.

Pump pressures should be well above regulated output pressures. Neglecting all other methods of fluid energy storage such as umbilical line expansion and subsea accumulation, accumulator capacity should be sufficient for worst case of the following:

- opening all valves on two wells without operation of the pumps,
- maintain open all subsea valves for 24 hours.

Failure on one accumulator shall not reduce the HPU accumulator capacity for the relevant line by more than 50%.

Fluid reservoirs shall be cylindrical stainless steel tanks equipped with circulating pumps and filters. Fluid reservoirs shall have connection points for nitrogen or dry air to replace the atmospheric air. Sample points shall be made at the lowest point of the reservoir and at pump outlets upstream filters.

Isolation valves and redundancy shall enable the operator to perform maintenance and change out regulators and filters without interrupting delivery of hydraulic power to subsea.

The HPU shall be designed to minimise the risk for common mode failures.

5.5 Umbilical Topside Termination

The electrical lines will be terminated in a junction box supplied by others. Topside interconnecting cabling to SPCU will be done by Topside CONTRACTOR, based on interface information from CONTRACTOR.

It is CONTRACTOR'S responsibility to specify, and provide functional requirements for the surface cables, tubing, interfaces and testing.

5.6 Umbilical Subsea Termination

Electrical and fibre optic lines of the umbilical are terminated in several pressure balanced connection chambers in the umbilical termination head. From these chambers the wires are fed to the wet mateable connectors on the termination head. The connection chambers shall be filled with oil or an insulating gel.

At any stage of the termination system each conductor shall be protected from seawater ingress by two separate and testable barriers. There is a requirement for a separate water blocking of each individual wire, and for each wire bundle (i.e. quad, cable sheath, fibre optic carrier, etc.).

The Umbilical Subsea Termination shall be designed to limit the consequences of faulty water barriers e.g. vulnerable parts like boot seals should not be located at the lowest point, redundant systems should be located in separate units, connection chambers (i.e. outer water barrier) should not be directly exposed to seawater, etc.

The design shall also take into consideration temperature effects during transport and installation, installation method and possible repair/intervention situation after long-term immersion.

5.7 Subsea Distribution Unit (SDU)

The SDU will be applicable for Concept 3 and may be included as a stand-alone unit located close to the X-Mas Trees. The SDU distribute umbilical lines to several X-Mas Tree systems. The SDU shall be retrievable. Each well will be connected to the SDU via Optical/Electrical/Hydraulic Jumpers. There shall be one parking place for jumper stab plate on each side of the SDU.

The unit shall be complete with tools and landing base. All SDU valves and connectors shall be operable by ROV. It shall be possible to isolate outputs for hydraulic, chemical and service lines.

If the same electrical power or communication line from the umbilical is distributed to more than one SCM, it shall be possible to isolate each output. Thus a fault in or downstream the output connector of the SDU shall not influence operation of the other SCMs.

5.8 Manifold Control Module (MCM)

The distributing function of electrical power and signal to the SCMs may be integrated in a MCM. The MCM shall have 25% spare connectors for power and signal distribution.

The MCM shall be located on the manifold centre or template.

The MCM will control the manifold pigging and circulation valves together with other manifold valves selected for remote control. The MCM will monitor any manifold mounted sensors.

5.8.1 Interfaces

A fault in or downstream of the power output connector of the MCM to one SCM should not influence the operation of the other SCMs. This may be achieved by including a Remote Power Controller (RPC), which disables the line when a short circuit occurs.

All MCM connectors shall be operable by ROV.

5.9 Subsea Accumulator Module (SAM)

The hydraulic accumulators for additional fluid capacity in the hydraulic system may be integrated in a SAM. The SAM shall be located on the manifold centre or template.



The SAM shall have a guiding system for installation and retrieval on mounting base. Hydraulic couplings shall not be exposed to forces related to guiding the SAM. Retrieval and installation of SAM shall be possible without reducing the pressure in the hydraulic supply lines or interrupting operation of the wells.

Accumulators on the SAM shall be dual redundant for each line. The sizing of accumulators shall be done based on hydraulic analysis.

HP, LP, Spare and return lines shall be routed via the SAM even if accumulation of fluid is not required on all lines. This is to enable reconfiguration of leaking lines.

Protection of accumulator precharge valves shall be fitted. There shall be easy access to check precharge, charge and release pressure of gas in accumulators, also with SAM mounted on the template/manifold.

If an accumulator is not retrievable as a module, e.g. fixed on a X-Mas Tree, an ROV operated isolation valve shall enable isolation of the accumulator.

5.10 Subsea Hydraulic Distribution Lines/Jumpers

The performance requirements for the hydraulic distribution lines and jumpers including hydraulic, chemical and service lines shall be established by CONTRACTOR on the basis of hydraulic analysis and simulation results.

Subsea distribution system shall be designed to minimise total number of couplers in series.

The hydraulic distribution lines are for Concept 3 part of the optical/electrical/hydraulic jumper from the SDU to the satellite well. Chemical lines and service lines must be designed to collapse resistance against full external hydrostatic pressure with one bar pressure inside.

The hydraulic distribution lines are for Concept 1, 2 and 4 part of the Manifold/Template or well Production Guide Base.

5.11 Subsea Optical/Electrical Jumpers

Subsea optical/electrical jumpers are used for distribution of power and signal to SCMs and MCMs. The jumpers will also be used for X-Mas Tree sensors, CITV, etc. All jumpers shall comprise hoses filled with dielectric oil.

Connection and replacement of electrical distribution jumpers shall be made by ROV using simple tools, with minimum implications on rig/vessel time.

The complete jumper for Concept 3 between SDU and directly to SCM shall be replaceable by ROV.

Initial installation of jumpers for Concept 1, 2 and 4 shall be verified onshore. Individual jumpers for distribution of power and signal shall be replaceable by ROV.

5.12 Subsea Control Module (SCM)

The SCM shall control and monitor X-Mas Tree valves and instrumentation.

5.12.1 General

The SCM shall have redundant electronics and electrical circuits (including solenoids) with no common mode failures. Each hydraulic output line shall have pressure transducers. Hydraulic supply- and return-lines shall have flowmeters and dual redundant pressure transducers.

The SCM shall have one ROV-connectable interface for each of the two SEMs for communication with the SPCU. The communication channels for each modem shall be dual redundant, i.e. each SEM will have dual redundant communication.

Power supply and communication system in MCM and SCM shall be built for a wide range of distances from SPCU. This implies that the SEM shall accept a wide range of power voltage and signal levels, and the amount of project specific types of MCM/SCM may be minimised.

The SCM shall have a guiding system for installation and retrieval on mounting base. Connectors and hydraulic couplings shall not be exposed to forces related to guiding the SCM. Retrieval and installation of SCM shall be possible without reducing the pressure in the hydraulic supply lines. The SCM shall be mechanically locked to the SCM Mounting Base.

The SCM includes directional control valves, hydraulic manifold and mounting base with electrical connectors and hydraulic couplers. Hydraulic manifold shall be made out of one piece of material, no lamination or similar is accepted. The drilling of the manifold or plugging of holes shall not result in dead ends where the fluid will not flow sufficiently during use to eliminate particle build-up.

Directional Control Valves shall have two independent coils, where each coil shall be capable of operation of the pilot valve. The DCV shall have a spring operated reset mechanism to make the valve fail safe on loss of hydraulic supply.

Seawater resistant DCV is preferred, i.e. DCV that is qualified for operation on a 50% mixture of seawater and hydraulic fluid for the systems lifetime.

Valve position for production system isolation valves shall be inferred by measuring hydraulic pressure to each actuator in combination with flow measurement for verification. Automatic generation of pressure footprints and fluid consumption at all valve operation shall be included.

Special care shall be taken to avoid traps for, and limit consequences of, well gas or seawater intrusion in the hydraulic system.

The electrical circuits and cabling inside the Subsea Control Module shall be designed for continuous operation in seawater (dielectric fluid displaced) for a minimum of two years. Electrical connections shall in general not be placed on the lowest levels in the SCM, to limit consequences of minor water intrusion. If electrical connections have to be located in the bottom of the SCM, the cabling shall be routed through a "gooseneck" located on top of the connector back part.

For diagnostic purposes a minimum of internal housekeeping measurements shall be provided:

- Insulation level of incoming connection (if not covered by topside measurement)
- Voltage level of incoming voltage with ability to measure voltage variations from DC to 1600 Hz
- Power supply output voltages
- Hydraulic pressures/flow
- Excitation voltages to aux. computer and X-Mas tree sensors

Reset or self-test of SEM shall not affect valve status, process sensor values or external power.

Software shall be developed according to ISO 9000 part 3. The documentation, including functional descriptions, shall at any stage in the development be ready for audit and reflect the actual software.

5.12.2 Interface

Description of signals shall be specified for each application by reference to international standards, or by detailed description of signal type and tolerances at several operating and fault conditions (open end, various loads, etc.)

5.13 Process Sensor

Process sensors for X-Mas Tree, choke and/or manifold shall include mounting flanges, jumpers and connectors.

For sensors directly interfaced to the process medium, potential plugging by sand, wax, asphaltenes or hydrates shall be given due consideration.

Pressure and temperature measurement interface to the process shall be by means of a virtually flush mounted membrane in direct contact with process fluid. Aperture to process fluid shall be 1" minimum.

Methods of in situ calibration or adjustment of the calibrated parameters must be taken into consideration when designing the system. However, drift of sensors must be sufficiently low to avoid planned calibration after installation on seabed for the lifetime of the equipment.

Requirements for accuracy and maximum allowable drift for process sensors including electronics in SEM are as follows:

- Pressure: 0.03%FS 0.02%/year
- Temperature: 0.2°C 0.2°C/year

CONTRACTOR shall demonstrate that all practical means have been taken to present the process temperature as accurate as possible. This includes aspects such as location of sensor elements within sensors, isolation of both sensor housing and sensor elements from X-mas tree and isolation of sensor housing.

Required barriers shall be included in pressure and temperature transducer design so that additional isolation valves are avoided.

Process sensors located on the X-Mas Tree shall be dual redundant.

5.14 Installation and Retrieval Tools

A common installation and retrieval tool for SCM, MCM and SAM shall be included.

The number of installation and retrieval tool functions shall be minimised. The operation shall preferably be carried out by means of ROV without special tools. Installation and retrieval tool shall incorporate ROV backup for release functions.

5.15 Test Equipment

Test equipment includes complete equipment for testing of all functions of the Production Control System both onshore and offshore. Emphasis shall be put on user friendliness of the test equipment, and COMPANY shall review design of user interface. Typical test equipment is:

- Electronic Test Unit (ETU)
- Electrical Power Unit (EPU)
- Cable Simulator
- Dummy SCM

- Test cables
- Sensor Simulators with simple adjustment and indication of pressure and temperature, i.e. one button for each process value
- Sensor Test Units
- Test and Flushing HPU (TFU) for Zone 1, hazardous area
- SCM Test Stand with X-Mas Tree Valve Actuator Simulator
- Test and Flushing plates
- Hydraulic Test Container (HTC) for SCM testing.

5.16 Electronic Test Unit (ETU)

The ETU shall perform the following tasks:

- Send commands to the SEM in order to test SCM/MCM and operate functions on the X-Mas Tree/Manifold before installation on seabed. The ETU shall be capable of operating both SEM's in the SCM simultaneously. For this task, the ETU shall be supplied with modem and test cables suitable for offshore use in non-hazardous area
- Send commands to the SEM through the umbilical in order to test SCM/SEM and operate functions on the X-Mas Tree/Manifold after installation on seabed. The ETU shall connect up to the SPCU on the platform and be capable of operating individual SEMs, without affecting the communication to any other SEMs
- Monitor the communication between SPCU and SEMs
- Simulate minimum 10 SEMs installed, complete with external interfacing equipment on the seabed and communicate with SAS through the SPCU. Both normal operation and error conditions have to be simulated.

The ETU shall be able to save and download configurations, to ease use on different locations. The ETU shall have a user-friendly operator interface with menu system and graphical presentations. All VDU pictures shall be easily printable.

All above listed tasks do not have to be performed by the same unit, as it may be more convenient to use standard equipment already available.

5.17 Requirements to mechanical interfaces

For mechanical mateable units, hardness difference in mating parts must be sufficient to make bearing effect.

All subsea parts not protected to the cathodic protection system must be of a material quality suitable for such use. Material selection to be approved by COMPANY.

The consequences of marine growth and deposits shall be evaluated during the design.

6. Fabrication, assembly and testing

6.1 Fabrication and Assembly

All applicable design reports, drawings and procedures shall have reached status Approved for Construction prior to commencement of fabrication.



Flushing is not accepted as primary method to obtain required cleanliness level. All parts and components of the subsea control system shall be clean before and during assembly. Cleanliness of the system according to [NAS 1638](#), Class 6 or better, shall be demonstrated at flushing conditions before delivery and at commissioning. Stability of cleanliness after a storage period of minimum 3 days shall also be demonstrated.

Environmental Stress Screening (ESS) shall be applied for all subsea instruments and electronics as according to COMPANY specification.

All one-atmospheric enclosures shall be helium leak checked or gas tested for minimum 24 hours.

6.2 Testing

The testing requirements in COMPANY Specification [GS SPS 001](#) are fully applicable.

All relevant documentation, including software design documentation, shall be updated and made available prior to start of tests.

6.2.1 Qualification and Verification Tests

All new equipment being introduced shall undergo a programme of qualification. Test programme and test procedures with clearly defined acceptance criteria shall be subject to COMPANY approval.

Reference is made to COMPANY Specification [GS SPS 022](#) and [GS SPS 021](#).

6.2.2 Unit Factory Acceptance Test (FAT)

Unit FAT shall be performed at the Unit manufacturing site.

During the FAT, attention shall in particular be paid to the following:

- Electro-hydraulic directional control valve performance and leak rates
- Monitoring system accuracy
- Accumulator precharge pressure
- Relief valve pressure setting
- Fluid and system cleanliness
- Insulation resistance and conductance
- Environmental Stress Screening
- ETU functionality and operational aspects
- Software download and revision control

Any failures, no-go or not accepted parts of the FAT shall require a complete re-test.

6.2.3 System FAT/Extended Factory Acceptance Test (EFAT)

All PCS Units mounted on Xmas Tree, Template/Manifold or SDU shall undergo an EFAT.

Retrievable Units shall be installed and retrieved using running tools, and tested on two different mounting bases.

During the EFAT, attention shall in particular be paid to the following:

- Electro-hydraulic directional control valve performance
- Monitoring system accuracy
- Relief valve pressure setting
- Verification of equipment mating
- Insulation resistance and conductance
- ETU functionality and operational aspects.

6.2.4 System Test

The SPCS shall go through a system test verifying the integrity of the SPCS and interfaces between the SPCS and all other interfacing subsystems (X-Mas Tree, Down hole sensors and actuators, Manifold systems, SAS, OPIS/IDUN, etc.).

During the System Test, attention shall in particular be paid to the following:

- Verification of equipment mating
- Software functionality and operational aspects
- Sensitivity tests

6.2.4.1 Sensitivity tests

The SPCS should go through a comprehensive sensitivity test. This test program shall be done on subsystems or total system as applicable and is regarded as a part of the system test.

The purpose with the sensitivity test is to vary key parameters in a controlled manner and monitor system performance/limits of operation. Faults and performance limit conditions introduced shall include short circuits on outputs, electrical noise injection and varying hydraulic supply pressure.

Criteria for system performance shall be developed and the different key parameters impact on system performance shall be documented.

6.2.5 Integration Test (IT)

During the Integration Test, attention shall in particular be paid to the following:

- Verification of equipment functionality during and after simulated installation.