

DESIGN AND OPERATION OF SUBSEA PRODUCTION CONTROL SYSTEMS (AMENDMENTS/SUPPLEMENTS TO ISO 13628-6)

DEP 37.80.00.33-Gen.

September 2010

DESIGN AND ENGINEERING PRACTICE



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PART I INTRODUCTION

1.1 SCOPE

This new DEP specifies requirements and gives recommendations for subsea production control systems.

This DEP is based on ISO 13628-6:2006. Part II of this DEP amend, supplement and delete various clauses of ISO 13628-6:2006.

NOTE: API 17F, 2nd edition, is identical to ISO 13628-6:2006.

All clauses of ISO 13628-6 that are not modified or deleted by this DEP shall remain valid as written.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorised access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in offshore oil and gas production facilities.

When DEPs are applied, a Management of Change (MOC) process should be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project, or operation or maintenance of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier/Vendor** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The **Purchaser** may be the Contractor or the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (Part III).

1.5 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the DEP Administrator at standards@shell.com, using the DEP Feedback Form. The DEP Feedback Form can be found on the main page of "DEPs on the Web", available through the Global Technical Standards web portal <http://swwww.shell.com/standards> and on the main page of the DEPs DVD-ROM.

PART II DESIGN AND OPERATION OF SUBSEA PRODUCTION CONTROL SYSTEMS (AMENDMENTS/SUPPLEMENTS TO ISO 13628-06 2006)

Part II of this DEP is written as amendments and supplements to ISO 13628-06:2006. Wherever reference is made to ISO 13628-06:2006, it shall be understood to mean ISO 13628-06:2006 as amended/supplemented by this DEP.

For ease of reference, the clause numbering of ISO 13628-06:2006 has been used throughout Part II of this DEP.

Clauses in ISO 13628-06:2006, which are not mentioned in this DEP, shall remain valid as written.

2. Normative references

ADD NEW:

See also Part III of this DEP.

3. Terms and definitions

3.4 design pressure

CHANGE CLAUSE TO:

pressure 10 % higher than maximum allowable operating pressure

3.12 intelligent well

CHANGE CLAUSE TO:

intelligent well (smart well)

ADD NEW:

3.28 maximum allowable operating pressure

the highest pressure that is allowed for continuous use

ADD NEW:

3.29 minimum operating pressure

lowest operating pressure, at any point in the system, during normal conditions at which the system can operate effectively

ADD NEW:

3.30 surface-controlled subsurface safety valve (SCSSV)

safety device that is located in the production bore of the well tubing below the subsea wellhead, and that will close upon loss of hydraulic pressure.

NOTE: Its function is to provide closure of the well flow in the event of catastrophic loss of the primary flow control safety equipment provided by the subsea tree assembly, or when commanded from the surface facility (e.g., in the event of an emergency shutdown).

ADD NEW:

3.31 dry mate connector

an electrical, fiber optic or electrical/fiber optic connector that is designed to be connected in a dry environment and is capable of operating in the subsea environment

ADD NEW:

3.32 wet mate connector

an electrical or fiber optic connector that is designed to be connected and operated in the subsea environment

ADD NEW:

3.33 redundancy

the duplication of components in a system with the intention of increasing the availability, usually as a backup in case of failure.

ADD NEW:

3.34 screen

an HMI graphic that fills the entire width of the monitor

ADD NEW:

3.35 popup

a window, less than the full size of the monitor, which shall appear on top of a screen

ADD NEW:

3.36 data sheet DEP 37.80.00.90-Gen

DEP 37.80.00.90-Gen, as used to specify / order project specific equipment / requirements

4. Abbreviated terms

ADD NEW:

- 1) AMV annulus master valve
- 2) ASD acoustic sand detector
- 3) AWG American wire gauge
- 4) AWW annulus wing valve
- 5) COV change over valve
- 6) CPU central processing unit
- 7) CRC cyclic redundancy check
- 8) Cv flow coefficient
- 9) DHI down hole interface
- 10) DHPT down hole pressure and temperature
- 11) DP differential pressure
- 12) ETU electronic test unit
- 13) EU engineering units
- 14) FCS facility control system
- 15) FDR functional design requirements
- 16) FDS functional design specifications
- 17) FS full scale
- 18) FSO fail-safe open
- 19) GVF gas volume fraction
- 20) HMI human-machine interface
- 21) IR insulation resistance
- 22) LCD liquid crystal display
- 23) LVDT linear variable differential transformer
- 24) MPFM multiphase flow meter
- 25) MTBF mean time between failures
- 26) MTU maintenance and testing unit
- 27) NEMA National Electrical Manufacturers Association
- 28) NPT national pipe thread
- 29) SPFM single-phase flow meter
- 30) SSES subsea emergency shutdown
- 31) SSV surface safety valve
- 32) VDU visual display unit
- 33) WPMS waterflood pressure management system
- 34) XOVS crossover valve

5. System requirements

5.3.2 Intelligent well application

CHANGE Last sentence to:

Automatic shutdown functionality may not be required for the downhole intelligent well functions.

5.3.3 Flexibility with respect to electrical load situations (power and communication)

CHANGE clause to:

The system shall be built to function properly over the entire range of electrical load variations to allow for flexibility regarding new wells.

5.3.4 Robustness of hydraulic system

CHANGE LAST SENTENCE TO:

The minimum working pressure shall not be less than 150 % of the highest delatching pressure of any DCV. The minimum working pressure shall not be less than 120 % of the start-to-close valve pressure.

5.3.5 Seawater ingress in hydraulic system

CHANGE clause to:

If seawater ingress prevention cannot be guaranteed or if there is a credible risk of seawater ingress SCM fluid-wetted components shall be considered along with procedures to flush out contaminated fluid.

5.4.1 GENERAL

ADD NEW:

o) multiphase flowmeter (MPFM);

The MPFM includes all sensors and flow computers capable of providing the volumetric flow and fractional content for gas, oil and water.

5.4.2.2.1 General

CHANGE 4TH PARAGRAPH TO:

Provisions shall be made to include a system pressure-relieving device, normally a system pressure relief valve, to ensure that surge pressures in the system do not exceed the design pressure of the system components.

NOTE: Design pressure of the system shall be selected from Recommended design-pressure classes, as per Section 5.4.2.2.2 Table 1

5.4.2.4 Temperature ratings (subsea-installed equipment)

Table 3 — Temperature rating — Subsea-installed equipment

Operate, a) Standard (Electronics and System),

CHANGE VALUES TO:

-5 to 55 (23 to 131)

5.4.5 Redundancy

c) CHANGE CLAUSE TO:

Active redundancy, which enables a seamless transfer to a secondary system in the event of a primary system failure, shall be implemented.

d) CHANGE CLAUSE TO:

The subsea electrical distribution system design shall be redundant and include spares that can be configured to replace failed circuits. Facilities shall be provided to enable routine monitoring of spare line integrity.

e) CHANGE CLAUSE TO:

The subsea hydraulic distribution system shall be redundant and shall include spares that can be configured to replace failed lines in either LP or HP service.

5.4.6 Reliability

CHANGE 1ST PARAGRAPH TO:

Required reliability of the subsea control system shall be optimized to result in highest MTBF as possible. The use of high-reliability components should be used in lieu of redundant components of more standard quality. Special consideration shall be given to the reliability of components that are difficult to repair or replace.

CHANGE 4TH PARAGRAPH TO:

Critical sensor systems located on subsea trees or manifolds shall have component reliability, or reliability obtained by redundancy, that is optimum relative to the need for the sensor data and the risk of subsea intervention.

CHANGE LAST PARAGRAPH TO:

Reliability figures for critical components and assemblies shall be documented by field data or alternatively justified by calculations, tests or an accepted industry database (such as OREDA).

5.5.1 General performance requirements

CHANGE 1ST PARAGRAPH TO:

Control system equipment built to this part of ISO 13628 shall perform in a manner that is efficient, safe and protects the environment. Performance requirements for the control system as a whole shall

5.5.2 Operating pressure

CHANGE LAST SENTENCE IN 1ST PARAGRAPH TO:

While a subsea valve is being actuated no other valves shall change their commanded state.

5.5.3 Fail-safe philosophy

CHANGE LAST SENTENCE TO:

There shall be no SINGLE subsea control system component failure that prevents the fail-safe closure of the SCSSV and the designated USV.

5.5.5.2 Interlocks

ADD NEW:

Interlocks shall be provided as stated in the Data Sheet (DEP 37.80.00.90-Gen).

5.5.5.4 Actuation indication

ADD NEW:

All actuator function lines shall be provided with pressure transducers in the SCM (to infer whether the controlled valve is open or closed) and provide pressure/time data for valve profiles.

5.5.5.6 Flushing of SCSSV hydraulic circuit

DELETE THIS CLAUSE

5.5.5.8 Control fluid venting and leakage

DELETE

Margins for leakage increase shall be allowed.

5.6.1 General design requirements

CHANGE LAST SENTENCE TO:

Early in the project, the Contractor and the Principal shall clearly establish utility interface requirements.

ADD NEW:

Check valves shall not be relied upon as pressure isolation devices.

5.6.2.1 Pressure-containing vessels

ADD NEW:

All hydraulic pressure containing components utilized for applications in excess of 0.1 Mpa (15psi) shall have a design pressure equal or greater than the system design pressure and a proof pressure test equal or greater than the system design proof pressure requirement per section 5.4.2.2.

5.6.3.1 General

ADD NEW ITEM TO REQUIREMENTS:

structural (static) analysis (emphasis shall be placed on using minimum yield material properties (i.e., bolts, manifold blocks, etc.))

5.6.3.3 Electrical power systems

CHANGE 7TH ITEM TO:

— SEM component stress levels shall be maintained within acceptable limits for normal and degraded modes of operation;

CHANGE 9TH ITEM TO:

maximum current load and itemized breakdown by individual components (sensor, card, etc.);

5.6.3.4 Electrical communication systems

CHANGE 1ST SENTENCE TO:

The electrical communication analysis shall establish the following:

5.6.5 Control system design documentation

ADD NEW:

For all new projects, the Contractor shall submit for the Principal's review and approval, as a minimum, the documentation requirements defined below.

- o Master Document List. This list acts as a register and schedule for project documentation. It is to be issued on a provisional basis at the time of Quotation for each new Project undertaken. The Master Document List shall define all deliverable documents and drawings to the Principal and shall be maintained by the Contractor and issued on a monthly timescale as the means for monitoring engineering/design performance and to establish documentation close out.
- o Quality Surveillance Plan. This is to be issued for each new project undertaken
- o Top Assembly Drawing and List of Materials. This is used to define the scope of supply
- o Functional Design Specifications for major items of equipment supply
- o Engineering Interface register and supporting documentation
- o General Arrangement drawings / Assembly drawings and Lists of Materials
- o Piping and Instrumentation drawings (P&IDs)
- o Process Engineering Flow Schemes (PEFS)
- o Wiring and interconnection diagrams
- o Equipment/Component data sheets
- o Electrical and Hydraulic Schematic drawings
- o Electrical Power, Signal and Hydraulic Analyses
- o Design Calculations (where these are needed to demonstrate compliance with the Principal's, Industry Standards' or Statutory requirements)
- o Operations and Maintenance Manuals (OMMs) shall be provided for all major delivered items of equipment, including operating and test software. Sub-supplier OMMs are to be modified as required such that the equipment operation within the Contractor's system is clearly addressed
- o Software documentation and licenses for all delivered software packages
- o Spares Lists for major items of deliverable equipment
- o Factory Acceptance, Site Integration and Factory Integration Test procedures
- o Equipment Handling, Storage and Preservation procedures
- o Offshore topsides equipment and software Installation and Hook-Up guidelines
- o Offshore Pre-Deployment and Pre-Commissioning Test procedures

All documents to be transmitted to the Principal for review and approval shall be in Adobe Portable Document Format (PDF) files and entered by the Contractor into the Principal's Livelink system. An electronic message (e-mail) should be sent to the Principal by the Contractor advising of each document transmission.

The Principal reserves the right to update or change the medium to store documents.

The Contractor shall provide paper copies of relevant documents on an ad-hoc basis for the purposes of meeting discussions, presentations with the Contractor or third parties, with whom the Contractor has interfaces within performance of the work.

Where the Contractor is providing additional documentation for future expansion of existing projects, the original documentation package shall be updated in full (including changes to Project Master Document List) via Livelink, with the new information under revision control. The Contractor shall notify the Principal of all additions and/or changes via e-mail. The Contractor need not provide CAD format drawings if the Contractor commits to providing maintainable drawings via Livelink in PDF format, in accordance with Project schedule or within three (3) weeks of request in the case of a non-project requirement. Otherwise, documentation shall be submitted in native format. This allows for timely updates for changes.

A draft of each document shall be submitted to the Principal for review at least two weeks prior to releasing the final revision.

The Contractor shall provide and maintain monthly a single controlled list of all project documentation. The list shall be provided in an electronic spreadsheet format (Microsoft Excel) and include, but not be limited to, document title, the Contractor's document number, the Principal's document number, current revision and date, author, system, etc.

the Contractor shall provide written procedures explaining the Contractor's documentation control system, including, but not limited to, location and accessibility of documents, provisions for receiving and replying to the Principal's comments, distribution process, etc.

The Contractor shall provide a distribution list for notification of revised documentation.

5.6.5.1 Manufacturer's engineering data records

ADD NEW:

Block diagrams or schematics shall include, but not be limited to, the following systems: subsea communications architecture, HPU hydraulic, HPU electrical power, HPU communications, SCM hydraulic, SCM electrical power, SCM communications, interface diagrams, subsea sensor electrical power, subsea sensor communications, etc.

5.6.5.2 Installation, operating and maintenance manual

CHANGE 1ST SENTENCE TO:

The installation, operating and maintenance manual(s) shall incorporate information on the following:

b) operating procedures;

2) general function and shutdown philosophy;

CHANGE LAST SENTENCE TO:

The approximate time required for shutdown actions to occur shall be noted.

3) system checkout.

CHANGE 3RD SENTENCE TO:

The procedure shall be written to allow testing to the fullest possible extent without interrupting well production.

CHANGE 5TH SENTENCE TO:

A document shall be prepared that collects all the alarm limits and allowable ranges for the process variables. This document shall be updated as needed and attached to the procedures.

c) maintenance procedures.

CHANGE 2ND SENTENCE TO:

Instructions for periodic checks and/or replacement of control system surface equipment shall be included.

5.6.5.3 Manufacturer's data record book

CHANGE 2ND SENTENCE TO:

The following shall be included:

ADD new:

Instrument data sheets shall be provided. Instrument data sheets shall clearly state the maximum allowable operating pressure and temperature, accuracy, drift, resolution, maximum power consumption, maximum and minimum input voltages and currents, and all other information related to the specification of the instrument.

The Contractor shall compile and issue for the Principal's review and acceptance a Manufacturing Data Book (MDB) package. This shall incorporate all relevant certification produced and the records of all relevant testing performed. All completed equipment shall be digitally photographed (minimum 1024x768 pixels resolution) and the images provided electronically via Livelink to the Principal, in addition to inclusion within relevant FAT documents.

The Contractor shall compile and deliver all final documentation (design, manufacturing and operation) via Livelink and/or via read only CD (or DVD) medium as required by the Principal. All files shall be stored as Adobe PDF format.

6. Surface equipment

6.2 **General requirements**

ADD NEW:

All host based Production Control System (PCS) equipment shall meet classification requirements, in accordance with the project data sheets (DEP 37.80.00.90-Gen).

6.4 **Design requirements**

ADD NEW:

Labeling for all surface equipment shall be in accordance with section 12.1.

6.4.1 Master control station (MCS)

ADD NEW:

The Contractor shall provide all hardware and software to implement the shutdown requirements as stated in the Data Sheet (DEP 37.80.00.90-Gen) as applicable. All shutdowns, once initiated, shall progress automatically without requiring operator intervention.

In the event that the shutdown initiation condition has been rectified, the system shall have provisions for aborting execution of shutdown commands.

6.4.1.1 **CHANGE CLAUSE TO:**

The MCS configuration shall be either fully integrated or partially integrated with the topsides control system or stand alone as stated in the Data Sheet (DEP 37.80.00.90-Gen). All configurations shall be comprised of logic solvers, data storage and HMI. The MCS shall be capable of being developed and operated independently of the DCS.

For integrated configurations, development shall be in close coordination with the DCS supplier to facilitate integration. The host DCS shall be the primary operators interface for control of the subsea system. The MCS is secondary, but able to perform subsea control should the DCS or the link to the DCS fail.

ADD new:

A fully integrated MCS configuration shall be constructed using the same type (style) hardware and software as used in the topsides control system.

A partially integrated MCS configuration may be constructed using hardware and software of a different type (style) than that used in the topsides control system. A subset of the Subsea HMI screens shall be mimicked in the DCS.

A stand-alone MCS configuration may be constructed using hardware and software different from that used in the DCS. Subsea HMI screens shall not be mimicked on the topsides control system

6.4.1.3 **CHANGE 1ST SENTENCE TO:**

The MCS shall provide the following additional capabilities as stated in the Data Sheet (DEP 37.80.00.90-Gen).

6.4.1.4 **CHANGE 1ST PARAGRAPH, 2ND SENTENCE TO:**

Start-up operations after shutdown situations shall be under the complete control of the operator, having the appropriate level of access, with a minimum number of inherent interlocks.

CHANGE LAST PARAGRAPH, 1ST SENTENCE TO:

The MCS shall allow for post-installation expansion of both of hardware and software without disruption to production, as stated in the Data Sheet (DEP 37.80.00.90-Gen).

ADD NEW:

6.4.1.5 **Enclosure**

a) general construction

The enclosure shall be a freestanding NEMA Type 12 cabinet(s).

The unit shall be designed to be modular in construction to simplify assembly, installation and maintenance.

All doors shall open 180 degrees and be provided with a key locking mechanism. Swing frames, if used, shall open 135 degrees. A glass door shall be provided where a solid door conceals an instrument or indicator.

The enclosures shall be provided with forklift slots and lifting padeyes and shall be of sufficient structural construction to prevent damage during lifting. If required, lifting straps, bars or other required lifting devices shall be provided. Mounting plinths shall be provided for bolting to the deck.

b) receptacles and lighting

Receptacles shall be provided so that all components (front and back) can be reached with a 6' cord. A minimum of one 42W fluorescent light with an automatic door control switch shall be provided in each cabinet to provide adequate illumination to all internal components for maintenance.

Sufficient spaces shall be provided for cable entry. All cables shall be properly glanded.

c) ventilation

A ventilation system (exhaust fans) shall be provided near the top of the enclosure with sufficient capacity to prevent excessive heat rise.

Air intake vents with removable filters shall be provided near the bottom of the enclosure.

d) health indicator

An internal temperature device shall be provided with a digital readout (for display on the front of the cabinet) and an adjustable digital output for monitor and alarming (e.g., 50 °C (120 °F)).

Green LED indicators shall be provided on the front of the cabinet indicating the health of each of the enclosed components (logic controllers, communication PC, data storage PC).

ADD NEW:

6.4.1.6 Wiring

Power conductors shall be PVC insulated with the operating temperature of -20 to 100 °C (-4 to 212 °F), stranded copper, 600VAC rated voltage and passes VW-1 flame test.

Digital and analog input/output conductors shall be PVC insulated with the operating temperature of -20 to 90 °C (-4 to 194 °F), stranded copper, 400VAC rated voltage.

Minimum conductor sizes shall be as follows:

- | | |
|------------------------------------|--------|
| 1) Main Circuit Breaker: | 8 AWG |
| 2) Voltmeter: | 16 AWG |
| 3) Ammeter: | 14 AWG |
| 4) Circuit Breaker, relay contact: | 14 AWG |
| 5) Digital and analog I/O: | 20 AWG |

Power and signal conductors and terminations shall be kept separated from one other.

All interfaces shall be pre-wired to terminal blocks. Fused terminal blocks shall be provided for internal power distribution. All internal wires (including shields) shall be terminated into terminal blocks complete with properly sized ferrule ends.

All cable trays shall be mounted with plastic rivets at maximum distance of 8 inches.

Physical covers shall be installed over all AC voltage terminations to prevent inadvertent contact with service personnel.

ADD NEW:

6.4.1.7 Grounding

All grounding conductors shall be stranded copper with green colored insulation, terminated in corrosion resistant terminal blocks. Power ground and signal shields shall be separated and have dedicated terminal blocks. All instrumentation-shielded cables shall be grounded at only one point. Grounding shall be as stated or as per local installation standards / requirements.

ADD NEW:

6.4.1.8 Logic solvers

Traditional MCS systems have included two redundant logic solvers. Each shall be fully capable of performing all of the functional requirements of the MCS.

In recent years systems have been provided using fault tolerant hardware where the redundancy management is implemented within the operating environment rather than the MCS application.

The functional requirements of both types of system are the same and include, but are not limited to the following:

- solve all required logic;
- interface with the data storage and HMI;
- control and monitor all communications;
- interface with the HPU;
- communicate through the EPU (in COPS) to control and monitor all subsea components (subsea instrumentation, valves, choke(s), DHPT, etc.);
- address and select SEMs;
- monitor diagnostic/housekeeping data in SCMs/SEMs;
- configure and download coefficients to DHPT gauge(s) given connection to downhole is via IWIS option 1 or 2 devices;
- provide alarms when limits are exceeded;
- perform automatic shutdown functions;
- provide shutdown overrides;
- provide all valve interlocks;
- request valve profiles;
- request fast scan data from DHPT and ASD;
- provide trending of subsea sensors;
- interface with the host control system (chemical permissives, etc.).

In the case of redundant logic solvers, at any given time, one logic solver shall operate as "active" and the other as "standby".

Independent watchdog hardware shall be provided to detect when a logic solver has ceased to solve logic or is no longer communicating.

When instructed by a watchdog, an alarm shall be generated and the active logic solver shall switch automatically to the standby logic solver without loss of monitoring and control capabilities, or the loss of data. Commands from the MCS to the SCM, especially shutdowns, shall continue as the standby logic solver becomes the active logic solver.

A means shall be provided to manually switch from active to the standby logic solver.

In the case of fault tolerant systems, on failure of a component within the system, the system shall continue functioning without loss of monitoring and control capabilities, or the loss of data. Commands from the MCS to the SCM, especially shutdowns, shall continue to completion.

For PC based control systems with fault tolerant hardware on failure of a component within the system the logic solver shall continue to operate without loss of monitoring and control capabilities, or the loss of data. Commands from the MCS to the SCM, especially shutdowns, shall continue to completion."

Detailed written software control procedures shall be provided for PC based control systems.

Provision shall be made to automatically save all user entered configuration data (alarm limits, timer values, etc) on a regular basis as stated in the Data Sheet (DEP 37.80.00.90-Gen) so that in the event of an unanticipated power failure, this data can easily be restored per the operating procedures.

ADD NEW:

6.4.1.9 Data storage

The MCS shall include a data storage capability fully able to perform all of, but not limited to, the following:

- interface with the logic solvers and HMI
- record all subsea instrumentation (every 15 s)
- record all valve function line pressures (every 15 s)
- record all SCM/SEM diagnostic/housekeeping data (every 5 min)
- record fast scan data from DHPT (every 1 s)
- record fast scan data from ASD (every 1 s)
- retrieve data when requested and provide to the HMI for trending
- store most recent valve profiles and provide as requested
- alarming on data value that fall outside of user defineable limits
- exporting data for use in other applications

All data shall have date/time and associated system (e.g., well, manifold, etc.).

Historical data shall be retrievable for no less than thirty days.

All necessary hardware (CD/DVD writer, etc.) and software shall be provided for archiving data. The user interface to archive data shall be through a pre-configured user-friendly program. Written data archiving procedure shall be provided.

PC shall be server class, have dual power supplies and at least a RAID1 hard drive configuration.

ADD NEW:

6.4.1.10 Human-machine interface (HMI)

As a minimum the HMI shall meet the requirements of the project mimic specification as stated in the Data Sheet (DEP 37.80.00.90-Gen). HMI screen content and functionality is described in Appendix 2 (as applicable).

ADD NEW:

6.4.1.11 Waterflood pressure management system (WPMS)

If reservoir water injection is used and the injection wells do not have DHPT sensors, a waterflood pressure management system shall be provided to maximize oil recovery as required by the Data Sheet (DEP 37.80.00.90-Gen). The system shall read, at operator configurable intervals, the necessary water injection and production well sensor data from the data storage PC database. The system shall provide the MCS HMI with a recommended tubing injection pressure and flowrate for each water injection well.

Alarm limits shall be provided to help prevent over pressurization of the reservoir. Alarm limits and calculated values shall be available for display on the MCS HMI (and available to the topsides control system on partially integrated MCS configurations). In addition, an optimal choke position setting shall be calculated and displayed for each water injection well. The system shall monitor produced fluid composition and alarm on potential water breakthrough.

The system shall be redundant with two separate networked computers or controllers.

It shall be possible to reconfigure the system to adapt to changes in field reservoir produced fluids properties. The software shall allow for the reconfiguration of the choke's properties.

A stand-alone PC simulator shall be provided to enable the system to be tested, configured and calibrated using process data to simulate actual well flowing conditions.

ADD NEW:

6.4.1.12 Subsea Interface to Topsides System (SITS)

SITS is a redundant communication gateway that provides a protocol conversion from the subsea vendor specific protocol to an industry standard protocol used by the FCS controllers used in the MCS. SITS shall have as a minimum the following functionality / characteristics:

- Act as a communication gateway based on industry logic controllers such as a PLC or similar device running a true real-time operating system capable of handling all of the data coming from all Subsea Control Module (SCM).
- It should be modular in design.
- Ability to handle redundant communication with Subsea Modem Unit (SMU) based on subsea vendor specific protocol which may be proprietary (queue, addressing, switching, etc).
- Ability to assemble proprietary data to/from SMU in data tables of an industry standard protocol and transmitted to FCS controllers over ethernet.
- Ability to monitor/ping its communication with MCS and SMU and set alarms upon failure of communication retries.
- Ability to switch seamlessly to secondary communication path upon failure of primary path.
- Ability to manually, through MCS HMI, switch or disable communication path
- Ability to retain last data on power down or cold start up.
- Ability to convert subsea instrument raw values to engineering units
- Ability to transmit process data to FCS controllers in MCS on change (programmable) to reduce communication traffic from SITS to MCS.
- Ability to program specialized shutdown sequences and logic such as choke movement.
- Ability to handle specialized data like valve signatures, fast scan data, etc. and pass it to dedicated Valve Signature Server (VSS).
- Ability to store housekeeping data
- Ability to interface to a Maintenance and Testing Unit (MTU), with or without MCS connected. This shall mean multiple ethernet ports. All of the hardware (processors, power supplies, communication equipment, cabling, etc.) should be fully redundant to avoid single point failure.
- SITS can be housed in either EPU or MCS panel. If it cannot be housed in either EPU or MCS, then a standalone panel shall be built for SITS similar to other enclosures in the subsea controls building.

6.4.2 Electrical power unit (EPU)

CHANGE 2ND PARAGRAPH, LAST SENTENCE TO:

The EPU shall include safety devices which ensure that, under electrical fault conditions, the equipment and personnel are protected from electrical hazard.

CHANGE 3RD PARAGRAPH, 1ST & 2ND SENTENCE TO:

If redundant power conductors are provided in the umbilical, the output voltage of the EPU shall be individually adjustable for each channel of each umbilical power pair. Each pair shall be galvanically segregated from the rest of the system.

CHANGE 4TH PARAGRAPH TO:

The design shall allow for access to individual power systems for maintenance and repair.

CHANGE 5TH PARAGRAPH TO:

The following EPU parameters shall be monitored by the MCS:

CHANGE THE LAST ITEM TO:

- line insulation.

ADD NEW:

6.4.2.1 Enclosure

a) general construction

Shall be provided per data sheet (DEP 37.80.00.90-Gen).

b) receptacles and lighting

Shall be provided per data sheet (DEP 37.80.00.90-Gen).

Shall be provided with intake air filtering.

c) ventilation

Shall be provided with intake air filtering.

d) health indicator

An internal temperature device shall be provided with a digital readout (for display on the front of the cabinet) and an adjustable digital output for monitor and alarming in the MCS (e.g., 50 °C (120 °F)).

Green LED indicators shall be provided on the front of the cabinet indicating the health of each of the communication lines. Red LED indicators shall be provided for each communication line on the front of the cabinet indicating a line insulation fault. If the communication method is not Superimposed Communications On Power System (COPS) then the modems may be located in the MCS.

ADD NEW:

6.4.2.2 Wiring

Shall be provided per 6.4.1.6.

ADD NEW:

6.4.2.3 Grounding

Shall be provided per 6.4.1.7.

ADD NEW:

6.4.2.4 Circuit breakers

In the event of a short circuit, the over-current protective relay shall automatically remove power to the umbilical by opening a thermal-magnetic circuit breaker.

High inrush current tolerant circuit breakers shall be used.

ADD NEW:

6.4.2.5 Programmable relays

Programmable relays shall be provided to detect under-voltage and over-voltage. Upon detection of an over-voltage or under-voltage condition, the relay shall de-energize the relay coil to turn off power to the circuit.

The protective device shall have programmable hysteresis to prevent relay chatter. The protective device shall have adjustable time delay to filter out momentary voltage spikes on the main power.

ADD NEW:

6.4.2.6 Insulation monitor

The EPU shall provide insulation monitors to detect insulation faults that may occur in the umbilical(s) or subsea electrical equipment.

The insulation monitors shall provide adjustable low and low-low alarm limits. In the event of a low-low alarm, a relay shall be provided, with an adjustable time delay, to remove power to the umbilical.

The insulation monitor shall have the ability to ignore wire-ground capacitance and not give false trips or spurious readings for umbilicals up to 20 miles. Manual override and test function shall also be provided.

A digital megohmmeter shall be located on the front of the enclosure to display the measured insulation resistance.

ADD NEW:

6.4.2.7 Surge protection

Surge suppressor shall be provided to protect electrical devices as well as the umbilical(s) in the event of a voltage surge. It shall consist of metal oxide varistors (a voltage dependent resistor that, due to its voltage and current characteristics, allows a high arresting capacity with a low residue voltage) or equivalent.

- | | | |
|----|----------------------------|------------------------------------|
| 1) | Surge suppressors voltage: | 500 VAC (nominal) |
| 2) | Arrester rated voltage: | 600 VAC |
| 3) | Discharge surge current: | 10 kA (nominal) to 40 kA (maximum) |
| 4) | Protection voltage level: | 2.45 kV to 2.8 kV |

6.4.3 Modem unit

ADD NEW:

In the case where combined power and signal is used the modem units shall be included as part of the EPU. Where distinct lines are used for power and communications the modem units shall be included as part of the MCS.

CHANGE 4TH PARAGRAPH TO:

Redundant communication paths shall BE provided. The redundant elements shall not share common hardware, such as modems or power supplies. It shall be possible to switch communications easily between the redundant paths. This feature shall be automatic with the status of the communication links being announced to the control system operator.

CHANGE 5TH PARAGRAPH TO:

The surface-to-surface communications link shall employ an industry standard communication protocol.

ADD NEW:

The communication signal shall be such that all SCM modem receivers and the surface modem receivers demonstrate a performance of no worse than on average 1 error in 1,000 messages (99.9%). The measurement should be made over at least 10,000 messages.

There shall be sufficient margin to accommodate cable/distribution system degradation over time.

As the cable/distribution system degrades over time, the performance should not degrade to below 1 error in 250 messages (99.6%).

The effective termination impedance shall be designed so that signal reflection effects are such that all SCM modem receivers and the surface modem receivers can operate at the required performance (99.9% reliability).

ADD NEW:

6.4.3.1 Filters

Filters shall have a maximum of total harmonic distortion (THD) of less than 5 %.

6.4.4 Uninterruptible power supply (UPS) (optional)

CHANGE 2ND PARAGRAPH, 2ND SENTENCE TO:

Each UPS shall have a capacity of 120 % of the current load, and should be designed to include future planned expansion of the production control system.

ADD NEW:

DEP 33.65.50.32-Gen. Shall apply.

The UPS shall alarm the MCS when not operating on inverted power (in bypass mode).

6.4.5.1 General

ADD NEW:

Components located as shown in Appendix 2 (HPU Simplified Flow Diagram) shall be provided.

All hydraulic pressure containing components utilized for applications in excess of 0.1 Mpa (15psi) shall have a design pressure equal or greater than the system design pressure and a proof pressure test equal or greater than the system design proof pressure requirement per section 5.4.2.2.

CHANGE 5TH PARAGRAPH TO:

HPU shall not have automatic filter bypasses that enable unfiltered fluid to pass around a filter blockage.

CHANGE 6TH PARAGRAPH TO:

Redundancy shall be provided on key components such as pumps, filters and pressure regulators.

CHANGE 7TH PARAGRAPH TO:

The same type (style) of tubing fitting shall be used for each pressure class throughout the system.

CHANGE 9TH PARAGRAPH TO:

The design shall allow maintainable components within the unit to be isolated for servicing or replacement without interrupting the normal operation.

CHANGE LAST PARAGRAPH TO:

The layout of the HPU shall allow easy and safe access to all components for maintenance, CALIBRATION and repair. Double block & bleed valves shall be used to isolate accumulators, pressure transmitters, pressure temperature gauges, etc. for safe servicing.

ADD NEW:

On cone & threaded connections (autoclave type fittings), a thread-locking compound shall be applied to the fitting nut threads to protect against loosening of the connection during shipment and operation. Once the fitting is made-up, torque-seal (or equivalent) shall be applied to the connection as a positive indicator of potential vibration loosening of the connection.

6.4.5.2 Accumulators

DELETE 1ST PARAGRAPH & NOTE.

CHANGE 3RD PARAGRAPH TO:

Nitrogen precharge pressure shall be significantly lower than normal hydraulic operating pressure to maximize stored energy in the event of a supply pump failure.

CHANGE LAST PARAGRAPH TO:

Visual indication of low nitrogen pressure shall be provided.

ADD NEW:

The design of the accumulator charge and vent lines shall include an easily accessible isolation valve between each accumulator and the charging/vent lines.

If burst discs are fitted to the gas side of the accumulator, a blowdown down tube shall be installed at the burst disc output.

6.4.5.3 Pumps

CHANGE LAST PARAGRAPH TO:

Anti-condensation heaters shall be provided for electrical motors.

ADD NEW:

Motor power supply requirements shall be as shown in Data Sheet (DEP 37.80.00.90-Gen).

A local hand-auto-off switch shall be provided for each motor. Motor shall not have provisions for running without automatic pressure control.

The motor starters may be located remotely from the skid if the response time from the control system is less than two seconds, otherwise, motor starters shall be located on the skid.

DEP 33.65.11.31-Gen. shall apply.

Over-pressure relief protection shall be provided with the discharge pressure venting into the return line.

Pump over-pressure relief valve should be set at the maximum working pressure of the pump or the piping system whichever is lower.

The filters shall be sized to provide high levels of filtration appropriate to their location and to provide sufficient services time prior to replacement. Main filters within the output and circulation routs shall be duplicated to allow in service changeover and repair. Differential pressure switches shall be used on all filters and shall be monitored from the local HPU HMI and the production MCS.

Circulation pump shall have an auto-off-hand switch. Motor should run continuously when in run and periodically when in auto.

A hydraulic hand-test pump shall be provided.

6.4.5.4 Reservoirs

CHANGE 1ST PARAGRAPH, 1ST 3 SENTENCES TO:

The main reservoir shall have a minimum capacity of 1.5 times the volume required to pressure charge the system including surface and subsea accumulators, umbilical and all valve operators and one full open and close cycle of chokes. However, if the main reservoir has a capacity equal to or greater than 2000 L (70.6 ft³), a spare capacity of 750 L (26.5 ft³) is acceptable. The reservoir(s) shall be sized, or alternative disposal means provided, to accommodate drainage of all subsea valve operator, accumulator and umbilical fluid in case of a total system depressurization. The reservoir should be sized to provide sufficient fluid for three complete subsea start-ups.

CHANGE 2ND PARAGRAPH TO:

The hydraulic fluid reservoirs shall be equipped with visual level indicators. Calibration of level transmitters shall be possible without draining of tanks.

CHANGE 3RD PARAGRAPH TO:

The reservoir(s) shall be fitted with an inspection/access hatch and tank-fill breather or pressure-relief mechanism.

CHANGE 4TH PARAGRAPH TO:

The hydraulic fluid tanks shall be designed to minimize build-up of contamination and facilitate flushing.

CHANGE 5TH PARAGRAPH TO:

Fluid reservoirs shall be made from non-corrosive material (316L stainless steel), and shall be equipped with circulating pump(s) and filters. Filters shall be located downstream of the pump(s).

CHANGE 6TH PARAGRAPH TO:

Two fluid reservoirs shall be provided, one used for the transport of new fluid, return fluid from subsea (if implemented) and return fluid from depressurization of the system; the other, used for supplying clean fluid to the subsea system. The two reservoirs shall be connected in case of overfilling either the return or the supply reservoir. The overflow point between the return and supply reservoir shall be a minimum 100 mm below the reservoir top.

ADD NEW:

The reservoir shall be sized to provide sufficient fluid for three complete subsea start-ups. If specified in the project-specific data sheet (DEP 37.80.00.90-Gen), nitrogen shall be injected at the top of the reservoir above the fluid line to form a continuously replenished dry inert barrier that will inhibit condensation and prevent the ingress of foreign matter. Nitrogen shall be supplied to the reservoir from the platform and delivered to the reservoir at a nominal pressure of 2 psi. A nitrogen flowmeter (to provide visual verification of nitrogen injection into the reservoir) shall be required. Flame arrestors should be considered when using flammable control fluid.

6.4.5.5 Control and monitoring

CHANGE 2ND PARAGRAPH, 1ST & 2ND SENTENCES TO:

Primary control shall be from the HPU control panel with monitoring from the MCS. A local HPU control panel shall be provided and fitted with all the necessary gauges, switches, valves and indicators to enable local operator control and local monitoring. See Appendix 2.

CHANGE 3RD PARAGRAPH TO:

The HPU control panel shall incorporate devices to bleed off system-control pressure upon receipt of a hard-wired failsafe ESD signal from the host.

CHANGE 5TH PARAGRAPH TO:

The HPU parameters monitored shall include the following:

ADD NEW:

The start and stop operation of the HPU pumps shall be controlled by 3 independent pressure transmitters in a voting arrangement. The average between the 3 shall be calculated and considered as the controlled pressure reading. A pressure transmitter value deviation greater than or equal to 10 % (settable) of the remaining two pressure transmitter

values shall raise an alarm and the alarmed reading shall be ignored from the calculation. In this case the average reading will be between the remaining two transmitters.

An automatic watchdog shall be provided. The watchdog shall be independent to the local control system and notify the MCS in the event that the local control system is no longer able to solve logic.

The HPU shall provide a manual means to bleed off pressure from a remote pushbutton.

The local control system shall be provided with redundant processors, a single PLC backplane and a single I/O rack. I/O of similar devices (pump1, pump2) shall be wired to different I/O cards.

If pneumatic piloted valves are utilized for hydraulic control, the pneumatic circuit shall have a pressure switch to monitor circuit pressure. The control system shall alarm when the low pressure setpoint is reported from the pressure transmitter. The low pressure alarm setpoint shall be based on pilot circuit minimum operating pressure requirements.

ADD NEW:

6.4.5.6 LP and HP Pump Control

- Relief valves upstream of the regulators shall be set to no more than the lower of the design pressure or the MAWP of any component in the system upstream of the regulator
- Each pump shall be controlled through a hand-off-automatic switch (with spring return for HAND mode).
- Shall have an emergency stop button located near the pump units to stop all pumps (including the recirculating pump).
- The first pump placed into automatic mode shall be designated as the primary pump.
- When both pumps are placed in automatic mode, the primary pump designation shall alternate after each pump run cycle.

ADD NEW:

6.4.5.7 Automatic Run Mode

- The LP (primary) pump start pressure shall be not less than 500 psi (34.5 bar) above the maximum LP regulated output pressure
- The HP (primary) pump start pressure shall be not less than 500 psi (34.5 bar) above the maximum HP regulated output pressure
- The LP and HP (standby) pumps shall start at the maximum regulated output pressure.
- The LP (primary) pump start-pump stop difference shall be not less than 750 psi (51.7 bar).
- The LP (primary and standby) pump stop pressure shall be no higher than 500 psi (34.5 bar) less than the LP relief valve setting.
- The HP (primary and standby) pump stop pressure shall be no higher than 750 psi (51.7bar) less than the HP relief valve setting.
- The HP (primary) pump start-pump stop difference shall be not less than 1000 psi (68.9 bar).
- All pumps on the LP or HP circuit shall stop if the respective non-regulated pressure HIGH HIGH alarm is triggered.
- All pumps shall stop if the supply reservoir LOW LOW level is triggered.
- All pumps shall stop if the pressure falls below LOW LOW setpoint for a set time specified in the data sheet (DEP 37.80.00.90-Gen).

ADD NEW:

6.4.5.8 Hand/Jog Mode

- All pumps shall stop at the pump stop pressure as described above or if the supply reservoir LOW LOW level alarm is triggered.

ADD NEW:

6.4.5.9 Recirculation Pump Control

- The recirculation pump shall be controlled through a hand-off-automatic switch (no spring return for HAND mode).
- The recirculation pump shall run continuously when in hand mode.
- The recirculation pump shall have three operational modes:
 - a. Flushing return reservoir
 - b. Flushing supply reservoir
 - c. Transfer fluid from the return reservoir to the supply reservoir
- The automatic switch position shall only control flushing modes.
- The recirculation pump shall stop in automatic mode once the pump run time is equal to the user defined pump timer setpoint. The pump shall be restarted after the user defined wait time.
- The recirculation pump shall stop if the return reservoir LOW LOW level alarm is triggered.
- The recirculation pump shall stop if the supply LOW LOW or HIGH HIGH level alarm is triggered.

ADD NEW:

6.4.5.10 HPU HMI Screen Definition

a) Reservoir and Circulation Circuit Screen

Display:

- a. Supply reservoir level
- b. Return reservoir level
- c. Supply reservoir LOW LOW level switch status
- d. Return reservoir LOW LOW level switch status
- e. Pump status (running or not running)
- f. Filter status
- g. Circulation circuit valve status

Display and Set:

- a. Pump run and wait time

b) Motor Statistics Screen

Display:

- a. Pump starts counter for each HPU pump
- b. Pump run time for each HPU pump

c) Low Pressure Non-regulated Circuit Screen

Display:

- a. Pump status (running and not running)
- b. Individual pressure readings for each voting pressure transmitter
- c. Pump control pressure transmitter fault status
- d. Pump circuit control pressure value (average of voting pressure transmitters)
- e. Filter Status

Display and Set:

- a. Pump primary and standby identification
- b. Primary pump start and stop values
- c. Standby pump start and stop values

d) High Pressure Non-regulated Circuit Screen

Display:

- a. Pump status (running and not running)
- b. Individual pressure readings for each voting pressure transmitter
- c. Pump control pressure transmitter fault status
- d. Pump circuit control pressure value (average of voting pressure transmitters)
- e. Filter Status

Display and Set:

- a. Pump primary and standby identification
- b. Primary pump start and stop values
- c. Standby pump start and stop values

e) Regulated Circuit Screen

Display:

- a. Regulated pressure reading
- b. Output pressure reading

- c. Circuit flowrate reading
- d. 24 hours flow totalizer value
- e. ESD valve status

f) Alarm Setpoint Screen

Display and Set:

- a. Non-regulated supply pressure HIGH
- b. Non-regulated supply pressure HIGH HIGH
- c. Non-regulated supply pressure LOW
- d. Non-regulated supply pressure LOW LOW
- e. Supply reservoir LOW level
- f. Supply reservoir LOW LOW level
- g. Supply reservoir HIGH level
- h. Supply reservoir HIGH HIGH level
- i. Supply reservoir LOW level
- j. Return reservoir LOW LOW level
- k. Return reservoir HIGH level
- l. Return reservoir HIGH HIGH level

g) Alarm Summary Screen

Display and Acknowledge:

- a. Summary of all alarms

ADD NEW:

6.4.5.11 Alarm Points

The following alarms shall be provided in the HPU HMI:

- a. Supply reservoir LOW level
- b. Supply reservoir LOW LOW level
- c. Supply reservoir HIGH level
- d. Supply reservoir HIGH HIGH level
- e. Return reservoir LOW level
- f. Return reservoir LOW LOW level
- g. Return reservoir HIGH level
- h. Return reservoir HIGH HIGH level
- i. Non-regulated supply pressure (HP & LP) HIGH
- j. Non-regulated supply pressure (HP & LP) HIGH HIGH
- k. Non-regulated supply pressure (HP & LP) LOW
- l. Non-regulated supply pressure (HP & LP) LOW LOW
- m. Instrument air pressure LOW
- n. Instrument air pressure HIGH
- o. Pump control pressure transmitter fault (HP & LP)
- p. Pump failure to start (HP & LP)
- q. High pressure differential across system filters (HP & LP)
- r. Extended supply pump run time (user defined) (HP & LP)

ADD NEW:

6.4.5.12 Skid

a) general construction

The HPU skid shall be of robust heavy-duty welded construction suitable for use in an oilfield environment.

A sloped roof shall be provided (as applicable per the Data Sheet (DEP 37.80.00.90-Gen)). Trolley hoist with pull chain or motorized winch shall be provided to facilitate motor replacement.

The skid base shall include a self-contained drip pan with a means to be connected to the platform drain system.

The skid shall be provided with lifting pad eyes and shall be of sufficient structural construction to prevent damage during lifting. If required, lifting straps, bars or other required lifting devices shall be provided. The skid shall be welded or bolted permanently to the deck.

The unit shall be designed to be modular in construction to simplify assembly, installation and maintenance.

The distribution portion of the HPU shall be constructed in modular sections. Each modular section shall include all hardware to provide two LP and two HP supplies. The HPU shall be expandable to no more than four distribution modules.

b) electrical

Fluorescent lighting shall be provided.

Sufficient spaces shall be provided for cable entry. All cables shall be properly glanded.

Instrumentation cabling from all sensors to the HPU control panel shall consist of marine armored (international) with PVC jacket with proper terminators.

6.4.6 Chemical injection unit (CIU)

ADD NEW:

The topsides Contractor should typically provide equipment described in (6.4.6).

6.4.7.1 General

ADD NEW:

The Contractor shall request the Principal's approval of hydraulic control fluid early in the design phase.

CHANGE LAST PARAGRAPH TO:

Reference shall be made to Annex C for control fluid specifications and testing.

7. Subsea equipment

7.2 General requirements

CHANGE 1ST PARAGRAPH, LAST SENTENCE TO:

Ease of installation and maintenance shall be considered.

CHANGE 2ND PARAGRAPH TO:

All subsea retrievable items of the same type shall be fully interchangeable unless system considerations dictate otherwise. The design shall consider shocks, vibrations and pressure/temperature variations experienced during transportation, including land, air and sea freight, and offshore operations during all seasons.

ADD NEW:

100 % traceability shall be required on all SCMs and subsea instrumentation shall include, but not be limited to, the following:

Documentation of hydraulic components shall be provided for, but not be limited to, the following:

a) Pressure containing component:

- serialization;
- material mechanical properties;
- material chemical properties;
- volumetric UT.

b) Bolting – batch lot certification:

- material mechanical properties;
- material chemical properties.

c) Elastomers:

- batch lot;
- cure date;
- shelf life.

d) Pressure containing components:

- hydraulic couplers;
- manifolds;
- pressure transmitter;
- DCV;
- filter housing;

- accumulators;
- flow meter;
- check / relief valve;
- selector valve;
- shuttle valve.

Documentation of electrical components shall be provided for, but not limited to, the following:

- SEM Electronics, sensors and subsea instrumentation
- Component traceability by serial number to manufacturing batch for all sub-components.

7.3 Functional requirements

CHANGE 1ST PARAGRAPH TO:

The functional requirements for subsea equipment shall include the following:

7.4.1.1 Subsea hydraulic distribution system

CHANGE 2ND PARAGRAPH TO:

Consideration shall be given to preventing pressure being trapped in critical tree-valve operators or other fail-closed safety systems in the event of inadvertent separation of hydraulic interfaces.

CHANGE 4TH PARAGRAPH, 1ST SENTENCE TO:

Design of template/manifold hydraulic distribution systems shall have ROV-reconfigurable connector plates or ROV operated isolation devices, so that leakage can be isolated from the system.

CHANGE LAST PARAGRAPH TO:

Design of hydraulic systems shall consider single-point (and common mode) failures, which may be addressed through the separation of physical routes and hydraulic isolation of redundant supplies.

7.4.1.2 Multifunction connections

CHANGE 1ST PARAGRAPH TO:

Multifunction connections shall be polarized or keyed such that only one possible orientation is possible. All connections shall be labeled for proper identification.

7.4.1.3 Pipe, tubing and hoses

CHANGE 5TH PARAGRAPH TO:

Design shall take into account the following:

ADDNEW:

Design shall take into account the vibration and shock loads placed on the pipe work and system from functional operation activities.

7.4.1.6 Subsea accumulators

DeLETE 2ND & 3RD PARAGRAPHS.

CHANGE 4TH PARAGRAPH TO:

Accumulator selection shall consider minimizing gas precharge loss due to diffusion or leakage.

CHANGE LAST PARAGRAPH TO:

Subsea accumulators may be mounted internally or externally (local or remote) to the SCM. If mounted external to the SCM, accumulator shells shall be painted to inhibit the absorption of hydrogen evolved from the cathodic protection reaction.

ADD NEW:

If accumulators are positioned on the outside of the SCM cover, they shall be mounted on the base plate and shall not interfere with the cover removal / installation and be pre-charged or vented without removal of the cover.

If accumulators are positioned on the inside of the cover they shall be pre-charged or vented without removal of the cover.

7.4.2.1 Subsea chemical-injection distribution system

CHANGE LAST PARAGRAPH TO:

Design of chemical injection systems shall consider single-point (and common mode) failures, which may be addressed through separation of physical routes and flow isolation of redundant supplies.

7.4.2.3 Special considerations

CHANGE 2ND PARAGRAPH TO:

If diffusion of chemicals through hose materials is anticipated, the system design shall ensure that the diffused chemicals do not contaminate the hydraulic control fluid through either leakage or secondary diffusion.

7.4.3.1 Subsea electrical distribution system

CHANGE 5TH PARAGRAPH TO:

Each SEM shall have a dedicated electrical supply line to allow a faulty SEM to be isolated. Two communication signals (one per SEM) shall be supplied through two electrical flying leads to the top of the SCM. Each channel shall be routed to a dedicated SEM.

CHANGE 6TH PARAGRAPH TO:

Electrical connectors shall have orientation keys to prevent misconnection and consequential damage.

CHANGE 9TH PARAGRAPH TO:

Connection of electrical distribution cabling and electrical jumpers made by ROV or diver using simple tools shall HAVE minimum demand on rig/vessel time.

CHANGE 10TH PARAGRAPH TO:

A minimum of two barriers shall be provided between sea water and any conductor. Barriers shall be qualified to ensure that the barriers are suitable and functional for operation in seawater.

CHANGE 11TH PARAGRAPH TO:

If an oil-filled system is selected, the cable assemblies shall be designed and installed such that any seawater entering the dielectric fluid moves away from the end terminations by gravity. The cables shall be installed into pressure-compensated fluid-filled lines.

ADD NEW:

Electrical conductors shall be rated for 125 % of maximum working voltage.

ADD NEW:

7.4.3.1.1 Electrical jumpers

Jumpers shall be permanently identified with a part number on the outer jacket. The ends of the jumper shall be identified (using 15 mm lettering) with unique connection identification.

Permanently installed electrical jumpers shall be secured with support brackets.

7.4.4 Subsea control module (SCM)

CHANGE 1ST PARAGRAPH TO:

The subsea control equipment for piloted or sequential hydraulic or electrohydraulic systems shall be packaged in retrievable units/housings.

ADD NEW:

See Appendix 3 for SCM Simplified Flow Diagram for component arrangements.

CHANGE 2ND PARAGRAPH TO:

Installation, retrieval or failure of one SCM shall not adversely affect the operation of any other SCM in the field.

CHANGE 3RD PARAGRAPH TO:

All SCMs shall be interchangeable in a field.

CHANGE 4TH PARAGRAPH TO:

All active electronic circuits shall be in enclosures filled with nitrogen gas at nominal 0.101 MPa (1 atm) pressure designed for full external pressure conditions. Requirements for

internal overpressure relief to environment by procedural or physical means in case of seal failure shall be considered.

CHANGE 5TH PARAGRAPH, 2ND SENTENCE TO:

The SCM design shall be optimized to limit the possibility of draining the dielectric fluid when installed subsea by making any necessary hydraulic penetrations to the module at as low a level as possible (water usually displaces dielectric fluid until the level of the leak is reached).

CHANGE 7TH PARAGRAPH TO:

In order to minimize the electrical power consumption, solenoid-operated valves shall be pulse-operated and hydraulically latched (with exception of the choke movement DCVs), with the exception of an electrically held fail-safe valve, if used.

ADD NEW:

The SCM shall be designed for installation and retrieval via a down line with assistance by an ROV. The SCM shall have a locator mechanism that provides alignment into the correct position during installation and prevents the SCM from being installed incorrectly.

SCM shall be provided with two identical Subsea Electronics Modules (SEMs), identified as SEM A and SEM B, with unique addresses, and shall be capable of full functionality from a single SEM or both. Electrical connectors for the SEMs shall be located on the top of the SCM enclosure.

The wiring harness inside of the SCM cover and external to the SEM should be continuous, without any splices.

If splices are present they shall be qualified to provide a water insulation barrier and shall be qualified for functional mechanical and electrical integrity, fracture and vibration resistance.

The SCM shall receive electrical power and communicate with the MCS and sensors on the tree via electrical connectors. The electrical pin connectors in the SCM shall include boot seals to prevent the ingress of water.

LP and HP circuits within the SCM shall be of manifold construction using corrosion resistant stainless steel suitable for seawater and hydraulic fluid. Tube connections without anti-vibration connections are not permitted in the LP or HP circuits and shall be minimized in the return circuits. Manifolds should not be bolted to a common item on parallel manifold faces and then bolted on a seal face at a right angle to a common element or each other.

The SCM shall be supplied with two HP and two LP hydraulic supplies via the base. Each supply shall have the facility to be remotely isolated within the SCM in the event of a line failure in the distribution system. Isolation shall occur prior to consolidation of the redundant supplies.

The hydraulic fluid returned to the SCM from the subsea valves shall be discharged directly to sea on two separate return vents lines (one for LP and one for HP) if the system is open loop. Hydraulic fluid from downhole hydraulic functions shall be isolated from the LP return vent circuit.

The SCM shall have a minimum of 22 LP functions and 2 HP functions.

If required by the hydraulic analysis in (5.6.3), the Contractor may install flow restrictors on the function lines of DCVs. Control system Cv shall fall within the choke maximum rated supply Cv.

The SCM shall control the valves and monitor external instrumentation as specified on the CV-Sensor matrix referenced on the attached data sheet (DEP 37.80.00.90-Gen).

ADD NEW

7.4.4.1 Enclosure

The outer enclosure (or cover) of the SCM shall be pressure/volume compensated to balance the dielectric oil chamber with the ambient seawater pressure to within 1 bar of ambient pressure.

The design of the enclosure shall facilitate all activities associated with the pre-charging / venting and physical handling of the accumulators. It shall be possible to remove the SCM cover without disturbing the accumulators.

The enclosure shall not be used for lifting or supporting the weight of the SCM unless it has been designed and tested for this service.

The outside of the SCM housing shall be painted with topcoat of high visibility epoxy paint as applicable per the Data Sheet (DEP 37.80.00.90-Gen).

All label text shall be black against a contrasting color for maximum visibility.

ADD NEW

7.4.4.2 SCM Locking Mechanism

Locking mechanism shall be designed to be operated using an ROV torque tool. The design shall incorporate the torque necessary to disengage the hydraulic couplers at the operating depth with no hydraulic pressure in the system.

SCM shall be designed with a secondary release mechanism in the event the primary locking mechanism fails to release. This design shall be capable of releasing the hydraulic couplers at the operating depth with no hydraulic pressure in the system.

ADD NEW

7.4.4.3 SCM Compensation System

The compensation system shall have sufficient volume to account for the expansion effects due to storage at maximum storage temperature and the deployed fluid compression, hydraulic fluid system compensation, and thermal compression.

The compensation system shall have a procedure to validate correct filling and removal of air voids prior to deployment.

The bladder shall be qualified to function throughout its design operating conditions.

The enclosure external pressure relief setting shall be set lower than the hydraulic return line relief setting.

(This is to ensure the ½ hydraulic accumulators remain functional during storage at elevated temperature).

The enclosure external relief shall be positioned at the bottom of the dielectric fluid to minimize the level of hydraulic fluid within the housing in the event of a hydraulic leak.

ADD NEW

7.4.4.4 Dielectric Fluid

The dielectric fluid shall have acceptable electrical (breakdown voltage capacity) and material compatibility characteristics.

ADD NEW

7.4.4.5 Control module receiver plate

The receiver plate shall be permanently mounted to the host structure via welding. The plate shall be electrically bonded to the host structure. All compliantly mounted items shall be electrically bonded to the plate via stainless steel earth braids.

Coupler and electrical connector positions shall ensure ease of plumbing, installation of instrumentation harnesses and physical access. All hydraulic couplers and tube ends shall be capped for protection and prevent ingress of debris.

Where SCM electrical functions are unused, long-term protective electrical connectors shall be used at the receiver plate to protect the unused SCM electrical connector positions.

The receiver plate shall be supplied with a protective cover.

The receiver plate shall be permanently marked to indicate the relevant coupler positions.

All tree and manifold sensors should be routed through the base of the SCM via the SCM receiver plate.

The receiver plate shall be machined from a single piece of stock. (Laminated plates are not allowed.)

ADD NEW

7.4.4.6 Directional control valves

Directional control valves shall be two-position, three-way solenoid-operated valves.

DCV shall have two electric solenoid coils each powered by a separate pair of wires.

In order to provide an additional barrier against contamination, DCV pilot stages shall be fitted with an integral filtration screen.

LP and HP DCVs shall be qualified per 11.2.4.

Measurements of pin settings shall be taken before and after qualification testing. The wear seen during qualification testing shall be applied to the production tolerances for validation as being functional for the endurance life requirement for all allowable ranges of initial pin settings.

The DCV unlatch pressure shall be less than the highest pressure for which a subsea valve actuator starts to move.

ADD NEW

7.4.4.7 Subsea accumulators

If required by the hydraulic analysis in (5.6.3), the Contractor should install accumulators in or on the SCM or on HDM or as tree plug-in module in accordance with (7.4.1.6).

ADD NEW

7.4.4.8 Compensator

If required by the hydraulic analysis in (5.6.3), the Contractor may install compensators on the return lines to assist with SCM deployment. Consideration should be given to deploying the SCM while already installed on a tree.

A bladder or piston type compensator may be provided on each LP and HP return line and shall be connected to the hydraulic circuit on one side and the environment (dielectric chamber) on the other.

The compensation volume shall be designed to ensure that the hydraulic circuit is depth compensated when running the SCM on a down line. Thermal effects from cooling control fluids shall also be accounted for in total volume

The compensator shall be suitable for forward and reverse pressure compensation without failure.

ADD NEW

7.4.4.9 Seals

All bolting calculations shall be made using minimum yield material properties

All bolting designs shall prohibit exceeding minimum material yield stresses

It is intended that tubing within the SCM be limited to the connections to the diaphragm accumulators in the return lines.

The design shall include the following:

- friction and wear increase in hydraulic service;
- seal material compatibility with hydraulic, dielectric fluids and seawater;
- corrosivity of hydraulic, dielectric fluids and seawater.

The primary method of sealing hydraulic components / manifolds shall be through the use of seals qualified in the application.

Qualification shall be comprised of the equivalent to API 17D qualification.

Seals shall be qualified for compatibility with the fluids that they will be exposed to. (Requirements should reference API 6A seal qualification process.)

ADD NEW

7.4.4.10 Wiring

Wiring outside of SEM shall be 20-gauge minimum.

PTs and wiring shall have IR of greater than 1 Gohm, with respect to ground, Low voltage wiring (< 24 V shall be measured at 50 V.) Power wiring shall be measured using 500 V.

ADD NEW

7.4.4.11 PTs

Pressure transducers (PTs) shall be provided on the following:

- the HP consolidated supply line header;
- the LP consolidated supply line header;
- each LP and HP function line;

PTs should be provided on the LP return line and HP return line (to assist in troubleshooting).

ADD NEW

7.4.4.12 Check valves

The hydraulic circuit shall be protected from seawater ingress at the vent points by the use of either a nonmetallic or corrosion resistant metal check valves.

Hydraulic vent line check valve relief setting shall be higher than the relief setting of the SCM dielectric housing check valve.

ADD NEW

7.4.4.13 Flowmeters

The LP and HP supply and LP return lines shall each have a flowmeter for providing remote indication of flow to the MCS.

Supply flowmeters shall be placed downstream of the supply accumulator to measure valve flow and not accumulator recharge flow.

ADD NEW

7.4.4.14 Hydraulic filters

In order to protect the hydraulic circuit from solid particle contamination, each of supply lines of the SCM shall be fitted with filters.

Hydraulic supply filters shall be installed upstream of all valves. Filters shall be a maximum of 12 µm. The filters shall be sized to protect the SCM for the design life assuming fluid cleanliness as stated in Data Sheet (DEP 37.80.00.90-Gen – Sec 5.4.3.2).

ADD NEW

7.4.4.15 Hydraulic couplers

The combination of the compensator, return line check valves and the coupler poppets shall ensure a positive pressure in the hydraulic circuit, thus preventing seawater ingress.

The hydraulic couplers shall be designed to minimize the ingress of water before and during connection.

7.4.5.1 SEM hardware

CHANGE 1ST PARAGRAPH TO:

The SEM hardware design shall provide the level of reliability as applicable per the Data Sheet (DEP 37.80.00.90-Gen).

CHANGE 3RD PARAGRAPH TO:

The SEM shall be designed with 50 % additional spare memory capacity for general use.

ADD NEW:

The SEM shall contain (as a minimum) the following

- o printed circuit board with CPU;
- o power supply equipment that is also used to distribute power to the external sensors
- o back plane for inter-board communications
- o analog input (AI) board (with analog to digital converters) to read 4-20mA sensors

- o digital output (DO) board (with individual control channels) to operate solenoids that allow the opening and closing of valves and stepping of chokes
- o serial input/output (SIO) board with multiple channels that allow the SEM to connect to external devices such as flowmeters, high accuracy pressure and temperature devices, ASDs
- o modem/filter to communicate to the MCS
- o CPU watchdog to monitor operation of the SEM and report any faults or errors to the MCS
- o memory buffers to store information to be transmitted to the MCS
- o IWIS compliant downhole interface card to operate DHPT gauges. NOTE: The DHPT interface card manufacturer shall be as stated in Data Sheet (DEP 37.80.00.90-Gen – Sec 7.4.5.1)

Should the need to remove or cycle power to the downhole interface card arise, a means shall be provided to do so without causing disruption to the rest of the SEM.

All power handling components shall be de-rated by 25 % of the OEM ratings.

The SEM shall, as a minimum, monitor and transmit to the MCS the following:

- o SEM internal voltage
- o SEM internal temperature
- o hydraulic supply pressures
- o communication status
- o hydraulic fluid flow volumes
- o hydraulic function/return line pressure
- o SCM water/fluid ingress level

Both SEMs should be capable of acquiring data simultaneously from all transmitters with the exception of the DHPT and MPFM.

Qualification testing shall be performed for all models of equipment. The tests shall be carried out in accordance with section 11.2.5.

7.4.5.2 SEM software

CHANGE 1ST PARAGRAPH, 1ST SENTENCE TO:

The SEM software shall be structured in functional tasks or modules, which shall be designed, coded and tested as independent units. Software shall be strictly controlled in accordance with the Principal's software control procedures, with documented software version/revision number and release date.

CHANGE 3RD PARAGRAPH TO:

The SEM software shall have built-in diagnostic functions to test the subsea controls hardware and software.

CHANGE 4TH PARAGRAPH TO:

The SEM shall be programmable to allow for reprogramming from the surface while subsea.

CHANGE 5TH PARAGRAPH TO:

The SEM shall have capacity to temporarily store all relevant data gathered from the subsea production system. All fast scan data shall be time stamped in the SEM as per the Data Sheet (DEP 37.80.00.90-Gen).

CHANGE 7TH PARAGRAPH TO:

The SEM shall be capable of performing sequenced monitoring operations and/or sequenced controlling based on one command from the MCS.

CHANGE 8TH PARAGRAPH TO:

The SEM software shall be designed to accommodate the downhole pressure and temperature information.

ADD NEW:

The SEM shall be able to receive signals from MCS and subsea internal and external sensors, process the data, act on the instructions received, provide housekeeping data, and then transmit to the MCS.

The SEM shall continuously scan all sensors and the data transmitted to the MCS on request.

SEM software shall be capable of providing control of choke valve using a step command function, a calculated position function and an automatic ramping sequence.

The SEM should have capability to download software and/or firmware to the attached subsea instrumentation while deployed subsea.

Each SEM shall have a verification signal to confirm that a command transmitted from the MCS has been received by the appropriate SEM and has been executed.

Valve Profiles

Each time the SCM is commanded to open or close a valve, the function line pressure, supply flow and LP return flow shall be automatically recorded and saved until the next valve command.

The hydraulic signature for supply, function and return line pressures during each valve operation shall be stored in the SEM. This information shall be retrievable for providing a valve profile in the MCS as specified in the Data Sheet (DEP 37.80.00.90-Gen). The profile information shall be sent to the MCS when requested.

7.4.6 Communication protocol

ADD NEW:

The communication shall not be sensitive to frequency drift. The message format shall be flexible and suitable for both short and long messages.

The protocol shall be capable of down loading of SEM software in less than 4 hours.

The communications protocol shall provide a means of ensuring the security of the data being transferred.

CHANGE 1ST PARAGRAH TO:

The communication system shall be based on a proven design or an industry standard.

CHANGE 3RD PARAGRAPH TO:

The communications and power systems shall be designed to withstand the normal noise and disturbances typically occurring in the operating environment without malfunction. The communications and power systems shall accommodate the specified range of voltage and frequency variations and the changes in the number of connected SEMs that the distribution can support.

CHANGE 4TH PARAGRAPH TO:

The MCS shall be the governing end of the communication link between the MCS and the SEM.

CHANGE 9TH PARAGRAPH TO:

The protocol shall be convenient for loading of the SEM software, external sensor and auxiliary computer software.

CHANGE LAST PARAGRAPH TO:

Communication between MCS and all SEMs shall use the same communication protocol. Communication protocol shall be based on a proven design or a recognised industry standard.

7.4.7 Subsea instrumentation

CHANGE 3RD PARAGRAPH TO:

Sensors, directly exposed to produced fluid, shall be designed to avoid the potential blocking of the interface by sand, hydrates or wax.

CHANGE 4TH PARAGRAPH TO:

Methods of calibration or adjustment of the sensor signals and remote diagnostics shall be taken into consideration when designing the system.

ADD NEW:

Subsea instrumentation as per SCM Cv-Sensor Matrix shall be provided, as specified within project Data Sheet (DEP 37.80.00.90-Gen, Section 7.4.7)

The Contractor shall track individual serial numbers for all subsea instrumentation, harnesses, housings, etc., for quality assurance purposes.

All subsea instrumentation shall be fabricated of corrosion resistant material and be compatible with the process media and external environment.

All subsea instrumentation shall be designed for the water depth and maximum operating working pressures as specified within project Data Sheet (DEP 37.80.00.90-Gen).

All subsea instrumentation shall be provided with electrical harnesses in accordance with (7.4.3.1.1), and shall be securely connected to the bottom of the SCM receiver plate, unless stated otherwise.

Qualification testing shall be performed per 11.2.5 for all models of subsea instrumentation, or proof of qualification testing shall be provided to the Principal for approval.

Qualification testing shall be performed for all models of equipment used for intelligent well systems. The tests shall be carried out in accordance with E.5.1.

Unless stated otherwise, the supply voltage for all subsea instrumentation shall be a nominal 24 VDC from the SCM.

The following information shall be provided for all subsea instrumentation:

1. Inrush current
2. Maximum input power required
3. Nominal power required
4. Input impedance

ADD NEW:

7.4.7.1 Acoustic sand detector (ASD)

The acoustic sand detector (ASD), if required, shall detect the presence of solid particles (primarily sand) in the flow path using acoustical energy. The ASD may generate electrical pulse sequences of frequency proportional to the measured characteristics, perform signal processing, and transmit the data via a serial signal to the SCM.

The ASD sensor shall be installed on a well's jumper in a housing suitable for ROV installation and retrieval. The design of the housing shall ensure proper alignment and engagement of the device to ensure proper operation.

The sensor shall be provided with an integral harness assembly or electrical jumper (as specified in 7.4.3.1.1) with a ROV connector.

The electronics should be redundant. The sensors should provide two-way communications, permit new software downloads from the MTU, provide diagnostic data to the SCM, and provide a health check of the complete signal loop.

A simulator shall be provided suitable for connection to the SCM. The simulator shall be capable of producing a variable test signal and providing all diagnostics data to the MCS.

ADD NEW:

7.4.7.2 Pressure/temperature transmitter

The combination pressure and temperature transmitter (PTT), if required, shall measure the pressure and temperature of the subsea process stream on subsea hardware.

Pressure and temperature ranges shall be as specified on the P&IDs / PEFSS, instrumentation data sheets, or Data Sheet (DEP 37.80.00.90-Gen).

Sensor shall be able to exceed the operating range by 1.5 x FS without degrading performance.

Unless specified otherwise, the pressure transmitter shall have an accuracy of $< \pm 0.03\%$ FS and a drift of $< \pm 0.1\%$ FS / year 5 deg C.

Unless specified otherwise, the temperature transmitter shall have an accuracy of $< \pm 0.2\%$ FS and a drift of $< \pm 0.1\%$ calibrated range / year 5 deg C.

Measurements shall be transmitted to the SCM via 4-20 mA or a standard industry serial data transfer protocol as specified on the Data Sheet (DEP 37.80.00.90-Gen).

PTs and wiring shall have an insulation resistance (with respect to ground) of $> 1 \text{ Gohm}$ at 50 V.

Mounting shall be through a standard 2" nominal API flange. Qualification testing shall be performed in accordance with (11.2.7), or proof of qualification testing shall be provided to the Principal for approval.

ADD NEW:

7.4.7.3 Single-phase flowmeters (SPFM)

SPFM shall be venturi or orifice type and use differential pressure to determine flow, unless stated otherwise.

Differential pressure transmitters shall be dual barrier/oil filled for hydrocarbon application.

ADD NEW:

7.4.7.4 Mutilphase flowmeter (MPFM)

a) general

A complete mutilphase flowmeter (MPFM) system shall be provided as applicable per the Data Sheet (DEP 37.80.00.90-Gen), including the flowmeter with flow computer and software, test unit, and simulator. The MPFM shall be based on existing proven technology and be capable of measuring flow regimes based on production profile data provided by the Principal. The meter shall provide the volumetric flow and fractional content for gas, oil and water without requiring separation, mixing or moving parts. The MPFM shall be designed for installation and retrieval via a down line with assistance by an ROV.

The meter shall be capable of operating in the ranges & with an accuracy as per MPFM data sheet referenced in (DEP 37.80.00.90-Gen).

Repeatability shall be within 2 % and drift shall be less than 0.2 % FS / year.

Operation of the meter shall be automatic and not require operator intervention. The meter shall not require recalibrating given unchanged process fluid properties.

The Contractor shall identify any and all limitations on the meter.

Meter shall be rated for the water depth and expected system pressures.

b) flowmeter

The flowmeter shall include completely redundant instrumentation (excluding the densitometer, if used).

Differential pressure transmitters shall have dual barriers and be oil filled.

c) flow computer

The flow computer and all associated electronics shall be contained in a sealed enclosure (or canister) suitable for protection against the subsea environment.

The enclosure shall be firmly connected to the meter body and be non-retrievable.

Two entirely redundant electronics, signal and power systems and connectors shall be provided.

Flow computers may be linked together, provided that a failure of one does not affect the other.

The flow computer shall have two connections to the SCM using a serial digital interface.

d) software

The flow computer shall be provided with all internal software capable of adjusting to each flow regime automatically.

Software shall be provided to upgrade, maintain and configure the MPFM from the surface. A complete Operators' Manuals shall be provided.

Meter shall be capable of storing and providing historical data for the previous 30 days.

e) test unit

The MPFM test unit shall include all modems, filters, cables and other hardware and all additional software to fully test a MPFM.

f) simulator

The MPFM simulator shall include all hardware and software required to simulate a MPFM. Simulator shall have a inrush and continuous power consumption comparable to the actual meter.

ADD NEW:

7.4.7.5 Downhole pressure and temperature (DHPT)

Downhole pressure and temperature (DHPT) gauge shall be provided as applicable per the Data Sheet (DEP 37.80.00.90-Gen). DHPT shall provide downhole pressure and temperature information when requested by the SCM.

ADD NEW:

7.4.7.6 Erosion detector (ED)

Erosion detector (ED) shall be provided, as required. EDs shall provide indication of erosion using two pressure transmitters. The first chamber shall erode and generate an alarm. The second chamber shall initiate an erosion detector shutdown (EDSD).

Mounting shall be through a standard 2" nominal API process flange.

ADD NEW:

7.4.7.7 Field Signature Method Spool (FSM)

FSM spools shall be provided as required. FSM spools are non-intrusive system that monitors the changes in pipe wall for monitoring pipe internal corrosion and erosion. The FSM spool shall be provided with a retrievable electronics module. Power and communications to be provided via the subsea control module. Configuration and specific project requirements shall be as stated in Data Sheet (DEP 37.80.00.90-Gen – Sec 7.4.4).

Mounting shall be through a standard 2" nominal API process flange.

7.4.9.3 High Integrity pipeline protection system (HIPPS) (optional)

CHANGE 2ND PARAGRAPH TO:

The HIPPS shall be an autonomous safety system with a local logic system controlling HIPPS activation.

The system shall include the following elements:

ADD NEW:

THE HIPPS system shall have a SIL Level as specified by local regulations.

7.4.10.1 General

CHANGE 1ST PARAGRAPH TO:

In order to test each type of equipment during FAT, integration testing and during commissioning offshore, a set of test equipment shall be required.

CHANGE 3RD PARAGRAPH TO:

The test equipment shall be capable of simulating all operations necessary to control and monitor the subsea production equipment.

CHANGE LAST PARAGRAPH TO:

The test equipment shall be designed with units identical to the production equipment where practical.

7.4.10.2 Control module test stand

CHANGE 1ST PARAGRAPH TO:

The control module test stand shall support the following test functions:

ADD NEW:

The control module test stand shall include the following features:

- The skid shall be of robust heavy-duty welded construction suitable for use in an oilfield environment.
- The skid base shall include a self contained drip pan. The skid shall be provided with forklift slots and lifting pad eyes and shall be of sufficient structural construction to

prevent damage during lifting. If required, lifting straps, bars or other required lifting devices shall be provided.

- The receiver plate shall be of the same type and style as described in 7.4.4.2.
- The control panel shall contain all valves, pressure gauges required to function test the SCM.
- The hydraulic interface panel shall be provided with hydraulic quick connectors for the LP, HP and return lines, Hoses may be used. Connectors shall be such that LP and HP lines are not interchangeable.
- The electrical interface junction box shall be provided with cables for the connection of electrical test equipment, such as DHPT simulator.
- All components, such as supply lines, function lines, valves and gauges, shall be clearly labeled.
- Pressure gauges shall operate between 25 % and 75 % of full scale for all test applications.
- LP and HP control fluid sample points shall be provided.

7.4.10.3 Test hydraulic power unit

CHANGE 1ST SENTENCE TO:

The test hydraulic power unit, if utilized, shall supply hydraulic fluid at system operating pressures to the control module test stand.

7.4.10.4 Dummy control module

CHANGE 1ST SENTENCE TO:

The dummy control module shall have a mechanical and hydraulic interface to the receiver plate similar to that of the control module.

7.4.10.5 Umbilical simulator

CHANGE 1ST PARAGRAPH TO:

A simulator shall be provided to accurately represent the characteristics of the electrical cables within the umbilical, for both power and communications.

7.4.10.6 Electronic test unit

CHANGE CLAUSE TO:

The electronic test unit shall be capable of performing the control and monitoring functions related directly to the operation of the SCM (all wells on one communications pair). All commands described in the communication protocol shall be supported. In addition, the electronic test unit shall be able to simulate one or more complete control modules. The electronic test unit may be a modular unit including a portable personal computer and necessary power/signal interfaces.

7.4.10.7 Sensor test unit

CHANGE 1ST SENTENCE TO:

The sensor test unit shall simulate all subsea instrumentation (exclusive of SCM internal instruments), including downhole sensors, if applicable.

ADD NEW:

7.4.10.8 SCM simulator

The SCM simulator shall connect to the EPU or MCS (as appropriate) and respond to MCS commands in the same manner as a SCM.

8. Interfaces

8.1 General

CHANGE CLAUSE TO:

Interfaces between parts of the production control system, other parts of the subsea and host control system systems are critical to successful operation and shall be fully defined during initial design.

8.2 Interface to host

CHANGE 5TH PARAGRAPH TO:

For an integrated system (Refer to 6.4.1 for MCS configuration.), the MCS shall be built and documented according to specifications applicable for the host facility where the equipment will be situated.

ADD NEW:

The failsafe (or faulted state) for all discrete electrical I/O shall be the zero voltage state.

8.4 Interface to workover control system

CHANGE 1ST PARAGRAPH, 1ST SENTENCE TO:

The interface between the production control system and the workover control system shall ensure that the workover system has control of all functions that can affect safety of the workover operation.

DELETE 1ST PARAGRAPH, 2ND SENTENCE.

9. Materials and fabrication

9.2.2 Corrosion considerations

CHANGE 1ST SENTENCE TO:

Material selection for corrosion protection shall take into account a marine and process fluids environment. as a minimum, the following shall be studied:

9.3.1 Fittings and connections

CHANGE 2ND PARAGRAPH TO:

The same type (style) of fitting shall be used for each pressure class throughout the system.

ADD NEW

NPT threads shall not be used.

Use of fittings in the subsea hydraulic system shall be restricted to a minimum. Welded connections shall be used where practical.

Fastener pre-load shall be performed using a calibrated torque wrench. Arrangement shall be made for verification that the specified torque has been applied.

9.3.3 Cleanliness

CHANGE 1ST PARAGRAPH, 2ND SENTENCE TO:

Equipment shall be cleaned to the specified cleanliness standard prior to assembly.

ADD NEW:

The hydraulic system should be assembled without valves and flow meters and flushed as an assembly prior to installation of the final components to ensure contamination is minimized.

9.3.4 Electrical and electronic assembly

CHANGE CLAUSE TO:

For the subsea electronics, reliability of components shall be established and shall meet the specified design life, free of failure.

ADD NEW:

All soldering performed on subsea equipment shall be performed by persons who are qualified to solder via certification to a recognized industry standard. High-resolution digital photographs (>2 megapixels) of each manually soldered connection shall be included in the subsea equipment data book.

10. Quality

ADD NEW:

The quality plan shall be approved by the Principal before commencement of manufacturing.

11. Testing

11.1 General

ADD NEW:

All equipment assemblies produced within the work shall be subject to individual Factory Acceptance Testing. New equipment designs shall be subjected to formal Qualification Testing. The Principal shall review and approve all FAT /QT test procedures.

New Projects, and certain extended equipment supplies shall be subject to Factory Integration Testing (FIT) to prove the integrity and functionality of the overall system prior to mobilization offshore for installation, hook-up and pre-commissioning. Depending on schedule requirements the Principal may only have limited equipment available, however the Contractor shall develop a suitable FIT Test Procedure and lead the work. The Contractor shall employ within performance of the FIT those personnel from the Contractor's Service Department who shall be responsible for supporting the offshore installation and pre-commissioning of the new system or the extension equipment.

The Contractor shall participate in Site Integration Testing (SIT) of the Contractor-supplied equipment within subsea hardware supplied by other Suppliers.

The above statements are intended to qualify the Principal's requirements with regard to the Contractor's standard practices for testing. Where conflict arises in scope or detail of individual test requirements, the Contractor shall propose solution for the Principal's approval.

All testing shall be performed in accordance with the Contractor's detailed written procedures. Procedures shall be submitted for review two weeks prior to testing. Invitations to witness all testing shall be sent to the Principal at least two weeks in advance. A test report including test measurements shall be provided.

CHANGE 2ND PARAGRAPH TO:

A comprehensive test program that demonstrates equipment functionality shall be undertaken to ensure that control system performance requirements are met.

11.2.1 General

CHANGE 1ST PARAGRAPH, 2ND SENTENCE TO:

At the discretion of the Principal, as an alternative to testing the Contractor may provide other objective evidence, consistent with documented industry practice, that the equipment will perform as specified.

CHANGE 2ND PARAGRAPH, 2ND SENTENCE TO:

Equipment or fixtures used to qualify designs shall be representative of production models in terms of design, dimensions and materials and manufacturing process.

CHANGE 3RD paragraph, 1ST sentence to:

If a product design undergoes any changes in fit, form, function or material, the Contractor shall document to the Principal the impact of such changes on the performance of the product.

CHANGE 5TH PARAGRAPH, 1ST SENTENCE TO:

A qualification test for subsea electronic assemblies shall be performed to qualify the design with respect to temperature cycling and vibration.

ADD NEW:

Step-by-step procedures with objectives and acceptance criteria shall be available prior to start of each qualification test.

Product qualification testing shall be conducted in accordance with API 17D sections 307.4 and 307.8, with records provided per section 307.10. Seals shall be qualified for compatibility with the fluids. (Requirements should reference API 6A seal qualification process.) Seal qualification shall be conducted in accordance with API 6A, Appendix F. (minimum 200 system pressure cycles and 200 operation cycles.)

11.2.2 Hydrostatic and pressure testing (internal and external)

CHANGE 1ST PARAGRAPH, 2ND SENTENCE TO:

Internal tests for components rated above 103.4 MPa (15,000 psi) shall be performed at 1.25 times the design pressure for surface equipment and 1.5 times the design pressure for subsea equipment.

CHANGE 2ND PARAGRAPH TO:

Test pressure shall be maintained for a minimum of 2 hours without external fluid leakage from any component, line or joint. An initial stabilizing hold time is acceptable prior to starting the 2-hour hold time.

ADD NEW:

Acceptance criteria

- 1) no visible leakage
- 3) pressure drop does not exceed 2% of the test pressure
- 4) test pressure does not drop below the minimum test pressure requirement
- 5) measured pressure decay meets the following:

Pressure decay in each 15 minute segment will be lower than the previous segment

15 to 30 minute decay < 0 to 15 minute decay

30 to 45 minute decay < 15 to 30 minute decay

45 to 60 minute decay < 30 to 45 minute decay

60 to 75 minute decay < 45 to 60 minute decay

75 to 90 minute decay < 60 to 75 minute decay

90 to 105 minute decay < 75 to 90 minute decay

105 to 120 minute decay < 90 to 105 minute decay

Total pressure decay for 120 minutes less than 2 %.

SCM

Qualification shall be comprised of the equivalent to API 17D qualification and a minimum of:

- a) Proof testing the complete SCM hydraulic circuit with all components to the proof test pressure (1.1 x 1.5 x working pressure);
- b) Low and high pressure tests (20 and 100 % of design pressure) with all components per the API hydraulic circuit requirements;
- c) 200 pressure cycles to design pressure with no hold on all components in SCM assembly (refer to API 17D section 307.4);
- d) 200 functions of each component with actuator simulators to generate flow. (refer to API 17D section 307.8);
- e) Final proof testing to full proof test at the completion of all testing with original acceptance criteria;
- f) DCV leakage within initial leakage rate at completion of testing;
- g) A 15 minute gas test at operating pressure shall be performed after the system proof test on each EUT with no bubbles as the acceptance criteria. Pressure testing shall be performed at or above the stated test pressures. Acceptance criteria shall be no visible leakage.

Pressure test results shall be recorded with 5 psi (0.3 bar) resolution or better and of a frequency of 1 second or faster.

11.2.4 Cycle testing

ADD NEW:

DCVs

The LP DCVs shall be designed and qualification tested to function for a minimum of 500,000 cycles or as specified in the Data Sheet (DEP 37.80.00.90-Gen) while maintaining original solenoid specification pull in voltage (current), leakage and delatch specifications.

The HP DCVs shall be designed and qualification tested to function for a minimum of 25,000 cycles or as specified in the Data Sheet (DEP 37.80.00.90-Gen) while maintaining original solenoid specification pull in voltage (current), leakage and delatch specifications.

11.2.5.1 General

CHANGE 3rd paragraph, last sentence to:

Monitoring of functions during sweeping for resonant frequencies is preferred, but may be omitted.

Resonant frequencies shall be recorded.

11.2.5.3 Temperature tests

CHANGE 1st paragraph, last sentence to:

During this soak, continuous functional tests shall be made and no malfunctions or defects detected.

ADD new:

11.2.6 DHPT Data Acquisition

Acceptance criteria pertaining to DHPT data acquisition system is for one hour of data (3600 data points) from each gauge, there shall be:

- 1) fewer than 180 bad data events
- 2) no more than 20 double data point events
- 3) no more than 5 triple data point events
- 4) zero occurrences of 20 consecutive bad data points

The bad data events are distributed more or less evenly throughout the entire data stream. A dynamic pressure simulator for DHPT input or an actual dynamic pressure generator shall be used.

ADD new:

11.2.7 Pressure/Temperature Sensor

Subsea Pressure/Temperature Sensors shall be qualified in accordance with the test procedures and acceptance criteria in Appendix 4. A minimum of 3 pressure/temperature sensors shall be required to successfully pass this test in order to be designated as a qualified product.

ADD new:

11.2.8 Differential Pressure (DP) Sensor (applicable to MPFM, SPFM installations)

A minimum of 3 DP sensors shall be required to successfully pass this test in order to be designated as a qualified product.

The subsea DP Sensor shall be qualified in accordance with the test procedures and acceptance criteria in Appendix 4 using the rated line (static) pressure combined with the rated DP pressure as the test pressure.

Additionally, cycling of the dynamic DP pressure to one of the DP ports shall be performed at test points A, C, D, E and F (Appendix 4 – Section 4). The dynamic DP pressure cycle shall consist of applying & removing the rated dynamic DP for 10 cycles.

This cycling of the dynamic DP pressure is to be repeated on the second port also.

DP sensor output readings shall be made at each of the test points (A thru F) both before and after the dynamic DP pressure cycling is performed.

A minimum of 5 points covering the entire dynamic DP pressure range shall be recorded for each DP pressure cycle.

11.3.1 General

ADD new:

Hydraulic testing shall be performed on the fully assembled hydraulic circuit with testing to the proof test.

Testing shall consist of two 15-minute tests with the pressure reduced to zero between the tests. Acceptance criteria shall be no visible leakage during or after the tests.

As a minimum, during the complete FAT, attention shall be paid to the following:

-DCV stroke travel settings

11.3.3 Function and continuity

CHANGE 2nd paragraph to:

Hydraulic circuits shall be tested at the proof pressure as a minimum.

ADD new:

Electrical circuits shall be tested at the highest and lowest allowable working voltages and currents

11.3.5.2 ESS test sequence

CHANGE 3rd paragraph to:

The random vibration shall be applied for a total of 10 min, divided into two 5-min segments before and after the thermal cycling.

CHANGE 5th paragraph, last sentence to:

Modification of the above spectrum shall not be performed without documenting and evaluating frequency spectrum of the specific application and shall require the Principal's approval.

11.3.6.1 Internal leakage testing

CHANGE 1st paragraph, 2nd & 3rd sentence to:

The test shall be performed at the maximum allowable operating pressure of the hydraulic control system, with all circuits being tested. The minimum duration for testing shall be 15 min.

CHANGE 1st item to:

- pressurizing the system to maximum allowable operating pressure, isolating the source of supply and monitoring pressure decay. Pressure decay shall be monitored and recorded using a gauge with 5 psi or better resolution;

11.3.6.2 Fluid flushing

ADD new:

The flushing fluid cleanliness shall meet or exceed the cleanliness requirements of the equipment under test.

ADD new:

11.3.7 Additional MCS FAT requirements

General

All testing shall be carried out to demonstrate the full functionality of the equipment.

MCS functional software and MCS configuration software versions used during the FAT shall be recorded in the FAT test results.

a) Visual Inspection

A visual inspection of the MCS cabinet(s) and components shall be conducted. If any punch list items arise from visual inspection, they shall be fixed before continuing with rest of the tests. All drawings shall be checked for accuracy, corrected and recorded with the FAT results.

b) Power On Test

Test power input to the main breaker of the MCS distribution panel from the UPS.

Each breaker shall be individually turned on and power shall be verified in each branch circuit up to the rated load.

c) Communication Test

The purpose of this test is to verify that the MCS communicates with other components.

d) Functionality Testing

Any and all functionality as stated in the equipment FDR or FDS.

e) Software Tests

Project software shall be loaded in accordance with the Contractor's written procedures (including PC operating system).

MCS functional software and MCS configuration software versions used during the FAT shall be recorded in the FAT test report.

ADD new:

11.3.8 Additional EPU FAT requirements

General

All testing shall be carried out to demonstrate the full functionality of the equipment.

a) Visual Inspection

Visually inspect the EPU cabinet(s) and components. If any punch list items arise from visual inspection, they shall be fixed before continuing with rest of the tests.

b) Power On Test

Test power input to the main breaker of the EPU distribution panel from the UPS.

Each breaker shall be individually turned on and power shall be verified in each branch circuit up to the load.

c) Protective Devices Test

All of the protective relaying features and settings shall be verified by simulating abnormal conditions that each protective device is designed to protect against, which include over-voltage, over-current, low insulation resistance, and voltage surge suppressors.

d) Power Transformer Test

Transformers shall be tested for insulation resistance (line to ground) prior to energizing. The resistance shall be greater than 1 GΩ.

Test the transformer turns ratio by applying voltage to the input and verifying secondary output based on the tap setting of the transformer. Using load and umbilical simulators verify current for each umbilical circuit and perform a burn-in test (minimum 24 hours).

e) EPU-SCM Communication Test

The purpose of this test is to verify that the modems enable the EPU to communicate with the SCM simulator.

After establishing connectivity, run for a minimum of 1 hour and record number of communication errors as well as verifying that other performance criteria of modem and filters are met.

This test is to be performed for each transformer/modem pair.

d) ETU-SCM Communication Test

The purpose of this test is to verify that the modems enable the ETU to communicate with the SCM simulator.

After establishing connectivity, run for a minimum of 1 hour and record number of communication errors as well as verifying that other performance criteria of modem and filters are met.

This test is to be performed for each transformer/modem pair.

ADD new:

11.3.9 Additional HPU FAT requirements

General

Testing shall be carried out to demonstrate the full functionality of the equipment.

All testing shall be carried out with test equipment rated for the working pressure ranges of the HPU.

Fluid samples shall be taken each day during testing. Include particle count reports in FAT report.

a) Visual Inspection

Visual inspection for leaks shall be made during testing. Visually inspect the HPU cabinet(s) and components. If any punch list items arise from visual inspection, they shall be fixed before continuing with rest of the tests. The equipment shall be checked for compliance with the P&ID and hydraulic schematics and any deviations shall be corrected and recorded with the FAT report.

The test shall demonstrate that the HPU provides the specified pressure output over the full flow rate range

b) Software Tests

Project software shall be loaded in accordance with the Contractor's written procedures.

HPU PLC functional software and HPU PLC configuration software versions used during the FAT shall be recorded in the FAT test report.

c) ESD Testing

ESD signal shall be sent to verify the pumps are stopped and the supply line pressures are vented.

d) Relief Valve Testing

All relief valves shall be tested to demonstrate that they vent at the specified pressures.

ADD new:

11.3.10 Additional SCM FAT requirements