

DEP SPECIFICATION

DESIGN AND OPERATION OF SUBSEA PRODUCTION CONTROL SYSTEMS (AMENDMENTS/SUPPLEMENTS TO API STD 17F)

DEP 37.80.00.33-Gen.

February 2016

ECCN EAR99

DESIGN AND ENGINEERING PRACTICE



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These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.

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- 3) Contractors/subcontractors and Manufacturers/Suppliers under a contract with users referred to under 1) or 2) which requires that tenders for projects, materials supplied or - generally - work performed on behalf of the said users comply with the relevant standards.

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All administrative queries should be directed to the DEP Administrator in Shell GSI.

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PART I INTRODUCTION

1.1 SCOPE

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

This DEP is based on API Std 17F: May 2014. Part III of this DEP amends, supplements and deletes various clauses of API Std 17F: May 2014. Part III follows the clause numbering of API Std 17F: May 2014 for easy reference.

NOTE: API STD 17F, 3rd edition, was intended to be identical to ISO 13628-6:2012, but due to unforeseen circumstances which prohibited collaboration between the two organizations the next release of ISO 13628-6 may introduce differences between these two standards.

All clauses of API Std 17F: May 2014 not modified by this DEP remain valid as written.

This is a revision of the DEP of the same number dated February 2015; see (1.5) regarding the changes.

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 authorisation 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 shall 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

1.3.1 General 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 or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (Part IV).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a minor update of the DEP of the same number dated February 2015 to correct one of the tables in Appendix G.

The following are the main, non-editorial changes:

Section/Clause	Change
Appendix G	Added Section 1.0 for the HPU inspection and test plan

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://www.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.
DEP Standard Form (Other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .

Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.

PART II GENERAL**1. AMENDMENT OF API STD 17F**

Part III of this DEP is written as amendments and supplements to API Std 17F: May 2014. Wherever reference is made to API Std 17F, it shall be understood to mean API Std 17F: May 2014 as amended/supplemented by this DEP.

For ease of reference, the clause numbering of API Std 17F has been used throughout Part III of this DEP.

Unless specified otherwise in this DEP, all occurrences of the word "should" in API Std 17F shall be replaced with the word "shall".

Tables and figures in this DEP not replacing the corresponding item in API Std 17F are numbered in relation to the DEP clause.

Clauses in API Std 17F, which are not mentioned in this DEP, shall remain valid as written.

PART III AMENDMENTS/SUPPLEMENTS TO API STD 17F**2. Normative References**

Add the following new clause:

1. See also Part III of this DEP.

3. Terms, Definitions, Acronyms, Abbreviations, and Symbols**3.1 Terms and Definitions****3.1.18****intelligent well**

Replace this definition with the following:

Intelligent well (smart well)

Well that employs permanently installed downhole sensors and/or permanently installed downhole control devices that are operable from a surface facility.

3.1.24**pressure****Design pressure (Component Based)**

Replace this definition with the following:

Pressure 10 % higher than the maximum allowable operating pressure

Add the following new definitions:

Maximum allowable operating pressure (Component and System Based)

Highest pressure that is allowed for continuous use

Minimum operating pressure (System Based)

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

3.1.31**surface controlled subsurface safety valve**

Add the following to this definition:

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 the following new definitions:

3.1.38**dry mate connector**

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

3.1.39**wet mate connector**

An electrical, fibre optic or electrical/fibre optic connector that is designed to be connected and operated in the subsea environment

3.1.40**redundancy**

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

**3.1.41
screen**

HMI graphic that fills the entire width of the monitor

**3.1.42
popup**

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

**3.1.43
data sheet DEP 37.80.00.90-Gen.**

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

3.2 Acronyms, Abbreviations, and Symbols

Add the following new acronyms:

AMV	annulus master valve
ASD	acoustic sand detector
AWG	American wire gauge
AWV	annulus wing valve
COV	change over valve
CPU	central processing unit
CRC	cyclic redundancy check
Cv	flow coefficient
DHI	downhole interface
DHPT	downhole pressure and temperature
DP	differential pressure
ETU	electronic test unit
EU	engineering units
FCS	facility control system
FDR	functional design requirements
FDS	functional design specifications
FS	full scale
FSO	fail-safe open
GVF	gas volume fraction
LCD	liquid crystal display
LVDT	linear variable differential transformer
MPFM	multiphase flow meter
MTBF	mean time between failures
MTU	maintenance and testing unit
NEMA	National Electrical Manufacturers Association
PT	pressure transducer
SGU	Subsea gateway unit
SPFM	single-phase flow meter
SSED	subsea emergency shutdown

SSV	surface safety valve
VDU	visual display unit
WPMS	waterflood pressure management system
XOV	crossover valve

4. System Requirements

4.2 Concept Development

Add the following to this clause:

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

4.3 Production Control System Functionality Requirement

4.3.6 Robustness of Hydraulic System

Replace the last sentence with the following:

1. The minimum operating pressure shall be the lower of
 - a. 150 % of the highest directional control valve (DCV) delatching pressure or
 - b. 20 % of the start-to-close valve pressure.

4.4 General Requirements

4.4.1 General Description

Add the following new clauses:

- n) 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.
- o) single phase flowmeter (SPFM)
- p) waterflood pressure management system (WPMS)

4.4.2 Service Condition

4.4.2.1 Suitability for Working Environment

Add the following to this clause:

1. The system shall have a design life per the Data Sheet DEP 37.80.00.90-Gen.

4.4.2.3 Temperature Ratings – Subsea-installed Equipment

Table 2 — Temperature rating — Subsea-installed equipment

Operate

- a) Standard (Electronics and System),

Replace values with the following:

1. -5 to 55 (23 to 131)

4.4.3 Hydraulic Supply System

4.4.3.1 Pressure Ratings

4.4.3.1.1 General

Replace the fourth paragraph with the following:

1. 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.

2. Design pressure of the system shall be selected from recommended design-pressure classes, per clause 4.4.3.1.2 and Table 3.

4.4.7 Redundancy

Replace the first sentence of the fourth bulleted item with the following:

1. The subsea electrical distribution system design shall be redundant and include spares that can be configured to replace failed circuits.

Replace the second sentence of the fifth bulleted item with the following:

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

4.4.8 Reliability

Replace the second sentence of the first paragraph with following:

1. High reliability components shall be used in lieu of redundant components of more standard quality.

4.5 Functional Requirements

4.5.2 Maximum and Minimum Working Pressure

Replace the last sentence of the first paragraph with the following:

1. While a subsea valve is being actuated no other valves on the same hydraulic circuit shall change their commanded state.

4.5.5 Functional Considerations

4.5.5.2 Interlocks

Add the following to this clause:

1. Interlocks shall be provided as specified in Data Sheet DEP 37.80.00.90-Gen.

4.5.5.4 Actuation Indication

Add the following to this clause:

1. 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.

Delete the following clause:

4.5.5.6 Flushing of SCSSV Hydraulic Circuit

4.5.5.8 Control Fluid Venting and Leakage

Delete the last sentence of the first paragraph:

4.6 Design Requirements

4.6.1 General Design Requirements

Add the following to this clause:

1. The Contractor shall follow the BP/Chevron/Shell/Statoil/Total Obsolescence Management Specification for Subsea Production Control Systems 5JUL2012.
2. Check valves shall not be relied upon as pressure isolation devices.

4.6.3 Design Methods

4.6.3.1 Pressure-Containing Vessels

Add the following to this clause:

1. All hydraulic pressure containing components utilized for applications in excess of 0.1 Mpa (15 psi) shall have a design pressure equal to, or greater than, the system design pressure and a proof pressure test equal to, or greater than, the system design proof pressure requirement per clause 3.1.24.

4.6.4 Design Analysis

4.6.4.1 General

Replace last bullet with the following to this clause:

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

4.6.4.3 Electrical Control Power Systems

Replace ninth bulleted item with the following:

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

4.6.6 Control System Design Documentation

Add the following to this clause:

1. For all new projects, the Contractor shall submit for the Principal's review and approval documentation per DEP 82.00.10.30-Gen. as a minimum and the documentation specified below. DEP 82.00.10.30-Gen. requirements shall prevail in the event of conflicting requirements.
 - a. 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. 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.
 - b. Quality surveillance plan. This is to be issued for each new project undertaken
 - c. Top assembly drawing and list of Materials. This is used to define the scope of supply
 - d. Functional design specifications for major items of equipment supply
 - e. Engineering interface register and supporting documentation
 - f. General arrangement drawings / assembly drawings and Lists of Materials
 - g. Piping and instrumentation drawings (P&IDs)
 - h. Process engineering flow schemes (PEFS)
 - i. Wiring and interconnection diagrams
 - j. Equipment/component data sheets
 - k. Electrical, optical and hydraulic schematic drawings
 - l. Electrical power, communication signal and hydraulic analyses
 - m. Design calculations (where these are needed to demonstrate compliance with the Principal's, industry standards' or statutory requirements)
 - n. Software testing philosophy / strategy
 - 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
 - p. Software documentation and licenses for all delivered software packages

- q. Spares lists (including OEM name and part number) for major items of deliverable equipment
 - r. Factory acceptance, site integration and factory integration test procedures
 - s. Equipment handling, storage and preservation procedures
 - t. Offshore topsides equipment and software installation and hook-up guidelines
 - u. Offshore pre-deployment and pre-commissioning test procedures
- 2. All documents transmitted to the Principal shall be in Adobe Portable Document Format (PDF) files and entered by the Contractor into the Principal's document control system. An electronic message (e-mail) should be sent to the Principal by the Contractor advising of each document transmission.
 - 3. The Principal reserves the right to update or change the medium to store documents.
 - 4. 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.
 - 5. If 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 the Principal's document control system, with the new information under revision control.
 - a. The Contractor shall notify the Principal of all additions and/or changes via e-mail.
 - b. The Contractor need not provide CAD format drawings if the Contractor commits to providing maintainable drawings via the Principal's document control system 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.
 - 6. A draft of each document shall be submitted to the Principal for review at least two weeks prior to releasing the final revision.
 - 7. 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.
 - 8. 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.
 - 9. The Contractor shall provide a distribution list for notification of revised documentation.

4.6.6.1 Manufacturer's Engineering Data Records

Add the following to this clause:

- 1. Block diagrams or schematics shall include, but not be limited to, the following systems: (1) subsea communications architecture, (2) HPU hydraulic, (3) HPU electrical power, (4) HPU communications, (5) SCM hydraulic, (6) SCM electrical power, (7) SCM communications, (8) interface diagrams, (9) subsea sensor electrical power, (10) subsea sensor communications, etc.

4.6.6.2 Installation, Operating and Maintenance Manual:

b)

- 3) *Replace last sentence with the following:*

1. This document shall be updated as needed and attached to the procedures.

4.6.6.3 Manufacturer's Data Record Book

Add the following to this clause:

1. 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.
2. The Contractor shall compile and issue for the Principal's review and acceptance a manufacturing data book (MDB) package.
 - a. The MDB package shall incorporate all relevant certification produced and the records of all relevant testing performed.
 - b. All completed equipment shall be digitally photographed (minimum 1024 x 768 pixels resolution) and the images provided electronically via CD/DVD/USB drive medium to the Principal, in addition to inclusion within relevant FAT documents.
3. The Contractor shall compile and deliver all final documentation (design, manufacturing and operation) via CD/DVD/USB drive medium as required by the Principal. All files shall be stored as Adobe PDF format.

5. Surface Equipment

5.2 General Requirements

Add the following to this clause:

1. 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.).

5.4 Design Requirements

Add the following to this clause:

1. Labelling for all surface equipment shall be in accordance with (10.1.1).

5.4.2 MCS

Replace the 1st sentence of the 3rd paragraph with the following:

1. The master control station (MCS) shall provide the following additional capabilities as specified in the Data Sheet (DEP 37.80.00.90-Gen.).

Replace the 1st sentence of the last paragraph with the following:

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

Add the following new clause:

5.4.2.1 General

1. The MCS configuration shall be either fully integrated or partially integrated with the topsides control system or stand alone as specified 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.
2. 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 it shall be able to perform subsea control should the DCS or the link to the DCS fail.

3. A fully integrated MCS configuration shall be constructed using the same type (style) hardware and software as used in the topsides control system.
4. 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.
5. 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. The Contractor shall provide all hardware and software to implement the shutdown requirements as specified in the Data Sheet (DEP 37.80.00.90-Gen.) as applicable. All shutdowns, once initiated, shall progress automatically without requiring operator intervention.
7. In the event that the shutdown initiation condition has been rectified, the system shall have provisions for aborting execution of shutdown commands.

Add the following new clause:

5.4.2.2 Enclosure

1. General Construction
 - a. The enclosure shall be a freestanding NEMA Type 12 or equivalent cabinet(s).
 - b. The unit shall be designed to be modular in construction to simplify assembly, installation and maintenance.
 - c. 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.
 - d. The enclosure shall be provided with forklift slots and lifting padeyes and shall be robust enough to prevent damage during lifting. Lifting straps, bars or other required lifting devices shall be provided. Mounting plinths shall be provided for bolting to the deck.
2. Receptacles and Lighting
 - a. Receptacles shall be provided so that all components (front and back) can be reached with a 2 m (6 ft) cord.
 - b. 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.
 - c. Sufficient spaces shall be provided for cable entry.
 - d. All cables shall be properly glanded. Transit blocks shall be provided for all glands.
3. Ventilation
 - a. A ventilation system (exhaust fans) shall be provided near the top of the enclosure with sufficient capacity to prevent excessive heat rise.
 - b. Air intake vents with removable filters shall be provided near the bottom of the enclosure.
4. Health Indicator
 - a. 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)).
 - b. 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 the following new clause:

5.4.2.3 Wiring

1. Power conductors shall be PVC insulated with the operating temperature of -20 °C to 100 °C (-4 °F to 212 °F), stranded copper, 600VAC rated voltage and passes VW-1 flame test.
2. Digital and analogue input/output conductors shall be PVC insulated with the operating temperature of -20 °C to 90 °C (-4 °F to 194 °F), stranded copper, 400VAC rated voltage.
3. Minimum conductor sizes shall be as follows:
 - a. Main Circuit Breaker: 8 AWG (10 mm²)
 - b. Voltmeter: 16 AWG (1.5 mm²)
 - c. Ammeter: 14 AWG (2.5 mm²)
 - d. Circuit Breaker, relay contact: 14 AWG (2.5 mm²)
 - e. Digital and analogue I/O: 20 AWG (0.5 mm²)
4. Power conductors and terminations shall be kept separate from signal conductors and terminations.
5. 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.
6. All cable trays shall be mounted with rivets at maximum distance of 200 mm (8 in).
7. All live terminals of equipment having a maximum (peak) voltage greater than 24V shall be shrouded or otherwise protected by barriers to a degree of protection of at least IP 2X. Barriers shall be of rigid, flame retardant, non-toxic and low halogen, transparent material to enable the screened components to be identified.

Add the following new clause:

5.4.2.4 Grounding

1. All grounding conductors shall be stranded copper with green (or green/yellow) coloured insulation, terminated in corrosion resistant terminal blocks.
2. Power ground and signal shields shall be separated and have dedicated terminal blocks.
3. All instrumentation-shielded cables shall be grounded at only one point.
4. Grounding shall be as specified in the Data Sheet (DEP 37.80.00.90-Gen.) or per local standards/requirements.
5. Grounding cable with cable number shall be shown on electrical drawings, interface drawings, GA and cable schedules.

Add the following new clause:

5.4.2.5 Logic Solvers

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

1. Each redundant logic solver shall be fully capable of performing all of the functional requirements of the MCS.
2. The functional requirements of both types of redundant system are the same and include, but are not limited to, the following:
 - a. solve all required logic;

- b. interface with the data storage and HMI;
 - c. control and monitor all communications;
 - d. interface with the HPU;
 - e. communicate through the EPU (in COPS) to control and monitor all subsea components (subsea instrumentation, valves, choke(s), DHPT, etc.);
 - f. address and select SEMs;
 - g. monitor diagnostic/housekeeping data in SCMs/SEMs, EPU and HPU;
 - h. configure and download coefficients to DHPT gauge(s) given connection to downhole is via IWIS option 1 or 2 devices;
 - i. provide alarms when limits are exceeded;
 - j. perform automatic shutdown functions;
 - k. provide shutdown overrides;
 - l. provide all valve interlocks;
 - m. request valve profiles;
 - n. request fast scan data from DHPT and ASD;
 - o. provide trending of subsea sensors;
 - p. interface with the host control system (chemical permissives, etc.).
3. In the case of redundant logic solvers, at any given time, one logic solver shall operate as "active" and the other as "standby".
 4. Independent watchdog hardware shall be provided to detect when a logic solver has ceased to solve logic or is no longer communicating.
 5. 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.
 6. A means shall be provided to manually switch from the active to the standby logic solver.
 7. 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.
 8. 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."
 9. Detailed written software control procedures shall be provided for PC based control systems.
 10. Provision shall be made to automatically save all user entered configuration data (alarm limits, timer values, etc.) on a regular basis as specified 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 the following new clause:

5.4.2.6 Data Storage

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

- a. interface with the logic solvers and HMI
 - b. record all subsea instrumentation (every 15 s)
 - c. record all valve function line pressures (every 15 s)
 - d. record all SCM/SEM diagnostic/housekeeping data (every 5 min)
 - e. record fast scan data from DHPT (every 1 s)
 - f. record fast scan data from ASD (every 1 s)
 - g. retrieve data when requested and provide to the HMI for trending
 - h. store most recent valve profiles and provide as requested
 - i. alerting on data value that fall outside of user definable limits
 - j. exporting data for use in other applications
2. All data shall have date/time and associated system (e.g., well, manifold, etc.).
 3. Historical data shall be retrievable for no less than thirty days.
 4. 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.
 5. PC shall be server class, have dual power supplies and at least a RAID1 hard drive configuration.

Add the following new clause:

5.4.2.7 Human-Machine Interface

1. As a minimum the human-machine interface (HMI) shall meet the requirements of the project mimic specification as specified in the Data Sheet (DEP 37.80.00.90-Gen.).
2. A fully integrated MCS shall have an HMI with the screen content and functionality described in Appendix A
3. A partially integrated MCS, or stand-alone MCS, shall have an HMI with the screen content and functionality described in Appendix B.

Add the following new clause:

5.4.2.8 Waterflood Pressure Management System

1. If reservoir water injection is used and the injection wells do not have DHPT sensors, a waterflood pressure management system (WPMS) shall be provided to maximize oil recovery as required by the Data Sheet (DEP 37.80.00.90-Gen.).
2. The WPMS shall read, at operator configurable intervals, the necessary water injection and production well sensor data from the data storage PC database. The WPMS shall provide the MCS HMI with a recommended tubing injection pressure and flowrate for each water injection well.
3. 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 on the MCS HMI for each water injection well.
4. The WPMS shall monitor produced fluid composition and alarm on potential water breakthrough.
5. The WPMS shall be redundant with two separate networked computers or controllers.
6. It shall be possible to reconfigure the WPMS to adapt to changes in field reservoir produced fluids properties. The software shall allow for the reconfiguration of the choke's properties.

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

Add the following new clause:

5.4.2.9 Subsea Interface to Topsides System

A subsea interface to topsides system (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.

1. The SITS shall have, as a minimum, the following functionality/characteristics:
 - a. 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 the subsea control modules (SCMs).
 - b. Modular in design.
 - c. Ability to handle redundant communication with Subsea Modem Unit (SMU) based on subsea vendor specific protocol which may be proprietary (queue, addressing, switching, etc.).
 - d. Ability to assemble proprietary data to/from SMU in data tables of an industry standard protocol and transmitted to FCS controllers over Ethernet.
 - e. Ability to monitor/ping its communication with MCS and SMU and set alarms upon failure of communication retries.
 - f. Ability to switch seamlessly to secondary communication path upon failure of primary path.
 - g. Ability to manually, through MCS HMI, switch or disable communication path
 - h. Ability to retain last data on power down or cold start up.
 - i. Ability to convert subsea instrument raw values to engineering units
 - j. Ability to transmit process data to FCS controllers in MCS on change (programmable) to reduce communication traffic from SITS to MCS.
 - k. Ability to handle specialized data like valve signatures, fast scan data, etc. and pass it to dedicated Valve Signature Server (VSS).
 - l. Ability to transmit housekeeping data to subsea historian
 - m. 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.
2. Unless otherwise specified, the SITS shall be housed in either the electrical power unit (EPU) or the MCS panel. If it cannot be housed in either the EPU or the MCS, then a stand-alone enclosure shall be built for the SITS similar to other enclosures in the subsea controls building.

5.4.3 EPU

Replace the sixth bulleted item in the fifth paragraph with the following:

1. line insulation.

Add the following new clause:

5.4.3.1 Enclosure

1. General construction shall be provided per data sheet (DEP 37.80.00.90-Gen.).
2. Receptacles and lighting shall be provided per data sheet (DEP 37.80.00.90-Gen.) and with intake air filtering.
3. Ventilation shall be provided with intake air filtering.

4. Health indication
 - a. 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)).
 - b. Green LED indicators (that can be seen from the front of the cabinet) shall be provided to indicate the health of each of the communication lines. Red LED indicators (that can be seen from the front of the cabinet) shall be provided for each communication line to indicate a line insulation fault. If the communication method is not a superimposed communications on power system (COPS), then the modems may be located in the MCS.
5. External noise level limit per data sheet (DEP 37.80.00.90-Gen.)
6. Automatic grounding of inactive communication lines shall be provided
7. Thermal analysis shall be conducted to demonstrate EPU will not overheat at full load.

Add the following new clause:

5.4.3.2 Wiring

1. Wiring shall be provided per 5.4.2.3.

Add the following new clause:

5.4.3.3 Grounding

1. Grounding shall be provided per 5.4.2.4.

Add the following new clause:

5.4.3.4 Circuit Breakers

1. 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.
2. High inrush current tolerant circuit breakers shall be used.

Add the following new clause:

5.4.3.5 Programmable Relays

1. 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.
2. 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 the following new clause:

5.4.3.6 Insulation Monitors

1. The EPU shall provide insulation monitors to detect insulation faults that may occur in the umbilical(s) or subsea electrical equipment.
2. 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.
3. The insulation monitors 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.
4. A digital megohmmeter shall be located on the front of the enclosure to display the measured insulation resistance.

Add the following new clause:

5.4.3.7 Surge Suppressor

1. A surge suppressor shall be provided to protect electrical devices as well as the umbilical(s) in the event of a voltage surge.
2. Surge suppressor 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.
3. Surge suppressors voltage: 500 VAC (nominal)
4. Arrester rated voltage: 600 VAC
5. Discharge surge current: 10 kA (nominal) to 40 kA (maximum)
6. Protection voltage level: 2.45 kV to 2.8 kV

5.4.4 Subsea Gateway Unit

Replace first sentence of fourth paragraph with the following:

1. Redundant communication paths shall be provided. The redundant elements shall not share common hardware (e.g. modems or power supplies).

Add the following to this clause:

2. In the case where combined power and signal is used the modem units shall be included as part of the EPU. Where dedicated lines are used for power and communications, the modem units may be included as part of the MCS.
3. 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.
4. There shall be sufficient margin to accommodate cable/distribution system degradation over time.
5. As the cable/distribution system degrades over time, the performance should not degrade to below 1 error in 250 messages (99.6 %).
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 the following new clause:

5.4.4.1 Filters

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

5.4.5 Uninterruptible Power Supply (UPS) (optional)

Replace third sentence of second paragraph with the following:

1. 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. Consideration should be given to the fault current capabilities of the UPS and the circuit breaker sizing to ensure that the electrical power system provides proper electrical protection for connected devices.

Add the following to this clause:

2. The appropriate regional standard for AC Systems shall apply: DEP 33.65.50.33-Gen. or DEP 33.65.50.32-Gen.
3. The UPS shall alert the MCS when not operating on inverted power (in bypass mode).

5.4.6 HPU**5.4.6.1 General**

Replace fifth paragraph with the following:

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

Replace sixth paragraph with the following:

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

Add the following to this clause:

3. Components located as shown in Appendix C (HPU Simplified Flow Diagram) shall be provided.
4. All hydraulic pressure containing components utilized for applications in excess of 0.1 MPa (15 psi) shall have a design pressure equal to, or greater than, the system design pressure and a proof pressure test equal to, or greater than, the system design proof pressure per (5.4.2.2).
5. Double block and bleed valves shall be used to isolate accumulators, pressure transmitters, pressure temperature gauges, etc. for safe servicing.
6. On cone and 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.
7. The HPU hydraulic fluid return circuit(s) to the reservoir tank should not have any restriction or possible restriction in place, i.e. filters, strainers, etc. Return line valves that are able to be locked in the open position may be allowed.
8. Return lines and relief lines shall be separate for different pressure circuits. Separate return lines for pump relief valves shall be provided.

5.4.6.2 Hydraulic Accumulators

Delete first paragraph and note.

Replace last paragraph with the following:

1. Visual indication of low nitrogen pressure shall be provided.

Add the following to this clause:

2. The design of the accumulator charge and vent lines shall include an easily accessible isolation valve between each accumulator and the charging/vent lines.
3. If burst discs are fitted to the gas side of the accumulator, a blowdown down tube shall be installed at the burst disc output.

5.4.6.4 Pumps

Replace fifth paragraph with the following:

1. Anti-condensation heaters shall be provided for electrical motors.

Add the following to this clause:

2. Motor power supply requirements shall be as specified in Data Sheet (DEP 37.80.00.90-Gen.).
3. A local hand-auto-off switch shall be provided for each motor. Motor shall not have provisions for running without automatic pressure control.
4. 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. The appropriate regional standard shall apply (DEP 33.65.11.31-Gen. or DEP 33.65.11.34-Gen.).

5. Over-pressure relief protection shall be provided with the discharge pressure venting into the return line.
6. Pump over-pressure relief valve should be set at the maximum working pressure of the pump or the piping system whichever is lower. DEP 80.36.00.30-Gen. shall apply.
7. 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 routes shall be duplicated to allow in service changeover and repair. Differential pressure switches shall be used on all filters and be monitored from the local HPU HMI and the production MCS.
8. Circulation pump shall have an auto-off-hand switch. Motor should run continuously when in HAND mode and periodically when in auto mode.
9. A hydraulic hand-test pump shall be provided.

5.4.6.5 Reservoirs

Replace 5th paragraph with the following:

1. Fluid reservoirs shall be made from non-corrosive material (such as 316L stainless steel), and equipped with circulating pump(s) and filters. Filters shall be located downstream of the pump(s). Sample points shall be located no higher than pump suction ports, taking samples from the active part of the reservoir.

Add the following to this clause:

2. 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 of 100 mm (4 in) below the reservoir top.
3. The reservoirs shall be sized to provide sufficient fluid for three complete subsea start-ups.
4. 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.
 - a. Nitrogen shall be supplied to the reservoir from the platform and delivered to the reservoir at a nominal pressure of 13 kPa (g) (2 psig).
 - b. A nitrogen flowmeter (to provide visual verification of nitrogen injection into the reservoir) shall be required.
5. Flame arrestors should be considered when using flammable control fluid.

5.4.6.6 Control and Monitoring

Replace first and second sentences of second paragraph with the following:

1. 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 B.

Replace third paragraph with the following:

2. The HPU shall incorporate dedicated devices for each hydraulic supply line to bleed off system-control pressure upon receipt of a hard-wired failsafe ESD signal from the host.

Replace fifth paragraph with the following:

3. The HPU shall include the following:

- a. The start and stop operation of the HPU pumps shall be controlled by 3 independent pressure transmitters in a voting arrangement.
 - i. The middle value of the three shall be determined and considered as the controlled pressure reading.
 - ii. If one pressure sensor fails at a high or a low value, then this middle-of-three voting system will still select one of the two remaining valid pressures.
 - iii. A pressure transmitter value deviation from the selected value of greater than or equal to 10 % (settable) by the two other pressure transmitter values shall raise an alarm.
- b. 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.
- c. The HPU shall provide a manual means to bleed off pressure from a remote pushbutton.
- d. 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.
- e. 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 the following new clause:

5.4.6.7 LP and HP Pump Control

1. 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
2. Each pump shall be controlled through a hand-off-automatic switch (with spring return for HAND mode).
3. Pump control shall have an emergency stop button located near the pump units to stop all pumps (including the recirculating pump).
4. The first (LP or HP) supply pump placed into automatic mode shall be designated as the primary pump for that line.
5. When both pumps are placed in automatic mode for a supply line, the primary pump designation shall alternate after each pump run cycle.

Add the following new clause:

5.4.6.8 Automatic Run Mode

1. Automatic run mode shall be controlled as follows:
 - a. The LP (primary) pump start pressure is not less than 34.5 bar (500 psi) above the maximum LP regulated output pressure
 - b. The HP (primary) pump start pressure is not less than 34.5 bar (500 psi) above the maximum HP regulated output pressure
 - c. The LP and HP (standby) pumps start at the maximum regulated output pressure.
 - d. The LP (primary) pump start-pump stop difference is not less than 51.7 bar (750 psi).

- e. The LP (primary and standby) pump stop pressure is no higher than 34.5 bar (500 psi) less than the LP relief valve setting.
- f. The HP (primary and standby) pump stop pressure is no higher than 51.7 bar (750 psi) less than the HP relief valve setting.
- g. The HP (primary) pump start-pump stop difference is not less than 68.9 bar (1000 psi).
- h. All pumps on the LP or HP circuit stop if the respective non-regulated pressure HIGH HIGH alarm is triggered.
- i. All pumps stop if the supply reservoir LOW LOW level is triggered.
- j. All pumps 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 the following new clause:

5.4.6.9 Hand/Jog Mode

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

Add the following new clause:

5.4.6.10 Recirculation Pump Control:

- 1. **Recirculation pump** shall be controlled as follows:
 - a. The recirculation pump is controlled through a hand-off-automatic switch (no spring return for hand mode).
 - b. The recirculation pump runs continuously when in hand mode.
 - c. The recirculation pump has three operational modes as follows:
 - i. Recirculate return reservoir
 - ii. Recirculate supply reservoir
 - iii. Transfer fluid from the return reservoir to the supply reservoir
 - d. The automatic switch position only controls recirculate modes.
 - e. The recirculation pump stops in automatic mode once the pump run time is equal to the user defined pump timer setpoint. The pump is restarted after the user defined wait time.
 - f. The recirculation pump stops if the return reservoir LOW LOW level alarm is triggered.
 - g. The recirculation pump stops if the supply LOW LOW or HIGH HIGH level alarm is triggered.

Add the following new clause:

5.4.6.11 HPU HMI Screen Definition

- 1. 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

2. Reservoir and Circulation Circuit Screen – Display and Set:
 - a. Pump run and wait time
3. Motor Statistics Screen – Display
 - a. Pump starts counter for each HPU pump
 - b. Pump run time for each HPU pump
 - c. Cumulative run time for each HPU pump
4. 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
5. Low Pressure Non-regulated Circuit Screen – Display and Set:
 - a. Pump primary and standby identification
 - b. Primary pump start and stop values
 - c. Standby pump start and stop values
6. 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
7. High Pressure Non-regulated Circuit Screen – Display and Set:
 - a. Pump primary and standby identification
 - b. Primary pump start and stop values
 - c. Standby pump start and stop values
8. 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
9. Variable 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
10. Alarm Summary Screen – Display and Acknowledge
- a. Summary of all alarms

Add the following new clause:

5.4.6.12 Variable List

1. The following variables 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 the following new clause:

5.4.6.13 Skid

1. General Construction
 - a. The HPU skid shall be of robust, heavy-duty welded construction suitable for use in an oilfield environment.
 - b. 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.
 - c. The skid base shall include a self-contained drip pan with a means to be connected to the platform drain system.
 - d. The skid shall be provided with lifting pad eyes and shall be robust enough to prevent damage during lifting. Lifting straps, bars or other required lifting

devices shall be provided. The skid shall be welded or bolted permanently to the deck.

- e. The unit shall be designed to be modular in construction to simplify assembly, installation and maintenance.
- f. 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.
- g. There shall be at least two entry /egress points on opposite ends of the HPU

2. Electrical

- a. Fluorescent lighting shall be provided.
- b. Sufficient spaces shall be provided for cable entry. All cables shall be properly glanded.
- c. Instrumentation cabling from all sensors to the HPU control panel shall consist of marine armoured (international) with PVC jacket with proper terminators.

5.4.7 Hydraulic Control Fluid

5.4.7.1 General

Add the following to this clause:

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

6. Subsea Equipment

6.2 General Requirements

Add the following to this clause:

- 1. 100 % traceability shall be required on all SCMs and subsea instrumentation including, but not be limited to, the following pressure containing components:
 - a. hydraulic couplers;
 - b. manifolds;
 - c. pressure transmitter;
 - d. DCV;
 - e. filter housing;
 - f. accumulators;
 - g. flow meter;
 - h. check / relief valve;
 - i. selector valve;
 - j. shuttle valve.
- 2. Documentation of hydraulic components shall be provided for, but not be limited to, the following:
 - a. Pressure containing component
 - i. serialization;
 - ii. material mechanical properties;
 - iii. material chemical properties;

- iv. volumetric UT.
 - b. Bolting – batch lot certification
 - i. material mechanical properties;
 - ii. material chemical properties.
 - c. Elastomers
 - i. batch lot;
 - ii. cure date;
 - iii. shelf life.
- 3. Documentation of electrical components shall be provided for, but not limited to, the following:
 - a. SEM Electronics, sensors and subsea instrumentation
 - b. Component traceability by serial number to manufacturing batch for all sub-components.

6.3 Functional Requirements

Replace first sentence with the following:

- 1. The functional requirements for subsea equipment shall include the following:

6.4 Design Requirements

6.4.1 Subsea Hydraulic Systems

6.4.1.2 Multifunction Connections

Replace second sentence in the first paragraph with the following:

- 1. All connections shall be labelled for proper identification.

6.4.1.3 Tubing and Hoses

Add the following to this clause:

- 1. Design shall take into account the vibration and shock loads placed on the tubing and other system components due to functional operation activities.

6.4.1.5 Subsea Accumulators

Add the following at end of second: paragraph:

- 1. (as applicable per the Data Sheet (DEP 37.80.00.90-Gen.)

Add the following to this clause:

- 2. If required by the hydraulic analysis, the Contractor should install accumulators in or on the SCM or on HDM or as tree plug-in module.
- 3. If accumulators are positioned on the outside of the SCM cover, they shall be mounted on the base plate and not interfere with the cover removal/installation and they shall be able to be pre-charged or vented without removal of the cover.

6.4.3 Subsea Electrical Systems

6.4.3.1 Subsea Electrical Distribution System

Replace second sentence in the tenth paragraph with the following:

- 1. Barriers shall be qualified to ensure that they are suitable for operation in seawater.

Add the following to this clause:

- 2. Two communication paths (one per SEM) shall be supplied through two electrical flying leads to the top of the SCM. Each path shall be routed to a dedicated SEM.

3. Electrical conductors shall be rated for 125 % of maximum working voltage and
4. Electrical jumpers shall be permanently identified with a part number on the outer jacket. The ends of the jumper shall be identified (using 15 mm [3/8 in] lettering) with unique connection identification.
5. An indication of when mating connectors are fully seated shall be provided for all wet-mate connectors.
6. Permanently installed electrical jumpers shall be secured with support brackets.

6.4.4 SCM

Replace seventh paragraph with the following:

1. 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 the following to this clause:

2. 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.
3. The SCM shall be provided with two identical subsea electronics modules (SEMs), identified as SEM A and SEM B, with unique addresses, and 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.
4. 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 be qualified for functional mechanical and electrical integrity, fracture and vibration resistance.
5. The SCM shall receive electrical power and communicate with the MCS and sensors on the tree via electrical connectors (Optical communication between the MCS and a subsea optical to electric signal converter is also permitted provided that the aforementioned communication path is also provided). The electrical pin connectors in the SCM shall include boot seals to prevent the ingress of water.
6. 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.
7. 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.
8. Hydraulic fluid from downhole hydraulic functions shall be isolated from the LP return vent circuit.
9. The SCM shall have a minimum of 22 LP functions and 2 HP functions. See Appendix C for SCM component arrangements.
10. If required by the hydraulic analysis, the Contractor may install flow restrictors on the function lines of DCVs. Control system Cv shall fall within the choke maximum rated supply Cv.
11. 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 the following new clause:

6.4.4.1 Enclosure

1. 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 (14.5 psi) of ambient pressure.
2. 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.
3. 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.
4. The outside of the SCM enclosure shall be painted with topcoat of high visibility epoxy paint as applicable per the Data Sheet (DEP 37.80.00.90-Gen.).
5. All label text shall be black against a contrasting colour for maximum visibility.

Add the following new clause:

6.4.4.2 SCM Locking Mechanism

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

Add the following new clause:

6.4.4.3 SCM Compensation System

1. The SCM 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.
2. The compensation system shall have a procedure to validate correct filling and removal of air voids prior to deployment.
3. The bladder shall be qualified to function throughout its design operating conditions.
4. 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.

5. 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 the following new clause:

6.4.4.4 Dielectric Fluid

1. The dielectric fluid shall have acceptable electrical (breakdown voltage capacity) and material compatibility characteristics per SCM Manufacturer's specification.

Add the following new clause:

6.4.4.5 Control Module Receiver Plate

1. The control module receiver plate shall be mounted to the host structure via welding or bolting. 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.

2. 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 to prevent ingress of debris.
3. 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.
4. The receiver plate shall be supplied with a protective cover.
5. The receiver plate shall be permanently marked to indicate the relevant coupler positions.
6. The receiver plate shall be machined from a single piece of stock. (Laminated plates are not allowed.)

Add the following new clause:

6.4.4.6 Directional Control Valves

1. DCVs shall be two-position, three-way solenoid-operated valves.
2. DCVs shall have two electric solenoid coils each powered by a separate pair of wires.
3. In order to provide an additional barrier against contamination, DCV pilot stages shall be fitted with an integral filtration screen.
4. LP and HP DCVs shall be qualified per (9.2.2.7).
5. 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.
6. The DCV unlatch pressure shall be less than the highest pressure for which a subsea valve actuator starts to move.

Add the following new clause:

6.4.4.7 Compensator

1. If required by the hydraulic analysis, 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.
2. The combination of compensator, return line checks valves, and coupler poppets shall ensure a positive pressure in the hydraulic circuit, thus preventing seawater ingress.
3. 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.
4. 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 the total volume.
5. The compensator shall be suitable for forward and reverse pressure compensation without failure.
6. When using HP intensifiers, the volumetric expansion of control fluid in the control line due to the temperature increase at well start-up should be taken into account for the design of the HP compensator.

Add the following new clause:

6.4.4.8 Seals

1. All bolting calculations shall be made using minimum yield material properties.
2. All bolting designs shall prohibit exceeding minimum material yield stresses.

3. It is intended that tubing within the SCM be limited to the connections to the diaphragm accumulators in the return lines.
4. The design of the seals shall consider the following:
 - a. friction and wear increase in hydraulic service;
 - b. seal material compatibility with hydraulic, dielectric fluids and seawater;
 - c. corrosivity of hydraulic, dielectric fluids and seawater.
5. The primary method of sealing hydraulic components/manifolds shall be through the use of seals qualified in the application. Qualification shall be equivalent to API 17D qualification.
6. Seals shall be qualified for compatibility with the fluids that they will be exposed to. (Requirements should reference API 6A seal qualification process.)

Add the following new clause:

6.4.4.9 Wiring

1. Wiring outside of SEM shall be 20-gauge minimum.
2. 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 the following new clause:

6.4.4.10 Pressure Transducers

1. Pressure transducers (PTs) shall be provided on the following:
 - a. the HP consolidated supply line header;
 - b. the LP consolidated supply line header;
 - c. each LP and HP function line;
2. PTs should be provided on both the LP and HP return lines (to assist in troubleshooting).

Add the following new clause:

6.4.4.11 Check Valves

1. The hydraulic circuit shall be protected from seawater ingress at the vent points by the use of either a non-metallic or a corrosion resistant metal check valve.
2. Hydraulic vent line check valve relief setting shall be higher than the relief setting of the SCM dielectric housing check valve.

Add the following new clause:

6.4.4.12 Flowmeters

1. The LP and HP supply and LP return lines shall each have a flowmeter for providing remote indication of flow to the MCS.
2. Supply flowmeters shall be placed downstream of the supply accumulator to measure valve flow and not accumulator recharge flow.

Add the following new clause:

6.4.4.13 Hydraulic Filters

1. In order to protect the hydraulic circuit from solid particle contamination, the supply lines of the SCM shall be fitted with filters.
2. Filters shall be installed on the hydraulic supply lines upstream of all valves.

3. Filters shall be a maximum of 12 μm (0.5 mil). The filters shall be sized to protect the SCM for the design life assuming fluid cleanliness as specified in Data Sheet (DEP 37.80.00.90-Gen., Section 4.4.3.5).

6.4.5 SEM

Add the following new clause:

6.4.5.1 SEM Hardware

1. The SEM hardware design shall provide the level of reliability as applicable per Data Sheet (DEP 37.80.00.90-Gen.).
2. The SEM shall be designed with 50 % additional spare memory capacity for general use.
3. The SEM shall contain (as a minimum) the following:
 - a. printed circuit board with CPU;
 - b. power supply equipment that is also used to distribute power to the external sensors;
 - c. back plane for inter-board communications;
 - d. analogue input (AI) board (with analogue to digital converters) to read 4-20mA sensors;
 - e. digital output (DO) board (with individual control channels) to operate solenoids that allow the opening and closing of valves and stepping of chokes;
 - f. 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;
 - g. modem/filter to communicate to the MCS;
 - h. CPU watchdog to monitor operation of the SEM and report any faults or errors to the MCS;
 - i. memory buffers to store information to be transmitted to the MCS;
 - j. IWIS compliant downhole interface card to operate DHPT gauges. The DHPT interface card manufacturer shall be as specified in Data Sheet (DEP 37.80.00.90-Gen., Section 6.4.5.1).
4. 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.
5. All power handling components shall be de-rated by 25 % of the OEM ratings.
6. The SEM shall, as a minimum, monitor and transmit to the MCS the following:
 - a. SEM internal voltage;
 - b. SEM internal temperature;
 - c. hydraulic supply pressures;
 - d. communication status;
 - e. hydraulic fluid flow volumes;
 - f. hydraulic function/return line pressure;
 - g. SCM water/fluid ingress level.
7. Both SEMs should be capable of acquiring data simultaneously from all transmitters with the exception of the DHPT and MPFM.
8. Qualification testing shall be performed for all models of equipment. The tests shall be carried out in accordance with (9.2.8).

6.4.6 Subsea Software and Configuration

Add the following to this clause:

1. Software shall be strictly controlled in accordance with the Principal's software control procedures, with documented software (and configuration files) version/revision number and release date.
2. The SEM shall have capacity to temporarily store all relevant data gathered from the subsea sensing devices. All fast scan data shall be time stamped in the SEM per Data Sheet (DEP 37.80.00.90-Gen.).
3. The SEM shall be capable of performing sequenced monitoring operations and/or sequenced controlling based on one command from the MCS.
4. The SEM software shall be designed to accommodate the downhole pressure and temperature information.
5. 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.
6. The SEM shall continuously scan all sensors and the data transmitted to the MCS on request.
7. 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.
8. The SEM should have the capability to download software and/or firmware to the attached subsea instrumentation while deployed subsea.
9. Each SEM shall have the capability to send a signal to confirm that a command transmitted from the MCS has been received by the appropriate SEM and has been executed.
10. 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.
11. 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 Data Sheet (DEP 37.80.00.90-Gen.). The profile information shall be sent to the MCS when requested.

6.4.7 Communication Protocol

Add the following to this clause:

1. The communication protocol shall not be sensitive to frequency drift. The message format shall be flexible and suitable for both short and long messages.
2. The communication protocol shall be capable of downloading SEM software in less than four hours.
3. The communication protocol shall provide a means of ensuring the security of the data being transferred.

6.4.8 Subsea Instrumentation

Replace third paragraph with the following:

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

Add the following to this clause:

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

3. The Contractor shall track individual serial numbers for all subsea instrumentation, harnesses, housings, etc., for quality assurance purposes.
4. All subsea instrumentation shall be fabricated of corrosion resistant material and be compatible with the process media and external environment.
5. All subsea instrumentation shall be designed for the water depth and maximum operating working pressures as specified in project Data Sheet (DEP 37.80.00.90-Gen.).
6. All subsea instrumentation shall be provided with electrical harnesses in accordance with (6.4.3.1). Harnesses shall be securely connected to the bottom of the SCM receiver plate, unless specified otherwise.
7. Qualification testing shall be performed per the appropriate section of (9.2.3) for all models of subsea instrumentation, or proof of qualification testing shall be provided to the Principal for approval.
8. 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).
9. Unless specified otherwise, the supply voltage for all subsea instrumentation shall be a nominal 24 VDC from the SCM.
10. The following information shall be provided for all subsea instrumentation:
 - a. inrush current
 - b. maximum input power required
 - c. nominal power required
 - d. input impedance

Add the following new clause:

6.4.8.1 Acoustic Sand Detector (ASD)

1. An acoustic sand detector (ASD), if required, shall detect the presence of solid particles (primarily sand) in the flow path using acoustical energy.
2. 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.
3. 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.
4. The ASD sensor shall be provided with an integral harness assembly or electrical jumper (as 6.4.3.1) with a ROV connector.
5. The electronics should be redundant. The ASD sensor 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.
6. 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 the following new clause:

6.4.8.2 Pressure/Temperature Transmitter

1. A combination pressure and temperature transmitter (PTT), if required, shall measure the pressure and temperature of the subsea process stream on subsea hardware.
2. 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.).

3. Transmitter sensor shall be able to exceed the operating range by $1.5 \times \text{FS}$ without degrading performance.
4. Unless specified otherwise, the pressure transmitter shall have an accuracy of $< \pm 0.03 \% \text{ FS}$ and a drift of $< \pm 0.1 \% \text{ FS} / \text{year } 5^{\circ}\text{C} (9^{\circ}\text{F})$.
5. Unless specified otherwise, the temperature transmitter shall have an accuracy of $< \pm 0.2 \% \text{ FS}$ and a drift of $< \pm 0.1 \% \text{ calibrated range/year } 5^{\circ}\text{C} (9^{\circ}\text{F})$.
6. Measurements shall be transmitted to the SCM via 4-20 mA or a standard industry serial data transfer protocol as specified on Data Sheet (DEP 37.80.00.90-Gen.).
7. PTs and wiring shall have an insulation resistance (with respect to ground) of $> 1 \text{ Gohm}$ at 50 V.
8. Transmitter mounting shall be through a standard DN 50 (NPS 2) nominal API flange.
9. Transmitter qualification testing shall be performed in accordance with (9.2.3.6) or proof of qualification testing shall be provided to the Principal for approval.

Add the following new clause:

6.4.8.3 Single-Phase Flowmeters (SPFM)

1. **Single-phase flowmeters (SPFMs)** shall be venturi or orifice type and use differential pressure to determine flow, unless specified otherwise.
2. Differential pressure transmitters shall be dual barrier/oil filled for hydrocarbon application.

Add the following new clause:

6.4.8.4 Multiphase flowmeter (MPFM)

6.4.8.4.1 General

1. A complete multiphase flowmeter (MPFM) system shall be provided as applicable per the Data Sheet (DEP 37.80.00.90-Gen.) The system shall include the flowmeter with flow computer and software, test unit, and simulator.
2. The MPFM shall be based on existing proven technology and shall be capable of measuring flow regimes based on production profile data provided by the Principal.
3. The MPFM 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.
4. The MPFM shall be capable of operating in the ranges and with an accuracy per the MPFM data sheet referenced in (DEP 37.80.00.90-Gen.).
5. Repeatability shall be within 2 % and drift shall be less than 0.2 % FS / year.
6. Operation of the MPFM shall be automatic and not require operator intervention. The MPFM shall not require recalibrating given unchanged process fluid properties.
7. The Contractor shall identify any and all limitations on the MPFM.
8. MPFM shall be rated for the water depth and expected system pressures.

6.4.8.4.2 Flowmeter

1. The flowmeter shall include completely redundant instrumentation (excluding the densitometer, if used).
2. Differential pressure transmitters shall have dual barriers and be oil filled.

6.4.8.4.3 Flow Computer

1. The flow computer and all associated electronics shall be contained in a sealed enclosure (or canister) suitable for protection against the subsea environment.
2. The enclosure shall be firmly connected to the meter body and be non-retrievable.

3. Two entirely redundant electronics, signal and power systems and connectors shall be provided.
4. Flow computers may be linked together, provided that a failure of one does not affect the other.
5. The flow computer shall have two connections to the SCM using a serial digital interface.

6.4.8.4.4 Software

1. The flow computer shall be provided with all internal software capable of adjusting to each flow regime automatically.
2. Software shall be provided to upgrade, maintain, and configure the MPFM from the surface. A complete operator manual shall be provided.
3. Meter shall be capable of storing and providing historical data for the previous 30 days.

6.4.8.4.5 Test unit

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

6.4.8.4.6 Simulator

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

Add the following new clause:

6.4.8.5 Downhole Pressure and Temperature (DHPT) Gauge

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

Add the following new clause:

6.4.8.6 Erosion Detector (ED)

1. An erosion detector (ED) shall be provided, as required per SCM CV-Sensor Matrix in Data Sheet (DEP 37.80.00.90-Gen., Section 6.4.4).
2. The ED 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).
3. Mounting of the ED shall be through a standard DN 50 (NPS 2) nominal API process flange.

Add the following new clause:

6.4.8.7 Field Signature Method (FSM) Spools

1. **Field signature method (FSM)** spools shall be provided as required per SCM CV-Sensor Matrix in Data Sheet (DEP 37.80.00.90-Gen., Section 6.4.4).

FSM spools are a non-intrusive system that monitors the changes in pipe wall for monitoring pipe internal corrosion and erosion.

2. FSM spools shall be provided with a retrievable electronics module. Power and communications shall be provided via the subsea control module. Configuration and specific project requirements shall be as specified in Data Sheet (DEP 37.80.00.90-Gen., Section 7.4.4).
3. Mounting of FSM spools shall be through standard DN 50 (NPS 2) nominal API process flanges.

6.4.11 Test Equipment

6.4.11.1 General

Replace first paragraph with the following:

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

6.4.11.2 Control Module Test Stand

Add the following to this clause:

1. The control module test stand shall include the following features:
 - a. A skid of robust heavy-duty welded construction suitable for use in an oilfield environment.
 - i. The skid base shall include a self-contained drip pan.
 - ii. The skid shall be provided with forklift slots and lifting pad eyes and be robust enough to prevent damage during lifting. If required, lifting straps, bars or other required lifting devices shall be provided.
 - b. A receiver plate of the same type and style as specified in (7.4.4.2).
 - c. A control panel that contains all valves and pressure gauges required to function test the SCM.
 - d. A hydraulic interface panel 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.
 - e. An electrical interface junction box with cables for the connection of electrical test equipment, such as DHPT simulator.
 - f. Clear labels for all components, such as supply lines, function-lines, valves and gauges.
 - g. Pressure gauges that operate between 25 % and 75 % of full scale for all test applications.
 - h. LP and HP control fluid sample points.

6.4.11.5 Umbilical simulator

Replace first paragraph with the following:

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

Add the following new clause:

6.4.11.8 SCM simulator

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

Add the following new clause:

6.4.11.9 Subsea Power and Communication Test Unit

A subsea power and communication test unit is a portable device that provides electrical power to an umbilical and/or one or more SCMs in addition to the complete functionality of the electronic test unit.

7 Interfaces

7.2 Interface to Host Facility

Add the following to this clause:

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

7.3 Interface to Workover Control System

Delete second sentence in first paragraph.

8 Materials and Fabrication

8.3 Fabrication

8.3.1 Fittings and Connections

Add the following to this clause:

1. NPT threads shall not be used.
2. Use of fittings in the subsea hydraulic system shall be restricted to a minimum. Welded connections shall be used where practical.
3. Fastener pre-load shall be performed using a calibrated torque wrench. Arrangement shall be made for verification that the specified torque has been applied.

8.3.3 Cleanliness

Add the following to this clause:

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

9 Testing

9.1 General

Replace second paragraph with the following:

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

Add the following to this clause:

2. All equipment assemblies produced within the work shall be subject to individual Factory Acceptance Testing (FAT). New equipment designs shall be subjected to formal Qualification Testing (QT). The Principal shall review and approve all FAT and QT procedures.
3. New control systems and certain extended equipment 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.
 - a. Depending on schedule requirements the Principal may only have limited equipment available, however the Contractor shall develop a suitable FIT procedure and lead the work.
 - b. 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 control system or the extended equipment.

4. The Contractor shall participate in SIT of Contractor-supplied equipment within subsea hardware provided by other Suppliers.

The above statements are intended to qualify the Principal's requirements with regard to the Contractor's standard practices for testing.

5. If conflict arises in scope or detail of individual test requirements, the Contractor shall propose solution for the Principal's approval.
6. 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. Test reports including test measurements shall be provided.

9.2 Qualification Testing

9.2.1 General

Replace second sentence in the second paragraph with the following:

1. 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 performs as specified.

Add the following to this clause:

2. Step-by-step procedures with objectives and acceptance criteria shall be available prior to start of each qualification test.
3. Product QT shall be conducted in accordance with sections 307.4 and 307.8 of API 17D, with records provided per section 307.10.
4. Seals shall be qualified for compatibility with the fluids. Seal qualification shall be conducted in accordance with API 6A, Appendix F (minimum 200 system pressure cycles and 200 operation cycles).

9.2.2 Qualification Testing of Hydro-mechanical Components

9.2.2.1 Hydrostatic Pressure Testing (Internal and External)

Replace fifth paragraph with the following:

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

Add the following to this clause:

2. Acceptance criteria for pressure testing shall be as follows:
 - a. No visible leakage
 - b. Pressure drop does not exceed 2% of the test pressure
 - c. Test pressure does not drop below the minimum test pressure requirement
 - d. Measured pressure decay in each 15 minute segment will be lower than the previous segment as follows:
 - i. 15 to 30 minute decay < 0 to 15 minute decay;
 - ii. 30 to 45 minute decay < 15 to 30 minute decay;
 - iii. 45 to 60 minute decay < 30 to 45 minute decay;
 - iv. 60 to 75 minute decay < 45 to 60 minute decay;
 - v. 75 to 90 minute decay < 60 to 75 minute decay;
 - vi. 90 to 105 minute decay < 75 to 90 minute decay;
 - vii. 105 to 120 minute decay < 90 to 105 minute decay.

- e. Total pressure decay for 120 minutes less than 2 %.

9.2.2.7 Cycle Function Testing

Add the following new clause:

9.2.2.7.1 DCVs

1. 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.
2. HP DCVs shall be designed and qualification tested to function for a minimum of 25,000 cycles or as specified in Data Sheet (DEP 37.80.00.90-Gen.) while maintaining original solenoid specification pull in voltage (current), leakage and delatch specifications.

Add the following new clause:

9.2.2.8 SCM

1. Qualification shall meet the requirements of API 17D or its equivalent and shall as a minimum cover the following:
 - 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.
2. Pressure test results shall be recorded with 0.3 bar (5 psi) resolution or better and of a frequency of 1 second or faster.

9.2.3 Qualification Testing of Subsea Electrical and Optical Equipment

9.2.3.1 General

Replace last sentence in third paragraph with the following:

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

9.2.3.3 Definition of Q1 and Q2 Temperature Tests

Add the following to this clause:

1. Temperature should be measured near or on the EUT. If the EUT is in an enclosed container, i.e., SEM can, testing time shall be adjusted to allow for the air inside of the container to heat or cool to the specified test temperature.

Add the following new clause:

9.2.3.5 DHPT Data Acquisition

1. Acceptance criteria pertaining to DHPT data acquisition system is for each hour of data (3600 data points) collected simultaneous from each gauge. There shall be:
 - a. fewer than 180 bad data events;
 - b. no more than 20 double data point events;
 - c. no more than 5 triple data point events;
 - d. zero occurrences of 20 consecutive bad data points;
 - e. test duration is 72 hours.
2. Bad data events shall be 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 the following new clause:

9.2.3.6 Pressure/Temperature Sensors

1. Subsea pressure/temperature sensors shall be qualified in accordance with the test procedures and acceptance criteria in Appendix E.
2. A minimum of three pressure/temperature sensors shall be required to successfully pass this test in order for the sensors to be designated as a qualified product.

Add the following new clause:

9.2.3.7 Differential Pressure Sensors Applicable to MPFM and SPFM Installations

1. A minimum of three DP sensors shall be required to successfully pass this test in order for the sensors to be designated as a qualified product.
2. The subsea DP sensors shall be qualified in accordance with the test procedures and acceptance criteria in Appendix D using the rated line (static) pressure combined with the rated DP pressure as the test pressure.
3. 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 D – section 4). The dynamic DP pressure cycle shall consist of applying and removing the rated dynamic DP for 10 cycles. Cycling of the dynamic DP pressure is to be repeated on the second port also.
4. 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.
5. A minimum of five points covering the entire dynamic DP pressure range shall be recorded for each DP pressure cycle.

Add the following new clause:

9.2.3.8 EPU/SGU

1. Full load test
 - a. Test – Fully populated cabinet, maximum ambient temperature, rated load on each device (passive loads are acceptable), duration should be sufficient to allow operating temperatures within the cabinet to reach steady state, thermocouples/RTDs placed throughout cabinet. At least one TPU shall be operated with its full complement of SEMs
 - b. Pass criteria – No component failure, no loss of communication between MCS, SGU and SCM, maximum temperature rise within the cabinet does not exceed 50 °C (90 °F).

2. Input voltage test
 - a. Test – Fully populated cabinet, rated load on each SGU, nominal ambient temperature (20 °C (68 °F)), supply voltage decreased from nominal voltage (230VAC) by -10%, held for 1 hour then increased back to the nominal voltage + 5% and held for a further hour. The transformers should be tapped to the lowest setting for the low voltage test and the highest voltage setting for the high voltage test. Passive loads are permitted (i.e. resistors) but shall be powered via the normal power supplies used to power the SEM.
 - b. Pass criteria – No abnormal functionality, no current trips
3. Impulse voltage test (input)
 - a. Test – fully populated cabinet, 10 +ve followed by 10 –ve voltage spikes at 5.5 times UN at the input to the EPU/SGU, per procedures given in IEC 60230
 - b. Pass criteria – No equipment damage Surge suppressors shall be replaced after this test.
4. Impulse voltage test (output)
 - a. Test – Apply 10 +ve followed by 10 –ve voltage spikes at 5.5 times maximum rated output on the output side of the EPU/SGU, as per procedures given in IEC 60230
 - b. Pass criteria – No equipment damage Surge suppressors shall be replaced after this test.
5. Short circuit testing (over current)
 - a. Test – Apply short circuit to the output of the EPU/SGU and monitor time taken for trip to occur for umbilical lengths of 0 km, 10 km, 20 km and 40 km
 - b. Pass criteria – EPU/SGU trips within acceptable limit, no damage to the EPU/SGU output
6. Over current protection
 - a. Test – Set the high current limit to an appropriate level and increase load until trip occurs
 - b. Pass criteria – EPU/SGU trips within 5% of trip threshold
7. Insulation resistance testing
 - a. Test – Assuming all other breakers in the cabinet, external to the EPU/SGU, are certified, apply ever decreasing resistance values between one conductor and ground for umbilical lengths of 0 km (0 mi), 10 km (6.2 mi), 20 km (12.4 mi) and 40 km (24.9 mi).
 - b. Pass criteria – Ground fault reported appropriately and alarms as expected
8. Under voltage protection
 - a. Test – EPU/SGU , Set the low voltage limit to an appropriate level and increase load until trip occurs.
 - b. Pass criteria – EPU/SGU trips within 5% of trip threshold
9. Over voltage protection
 - a. Test – EPU/SGU, Set the high voltage limit to an appropriate level and reduce load until trip occurs.
 - b. Pass criteria – EPU/SGU trips within 5% of trip threshold
10. Brownout test
 - a. Test – Fully populated cabinet, preferably fully loaded, Reduce input voltage until all SGUs turn off, wait for 1 s, then raise the voltage to the nominal value,

reduce input voltage again until all SGUs turn off, repeat for a total of 10 on/off cycles.

- b. Pass criteria – After brownout condition, cabinet and SGU power is re-energized, but subsea EPU power output remains de-energized.

11. EMC immunity test

- a. Test – Per IEC 60533 where applicable, Test shall include two-way radios and radar.
- b. Pass criteria – Compliance to the standard

12. Power cycling

- a. Test – Fully populated cabinet, preferably fully loaded, Cycle power via main incomer 50 times. System must be allowed to reach stable operating condition, i.e., fully booted up and communicating to MCS/SCM prior to disconnecting power. Test should be repeated with just one EPU and its associated SGUs.
- b. Pass criteria – No abnormal functionality

13. Redundant power switch over test

- a. Test – All power supplies that have redundant power capability
- b. Pass criteria – No loss of functionality on loss of primary power, i.e., back-up or redundant supply switches in sufficiently quickly to prevent loss of functionality

14. Loss of cooling test

- a. Test – Fully populated cabinet, fully loaded, nominal ambient temperature (20 °C (68 °F)), Monitor temperatures throughout the cabinet whilst exhaust and intake fans are turned off (one by one)
- b. Pass criteria – High temperature alarms raised within sufficient time to prevent a trip (sufficient time defined as 30 minutes for an operator to respond). Dependent on fan configuration and power supplies, any loss of one component should not cause internal component temperatures to exceed the 90°C or any part of the EPU to trip.

9.3 Factory Acceptance Tests (FATs)

9.3.1 General

Add the following to this clause:

1. Hydraulic testing shall be performed on the fully assembled hydraulic circuit with testing to the proof test.
2. Hydraulic 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.
3. As a minimum, during the complete FAT, attention shall be paid to DCV stroke travel settings.

9.3.2 Hydraulic Systems and Components

9.3.2.2 Internal Leakage Testing

Replace second and third sentence in the first paragraph with the following:

1. Testing 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.

Replace first sentence in first bulleted item with the following:

2. Pressure decay shall be monitored and recorded using a gauge with 0.3 bar (5 psi) or better resolution.

Add the following to this clause:

3. When measuring leakage of ganged devices such as DCVs, the maximum acceptable leakage rate shall be the mean of the individual DCV FAT results multiplied by the number of DCVs within the SCM.

9.3.2.3 Function and Continuity

Replace second paragraph with the following:

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

Add the following to this clause:

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

9.3.2.5 Fluid Flushing

Add the following to this clause:

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

9.3.3 Subsea Electrical and Optical Systems and Equipment

9.3.3.3 ESS Vibration Test Sequence

Replace last sentence in next to last paragraph with the following:

1. 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.

9.3.4 Other Testing That May Be Required

9.3.4.2 Integrated System Tests

Replace first sentence with the following:

1. An integrated system test shall be performed as specified on Data Sheet (DEP 37.80.00.90-Gen.).

Add the following to this clause:

2. The testing shall include the tree sensors, acoustic sand detector, MPFM, downhole DHPT gauges, SCM and MCS (as applicable).
3. Emphasis shall be placed on testing system functionality that was not tested during FAT (such as the operation of the choke) (if applicable).
4. The testing shall validate the required update rates for DHPT, ASD, tree/manifold/sled sensors and MPFM data.
5. Record the actual response time and profile of subsea actuators (if applicable).

Add the following new clause:

9.3.4.3 Additional MCS FAT requirements

1. General
 - a. All testing shall be carried out to demonstrate the full functionality of the equipment.
 - b. MCS functional software and MCS configuration software versions used during the FAT shall be recorded in the FAT test results.

2. Visual Inspection
 - a. 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.
 - b. All drawings shall be checked for accuracy, corrected and recorded with the FAT results.
3. Power On Test
 - a. Test power input to the main breaker of the MCS distribution panel from the UPS.
 - b. Each breaker shall be individually turned on and power verified in each branch circuit up to the rated load.
4. Communication Test
 - a. The purpose of the communication test is to verify that the MCS communicates with other components.
5. Functionality Testing
 - a. Any and all functionality as stated in the equipment functional design requirements (FDR) or functional design specifications (FDS).
6. Software Tests
 - a. Project software shall be loaded in accordance with the Contractor's written procedures (including PC operating system).
 - b. MCS functional software and MCS configuration software versions used during the FAT shall be recorded in the FAT test report.

Add the following new clause:

9.3.4.4 Additional EPU FAT requirements

1. All testing shall be carried out to demonstrate the full functionality of the equipment.
2. Visual Inspection
 - a. 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.
3. Power On Test
 - a. Test power input to the main breaker of the EPU distribution panel from the UPS.
 - b. Each breaker shall be individually turned on and power verified in each branch circuit up to the load.
4. Protective Devices Test
 - a. 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.
5. Power Transformer Test
 - a. Transformers shall be tested for insulation resistance (line to ground) prior to energizing. The resistance shall be greater than 1 GΩ.
 - b. 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).

6. EPU-SCM Communication Test
 - a. The purpose of the EPU-SCM communication test is to verify that the modems enable the EPU to communicate with the SCM simulator.
 - b. 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.
 - c. This test shall be performed for each transformer/modem pair.
7. ETU-SCM Communication Test
 - a. The purpose of ETU-SCM communication test is to verify that the modems enable the ETU to communicate with the SCM simulator.
 - b. 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.
 - c. This test shall be performed for each transformer/modem pair.

Add the following new clause:

9.3.4.5 Additional HPU FAT Requirements

1. General
 - a. Testing shall be carried out to demonstrate the full functionality of the equipment.
 - b. All testing shall be carried out with test equipment rated for the working pressure ranges of the HPU.
 - c. Fluid samples shall be taken each day during testing. Include particle count reports in FAT report.
2. Visual Inspection
 - a. 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 corrected and recorded with the FAT report.
 - b. The inspection shall demonstrate that the HPU provides the specified pressure output over the full flow rate range
3. Software Tests
 - a. Project software shall be loaded in accordance with the Contractor's written procedures.
 - b. HPU PLC functional software and HPU PLC configuration software versions used during the FAT shall be recorded in the FAT test report.
4. ESD Testing
 - a. ESD signal shall be sent to verify the pumps are stopped and the supply line pressures are vented.
5. Relief Valve Testing
 - a. All relief valves shall be tested to demonstrate that they vent at the specified pressures.

Add the following new clause:

9.3.4.6 Additional SCM FAT Requirements

1. General
 - a. Testing may use the electronic test unit if the MCS is not available.
 - b. All testing shall be carried out with test equipment rated for the design ranges of the SCM. SCM shall be tested on the control module test stand (where applicable).
 - c. Fluid samples shall be taken each day during testing. Include particle count reports in FAT report.
 - d. Testing shall be carried out to demonstrate the full functionality of the equipment.
2. Visual Inspection
 - a. Visually inspect the SCM 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 corrected and recorded with the FAT report.
 - b. Visual inspection for leaks shall be made during testing.
3. Software Tests
 - a. SCM shall automatically reply to the ETU request.
 - b. Project software shall be loaded in accordance with the Contractor's written procedures. Duration time to download to an SEM shall be noted.
 - c. SCM functional software and SCM configuration software versions used during the FAT shall be recorded in the FAT report.
4. Functional Tests
 - a. All SCM functionality shall be tested.
 - b. Functional tests shall be repeated for each SEM individually. Functional tests shall be performed while simulating the failure of one of the SEMs.
5. Hyperbaric Tests
 - a. Each SCM shall be tested to demonstrate its functionality during its hyperbaric test as part of the SCM FAT.

Add the following new clause:

9.3.4.7 Additional subsea instrumentation FAT requirements

1. General
 - a. Testing may use the electronic test unit if the SCM or MCS is not available.
 - b. All testing shall be carried out with test equipment rated for the design ranges of the subsea sensor.
 - c. Testing shall be carried out to demonstrate the full functionality of the equipment.
2. Electrical Test
 - a. IR testing shall be performed. Acceptance criteria is > 1 Gohm. Test voltage shall be specified in Manufacturers FAT procedure.
3. Communication Test
 - a. Sensor shall automatically reply to the ETU request.

4. Hyperbaric Tests

- a. Each subsea instrument shall be tested to demonstrate its functionality during its hyperbaric test.

9.4 Documentation

Add the following to this clause:

1. All reports and procedures shall be provided in electronic format.

Add the following new clause:

9.5 Inspection and Test Plan Requirements

1. As a minimum the equipment inspection and test plan shall be performed as specified in Appendix G (as applicable).

10 Marking, Packaging, Storage, and Shipping

10.1 Marking

10.1.1 Component identification

Add the following to this clause:

1. All assemblies shall be marked or tagged with the Manufacturer's name, part name, part number, weight and serial number.
2. All surface mounted components shall be labelled, and the following shall apply:
 - a. All labels except danger labels are engraved with black characters on a white background; with engrave lettering a minimum of 5 mm (3/16 in) high.
 - b. Danger labels are engraved with white characters on a red background, with engrave lettering a minimum of 5 mm (3/16 in) high.
 - c. Labels are 3-ply phenolic and constructed of materials 3 mm (1/8 in) thick
 - d. Label edges are bevelled at 45°
 - e. Labels are mounted with aluminium screws.
 - f. Any unused modules are labelled "Spare" (e.g., Spare No. 1)
3. Wire tags/markers shall be labelled at both ends indicating the destination of the wire. Tags/markers shall be permanent heat shrink PVC or polyolefin that has a non-slip grip on the conductor insulation. The markers shall be white with black typed characters (e.g., TB1-01).
4. The Contractor shall ensure that the goods, and components of the goods if different entities manufacture such components, are clearly and permanently marked with the Manufacturer's name, trademark or distinguishing mark which clearly identifies the Manufacturer. In addition, if the Contractor is not the Manufacturer, the Contractor shall ensure that the goods are, without infringing third parties' rights, clearly and permanently marked as having been supplied by the Contractor to the Principal.
5. The Contractor shall ensure that prior to delivery, the goods and all components are marked in accordance with the provisions of the contract.
 - a. If the contract makes no provision for marking, the goods or any components shall not (without the prior written consent of the Principal) be marked with the name, badge or any other mark used exclusively by the Principal.
 - b. Any goods or components marked with Principal exclusive markings shall not be disposed of to any third party without the prior written consent of the Principal unless such markings are first erased to the satisfaction of the Principal.