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Petroleum and natural gas industries — Design and operation of subsea production systems —

Part 6: Subsea production control systems

Industries du pétrole et du gaz naturel — Conception et fonctionnement des systèmes de production immergés —

Partie 6: Commandes pour équipements immergés

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this part of ISO 13628 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

International Standard ISO 13628-6 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

ISO 13628 consists of the following parts, under the general title *Petroleum and natural gas industries — Design and operation of subsea production systems*:

— *Part 1: General requirements and recommendations*

— *Part 2: Flexible pipe systems for subsea and marine applications*

— *Part 3: Through flowline (TFL) systems*

— *Part 4: Subsea wellhead and tree equipment*

— *Part 5: Subsea control umbilicals*

— *Part 6: Subsea production control systems*

— *Part 7: Workover/completion riser systems*

— *Part 8: Remotely Operated Vehicle (ROV) interfaces on subsea production systems*

— *Part 9: Remotely Operated Tool (ROT) intervention systems*

Annex C forms a normative part of this part of ISO 13628. Annexes A, B and D are for information only.

Introduction

Description of hardware is included in this part of ISO 13628 to illustrate functional requirements. This part of ISO 13628 should not be interpreted in a way which would limit new solutions with documented improved life-cycle benefits.

Petroleum and natural gas industries — Design and operation of subsea production systems —

Part 6: Subsea production control systems

1 Scope

This part of ISO 13628 is applicable to design, fabrication, testing, installation and operation of subsea production control systems.

This part of ISO 13628 covers surface control system equipment, subsea-installed control system equipment and control fluids. This equipment is utilized for control of subsea production of oil and gas and for subsea water and gas injection services. Where applicable, this part of ISO 13628 may be used for equipment on multiple-well applications.

NOTE Typical main elements of a subsea production control system are described in 5.1.1.

This part of ISO 13628 establishes design standards for systems, subsystems, components and operating fluids in order to provide for the safe and functional control of subsea production equipment.

This part of ISO 13628 contains various types of information related to subsea production control systems. They are:

— informative data which provide an overview of the architecture and general functionality of control systems for the purpose of introduction and information;

— basic prescriptive data which must be adhered to by all types of control system;

— selective prescriptive data which is control-system-type sensitive and need only be adhered to when it is relevant;

— optional data or requirements which need only be adopted when considered necessary either by the purchaser or the vendor.

In view of the diverse nature of the data provided, control system purchasers and specifiers are advised to select from this part of ISO 13628 only the provisions needed for the application at hand. Failure to adopt a selective approach to the provisions contained herein can lead to overspecification and higher purchase costs.

Downhole intelligent well-control equipment is beyond the scope of this part of ISO 13628.

Rework and repair of used equipment are beyond the scope of this part of ISO 13628.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 13628. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 13628 are encouraged to investigate the

possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 4406:1987, *Hydraulic fluid power — Fluids — Method for coding level of contamination by solid particles*.

ISO 6073, *Hydraulic fluid power — Petroleum fluids — Prediction of bulk moduli*.

ISO 10432, *Petroleum and natural gas industries — Down hole equipment — Subsurface safety valve equipment.*

ISO 13628-5, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 5: Subsea control umbilicals*.

EN 287-1 + A1, *Approval testing of welders — Fusion welding — Part 1: Steels (Amendment A1:1997 included)*.

EN 287-2 + A1, *Approval testing of welders — Fusion welding — Part 2: Aluminium and aluminium alloys (Amendment A1:1997 included)*.

EN 288 (all applicable parts), *Specification and approval of welding procedures for metallic materials*.

ANSI/ASME B31.3, *Process Piping*.

API RP 14H, *Installation, Maintenance and Repair of Surface Safety Valves and Underwater Safety Valves Offshore*.

API Spec 6A, *Wellhead and Christmas Tree Equipment*.

API Spec 17D, *Subsea Wellhead and Christmas Tree Equipment*.

ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, *Rules for Construction of Pressure Vessels*.

ASME Boiler and Pressure Vessel Code, Section IX, *Welding and Brazing Qualifications*.

ASTM D92, *Test Method for Flash and Fire Points by Cleveland Open Cup*.

ASTM D445, *Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity)*.

ASTM D471, *Test Method for Rubber Property — Effect of Liquids*.

ASTM D665, *Test Method for Rust Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water*.

ASTM D892, *Test Method for Foaming Characteristics of Lubricating Oils*.

ASTM D1293, *Test Methods for pH of Water*.

ASTM D1889, *Test Methods for Turbidity of Water*.

ASTM D2596, *Test Method for Measurement of Extreme-Pressure Properties of Lubricating Grease (Four-Ball Method)*.

ASTM D4006, *Test Method for Water in Crude Oil by Distillation*.

BS 7201-1, *Hydraulic fluid power — Gas-loaded accumulators — Part 1: Specification for seamless steel accumulator bodies above 0,5 L water capacity*.

BS 7201-2, *Hydraulic fluid power — Gas-loaded accumulators — Part 2: Dimensions of gas ports*.

IP 280, *Petroleum Products and Lubricants — Determination of Oxidation Stability*.

NAS 1638-64, *National Aerospace Standard — Cleanliness Requirements of Parts Used in Hydraulic Systems*.

3 Terms and definitions

For the purposes of this part of ISO 13628, the following terms and definitions apply.

3.1
boost
pressure maintained on the spring-return side of a subsea actuator for the purposes of improving closing-time response

3.2
commanded closure
closure of the underwater safety valve and possibly other valves depending on the control system design

NOTE Such commands may originate manually, automatically or as part of an ESD.

3.3
control path length
CPL
total distance that a control signal (electrical or hydraulic) travels to the subsea control module or valve actuator

3.4
design pressure
rated working pressure
pressure which is equal to or greater than the maximum service conditions, and for which all components are rated

3.5
direct hydraulic control
control method wherein hydraulic pressure is applied through an umbilical line to act directly on a subsea valve actuator

NOTE Upon venting of the pressure at the surface, the control fluid is returned through the umbilical to the surface due to the action of the restoring spring in the valve actuator. Subsea functions may be ganged together to reduce the number of umbilical lines.

3.6
downstream
direction away from the source of pressure or flow

3.7
electrohydraulic control
control method wherein electrical signals are conducted to the subsea system and used to open or close electrically-controlled hydraulic control valves

NOTE Hydraulic fluid is locally sourced and acts on the associated subsea valve actuator. "Locally sourced" may mean locally stored pressurized fluid or fluid supplied by a hydraulic umbilical line. With electrohydraulic control systems, data telemetry (readback) is readily available at high speed. Multiplexing of the electrical signals reduces the number of conductors in the electrical umbilical.

3.8
hydrostatic test pressure
proof pressure
maximum test pressure at a level greater than the design pressure (rated working pressure)

3.9
minimum operating pressure
lowest operating pressure, at any point in the system, during normal conditions at which the system can operate effectively

3.10
offset
horizontal component of CPL

3.11
response time
sum of the signal time and the shift time

3.12
running tool
tool used to operate, retrieve, position or connect subsea equipment remotely from the surface

NOTE An example is the subsea control-module running tool.

3.13
shift time
period of time elapsed between the arrival of a control signal at the subsea location and the completion of the control function execution

NOTE Of primary interest is the time to fully stroke, on a subsea tree, a master or wing valve that has been designated as the underwater safety valve.

3.14
signal time
period of time elapsed between the remote initiation of a control command and the initiation of a control function operation subsea

3.15
subsea production control system
control system operating a subsea production system during production operations

3.16
surface-controlled subsurface safety valve
SCSSV
safety device that is located in the production bore of the well tubing below the subsea wellhead, and that will close upon loss of hydraulic pressure, as defined in ISO 10432

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 Level 0.

3.17
surface safety valve
SSV
safety device that is located in the production bore of the well tubing above the wellhead (platform well), or at the point of subsea well production embarkation onto a platform, as defined in API RP 14H, and that will close upon loss of hydraulic pressure

3.18
umbilical
group of electric cables, hoses or steel tubes, either on their own or in combination (or with optical fibre cables), cabled together for flexibility and oversheathed and/or armoured for mechanical strength

3.19
underwater safety valve
USV
safety valve assembly that is declared to be the USV as defined in API RP 14H and will close upon loss of hydraulic pressure

3.20
upstream
direction towards the source of pressure or flow

4 Abbreviated terms

ANSI	American National Standards Institute
API	American Petroleum Institute
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BER	bit error rate
cfu	colony-forming units
CIGRE	International Conference on Large Electrical Systems
CIU	chemical injection unit
CPL	control path length
CRC	cyclic redundancy check
DCS	distributed control system
DCV	directional control valve
DHPT	downhole pressure and temperature
EPU	electrical power unit
ESD	emergency shutdown
EXT	extended
FAT	factory acceptance test
FMECA	failure mode effect and criticality analysis
HIPPS	high integrity pipeline protection system
HP	high pressure
HPU	hydraulic power unit
IEC	International Electrotechnical Commission
IP	Institute of Petroleum
LP	low pressure
MCS	master control station
MEA	malt extract agar
MIL-STD	Military Standard
NAS	National Aerospace Standard Institute
NBR	natural buna rubber
NPT	national pipe thread
PARCOMS	Paris Commission
PC	personal computer
PREP	preparation

PSD	process shutdown
PTFE	polytetrafluoroethylene
QA	quality assurance
ROV	remotely operated vehicle
SCM	subsea control module
SCSSV	surface-controlled subsurface safety valve
SEM	subsea electronic module
SSV	surface safety valve
STD	standard
TAN	total acid number
TBN	total base number
THPU	test hydraulic power unit
TSA	tryptone soya agar
UPS	uninterruptible power supply
USV	underwater safety valve
VAC	volts alternating current
VDU	video display unit

5 System requirements

5.1 General requirements

5.1.1 General

The main elements of a subsea production control system typically include the following:

a) **hydraulic power unit (HPU);**
The HPU provides a stable and clean supply of hydraulic fluid to the remotely operated subsea valves. The fluid is supplied via the hydraulic umbilical, the subsea hydraulic distribution system, and the SCMs to operate subsea valve actuators.

b) **master control station (MCS);**
The MCS may be the central control "node" containing application software required to control and monitor the subsea production system and associated topside equipment such as the HPU and EPU.

c) **distributed control system (DCS);**
The DCS can perform the same functions as an MCS, but with a decentralized configuration.

d) **electrical power unit (EPU);**
The EPU supplies electrical power at the desired voltage and frequency to the subsea users. Power transmission is performed via the electrical umbilical and the subsea electrical distribution system.

e) **modem unit;**
This unit modulates communication signals for transmission to and from the applicable subsea users.

f) **uninterruptible power supply (UPS);**
The UPS is typically provided to ensure safe and reliable electrical power to the subsea production control system.

g) **umbilical;**
The umbilical(s) transfers electrical power and signals, hydraulic power, and/or chemicals to the subsea components of the subsea production system. Signals may be transmitted via power cable (signal on power), signal cable or fibre optic.

h) **subsea control module (SCM);**
In a piloted-hydraulic, electrohydraulic or electric control system, the SCM is the unit which upon command from the MCS directs hydraulic fluid to operate subsea valves. In an electrohydraulic system the SCM also gathers information from sensors located subsea and transmits the sensor values to the topside facility.

i) **subsea distribution systems;**
Distribution systems distribute electrical, hydraulic and chemical supply from the umbilical termination(s) to the subsea trees, manifold valves, injection points, and the control modules of the subsea production control system.

j) **subsea located sensors;**
Sensors located in the SCMs, or on subsea trees or manifolds, provide data to help monitor operation of the subsea production system.

k) **control fluids;**
Oil-based or water-based liquids that are used to convey control and/or hydraulic power from the surface HPU or local storage to the SCM and subsea valve actuators.

l) **control buoy.**
A moored buoy housing generation, communication and chemical injection (optional) equipment. The buoy is connected to the subsea components of the subsea production system via an electrical/fibre optic/hydraulic control umbilical. The buoy can communicate with the surface production facility via acoustic, radio or satellite links or a combination thereof.

This part of ISO 13628 covers all systems, both hydraulic and electrohydraulic. Only the relevant clauses should be used.

5.1.2 Service conditions

5.1.2.1 Suitability for working environment

The subsea control system shall be designed and operated with consideration for the external environment. For surface facilities, this will include climatic conditions, corrosion, marine growth, tidal forces, illumination, and hazardous area classifications. For the subsea environment, this will include corrosion, ambient pressure and temperature, and maintenance considerations.

Product designs shall be capable of withstanding design pressure (rated working pressure) at rated temperature without degradation, exceedance of allowable stresses, or impairment of other performance requirements for the design life of the system.

5.1.2.2 Pressure ratings

5.1.2.2.1 General

The design shall take into account the effects of pressure containment and other pressure-induced loads. Specialized conditions shall also be considered, such as pressure rating changes in system and component interfaces (such as subsea control module to receiver plate, umbilical to tree-mounted terminations) and pressurizing with temporary plugs and caps installed. The effects of external loads (i.e. bending moments, tension), ambient hydrostatic loads and fatigue shall be considered.

Hydraulic systems shall have a maximum allowable operating pressure at least 10 % below design pressure (rated working pressure).

5.1.2.2.2 Hydraulic control components

Hydraulic control components other than for SCSSV circuits shall have design pressures (rated working pressures) of 10,3 MPa, 20,7 MPa or 34,5 MPa (1 500 psi, 3 000 psi or 5 000 psi) or according to the manufacturer's written specification. Hydraulic control circuits for SCSSVs shall have a design pressure (rated working pressure) in accordance with the manufacturer's written specification.

5.1.2.2.3 Other equipment

The design pressure (rated working pressure) of other equipment such as running, retrieval and test tools shall comply with manufacturer's written specifications.

5.1.2.3 Temperature ratings (surface-installed equipment)

5.1.2.3.1 Without controlled environment

Surface-installed equipment covered by this part of ISO 13628 and not installed in a controlled environment shall be designed, tested, operated and stored in accordance with the temperature ratings listed in Table 1.

Table 1 — Temperature rating — Surface-installed equipment without controlled environment

	Electronics		System	
	°C	(°F)	°C	(°F)
Design				
a) Standard	0 to 40	(32 to 104)	0 to 40	(32 to 104)
b) Extended	– 18 to 70	(0 to 158)	– 18 to 40	(0 to 104)
Operate				
a) Standard	0 to 40	(32 to 104)	0 to 40	(32 to 104)
b) Extended	– 5 to 40	(23 to 104)	– 5 to 40	(23 to 104)
Store	– 18 to 50	(0 to 122)	– 18 to 50	(0 to 122)

Temperatures relate to environment, not individual components.

Equipment shall be marked in accordance with 12.1.2.

5.1.2.3.2 Controlled environment

Surface-installed equipment covered by this part of ISO 13628, and installed in a controlled environment, shall be designed, tested, operated and stored in accordance with temperature ratings compatible with the specified controlled environment.

Packaged assemblies or components that are restricted for use in a controlled environment shall be appropriately marked in accordance with the provision of 12.1.3.

5.1.2.4 Temperature ratings (subsea-installed equipment)

Subsea-installed equipment covered by this part of ISO 13628 shall be designed, tested, operated and stored in accordance with the temperature ratings listed in Table 2.

Table 2 — Temperature rating — Subsea-installed equipment

	Electronics		System	
	°C	(°F)	°C	(°F)
Design				
a) Standard	– 10 to 70	(14 to 158)	0 to 40	(32 to 104)
b) Extended	– 18 to 70	(0 to 158)	– 18 to 40	(0 to 104)
Test				
a) Standard	– 10 to 40	(14 to 104)	N/A	N/A
b) Extended	– 18 to 40	(0 to 104)		
Operate				
a) Standard	0 to 40	(32 to 104)	0 to 40	(32 to 104)
b) Extended	– 5 to 40	(23 to 104)	– 5 to 40	(23 to 104)
Store	– 18 to 50	(0 to 122)	– 18 to 50	(0 to 122)

Temperatures in Table 2 relate to environment, not individual components. Subsea sensors which monitor produced or injected fluid may operate outside the ranges given; they shall be rated accordingly.

Equipment shall be marked in accordance with 12.1.2.

5.1.2.5 Storage/test temperature recommendations

If subsea-installed or surface-installed equipment is to be stored or tested on the surface at a temperature outside its temperature rating, then the manufacturer should be contacted to determine if special storage or surface testing procedures are recommended. Manufacturers shall document any such special storage or surface testing considerations.

5.1.2.6 External hydrostatic pressure

In subsea applications, external hydrostatic pressure may be higher than internal system pressure. This external loading situation shall be considered, especially relative to seal design, self-sealing couplings and one-atmosphere enclosures. Umbilical collapse during installation and in service should also be considered.

5.1.2.7 Fluid compatibility

Components shall be selected considering compatibility with both control fluid and chemical injection fluid.

5.1.3 Hydraulic system

5.1.3.1 Hydraulic fluid

Selection of hydraulic fluid shall consider the maximum temperature and pressure to which the hydraulic fluid can be exposed in the well. All parts and components in the system shall be compatible with the selected fluid. Reference should be made to annex A.

5.1.3.2 Cleanliness

The hydraulic fluid-wetted portion of the control system shall be prepared to a cleanliness level as defined in NAS 1638 or ISO 4406. The selected level shall be clearly identified in the manufacturer's written system specification and shall be demonstrated during the testing of the system.