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

Part 6: Subsea production control systems

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Industries du pétrole et du gaz naturel — Conception et exploitation 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 2.

The main task of technical committees is to prepare International Standards. 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 document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

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*.

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This second edition cancels and replaces the first edition (ISO 13628-6:2000) which has been technically revised.

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

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— *Part 1: General requirements and recommendations*

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

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

— *Part 4: Subsea wellhead and tree equipment*

— *Part 5: Subsea umbilicals*

— *Part 6: Subsea production control systems*

— *Part 7: Completion/workover riser systems*

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

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

— *Part 10: Specification for bonded flexible pipe*

— *Part 11: Flexible pipe systems for subsea and marine applications*

Part 12 on dynamic production risers is in preparation.

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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 can be used for equipment on multiple-well applications.

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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.

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

- informative data that provide an overview of the architecture and general functionality of control systems for the purpose of introduction and information;
- basic prescriptive data that shall be adhered to by all types of control system;
- selective prescriptive data that are control-system-type sensitive and shall be adhered to only when they are relevant;
- optional data or requirements that need be adopted only 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.

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

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2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3722, *Hydraulic fluid power — Fluid sample containers — Qualifying and controlling cleaning methods*

ISO 4406:1999 *Hydraulic fluid power — Fluids — Method for coding the level of contamination by solid particles*

ISO 7498 (all parts), *Information processing systems — Open Systems Interconnection — Basic Reference Model*

ISO 9606-1, *Approval testing of welders — Fusion welding — Part 1: Steels*

ISO 9606-2, *Qualification test of welders — Fusion welding — Part 2: Aluminium and aluminium alloys*

ISO 10423, *Petroleum and natural gas industries — Drilling and production equipment — Wellhead and christmas tree equipment*

ISO 10945, *Hydraulic fluid power — Gas-loaded accumulators — Dimensions of gas ports*

ISO/TR 10949, *Hydraulic fluid power — Component cleanliness — Guidelines for achieving and controlling cleanliness of components from manufacture to installation*

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ISO 13628-4, *Petroleum and natural gas industries — Design and operation of subsea production systems — Part 4: Subsea wellhead and tree equipment*

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

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ISO 15607, *Specification and qualification of welding procedures for metallic materials — General rules*

ISO 15609-2, *Specification and qualification of welding procedures for metallic materials — Welding procedure specification — Part 2: Gas welding*

ISO 15610, *Specification and qualification of welding procedures for metallic materials — Qualification based on tested welding consumables*

ISO 15611, *Specification and qualification of welding procedures for metallic materials — Qualification based on previous welding experience*

ISO 15612, *Specification and qualification of welding procedures for metallic materials — Qualification by adoption of a standard welding procedure*

ISO 15613, *Specification and qualification of welding procedures for metallic materials — Qualification based on pre-production welding test*

ISO 15614-1, *Specification and qualification of welding procedures for metallic materials — Welding procedure test — Part 1: Arc and gas welding of steels and arc welding of nickel and nickel alloys*

ISO/TS 16431, *Hydraulic fluid power — Assembled systems — Verification of cleanliness*

ANSI/ASME B31.3, *Process Piping*

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

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

ASTM D97, *Standard Method for Pour Point of Petroleum Products*

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

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

ASTM D665:2003, *Standard Test Method for Rust Preventing Characteristics of Inhibited Mineral Oil in the Presence of Water*

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

ASTM D1141, *Standard Practice for the Preparation of Substitute Ocean Water*

ASTM D1298, *Standard Test Method for Density, Relative Density (Specific Gravity), or API Gravity of Crude Petroleum and Liquid Petroleum Products by Hydrometer Method*

ASTM D2625, *Standard Test Method for Endurance (Wear) Life and Load-Carrying Capacity of Solid Film Lubricants (Falex Pin and Vee Method)*

ASTM D2670, *Standard Test Method for Measuring Wear Properties of Fluid Lubricants (Falex Pin and Vee Block Method)*

ASTM D3233, *Standard Test Methods for Measurement of Extreme Pressure Properties of Fluid Lubricants (Falex Pin and Vee Block Methods)*

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ASTM G1:2003, *Standard Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens*

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

DIN 41612-2, *Special contacts for multi two-part connectors; concentric contacts (type C)*

IEC 61892 (all parts), *Electrical installations of ships and of mobile and fixed offshore units*

Internet RFC 791, *Internet Protocol, http://www.faqs.org/rfcs/rfc791.html*

Internet RFC 793, *The Transmission Control Protocol (TCP), http://www.faqs.org/rfcs/rfc793.html*

Internet RFC 1332, *The PPP Internet Protocol Control Protocol (IPCP), http://www.ietf.org/rfc/rfc1332.txt*

Internet RFC 1661, *The Point-to-Point Protocol (PPP), http://www.faqs.org/rfcs/rfc1661.html*

IP 34*, Determination of flash point Pensky-Martens closed cup method*

IP 135:2005, *Determination of rust-preventing characteristics of steam-turbine oil in the presence of water*

3 Terms and definitions

For the purposes of this document, 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

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

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

3.3
control path
total distance that a control signal (e.g. electrical, optical, hydraulic) travels from the topside control system to the subsea control module or valve actuator

3.4
design pressure
maximum pressure for which the system or component was designed for continuous usage

3.5
design life
specified operational life of system after pre-delivery test

3.6
diagnostic data
data provided to monitor the condition of the downhole equipment

NOTE Can include the ability to make (engineering) adjustments.

3.7
direct hydraulic control
control method wherein hydraulic pressure is applied through an umbilical line to act directly on a subsea valve actuator

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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.

3.8
downstream
away from a component in the direction of flow

3.9
electrohydraulic control
control method wherein communication 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 communication signals reduces the number of conductors in the umbilical.

3.10
expert operation
operating the IWCS with other control commands or other methods than used for normal operation

NOTE Typically used by IWCS supplier or other skilled resource to read IWCS diagnostic data and make (engineering) adjustments to IWCS equipment.

3.11
hydrostatic test pressure
maximum test pressure at a level greater than the design pressure (rated working pressure)

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3.12
intelligent well
well that employs permanently installed downhole sensors and/or permanently installed downhole control devices that are operable from a surface facility

3.13
intelligent well control system
control system used to operate an intelligent well

3.14
normal operation
operating the system to perform the intended basic functionality

3.15
offset
horizontal component of control path length

3.16
proof pressure
maximum test pressure at a level greater than the design pressure

3.17
response time
sum of the signal time and the shift time

3.18
running tool
tool used to install, operate, retrieve, position or connect subsea equipment remotely from the surface

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

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3.19
shift time
period of time elapsed between the arrival of a control signal at the subsea location (the completion of the signal time) and the completion of the control function operation

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.

3.20
signal time
period of time elapsed between the remote initiation of a control command and the initiation of a control function operation subsea (the commencement of the shift time)

3.21
subsea production control system
control system operating a subsea production system during production operations

3.22
surface safety valve
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, and that will automatically close upon loss of hydraulic pressure

3.23
umbilical
combination of electric cables, hoses or steel tubes, either on their own or in combination (or with fibre optic cables), cabled together for flexibility and over-sheathed and/or armoured for mechanical strength and typically supplying power and hydraulics, communication and chemicals to a subsea system

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3.24
underwater safety valve
safety valve assembly that is declared to be the USV and which will automatically close upon loss of power to that actuator

3.25
upstream
away from a component against the direction of flow

3.26
well data
data provided from the downhole equipment for reservoir description, flow calculations and routine production monitoring

NOTE Typically, these include sensor readings and valve positions.

3.27
β
filtration ratio

4 Abbreviated terms

ANSI	American National Standards Institute
AC	alternating current
API	American Petroleum Institute
AS	Aerospace Standard
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWS	American Welding Society
BER	bit error rate
capex	capital expenditure
CB	centre of buoyancy
CISPR	Comité International Spécial des Perturations Radioelectrique (International Special Committee on Radio-Interference)
CIU	chemical injection unit
CIV	chemical injection valve
CPS	combined power and signal
CW	clockwise
DC	direct current
DCS	distributed control system
DCV	directional control valve
DH	direct hydraulic
EPU	electrical power unit
EM	electromagnetic
EMC	electromagnetic compatibility
ESD	emergency shutdown
ESS	environmental stress screening
ETH	ethernet
EUT	equipment under test

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EXT	extended
FAT	factory acceptance test
GND	ground
HF	high frequency
HIPPS	high integrity pipeline protection system
HP	high pressure
HPU	hydraulic power unit
HRC	hardness Rockwell C
HV	high voltage
IEC	International Electrotechnical Commission
I/O	input/output
IP	Institute of Petroleum
iSEM	intelligent well subsea electronics module
ISM	industrial, scientific and medical
ITE	information technology equipment
IWCS	intelligent well control system
IWE	intelligent well equipment
LF	low frequency
LP	low pressure
MCS	master control station
MIL-STD	Military Standard
mo	month
MV	manifold valve
OPC	object linking and embedding (OLE) for process control
Opex	operational expenditure
OREDA	offshore reliability data
OSI	open system interconnection
PH	piloted hydraulic
PMV	production master valve
PSD	process shutdown
PTFE	polytetrafluoroethylene
PWV	production wing valve
RET	return
RMS	root mean square
ROV	remotely operated vehicle
RPC	remote procedure call
RX	radio receiver
SCM	subsea control module
SCSSV	surface-controlled subsurface safety valve
SEM	subsea electronic module
TAN	total acid number
TBD	to be decided
TBN	total base number
TCP	transmission control protocol

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THD	total harmonic distortion
TX	radio transmitter
UPS	uninterruptible power supply
USV	underwater safety valve
VAC	volts alternating current
VDC	volts direct current
wk	week
yr	year

5 System requirements

5.1 General

In 5.2 to 5.6 are described the activities of specifying organisations. Reference should be made to Annex A for types and selection of control system, and to Annex B for typical control and monitoring functions.

5.2 Concept development

During front-end engineering, possible impact on control system functionality and infrastructure related to the following items shall be considered:

— flexibility with respect to production scenarios;

— optimization with respect to operation;

— optimization with respect to cost-effective installation;

— optimization with respect to phased production development;

— flow assurance;

— project execution time;

— life cycle cost [component cost (capex), installation cost (opex), operation/maintenance/intervention cost (opex)].

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Operational philosophy, installation sequences and possible operational challenges shall be evaluated during front-end engineering.

Reference should be made to Annex D for operational considerations with respect to flowline pressure exposure.

5.3 Production control system functionality requirement

5.3.1 General

The subsea production control system shall allow for flexibility and optimization. The basic system design shall to a maximum extent allow for a full range of functionality with use of existing infrastructure.

The following elements shall be considered during system engineering:

— intelligent well application;

— flexibility with respect to electrical load situations (power and communication);

— robustness of hydraulic system;

— prevention of seawater ingress in hydraulic system;

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— seawater ingress material compatibility;

— subsea intervention;

— increased scope with respect to number of wells;

— increased scope with respect to number of umbilicals;

— increased scope with respect to control/instrumentation functionality;

— interface toward subsea separation/subsea boosting systems;

— subsea chemical injection;

— downhole instrumentation system interfaces;

— downhole chemical injection.

5.3.2 Intelligent well application

If an intelligent well completion is clearly defined as a current or future requirement by front-end engineering efforts, the control system will provide valve functionality, data retrieval, computational support and communication pathways without the need for changing the subsea umbilical system and the associated distribution system. Subsea control modules may be expected to be retrieved and retrofitted to accommodate the introduction of smart well systems at a future date.

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

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

The system should be built to function properly within a large range of electrical load variations to allow for flexibility regarding new wells. Load flexibility can help overcome electrical distribution system failures by connecting more wells to the same cable.

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5.3.4 Robustness of hydraulic system

The hydraulic system shall be robust and maintain acceptable pressure values in the SCM during all modes of operation.

Actuation of valve actuators shall not cause alarms or unintended valve movement due to low supply pressure in the SCM. The pressure should not drop below 150 % of the highest latching pressure of any DCV.

5.3.5 Seawater ingress in hydraulic system

The hydraulic system shall be designed to minimize seawater ingress in all operational scenarios, including installation and retrieval of individual units. If seawater ingress prevention cannot be guaranteed or if there is a credible risk of seawater ingress, SCM fluid-wetted components should be considered along with procedures to flush out contaminated fluid.

5.3.6 Subsea intervention

The subsea control system shall be designed for cost-effective subsea intervention tasks, with respect to both ROV and diver applications.

5.3.7 Increased scope with respect to number of wells

The system shall allow for flexibility with respect to number of wells tied into the system. Operational and criticality analysis should represent the practical limitations with respect to number of wells rather than mechanical limitations.

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