NORSOK STANDARD

SUBSEA PRODUCTION SYSTEMS

U-001
Rev. 2, June 1998

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FOREWORD

NORSOK (The competitive standing of the Norwegian offshore sector) is the industry initiative to add value, reduce cost and lead time and eliminate unnecessary activities in offshore field developments and operations.

The NORSOK standards are developed by the Norwegian petroleum industry as a part of the NORSOK initiative and supported by OLF (The Norwegian Oil Industry Association) and TBL (Federation of Norwegian Engineering Industries). NORSOK standards are administered and issued by NTS (Norwegian Technology Standards Institution).

The purpose of NORSOK standards is to contribute to meet the NORSOK goals, e.g. by replacing individual oil company specifications and other industry guidelines and documents for use in existing and future petroleum industry developments.

The NORSOK standards make extensive references to international standards. Where relevant, the contents of a NORSOK standard will be used to provide input to the international standardisation process. Subject to implementation into international standards, the NORSOK standard will be withdrawn.

INTRODUCTION

Input from the Norwegian Deepwater Programme and NDP's guidelines are included in this revision 2 of NORSOK standard U-001, which replace revision 1 of U-DP-001. This revision has been substantially reduced in text due to the development of new ISO standards for the subsea area. For the same reasons, NORSOK standards U-CR-003 Subsea christmas tree systems, U-CR-005 Subsea production control systems and U-CR-008 Subsea colour and marking, have been withdrawn and references made to the new ISO standards being developed.

The NORSOK standards provide specific national requirements. The standards are supplements to international standards. Therefore, this standard shall be used in conjunction with current revision of ISO 13628-1 and the other parts as referenced in clause 2 herein.

The ISO standards are at different levels of completion. It is considered that ISO standards at DIS or FDIS stages are sufficiently mature to be used as references in this NORSOK standard.

1 SCOPE

This NORSOK standard covers all phases of a project and sets the overall design requirements for underwater production systems and the interfaces between the subsea system and the surrounding systems. More detailed requirements are formulated in relevant subsystem standards.

This standard also sets requirements for verification of system performance either by analysis or by testing. The type/extent of verification will be dependent on the content of new and unproven technology in the system.

2 NORMATIVE REFERENCES

The following standards include provisions which, through reference in this text, constitute provisions of this NORSOK standard. Latest issue of the references shall be used unless otherwise agreed. (Note 1). Other recognised standards may be used provided it can be shown that they meet or exceed the requirements of the standards referenced below.

API RP 17C	TFL systems (replace with ISO 13628-3 when issued at DIS/FDIS level)
API RP 17G	Design and Operation of Completion/Workover Riser System (replace with ISO 13628-7 when issued at DIS/FDIS level)
API RP 17I	Installation of Subsea Umbilicals
ISO 10420	Flexible pipe systems for subsea and marine riser application
ISO 10423	Specification for valves, wellhead and x-mas tree equipment
ISO 13628-1	Design and operation of subsea production systems. General requirements and recommendations. (Note 2)
ISO 13628-2	Flexible Pipe (Note 2)
ISO 13628-4	Subsea Wellhead and Christmas Tree Equipment (Note 2)
ISO 13 628-6	Subsea Production Controls (Note 2)
ISO 13 628-9	ROT Intervention Systems (Note 2)
NORSOK I-CR-002	Safety and automation systems
NORSOK M-001	Material Selection
NORSOK M-501	Surface Preparation and Protective Coating
NORSOK M-503	Cathodic Protection
NORSOK O-CR-001	Life Cycle Cost for systems and equipment
NORSOK O-CR-002	Life Cycle Cost for production facilities
NORSOK U-002	Subsea Structures and Piping Systems
NORSOK U-006	Subsea Production Control Umbilical
NORSOK U-007	Subsea Intervention System
NORSOK Z-001	Documentation for operation.
NORSOK Z-DP-002	Coding system.

Note1: Order of precedence is NORSOK, ISO and API standards.

Note 2: Use latest issue (presently at DIS or FDIS level).

3 DEFINITIONS AND ABBREVIATIONS

3.1 Definitions

Shall Verbal form used to indicate requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted, unless accepted by all involved parties.

Should Verbal form used to indicate that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others, or that a certain course of action is preferred but not necessarily required.

3.2 Abbreviations

AMV	Annulus Master Valve
ASV	Annulus Swab Valve
AWV	Annulus Wing Valve
CIV	Corrosion Inhibitor Injection Valve
CT	Coiled Tubing
DCI	Downhole control and instrumentation
DP	Dynamic positioning
MIV	Methanol Injection Valve
PCV	Production Choke Valve
PGB	Permanent Guide base
PICT	Pull In and Connection Tool
PMV	Production Master Valve
PSV	Production Swab Valve
PXT	Pressure and temperature sensors
PWV	Production Wing Valve
SIV	Scale Inhibitor Injection Valve
STT	Surface Test Tree
SCSSV	Surface Controlled Subsurface Safety Valves
TH	Tubing Hanger
XOV	Crossover Valve

4 TYPICAL SYSTEM ARCHITECTURE

The subsea system is divided into typical subsystems as shown in fig. 1. The main subsystems are:

- Wellhead, tubing hanger, X-mas tree with choke, PGB, completion workover riser, workover control system.

- Production Control System: typically include subsea control module electronics and hydraulics, subsea electrical/hydraulic and chemical injection distribution system, tree instrumentation, misc. tools, and master control-, power/comms- and hydraulic power units on surface.

- Umbilical: electrical, hydraulic and chemical lines including terminations.
- Intervention system: typically include tools for pull in and connection of sealines/umbilicals, tools for running of choke, control pod, pig launcher etc., surface control container, umbilical winch, lift wire winch, heave compensation equipment etc.
- Subsea structures and piping systems: template and satellite structures, manifold and riser base structures, protection structures, piping modules.
- Subsea flowlines: any risers, hard pipes, flexible lines, rigid risers, dynamic risers.
- Subsea processing: metering, boosting, separation, water injection etc.

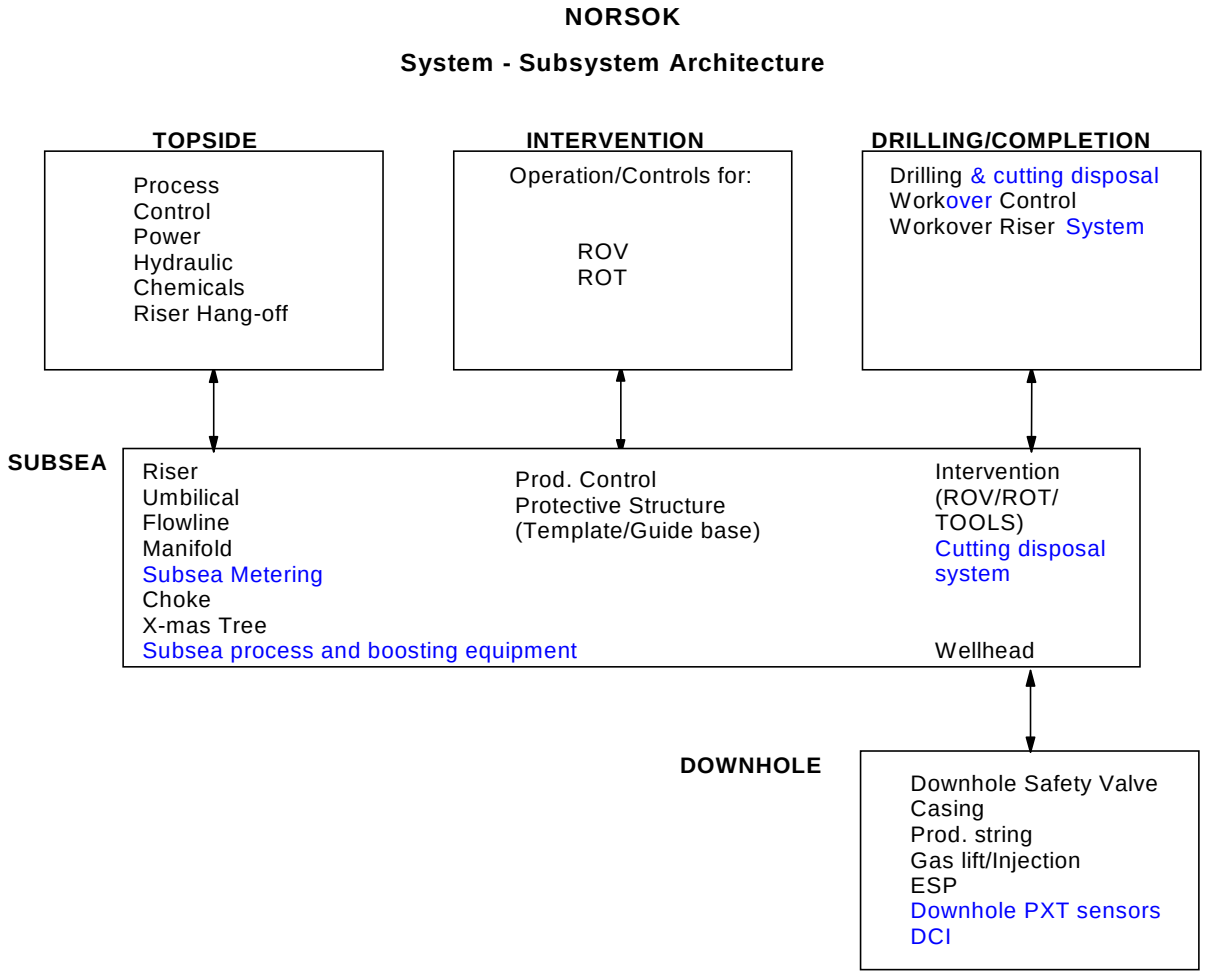

Fig 1 - Typical subsea production system block diagram

5 DESIGN REQUIREMENTS

5.1 General design requirements

a) The subsea production system and equipment, shall comply with ISO 13628 (several parts) and the other standards given in clause 2 Normative references, and meet the safety level agreed between the interested parties and be optimised with respect to life cycle cost.

b) Subsea systems should be designed for diverless installation and intervention. Diving operations shall not be planned in water depths exceeding 180 m.

c) All equipment shall be designed and tested where practicable for the actual operational conditions during field life. The system shall be compatible with all produced and injected fluids, as well as hydraulic fluids.

d) All pressure containing equipment shall be rated to the highest system operating pressure. System operating pressure includes normal production operation, workover operations and barrier testing.

e) Hydrostatic pressure shall be considered in the design of components under all operational conditions (e.g. blowdown).

f) The system shall be designed such that any operation can be terminated leaving the well(s) in a safe state when predefined operational limits are exceeded.

g) The sub system design work should include the definition of all interfaces between subsystems, typically listed in clause 4.

h) The system shall be designed for easy fault diagnosis without system retrieval.

i) A high system availability should be obtained through use of simple designs and high quality products (suppliers standard equipment with an in field performance record). Use of redundant designs should only be selected after a cost/benefit analysis.

j) Operational reliability shall be documented for the subsea systems.

k) For non critical temporary equipment relaxed requirements may be accepted.

l) Intervention interfaces shall be defined according to the standards referenced in clause 2.

m) Connectors with critical functions shall have an arrangement preventing unintentional release for predetermined design conditions.

5.2 Procedures/limitations for the operations

The subsea system design work should include the definition of procedures/limitations for major operational modes, including installation and abandonment.

a) **Well completion/testing/killing/intervention/workover.** This mode of operation may include simultaneous operations, e.g. one well is controlled from the rig while adjacent wells are producing and are controlled from the process facilities.

Equipment operational limitations, during installation and retrieval shall be defined. Safety with respect to running offset well location to be assessed.

b) **Pull in and connection of flowlines/umbilicals.** This operation can be performed:
- as an independent operation from typical installation vessels before the wells are completed
- after the well is completed
- from the drilling unit simultaneous with drilling/completion operations.

c) **Normal production.** This mode will include regular remote pressure testing of subsea barriers and routine inspection and maintenance by ROV, and well rate testing. Pipelines may be inspected by instrument pigs or other methods. Pipeline system ID, bends and transitions shall accommodate this requirement.

d) **Repair of subsea equipment.** Repair is normally done by replacement of components (e.g. valves, inserts) or by replacement of bigger modules carried out by dedicated remoted operated tools. The subsea production system design should consider to enable replacement of equipment while main parts of the system are in operation.

5.3 Requirements relating to barriers

During production activities at least two independent and tested barriers shall be normally available between reservoir and environment in order to prevent an unintentional flow from the well. The barriers shall be designed for rapid reestablishment of a lost barrier. The position status of the barriers shall be known at all times.

One barrier may be acceptable in the case where the reservoir can not produce to the environment without pressure boosting.

During normal production the X-mas tree, as a complete unit is defined as one of the two barriers. The other barrier is normally the downhole safety valve.

When a workover vessel has assumed well control via the workover control system, the normal production control system shall be disabled. It shall be possible to initiate shutdown of the neighbouring wells from the intervention vessel.

All hydraulic penetrations through the wellhead connection shall fulfil the barrier requirement, and shall normally be equipped with isolation valves.

Connection and disconnection of a tree from a pressurised manifold may be performed with one single isolation valve if its pressure containing integrity has been tested. The same would apply when connecting and disconnecting a pig launcher to a pipeline hub.

5.4 Wellheads and X-mas trees

Subsea wellheads and X-mas trees shall meet the requirements of ISO 13628-4 (currently at FDIS stage).

5.5 Subsea production control systems

Subsea production control systems shall meet the requirements of ISO 13628-6 (currently at DIS stage).

5.6 Dropped objects and trawlgear protection

Any special dropped object protection should be evaluated on the basis of probability of drop/hit combined with the hazardous consequence of hit.

In areas with fishing activity two options exist:

- Establishment of a restricted zone (no bottom gear fishing is allowed in the area). This will require trawl resistant structures and/or continuous surveillance .
- If the establishment of a restricted zone is not allowed, the use of overtrawlable structures are required.

Different requirement may apply for deep water.

5.7 Requirements to instrumentation, valve position indicators and valve overrides

The subsea production system shall be equipped with pressure monitoring at points necessary for a satisfactory functioning of the system, and for pressure testing of the barrier valves. The need for temperature monitoring and leak detection systems shall be considered in each individual case.

All valves (hydraulic or mechanical) that are required to pass plugs, tools or pigs through, and where damage may occur if the valve is not fully open, shall have mechanical position indication of fully open and closed position.

All ROV operated valves shall have visual position indication.

All valves in the vertical bores subject to wireline and coiled tubing operations shall be equipped with and independent override, except for equipment run inside the marine riser.