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Petroleum and natural gas industries — Drilling and production equipment —

Part 2:
Deepwater drilling riser methodologies, operations, and integrity technical report

Industries du pétrole et du gaz naturel — Équipement de forage et de production —

Partie 2: Méthodologies, opérations et rapport technique d'intégrité relatifs aux tubes prolongateurs pour forages en eaux profondes

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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.

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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.

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ISO/TR 13624-2 was prepared by Technical Committee ISO/TC 67, *Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries*, Subcommittee SC 4, *Drilling and production equipment*.

ISO/TR 13624 consists of the following parts, under the general title *Petroleum and natural gas industries — Drilling and production equipment*:

— *Part 1: Design and operation of marine drilling riser equipment*

— *Part 2: Deepwater drilling riser methodologies, operations, and integrity technical report*

Introduction

Since API RP 16Q was issued in 1993, hydrocarbon exploration in 1 200+ m (4 000+ ft) water depths has increased significantly. As a consequence, the need was identified to update that code of practice to address the issues particular to deepwater operations.

Under the auspices of the DeepStar programme, substantial work was commissioned during 1999 and 2000 by the DeepStar Drilling Committee 4502 and led to the development of *Deepwater Drilling Riser Methodologies, Operations, and Integrity Guidelines* in February 2001. Several contractors participated in these efforts. These guidelines were intended to supplement and update the existing API RP 16Q:1993 for deepwater application. In a subsequent joint industry project and in collaboration with DeepStar and the API, these guidelines were later supplemented with other identified revisions and technically edited by an API task group to produce the revision of API RP 16Q:1993 as ISO 13624-1 and the API Technical Report TR1.

This Technical Report is a supplement to the revised API RP 16Q and provides guidance on various analysis methodologies and operating practices.

NOTE The figures have been reproduced as provided by the Technical Committee and, in some cases, contain only USC units.

Petroleum and natural gas industries — Drilling and production equipment —

Part 2: Deepwater drilling riser methodologies, operations, and integrity technical report

1 Scope

This part of ISO 13624 pertains to mobile offshore drilling units that employ a subsea BOP stack deployed at the seafloor. It is intended that the drilling riser analysis methodologies discussed in this part of ISO 13624 be used and interpreted in the context of ISO 13624-1.

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 13624-1:2009, *Petroleum and natural gas industries — Drilling and production equipment — Part 1: Design and operation of marine drilling riser equipment*

API RP 16Q:1993, *Design, Selection, Operation and Maintenance of Marine Drilling Riser Systems*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
accumulator
⟨BOP⟩ pressure vessel charged with gas (e.g. nitrogen) over liquid and used to store hydraulic fluid under pressure for operation of blowout preventers

3.2
accumulator
riser tensioner
pressure vessel charged with gas (e.g. nitrogen) over liquid that is pressurized on the gas side from the tensioner high-pressure gas supply bottles and supplies high-pressure hydraulic fluid to energize the riser tensioner cylinder

3.3
air-can buoyancy
tension applied to the riser string by the net buoyancy of an air chamber created by a closed-top, open-bottom cylinder forming an air-filled annulus around the outside of the riser pipe

3.4
annulus
space between two pipes, when one pipe is positioned inside the other

3.5
apparent weight
effective weight
submerged weight
riser weight in air minus buoyancy

NOTE Apparent weight is commonly referred to as weight in water, wet weight, submerged weight or effective weight.

3.6
auxiliary line
conduit (excluding choke-and-kill lines) attached to the outside of the riser main tube

EXAMPLE Hydraulic supply line, buoyancy-control line, mud-boost line.

3.7
ball joint
ball-and-socket assembly having a central through passage that has an internal diameter equal to or greater than that of the riser and that may be positioned in the riser string to reduce local bending stresses

3.8
blowout
uncontrolled flow of well fluids from the well bore

3.9
blowout preventer
BOP
device attached immediately above the casing, which can be closed to shut in the well

3.10
blowout preventer
⟨annular type⟩ remotely controlled device that can form a seal in the annular space around any object in the well bore or upon itself

NOTE Compression of a reinforced elastomer packing element by hydraulic pressure affects the seal.

3.11
BOP stack
assemblage of well-control equipment, including BOPs, spools, valves, hydraulic connectors and nipples, that connects to the subsea wellhead

NOTE Common usage of this term sometimes includes the lower marine riser package (LMRP).

3.12
box
female member of a riser coupling, C&K line stab assembly or auxiliary line stab assembly

3.13
buoyancy-control line
auxiliary line dedicated to controlling, charging or discharging air-can buoyancy chambers

3.14
buoyancy modules
devices added to riser joints to reduce their apparent weight, thereby reducing riser top tension requirements

3.15
choke-and-kill lines
C&K lines
kill line
external conduits arranged laterally along the riser pipe and used for circulation of fluids into and out of the well bore to control well pressure

3.16
control pod
assembly of subsea valves and regulators that, when activated from the surface, directs hydraulic fluid through special porting to operate BOP equipment

3.17
coupling
mechanical means of joining two sections of riser pipe in an end-to-end engagement

3.18
diverter
device attached to the wellhead or marine riser to close the vertical flow path and direct well flow away from the drill floor and rig

3.19
drift-off
unplanned lateral move of a dynamically positioned vessel off its intended location relative to the wellhead, generally caused by loss of either stationkeeping control or propulsion

3.20
drilling fluid
mud
water- or oil-based fluid circulated down the drillpipe into the well and back up to the rig for purposes including containment of formation pressure, the removal of cuttings, bit lubrication and cooling, treating the wall of the well and providing a transmission medium for well data

3.21
drive-off
unplanned move of a dynamically positioned vessel off location driven by the vessel's main propulsion or stationkeeping thrusters

3.22
dynamic positioning
⟨automatic stationkeeping⟩ computerized means of maintaining a vessel on location by selectively driving and/or directing thrusters

3.23
effective tension
axial tension that is calculated at any point along a riser in water considering only the top tension and the apparent weight of the riser and its contents

NOTE See ISO 13624-1:2009, 5.4.3, and Sparks, 1984.

3.24
factory acceptance testing
FAT
testing by a manufacturer of a particular product to validate its conformance to performance specifications and ratings

3.25
fill valve
valve used to fill the riser with seawater to prevent riser collapse

3.26
fleet angle
⟨marine riser⟩ angle between the vertical axis and a riser tensioner line at the point where the line connects to the telescopic joint

NOTE This angle changes with change in elevation of the vessel.

3.27
flex joint
steel and elastomer assembly having a central through-passage area equal to or greater than the riser bore

NOTE Flex joints are commonly placed at the bottom of the riser to reduce local bending stresses at the transition from riser to lower marine riser package.

3.28
heave
vessel motion in the vertical direction

3.29
hot-spot stress
local peak stress
highest stress in the region or component under consideration, which causes no significant distortion and is principally objectionable as a possible initiation site for a fatigue crack

NOTE These stresses are highly localized and occur at geometric discontinuities.

3.30
hydraulic connector
a mechanical device that is activated hydraulically and connects the BOP stack to the wellhead or the LMRP to the BOP stack

3.31
hydraulic supply line
auxiliary line from the vessel to the subsea BOP stack that supplies control-system operating fluid to the LMRP and BOP stack

3.32
jumper hose
flexible section of choke, kill or auxiliary line that provides a continuous flow around a flex/ball joint while accommodating the angular motion at the flex/ball joint

3.33
lower marine riser package
LMRP
upper section of a two-section subsea BOP stack consisting of a hydraulic connector, annular BOP, ball/flex joint, riser adapter, jumper hoses for the choke, kill and auxiliary lines, and subsea control pods

NOTE The LMRP lands in the top of the lower subsea BOP stack.

3.34
mud-boost line
auxiliary line that provides a supplementary fluid supply from the surface and injects it into the riser at the LMRP to assist in the circulation of drill cuttings up the marine riser, when required

3.35
pin
male member of a riser coupling or a choke, kill or auxiliary line stab assembly

3.36
pup joint
shorter-than-standard length riser joint

3.37
response amplitude operator
RAO
⟨regular waves⟩ ratio of a vessel's motion to the wave amplitude causing that motion and presented over a range of wave periods

3.38
riser adapter
crossover between riser and flex/ball joint

3.39
riser disconnect
operation of unlatching of the riser connector to separate the riser and LMRP from the BOP stack

3.40
riser joint
section of the riser main tube having ends fitted with a box and pin and including choke, kill and (optional) auxiliary lines and their support brackets

3.41
riser main tube
riser pipe
seamless or electric welded pipe that forms the principal conduit of the riser joint that guides the drill string and contains the return fluid flow from the well

3.42
riser string
deployed assembly of riser joints

3.43
riser tensioner
means for providing and maintaining top tension on the deployed riser string to prevent buckling

3.44
riser tensioner ring
structural interface of the telescopic joint outer barrel and the riser tensioners

3.45
rotary kelly bushing
RKB
commonly used vertical reference from the drillfloor

3.46
slip joint
telescopic joint
riser joint having an inner barrel and an outer barrel with means of sealing in between

NOTE The inner and outer barrels of the telescopic joint move relative to each other to compensate for the required change in the length of the riser string as the vessel experiences surge, sway and heave.

3.47
stab
mating box and pin assembly that provides pressure-tight engagement of two pipe joints

NOTE 1 An external mechanism is usually used to keep the box and pin engaged.

NOTE 2 Riser joint choke-and-kill stabs are retained in the stab mode by the make-up of the riser coupling.

3.48
standard riser joint
joint of typical length for a particular drilling vessel's riser storage racks, the derrick V-door size, riser handling equipment capacity or a particular riser purchase

3.49
strakes
helically wound appendages attached to the outside of the riser to suppress vortex-induced vibrations

3.50
stress amplification factor
SAF
ratio of the local peak alternating stress in a component (including welds) to the nominal alternating stress in the pipe wall at the location of the component

NOTE This factor is used to account for the increase in the stresses caused by geometric stress amplifiers that occur in riser components.

3.51
surge
vessel motion along the fore/aft axis

3.52
sway
vessel motion along the port/starboard axis

3.53
terminal fitting
connection between a rigid choke, kill or auxiliary line on a telescopic joint and its drape hose, effecting a nominal 180° turn in flow direction

3.54
vortex-induced vibration
VIV
in-line and transverse oscillation of a riser in a current induced by the periodic shedding of vortices

3.55
wellhead connector
stack connector
hydraulically operated connector that joins the BOP stack to the subsea wellhead

4 Abbreviated terms

BOP	blowout preventer
DP	dynamic positioning
DTL	dynamic tension limit
ID	internal diameter
LFJ	lower flex joint
LMRP	lower marine riser package
OD	outside diameter
RAOs	response amplitude operators
RKB	rotary kelly bushing
ROV	remotely operated vehicle
SAF	stress amplification factor
TJ	telescopic joint
UFJ	upper flex joint
WSD	working stress design

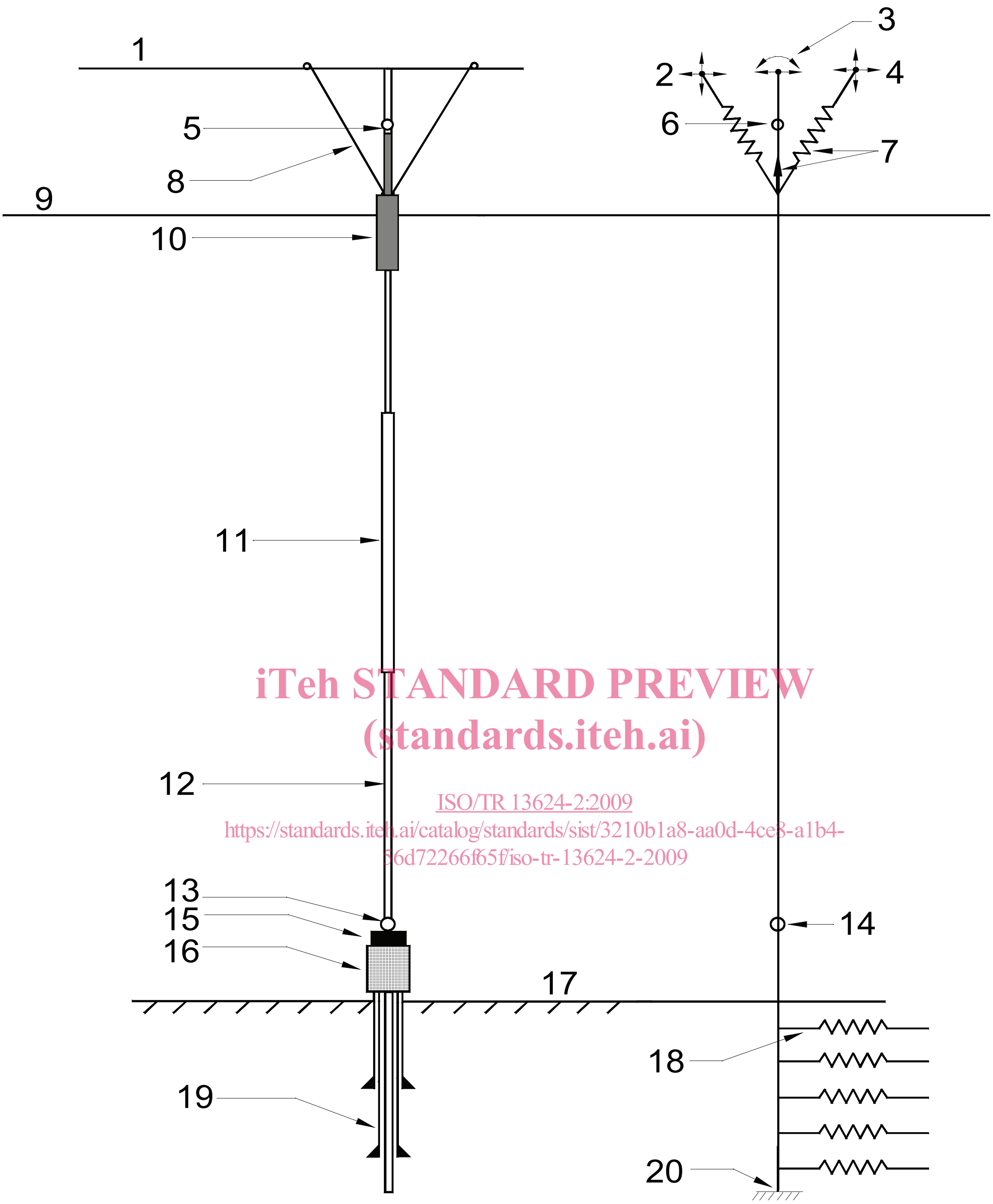
5 Coupled drilling riser/conductor analysis methodology and worked example

5.1 Coupled methodology

In a coupled analysis, the riser system analysed extends from the conductor up to the upper flex joint or ball joint. Therefore, the vessel motions applied at the upper flex joint or ball joint along with the wave and current loading can be used to predict the behaviour of the riser down to the displacements of the conductor in the soil structure. This is a single-stage procedure. Figure 1 shows a schematic of a coupled model.

5.2 Decoupled methodology

The decoupled methodology is a two-stage procedure where two separate models are used to predict the behaviour in the full riser system. The first model represents the riser system from the top of the subsea BOP/LMRP to the upper flex joint or ball joint. The second model represents the riser from the conductor up to the BOP/LMRP. The loads at the base of the first model (top of BOP/LMRP to upper flex joint or ball joint) are then applied to the top of the second model to evaluate the behaviour of the conductor and riser at the mudline. Figure 2 shows a schematic of a decoupled model.



Key

1 drill deck (RKB)
2 heave/surge/sway
3 surge/sway/pitch/roll
4 heave/surge/sway
5 upper flex joint
6 upper flex joint (articulation element)
7 tensioner system modeled with spring/beam elements or equivalent vertical tension
8 tensioners
9 MWL
10 slip joint
11 riser buoyancy joints
12 bare riser joints
13 lower flex joint
14 lower flex joint (articulation element)
15 LMRP
16 BOP
17 mudline
18 spring elements to model soil-structure interaction
19 conductor/casing
20 fixed in all degrees of freedom

Figure 1 — Drilling riser system configuration and coupled analysis model

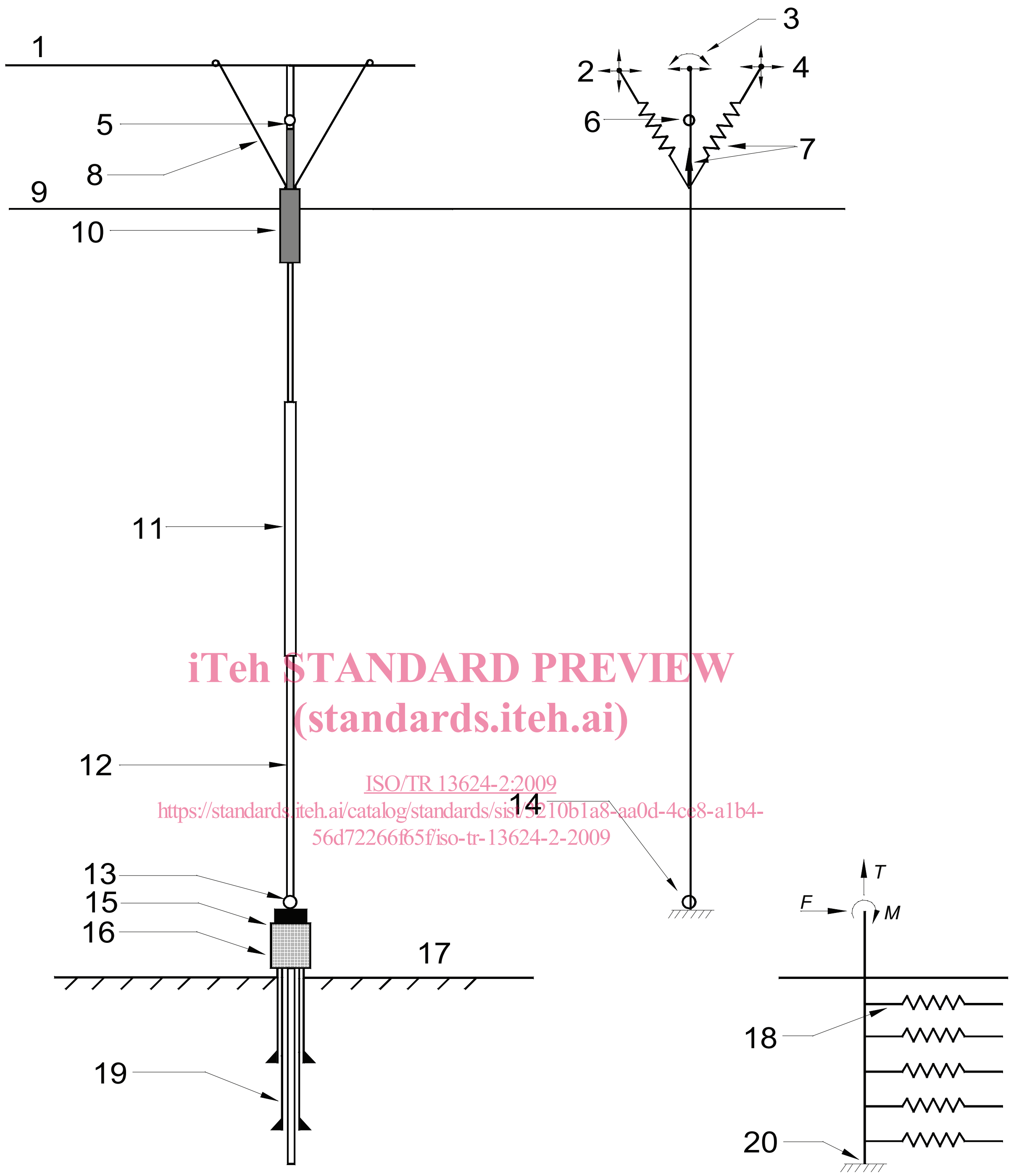


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Figure 2 — Drilling riser system configuration and decoupled analysis models