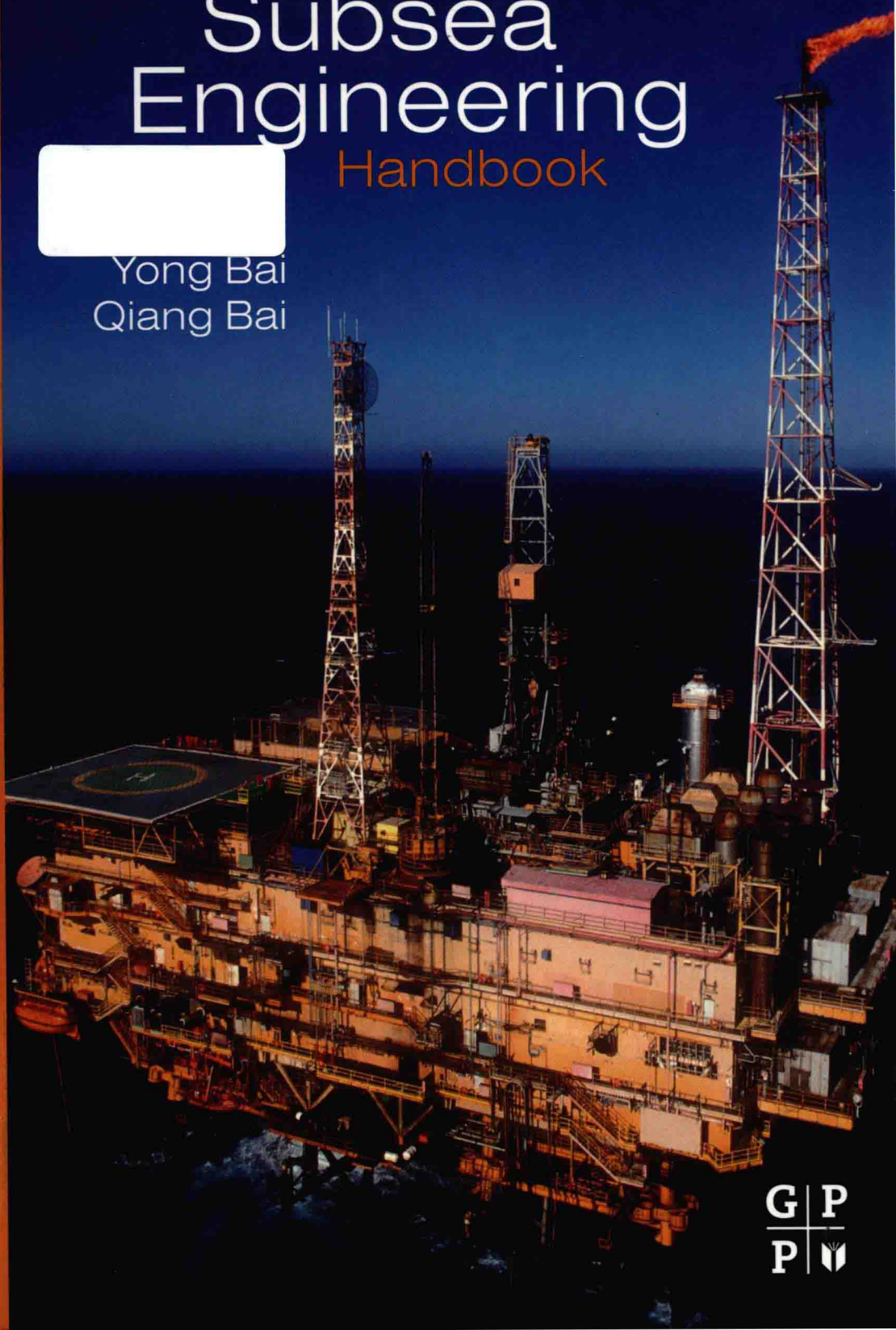
Subsea Engineering Handbook

Yong Bai
Qiang Bai



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Technology: Engineering/Energy/Construction

Subsea Engineering Handbook

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An expert guide to the key processes, technologies, and equipment that comprise contemporary offshore structures.

Key Features

- Provides up-to-date technical overview of deepwater riser engineering
- Conveys easy-to-understand information about design, analysis, and installation
- Addresses issues concerning both fixed and floating platforms
- Covers technical equipment such as subsea control systems and pressure piping
- Includes discussions on connectors and equipment layout as well as remotely operated vehicles
- Is packed with easy-to-use design and analysis information

Written with clear and concise language, *Subsea Engineering Handbook* is based on the authors' 30 years of experience in the design, analysis, and installation of offshore structures. The authors provide engineers with extensive coverage of the entire spectrum of subjects in the discipline, from pipe installation and routing selection and planning to design, construction, and installation of fixed and floating platforms.

Full coverage is also given to topics such as materials and corrosion, inspection, welding, repair, risk assessment, and applicable design solutions. This book is a "must have" for anyone who has an appreciation of the overall issues and directed approaches to subsea engineering design solutions.

Related Titles

Ahmed/*Advanced Reservoir Engineering*/978-0750677332
Ahmed/*Reservoir Engineering Handbook*, 4th edition/978-1856178037
Donaldson/*Petrophysics*, 2nd edition/978-0750677110

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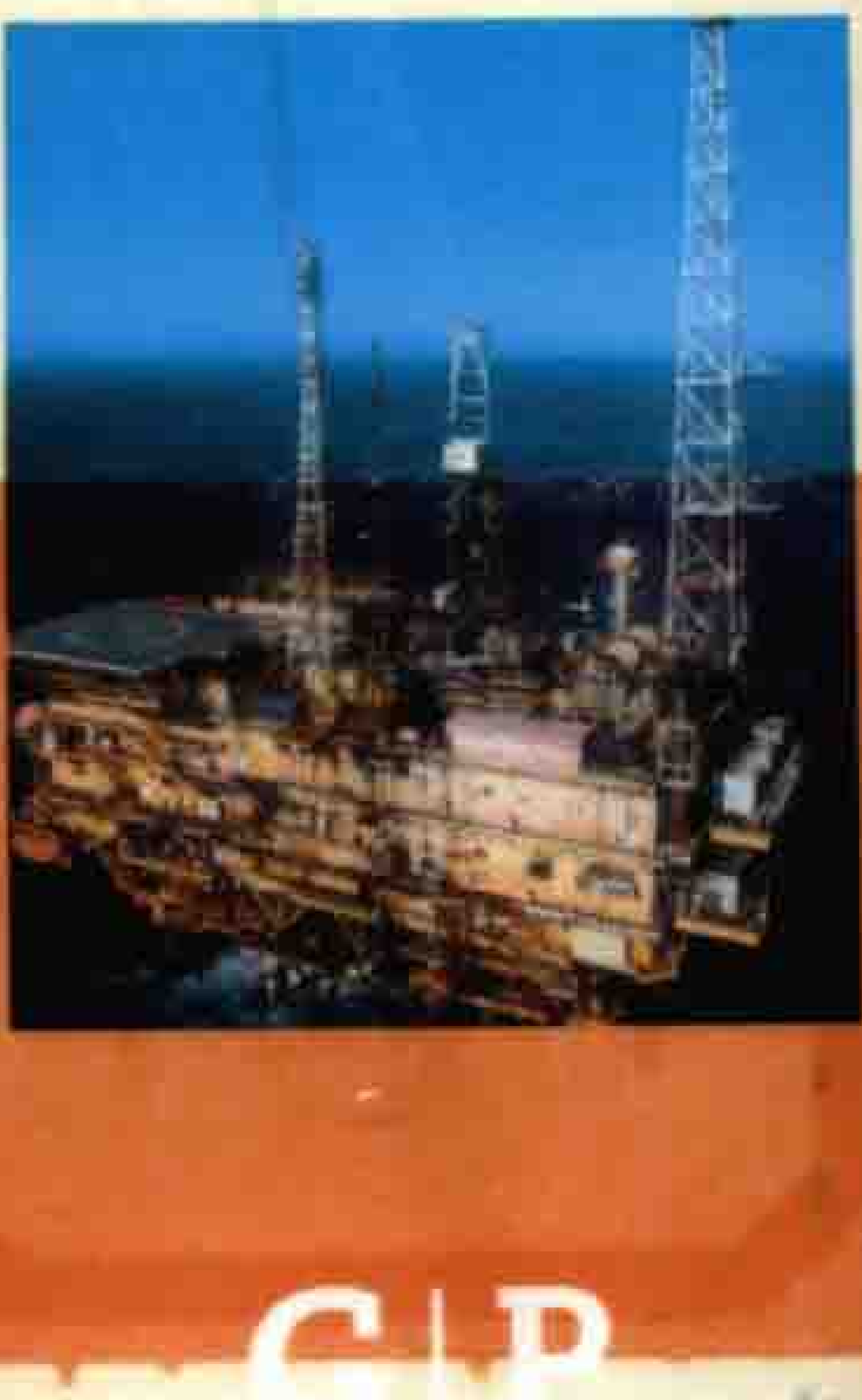

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SUBSEA ENGINEERING HANDBOOK

PREFACE

MAY 2010

Subsea engineering is now a big discipline for the design, analysis, construction, installation and integrity management of subsea wellheads, trees, manifolds, jumpers, PLETS and PLEMs, etc. However, there is no book available that helps engineers understand the principles of subsea engineering.

This book is written for those who wish to become subsea engineers.

With the continuous encouragement of Mr. Ken McCombs of Elsevier, the authors spent a couple of years writing this book. The authors would like to thank those individuals who provided editing assistance (Ms. Lihua Bai & Ms. Shuhua Bai), initial technical writing for Chapters 1-4 (Mr. Youxiang Cheng), Chapters 6-8 (Mr. Xiaohai Song), Chapter 11 (Mr. Shiliang He), Chapter 5 (Mr. HongDong Qiao), Chapter 23 (Mr. Liangbiao Xu) and Chapter 27 (Mr. Mike Bian). They are employees of Offshore Pipelines & Risers (OPR) Inc. (bai@opr-inc.com, www.opr-inc.com, www.baiyongoe.com).

Thanks to all persons involved in reviewing the book, particularly Ms. Mohanambal Natarajan of Elsevier, who provided editory assistance.

We thank our families and friends for their support.

The first author would like to thank Zhejiang University for their support for publishing this book.

Prof. Yong Bai & Dr. Qiang Bai
Houston, USA

ABOUT THE AUTHORS

Professor Yong Bai is the president of Offshore Pipelines & Risers Inc. in Houston, and also the director of the Offshore Engineering Research Center at Zhejiang University. He has previously taught at Stavanger University in Norway where he was a professor of offshore structures. He has also worked with ABS as manager of the Offshore Technology Department and DNV as the JIP project manager.

Professor Yong Bai has also worked for Shell International E & P as a staff engineer. Through working at JP Kenny as manager of advanced engineering and at MCS as vice president of engineering, he has contributed to the advancement of methods and tools for the design and analysis of subsea pipelines and risers. Professor Bai is the author of the books *Marine Structural Design* and *Subsea Pipelines and Risers* and more than 100 papers on the design and installation of subsea pipelines and risers.

OPR has offices in Houston, Texas, USA; Kuala Lumpur, Malaysia; and Harbin, Beijing, and Shanghai, China. OPR is engaged in the design, analysis, installation, engineering, and integrity management of pipelines, risers, and subsea systems such as subsea wellheads, trees, manifolds, and PLET/PLEMs.

Dr. Qiang Bai has more than 20 years of experience in subsea/offshore engineering including research and engineering execution. He has worked at Kyushu University in Japan, UCLA, OPE, JP Kenny, and Technip. His experience includes various aspects of flow assurance and the design and installation of subsea structures, pipelines, and riser systems. Dr. Bai is coauthor of *Subsea Pipelines and Risers*.

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LIST OF ABBREVIATIONS

A &R - Abandonment and recovery
AA - Anti agglomerate
AACE - Advancement of cost engineering
AAV - Annulus access valve
ACFM - Alternating current field measurement
AHC - Active heave compensation
AHV - Anchor handling vessel
AMV - Annulus master valve
APDU - Asphaltene precipitation detection unit
APV - Air pressure vessel
ASD - Allowable stress design
ASV - Annulus swab valve
AUV - Autonomous underwater vehicle
AWV - Annulus wing valve
B&C - Burial and coating
BM - Bending moment
BOPD - Barrels of oil per day
BR - Bend restrictor
C/WO - Completion and workover
CAPEX - Capital expenditures
CAPEX - Capital expenditures
CAT - Connector actuation tool
CCD - Charge-coupled device
CCO - Component change-out tool
CDTM - Control depth towing method
CFP – Cold flow pipeline
CG - Center of gravity
CI - Corrosion inhibitor
CII - Colloidal instability index
CIU - Chemical injection unit
CMC - Crown-mounted compensator
CoB - Cost of blowout
CoG - Center of gravity
CP - Cathodic protection
CPT - Compliant piled tower

CPT - Cone penetration test
CRA - Corrosion-resistant alloy
CV - Coefficient value
CVC - Pipeline end connector
CVI - Close visual inspection
DA - Diver assist
DCU - Dry completion unit
DDF - Deepdraft semi-submersible
DEG - Diethylene glycol
DFT - Dry film thickness
DGPS - Differential global positioning system
DH - Direct hydraulic
DHSV - Downhole safety valve
DOP - Dilution of position
DP - Dynamic positioning
DSS - Direct simple shear
DSV - Diving support vessel
EC - External corrosion
EDM - Electrical distribution module
EDP - Emergency disconnect package
EDU - Electrical distribution unit
EFAT - Extended factory acceptance test
EFL - Electric flying lead
EGL - Energy grade line
EH - Electrical heating
EI - External impact
EOS - Equation of state
EPCI - Engineering, procurement, construction and installation
EPU - Electrical power unit
EQD - Emergency quick disconnect
ESD - Emergency shutdown
ESP - Electrical submersible pump
FAR - Flexural anchor reaction
FAT - Factory acceptance test
FBE - Fusion bonded epoxy
FDM - Finite difference method
FE - Finite element
FEA - Finite element analysis
FEED - Front-end engineering design

FEM - Finite element Method
FMECA - Failure mode, effects, and criticality analysis
FOS - Factor of safety
FPDU -Floating production and drilling unit
FPS - Floating production system
FPSO - Floating production, storage and offloading
FPU - Floating production unit
FSHR - Free standing hybrid riser
FSO - Floating storage and offloading
FSV - Field support vessel
FTA - Fault tree analysis
GL - Guideline
GLL - Guideline-less
GoM - Gulf of Mexico
GOR - Gas/oil ratio
GPS - Global positioning system
GSPU - Polyurethane-glass syntactic
GVI - General visual inspection
HAZID - Hazard identification
HCLS - Heave compensated landing system
HCM - HIPPS control module
HCR - High collapse resistance
HDM -Hydraulic distribution module
HDPE - High density polyethylene
HFL - Hydraulic flying lead
HGL - Hydraulic grade line
HIPPS - High integrity pressure protection system
HISC - Hydrogen-induced stress cracking
HLV - Heavy lift vessel
HMI- Human machine interface
HP/HT - High pressure high temperature
HPU - Hydraulic power unit
HR - Hybrid riser
HSE - Health, safety, and environmental
HSP - Hydraulic submersible pump
HT - Horizontal tree
HTGC - High temperature gas chromatography
HXT - Horizontal tree
HXU - Heat exchanger unit

IA - Inhibitor availability
IBWM - International bureau of weights and measures
IC - Internal corrosion
ICCP - Impressed current cathodic protection
IE - Internal erosion
IMR - Inspection, maintenance, and repair
IPU - Integrated production umbilical
IRP - Inspection reference plan
IRR - Internal rate of return
ISA - Instrument society of America
ISO - International Organization for Standards
IWOCS – Installation and workover control system
JIC - Joint industry conference
JT - Joule Thompson
KI - Kinetic inhibitor
L/D - Length/diameter
LARS - Launch and recovery system
LBL - Long baseline
LC - Life cycle cost
LCWR - Lost capacity while waiting on rig
LDHI - Low dosage hydrate inhibitor
LFJ - Lower flexjoint
LOT - Linear override tool
LP - Low pressure
LPMV - Lower production master valve
LRP - Lower riser package
LWRP - Lower workover riser package
MAOP - Maximum allowable operating pressure
MASP - Maximum allowable surge pressure
MBR - Minimum bend radius
MCS - Master control station
MEG - Mono ethylene glycol
MF - Medium frequency
MIC - Microbiological induced corrosion
MMBOE - Million barrels of oil equivalent
MOPU - Mobile offshore drilling unit
MPI - Magnetic particle inspection
MPP - Multiphase pump
MQC - Multiple quick connector

MRP - Maintenance reference plan
MTO - Material take-off
NAS - National aerospace standard
NDE - None destructive examination
NDT - Nondestructive testing
NGS - nitrogen generating system
NPV - Net present value
NS - North sea
NTNU - The Norwegian university of science and technology
O&M - Operations and maintenance
OCR - Over consolidation ratio
OCS - Operational Control System
OHTC - Overall heat transfer coefficient
OPEX - Operation expenditures
OREDA - Offshore reliability data
OSI - Oil States Industries
OTC - Offshore Technology conference
PAN - Programmable acoustic navigator
PCP - Piezocone penetration
PGB - Production guide base
PHC - Passive heave compensator
PhS - Phenolic syntactic
PIP - Pipe in pipe
PLC - Programmable logic controller
PLEM - Pipeline end manifold
PLET - Pipeline end termination
PLL - Potential loss of life
PMV - Production master valve
PMV - Production master valve
PoB - Probability of blowout
POD - Point of disconnect
PP - Polypropylene
PPF - Polypropylene foam
PSCM - Procurement and supply chain management
PSV - Production swab valve
PT - Pressure transmitter
PTT - Pressure/Temperature Transducer
PU - Polyurethane
PWV - Production wing valve

QC - Quality control
QE - Quality engineer
QP - Quality program
QRA - Quantitative risk assessment
RAO -Response amplitude operator
RBD - Reliability block diagram
RBI - Risk-based inspection
RCDA - Reliability-centered design analysis
RCMM - Reliability capability maturity model
REB - Reverse end bearing
ROT - Remote operated tool
ROV - Remote operated vehicle
RPPF - Polypropylene-reinforced foam combination
RSV - ROV support vessel
SAM - Subsea accumulator module
SAMMB - Subsea accumulator module mating block
SBP - Sub-bottom profiler
SCF - Stress concentration factor
SCM - Subsea control module
SCMMB - Subsea control module mounting base
SCR - Steel catenary riser
SCSSV - Surface controlled subsurface safety valve
SDA - Subsea distribution assembly
SDS - Subsea distribution system
SDU - Subsea distribution unit
SEM - Subsea electronics module
SEP - Epoxy syntactic
SEPLA - Suction embedded plate anchor
SIS - Safety instrumented system
SIT - Silicon intensified target
SIT - System integration test
SLEM - Simple linear elastic model
SPCS - Subsea production control system
SPCU - Subsea production communication unit
SPS - Subsea production system
SPU - Polyurethane-syntactic
SSC - Sulfide stress cracking
SSCC - Stress corrosion cracking
SSP - Subsea processing

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