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Guidance on Practice for Riser Vortex Induced Vibration Design

GP 65-72

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**

Foreword

This is the first issue of Engineering Technical Practice (ETP) BP GP 65-72. This Guidance on Practice (GP) is based on parts of heritage documents from the merged BP companies as follows:

British Petroleum

S/EPT/107/04, Rev1.1 Modelling Guidelines for Riser Vortex-Induced-Vibration (March 2005).

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Introduction

- a. This version of GP 65-72 supersedes earlier versions, including Exploration and Production Technology Group (EPTG) S/EPT/107/04, Rev 1.1.
- b. Vortex induced vibration (VIV) is a complex phenomenon that has been the subject of extensive research by both individual organisations and joint industry projects (JIPs). There is still limited understanding of VIV, resulting in substantial uncertainty in VIV modelling. Consequently, a rational strategy for risk management of riser VIV fatigue is under development by BP.
- c. This GP represents a significant step forward in defining guidance for riser VIV modelling. Periodic updates will be performed to accommodate new findings.
- d. Much of the data and results forming the basis of this guide are confidential to BP and/or JIP participants. For this reason, the document may only be shared with Contractors or third parties under cover of an appropriately worded confidentiality agreement.
- e. This GP essentially defines the “what” of riser VIV design, while GN 65-701 describes the “how” of riser hydrodynamics modelling in general (VIV and Morison based analysis).
- f. Due to the large scale reorganisation of (and additions to) information contained in this GP relative to earlier issues, no further description of changes made is attempted, as noted in Annex A.



1. Scope

- a. This GP provides guidance on assessment of riser VIV caused by currents.
- b. This GP describes BP recommended practice for VIV modelling of dynamic riser systems and explains BP preferred approach to design of riser systems subject to VIV.
- c. Reference is made to other types of riser response, including:
 1. Riser VIV due to general vessel motion.
 2. Riser VIV and non-VIV response due to vessel VIV or vortex induced motion (VIM), typically of spars.
 3. Wake induced oscillation (WIO) and riser interference.
 4. Galloping.
- d. Limited information is provided on design, selection, and use of VIV suppression devices.
- e. A major objective of this GP is to provide reliable guidance for prediction of riser fatigue damage due to VIV in general (as far as reasonably possible with current state of the art) but with special emphasis on current-induced VIV.

VIV is unlikely to affect extreme case load checks to an important degree.

- f. Content has been developed primarily for global response of tension dominated deepwater risers, although much of this GP is also applicable for shallower water (100 m [328 ft]). “Tension dominated” means that at least the first few natural modes and frequencies are governed by tension rather than by bending stiffness. For structures that do not fit this description or for novel or unusual designs, EPTG should be consulted on applicability.

2. Normative references

The following normative documents contain requirements that, through reference in this text, constitute requirements of this technical practice. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this technical practice 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.

BP

GN 65-701	Riser Hydrodynamics Modelling.
GN 65-704	Riser Fatigue Calculation.
GN 65-707	Metoccean Data.
GP 65-74	Guidance on Design of Top Tensioned Risers.

Det Norske Veritas (DNV)

DNV-OS-F201	Dynamic Risers, 2001.
DNV-RP-F105	Free Spanning Pipelines.
DNV-RP-F203	Riser Interference, June 2004 (Draft).
DNV-RP-F204	Riser Fatigue, August 2004 (Draft).
DNV CN 30.5	Classification Note (CN) 30.5 “Environmental Conditions and Environmental Loads” (to be superseded by DNV-RP-C205).



Miscellaneous references

2H Offshore	“BP Shah Deniz Damping Tests”, report 1727-RPT-1202-Rev1, September 2004.
Blevins	“Flow-Induced Vibration”, 1994, Krieger Publishing Co.
Finn, et al	“Time Domain Prediction of Riser VIV”, 4th Int. Conf. Advances in Riser Technologies, May 1999.
Huse, et al	“VIV-Induced Axial Vibrations in Deep Sea Risers”, OTC10932 1999.
RiserTec	“Review of BP VIV Testing: SHEAR7 Calibration Against NDP High Mode Strake VIV Tests”, report BP-004-005I-REP-008-Rev3, February 2005.

3. Abbreviations and Definitions

For the purpose of this GP the following abbreviations apply:

CFD	Computational fluid dynamics.
ECA	Engineering criticality assessment.
EPTG	Exploration and Production Technology Group.
FE	Finite element.
FM	Fracture mechanics.
FSF	Fatigue safety factor.
GOM	Gulf of Mexico.
JIP	Joint industry project.
Re	Reynolds number.
R&D	Research and development.
SCF	Stress concentration factor.
SCR	Steel catenary riser.
St	Strouhal number, fD/U , (f = shedding frequency, D = diameter, U = current speed).
S-N	Stress-cycle log relation.
TTR	Top tensioned vertical riser.
VIM	Vortex induced motion (of vessels).
VIV	Vortex induced vibration.
Vr	Reduced velocity U/fD , (U = current speed, f = actual response frequency, D = diameter).
Vrn	Reduced velocity, U/f_nD , (U = current speed, f_n = natural frequency, D = diameter).
WIO	Wake induced oscillation.



For the purpose of this GP the following definitions apply:

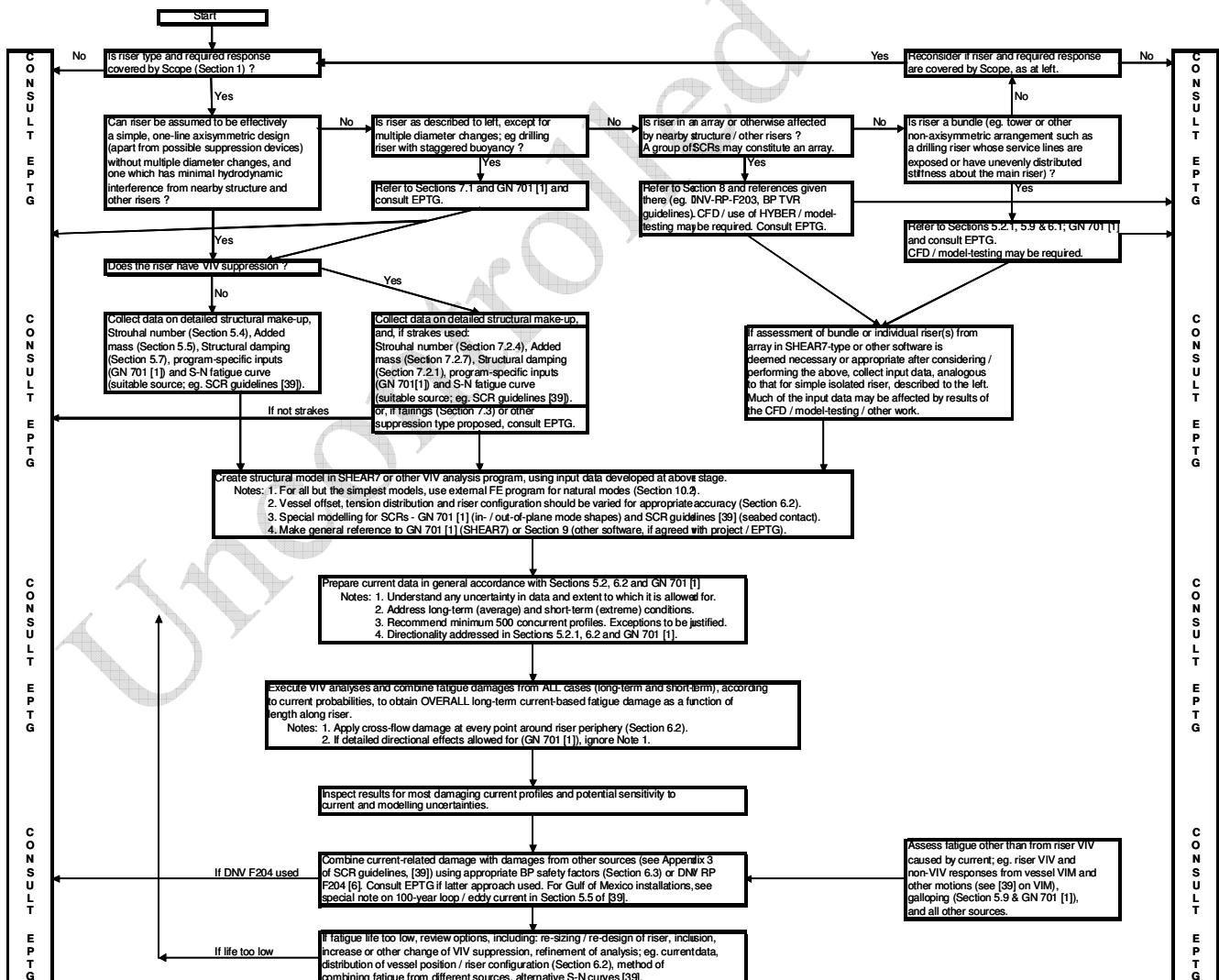
- Shall The word “shall” is to be understood as mandatory
- Should The word “should” is to be understood as strongly recommended
- May The word “may” is to be understood as allowable

4. Riser VIV design guidelines

- GN 65-701 should be consulted for assistance with calculations associated with design recommendations, together with suggested trends emerging from latest research findings.
- EPTG should be consulted for latest advice on data, recommendations, supporting material, or if clarification or further guidance is needed.
- Figure 1 is an overview flowchart for using the current guidelines.

Figure 1 - Riser VIV fatigue assessment using design guidelines

- Notes on Figure 1



1. Tentatively assumes SHEAR7 is used, but is more broadly applicable.
2. Assumes detailed design stage, but is also a guide to preliminary assessment.
3. For fracture mechanics and engineering criticality assessment (ECA), see 7.3 and GN 65-704, Chapter 9.
4. Flowchart is an aid to using full GP, but not a substitute.

5. Risk management strategy

- a. Dynamic riser systems shall be assessed by a competent person for susceptibility to VIV motion, hydrodynamic instabilities, and the associated loadings and fatigue damage.
- b. The BP recommended risk management strategy for riser VIV fatigue is based on predictive analytical modelling and riser performance monitoring.

There is future need:

- *To improve confidence in existing software through calibration.*
- *For a risk based approach where safety factors are tailored to prediction variability in conjunction with an associated failure probability.*

Work to develop new SHEAR7 strake models through calibration with high quality experimental data (RiserTec report and Bibliographic refs. [1], [2] and [3]) has allowed BP to reduce conservatism and improve confidence in damage rate predictions for straked risers. Future availability of quality field data from BP riser integrity monitoring programmes will allow better calibration.

A comprehensive back analysis is being performed to calibrate SHEAR7 against long riser response measurements, with emphasis on drilling risers. This should result in improved guidance on SHEAR7 input data and associated fatigue safety factors (FSFs).

With a larger database, "behaviour categories" become useful, as in Table 1.

Table 1 - Riser behaviour categories

Category A: Riser type	Category B: Mode response	Category C: VIV Suppression	Category D: Environment
A1: High tension	B1: Single mode	C1: Full coverage	D1: Uniform current
A2: Low tension	B2: Low mode (2 to 9)	C2: Partial coverage	D2: Sheared current
	B3: High mode (>10)		D3: Multi-directional
			D4: Wave influenced

For example, a drilling riser in the Schiehallion Field would be defined as A1/B2/C1/D2, for which a specific VIV model (or parameter set) would be available, with a recommended FSF for a given reliability requirement. Calibrated software with tailored FSFs would be provided for each combination of interest. This approach remains under development.

6. General and plain pipe VIV analysis and design

6.1. Introduction

- a. SHEAR7 v4.4 (briefly overviewed in 10 and described in more detail in GN 65-701) should be used for riser VIV analysis.
- b. Programs other than SHEAR7 v4.4 may be used for riser VIV analysis, as discussed in 10.

Some limitations and uncertainties in VIV measurement and prediction are:



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