

DEP SPECIFICATION

PIPE-SOIL INTERACTION ON A SOFT CLAY SEABED

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DESIGN AND ENGINEERING PRACTICE



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PREFACE

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These views are based on the experience acquired during involvement with the design, construction, operation and maintenance of processing units and facilities. Where deemed appropriate DEPs are based on, or reference international, regional, national and industry standards.

The objective is to set the standard for good design and engineering practice to be applied by Shell companies in oil and gas production, oil refining, gas handling, gasification, chemical processing, or any other such facility, and thereby to help achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to Shell companies for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual Operating Units to adapt the information set forth in DEPs to their own environment and requirements.

When Contractors or Manufacturers/Suppliers use DEPs, they shall be solely responsible for such use, including the quality of their work and the attainment of the required design and engineering standards. In particular, for those requirements not specifically covered, the Principal will typically expect them to follow those design and engineering practices that will achieve at least the same level of integrity as reflected in the DEPs. If in doubt, the Contractor or Manufacturer/Supplier shall, without detracting from his own responsibility, consult the Principal.

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All administrative queries should be directed to the DEP Administrator in Shell GSI.

TABLE OF CONTENTS

1.	INTRODUCTION	4
1.1	SCOPE.....	4
1.2	DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS	4
1.3	DEFINITIONS	4
1.4	CROSS-REFERENCES	6
1.5	SUMMARY OF MAIN CHANGES.....	6
1.6	COMMENTS ON THIS DEP	6
1.7	DUAL UNITS.....	7
1.8	NON NORMATIVE TEXT (COMMENTARY).....	7
2.	GENERAL REQUIREMENTS	8
2.1	OBJECTIVES.....	8
2.2	BACKGROUND	8
2.3	EXTERNAL STANDARDS.....	8
3.	SOIL PROPERTIES REQUIRED FOR DESIGN.....	9
3.1	GENERAL	9
3.2	GEOPHYSICAL SURVEY	9
3.3	GEOHAZARDS	9
3.4	GEOTECHNICAL SURVEY REQUIREMENTS.....	9
4.	DETERMINATION OF PIPELINE SOIL INTERACTION PARAMETERS.....	12
4.1	PIPE EMBEDMENT	12
4.2	VERTICAL PIPE-SOIL STIFFNESS.....	13
4.3	AXIAL RESISTANCE.....	13
4.4	LATERAL RESISTANCE	17
5.	REFERENCES	21
6.	BIBLIOGRAPHY	22

1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the characterization and representation of the soil in pipe-soil interaction modeling of a pipeline or flowline on a normally consolidated or lightly overconsolidated clay seabed. It is intended to address the derivation of soil resistance in applications of curve stability, thermal expansion, pipe lateral buckling and walking problems associated with flowlines.

Normally consolidated marine clays are typically encountered where suspended sediments (e.g., from rivers) are carried by currents that are not strong enough to carry coarser sediments. They are typically encountered at or near the seafloor in marine continental slope/rise environments and certain continental shelf areas.

This DEP is applicable only for pipes laid on the seabed, for which only the strength up to a depth of at most 2 m (6.5 ft) is relevant.

This DEP includes requirements for the geotechnical survey, testing and data collection, in order to determine the soil parameters required in the pipe-soil interaction analyses.

This DEP also applies to determine pipe-soil interaction properties on a silt seabed if the silt has comparable strength and stiffness properties to a soft clay.

This is a revision of the DEP of the same number dated September 2012; see (1.5) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorized by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them. Any authorized access to DEPs does not for that reason constitute an authorization to any documents, data or information to which the DEPs may refer.

This DEP is intended for use in facilities related to oil and gas production, gas handling, oil refining, chemical processing, gasification, distribution and supply/marketing. This DEP may also be applied in other similar facilities.

When DEPs are applied, a Management of Change (MOC) process shall be implemented; this is of particular importance when existing facilities are to be modified.

If national and/or local regulations exist in which some of the requirements could be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which of the requirements are the more stringent and which combination of requirements will be acceptable with regards to the safety, environmental, economic and legal aspects. In all cases, the Contractor shall inform the Principal of any deviation from the requirements of this DEP which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned, the objective being to obtain agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party that carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier** is the party that manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party that initiates the project and ultimately pays for it. The Principal may also include an agent or consultant authorized to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

Term	Definition
Administrator	Person responsible for administration of the DEP system.
Approve, Approved, or Approval	Principal's written agreement, prior to ordering material and/or beginning work, that the submitted item has been performed in accordance with the project requirements.
Axial direction	Parallel to the route direction of the pipe.
External Standard	Standard issues under the auspices of a non-Group entity, e.g., ISO, EN, ANSI, BS, API.
Heavy pipe	A pipeline that is expected to move deeper when displaced laterally during buckling, having a normalised weight of $V/s_u D > 2$, where V is the pipe weight, s_u is the intact soil undrained strength at the depth of the pipe invert and D is the pipe diameter.
High	The high value for an uncertain parameter (e.g., soil property, or soil resistance to pipe movement) is one that has 5 % probability of being exceeded.
Lateral direction	Direction that is perpendicular to the route direction of the pipe.
Light pipe	A pipeline that is expected to rise when displaced laterally during buckling, having a normalised weight of $V/s_u D < 2$, where V is the pipe weight, s_u is the intact soil undrained strength at the depth of the pipe invert and D is the pipe diameter.
Limit states design	A design process which, per DEP 31.40.10.18-Gen., has been deemed applicable.
Low	The low value for an uncertain parameter is one for which the probability of an even lower value is 5 %.
Modeling uncertainty	Uncertainty in parameter calculated by a formula or calculation method that arises that remains even when all the input parameters to the formula or calculation method are known exactly, i.e., this pertains to the accuracy of the formula, due to assumptions, approximations or empirical fits that it represents.
Parameter uncertainty	Uncertainty in parameter calculated by a formula or calculation method that arises due to uncertainty in the input parameters to the formula or calculation method.
Pipe-Soil Interaction (PSI)	Interaction between the pipe and the soil supporting that requires a mathematical description of the soil resistance to pipe movements in order to determine by analysis the stresses and strains in the pipe, its displacements and the loads the soil exerts on it. Typically, such mathematical description of the soil resistance is in the form of nonlinear and/or inelastic springs, or a frictional surface that is not fully hard and may allow different friction coefficients to be used as a function of direction (axial or lateral), (cyclic) movement history or normal force. Full three-dimensional continuum modeling of the soil is not covered by this DEP. It may be used subject to approval by the Principal.

Term	Definition
Standard	A document, established by consensus and approved by a recognised body that provides, for common and repeated use, rules, guidelines or characteristics for activities and their results, aimed at the achievement of the optimum degree of order in a given context.
Subject matter expert	Person accepted by the Principal has having specific expertise and knowledge in the subject area

1.3.3 Abbreviations

Term	Definition
BE	Best Estimate
CRS	Constant Rate of Strain
DEP	Design Engineering Practice
HE	High Estimate
LE	Low Estimate
JIP	Joint Industry Project
PSI	Pipe-Soil Interaction
SHANSEP	Stress History and Normalised Soil Engineering Properties
SI	International System of Units
USC (Units)	United States Customary (Units)

1.4 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section or clause number is shown in brackets (). Other documents referenced by this DEP are listed in (5).

1.5 SUMMARY OF MAIN CHANGES

This DEP is a full revision of the DEP of the same number dated September 2012. It has been updated to reflect the 2015 version of the SAFEBUCK guidelines on safe design of pipelines with lateral buckling. The changes are too numerous to itemise.

1.6 COMMENTS ON THIS DEP

Comments on this DEP may be submitted to the Administrator using one of the following options:

Shell DEPs Online (Users with access to Shell DEPs Online)	Enter the Shell DEPs Online system at https://www.shelldeps.com Select a DEP and then go to the details screen for that DEP. Click on the "Give feedback" link, fill in the online form and submit.
DEP Feedback System (Users with access to Shell Wide Web)	Enter comments directly in the DEP Feedback System which is accessible from the Technical Standards Portal http://sww.shell.com/standards . Select "Submit DEP Feedback", fill in the online form and submit.

DEP Standard Form (Other users)	Use DEP Standard Form 00.00.05.80-Gen. to record feedback and email the form to the Administrator at standards@shell.com .
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Feedback that has been registered in the DEP Feedback System by using one of the above options will be reviewed by the DEP Custodian for potential improvements to the DEP.

1.7 DUAL UNITS

This DEP contains both the International System (SI) units, as well as the corresponding US Customary (USC) units, which are given following the SI units in brackets. When agreed by the Principal, the indicated USC values/units may be used.

1.8 NON NORMATIVE TEXT (COMMENTARY)

Text shown in italic style in this DEP indicates text that is non-normative and is provided as explanation or background information only.

Non-normative text is normally indented slightly to the right of the relevant DEP clause.