

PIPELINE/TRAWLGEAR INTERACTION

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for the design of submarine pipelines against trawlgear interaction loads. This includes predicting the local response of the pipeline to impact loads and the global (bending) response of the pipeline to pullover loads, and acceptance criteria for the integrity of the pipeline following the interaction event.

This DEP is a revision of the DEP of the same number dated December 1997; see (1.6) regarding the changes.

1.2 DISTRIBUTION, INTENDED USE AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by Shell GSI, the distribution of this DEP is confined to Shell companies and, where necessary, to Contractors and Manufacturers/Suppliers nominated by them.

This DEP is intended for use in oil refineries, chemical plants, gas plants, exploration and production facilities and, where applicable, supply/marketing installations.

When DEPs are applied, a Management of Change (MOC) process should 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 may 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 as regards 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 with the object of obtaining agreement to follow this DEP as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

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

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

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may include an agent or consultant authorised 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

The following specific definitions and terminology are used in this DEP:

Beam shoe: The two shoes attached at each end of a trawl beam, which provide the connection points for the towing chains and the net.

Beam trawl: The combined trawl beam and beam shoes assembly.

Denting: Local deformations of the wall of the pipeline, primarily due to transient loads at the moment of impact.

Hooking: Trawlgear snagging on a pipeline preventing the passage of the trawlgear.

Pullover: Trawlgear movement over and past the pipeline, typically inducing loads on the pipeline that last several seconds.

Sweep line: The tow wires between each otter trawl board and the net.

Trawl beam: The steel beam between the two beam shoes.

Trawl board: The door beam between the two beam shoes.

Trawlgear: The seabed equipment used for trawling. In the context of trawlgear/pipeline interaction, this primarily constitutes the trawl beam and the two beam shoes for beam trawling, and the two trawl boards for otter trawling.

Warp line: The tow wire connecting the trawler vessel to the seabed trawl board or trawl beam.

1.4 NOTATION

The following notation (with appropriate SI units) is used in this DEP:

α	coefficient of linear thermal expansion ($^{\circ}\text{C}^{-1}$)
β	empirical factor
ρ	density of sea water (kg/m^3)
ϕ	directional weighting factor
κ	bending curvature ($1/\text{m}$)
γ	submerged weight of soil (N/m^3)
μ	lateral friction coefficient
ν	Poisson's ratio
∇	displaced volume of trawlgear
A	cross-sectional area of pipe steel (m^2)
A_e	half area of pipe cross-section embedded below the seabed (m^2)
B	half trawl board height (m)
C_a	added mass coefficient
e	exposed proportion of the pipeline length
d_I	dent depth at impact (m)
E	Young's modulus (N/m^2)
E_I	impact energy (J)
F_p	total pullover force (N)
$\bar{F}_p$	dimensionless parameter group for determining F_p
F_z	vertical component of pullover force (N)

$\bar{F}_z$	dimensionless parameter group for determining F_z
F_r	lateral soil resistance (N/m)
f_c	crossing frequency (year ⁻¹)
G	span gap below the pipe (m)
$\bar{G}$	dimensionless parameter group for span gap G
h	beam shoe attachment point height (m)
$\bar{H}$	dimensionless parameter group for attachment point height h .
I	fishing intensity (hours/km ² /year)
k	warp line elasticity (N/m)
m	mass (kg)
m_e	effective mass (kg)
N_e	effective axial force in pipeline (N)
OD	pipeline overall diameter including coatings (m)
OD_{st}	pipeline steel outside diameter (m)
P_i	pipeline internal pressure (N/m ²)
S_y	pipe yield stress (N/m ²)
t	pipeline steel wall thickness (m) or pullover duration(s)
$\bar{t}$	dimensionless parameter group for determining t (pullover duration)
ΔT	difference between the predicted maximum operating temperature and the temperature of the pipeline during installation (°C)
V	trawling velocity (m/s)
W	current value of the vertical foundation reaction per unit length (N/m)

1.5 CROSS-REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced in this DEP are listed in (6) and (7).

1.6 SUMMARY OF MAIN CHANGES SINCE PREVIOUS EDITION

The previous edition of this DEP was dated July 1998. This revision has been primarily editorial, the only significant technical change being the correction of equations in Appendix A.2.2.

NOTE: The results of a 2005 study looking at the overtrawling of large diameter pipelines and the possible use of model scale data to predict the behaviour of full scale fishing interaction have not been reflected in this revision. Following review, they may be incorporated in a future revision.

1.7 COMMENTS ON THIS DEP

Comments on this DEP may be sent to the DEP Administrator at standards@shell.com. Shell staff may also post comments on this DEP on the Surface Global Network (SGN) under the Standards folder. The DEP Administrator and DEP Author monitor these folders on a regular basis.

2. TRAWLING AND FISHING STATISTICS

2.1 TRAWLING AND TRAWLGEAR

Fishing activities employing bottom trawlgear along the route of a planned offshore pipeline need to be addressed during the design of that pipeline for two reasons:

- possible consequences of fishing activities on the integrity of the pipeline;
- possible hazards to fishermen from the presence of the pipeline.

Fishing activities employing bottom trawlgear can be categorised as otter trawling and beam trawling. The main difference is the type of trawlgear employed.

2.1.1 Otter trawling

Otter trawling is illustrated in (Figure 2.1). The figure shows a single vessel towing the net. Another form of otter trawling, pair trawling, is performed by two vessels each towing one side of the net.

The mouth of the net is held open by two trawl boards, one on either side of the net. The trawl boards are kept apart by hydrodynamic forces induced by the offset between the warp line (between the board and the vessel) and sweep line (between the board and net). The warp line lengths are typically two to three times the water depth.

A number of different types of trawl board are in use. Typical trawl boards are illustrated in (Figure 2.2).

NOTE: The four most common trawl boards used in the North Sea are the oval, polyvalent, 'V' shaped and rectangular shaped boards. The oval, polyvalent and rectangular trawl boards are steel-frame wooden structures. The oval and polyvalent trawl boards are used by most North Sea and Atlantic fishery nations. The rectangular trawl board is the traditional trawl board used by the fisheries of Western Europe, and its abrupt front edge may produce severe impacts with pipelines. The 'V' shaped board is an all-steel structure and is used by several nations fishing in the North Sea and the Atlantic.

2.1.2 Beam trawling

Beam trawling is illustrated in (Figure 2.3). The mouth of the net is held open on a transverse beam which slides across the seabed on shoes at each end of the beam. Currently metal beams are usually used, generally towed in pairs depending on the size of the vessel.

Details of a typical beam shoe are shown in (Figure 2.4). The beam shoes support the beam at a short distance above the seabed. The front edge of the shoe may be straight, sloping or curved. The ability of the shoe to ride over seabed obstructions can be improved by the use of "hoop bars" fitted to the front edge.

The beam is pulled by towing chains which are attached to each shoe. The towing chains are approximately the same length as the width of the trawl beam, and are connected to a single warp line through a towing block ahead of the beam. The warp line lengths are typically two to three times the water depth. The towing chains are attached to one of a number of towing points located on the front of each shoe.

2.2 FISHING STATISTICS

Fishing techniques are subject to constant change. Studies addressing interaction between pipelines and fishing activities should therefore always commence with a prediction of the fishing techniques and fishing intensity, based on:

- a review of available statistics;
- anticipated developments in the fishing industry.

The fishing data to be defined should include:

- trawling techniques;
- trawling velocities;
- gear type, mass and dimensions;
- direction (random, perpendicular or parallel);
- intensity.

NOTES: 1. Trawling intensity is conventionally defined in terms of hours fished per km² per year. Fishing statistics are usually held by the International Council for the Exploration of the Seas (I.C.E.S) and relevant Government organisations. For example, potential sources of fishing statistics for the North Sea are:

Netherlands: Rijksinstituut voor Visserijonderzoek, IJmuiden

Belgium: Ministère de l'Agriculture, Ostende

England and Wales: Ministry of Agriculture, Fisheries and Food, Lowestoft

Scotland: Department of Agriculture and Fisheries for Scotland, Aberdeen

Norway: Fiskeridirektoratets Havforsknings Institut, Bergen

Denmark: Danmarks Fiskeri- og Havundersøgelser, Charlottenlund

2. For otter trawls, typical trawling velocities and trawl board masses (1995 figures) are shown below:

Fishing Vessel	Trawlgear Velocity (knots)	Trawlgear Mass (tonnes)
French Stern	4.0	1.4
German Stern	4.5	2.2
Norwegian	5.0	2.3
UK Light	3.2	1.2
UK Motor	2.5	1.2

3. Typical trawling velocities for a Dutch beam trawl are up to 8 knots. Typical trawlgear masses are 2.4 tonnes for both shoes and 2.6 tonnes for the beam (1995 figures).

2.3 CROSSING FREQUENCY

The frequency of pipeline crossings is related to the fishing intensity by the expression

$$f_c = \phi e I V \quad (\text{expression 2.1})$$

where

f_c is the number of crossings per year per km length of the pipeline;

I is the fishing intensity in fishing hours per km² per year;

V is the trawling velocity;

e is the proportion of the pipeline length that is exposed and therefore potentially subject to trawlgear crossings.

The constant ϕ depends on the predominant trawling direction. Values of ϕ are shown in (Table 2.1).

Table 2.1 Trawling Directional Factor, ϕ

Trawling Direction	Constant ϕ
Randomly distributed	$2/\pi$
Perpendicular to the pipeline route	1
Parallel to the pipeline route	0