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A Review on Vibrations of Marine Pipelines

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ABSTRACT

A comprehensive review is presented of vibrations of marine pipelines. The review is organized in four main sections, namely vibrations of wall-free cylinders in steady current, vibrations of wall-free cylinders in waves, the influence of the close proximity of the seabed, and finally forces on a vibrating pipeline.

INTRODUCTION

When pipelines are not buried, unsupported pipeline spans may exist in most locations. When spans develop due to scour they may change location from time to time, while in the case of pipeline crossings or seabed unevenness (where the bed is nonerodible), the locations are fixed. The span length may vary from 10 to 100 times the pipeline diameter, with a clearance from the sea bottom in the range of practically nil to 2 or even 3 times the pipeline diameter (Orgill et al., 1992). Such a pipeline span, when exposed to flow action, may undergo flow-induced vibrations (Fig. 1).

Flow-induced vibrations of pipelines have been the subject of extensive research in the last decade or so. A large volume of knowledge has accumulated as a result of this extensive research. The purpose of the present paper is to review this research work.

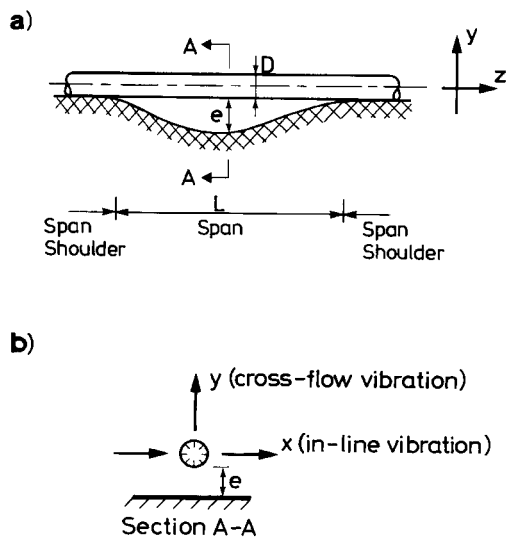

Fig. 1 Definition sketch

VIBRATIONS OF WALL-FREE CYLINDERS IN STEADY CURRENT

This and the following section will focus on the fundamental case, namely the wall-free cylinder. It may be noted that, apart from its fundamental importance, the wall-free cylinder case may be regarded as a special case with regard to vibrations of marine pipelines, since the pipeline will behave much the same as a wall-free cylinder when the clearance between the pipe and the sea bottom is large (larger than, say, 1.5-2 in diameter).

It is known that a cylinder exposed to a steady current experiences vortex shedding if the Reynolds number, $Re = UD/\nu$, is larger than about 40 (Batchelor, 1967). Here U = the flow velocity, D = the cylinder diameter and ν = the kinematic viscosity. The vortex shedding phenomenon results in a periodic variation of the force on the cylinder; the lift force oscillates at the vortex-shedding frequency, while the drag force oscillates at twice the vortex-shedding frequency.

If the cylinder is a flexibly mounted cylinder, these forces may induce vibrations. The lift force induces *cross-flow vibrations*, while the drag force induces *inline vibrations* (Fig. 1b). These vibrations are generally termed the vortex-induced vibrations.

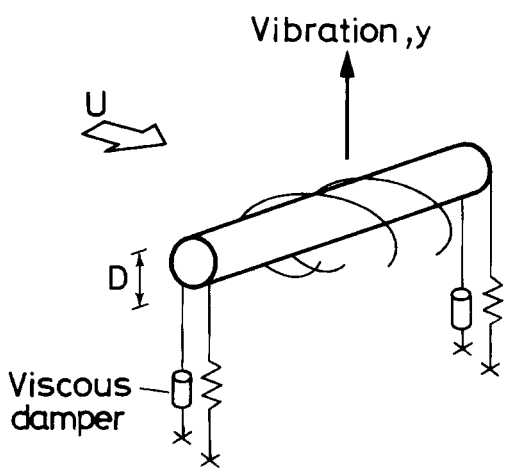

Fig. 2 Sketch of test setup with 1 degree of freedom of movement

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KEY WORDS: Current, flow-induced vibrations, lift force, marine pipeline, vibration, vortex shedding, waves.