An Overview of Seabed Storage Methods for Pipelines and Other Oil and Gas Equipment

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(Received December 02, 2016; Revised December 02, 2016; Accepted January 24, 2017)

In the construction of subsea oil and gas developments, it is increasingly common that subsea oil and gas equipment will be installed in subsea well before final hookup and production. Installation of wellheads, subsea hardware, pipelines, and surface facilities (platforms, FPSO, FLNG, connected terminals, or gas plants) are increasingly driven by independent cost and vessel availability schedules; this gives rise to requirements that the subsea facilities must be stored in the seabed for a specific time. In addition, schedule delays, particularly in the installation or startup of the connected platform, FPSO, FLNG, or onshore plant may cause unexpected extensions of the intended storage period. Currently, there are two methods commonly used for storage subsea facilities in the seabed: dry parking and wet parking. Each method has its own risks, challenges, and implications for the facility life and its integrity. The corrosion management and preservation method selection is a crucial factor to be considered in choosing the appropriate storage method and achieving a successful seabed storage. An overview of those factors is presented, along with a discussion on the internal corrosion threats and assessments.

**Keywords:** seabed storage, dry parking, wet parking, corrosion, microbial, chemical treatment

1. Introduction

The oil and gas industry is trending towards an increasing number of deep water developments, complex production facilities (e.g. FLNG) and hotter and more corrosive production sources requiring the use of corrosion resistant alloy (CRA) material clad and lined pipelines. Wellheads, subsea facilities and pipelines are increasingly being installed in separate operations, to take advantage of cost savings and vessel availability – these operations may be several years apart. The facilities can only be put into production (and exposed to the final corrosion control method) when the parent production facility – the host platform, floating production storage and offloading (FPSO), floating liquefied natural gas (FLNG) vessel, oil terminal or gas plant is available. Even if the installation process goes precisely as planned, the subsea assets may be installed several years before production begins. However, due to the ever increasing complexity of the production facilities, extended delays in delivery/startup are often encountered. This must be factored into the design and specification of seabed storage operations.

When the seabed storage goes wrong the consequences can be significant. The subsea facilities can be in a damaged condition with compromised integrity even before production is commenced. Even in mild cases, costly additional inspection and fitness-for-purpose assessments become necessary. In more severe examples, the design life of the equipment may be reduced, or equipment repair, replacement, or startup delays may be necessary. In a subsea development where billions of dollars have been invested, this risk has to be managed to an acceptable level. This paper describes the crucial factors that determine the success of seabed storage. The internal and external corrosion threats during seabed storage are discussed. Then guidelines are presented for the selection of the appropriate corrosion management and preservation strategies.

2. Storage Method Options

There are two common methods for storage of production equipment in seabed: “dry parking” and “wet parking”.

Dry parking is a method whereby the equipment is filled with gas. The gas could be dehydrated air or an inert gas such as nitrogen and may be at atmospheric pressure, or pressurised above hydrostatic ambient to resist in-leakage.
In wet parking, the filling medium is a non-corrosive liquid, such as MEG, chemically treated potable water, or chemically treated seawater.

Table 1 summarises the storage methods, and associated principal advantages and disadvantages.

### 3. Corrosion Threats and Assessment

The principal potential risks of corrosion during subsea storage are discussed below.

#### 3.1 External corrosion

The risks of external corrosion due to seawater exposure during seabed storage (irrespective of the method chosen) are effectively the same as during normal operation. The potential corrosion rates are arguably lower due to lower temperatures, but the solution is the same application of anti-corrosion coatings and cathodic protection that will have been provided for the operational design life. There are two minor additional threats inherent in seabed storage. The first is to ensure that the additional subsea exposure from the storage period is included in the CP design life; for example, a facility with a 20 year design life plus a 2 seabed year storage period will need