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## Waterflood Operability—Process and Chemical Issues

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### Abstract

In the last few years, Shell has implemented three deepwater waterflood systems. They are all on floating installations, employ relatively compact and light weight facility designs and are roughly the same capacity. While their overall designs are similar, important details of the designs are different, and the project management strategies were significantly different as well. The startup and initial run time experience of these waterfloods facilities differed greatly, ranging from significant downtime for the first project to nearly complete success for the last one. Shell is in the process of sanctioning a fourth deepwater waterflood system that is larger and more complex than the previous three. Obviously, Shell has already learned a great deal about how to successfully implement a deepwater waterflood project. Before we develop the new project however, we are capturing our waterflood experience to date.

### Introduction

In keeping with the theme of this OTC Session, “Challenges of Deepwater Waterflood Systems,” this paper focuses on the challenges that are unique to deepwater waterflood systems. The list of challenges that are given below is based on a review of the startup and initial operating experience of three recently built systems. First the challenges are described, then the background on each of the waterfloods is given, then we describe how the different waterflood systems approached the challenges, and what the outcome of these different approaches were.

In this paper, the following challenges of deepwater waterflood facilities systems are considered:

1. **Material selection / corrosion engineering**
2. **Oxygen control**
3. **Filtration**
4. **Fluid dynamics**
5. **Anti-Souring / Reservoir Management Strategy**

There are other features of waterflood systems that are discussed below. The list above includes only those challenges that have been found to have a significant impact on the reliability uptime and operability of the project. In this section, these challenges are described in more detail and we give the reasons why they are challenging.

- 1) **Material Selection / Corrosion Engineering:** The corrosive properties of oxygenated seawater are significant and pose a challenge to all industries that are involved with seawater including shipping, marine fishing, recreational boating, bridge building, etc.. This problem has been around for many years. While there are many more materials alternatives available today, material selection is still a challenge. Also, due to chloride stress corrosion cracking, the marine environment poses material selection challenges for even those components that do not handle the seawater directly. Not only is material selection a challenge but also quality assurance is a challenge - i.e. making sure that you get the material that you selected.
- 2) **Oxygen Control:** Closely related to materials selection is oxygen control. In fact, oxygen control is such a challenge, that many waterflood teams consider the option of injecting “raw” seawater. To do so, the materials have to be resistant to oxygenated seawater, which trades one challenge for another. In the end, most projects select deoxygenation in part because of materials performance uncertainty and cost. Compounding the challenge for deepwater projects is that traditional methods (vacuum tower, gas stripping tower) are large and heavy. So there has been significant effort to develop relatively compact and lightweight deoxygenation systems. There are several variables that can affect the oxygen concentration throughout the control system. In addition to the challenges of oxygen control, oxygen sensing / measurement is also a challenge. Thus, there is always an uncertainty in the validity of the data. Significant time and effort are usually spent by the project team to overcome these challenges.
- 3) **Filtration:** Deepwater waterflood systems actually have less severe filtration challenges than near-shore waterfloods. Also, it is now commonly recognized that injectivity impairment is significantly reduced if injection pressure is maintained above frac pressures and this is the typical strategy employed. With these factors in mind, it would seem that filtration is not a challenge at all. However, filtration becomes a challenge because of one important decision – whether or not to use deep bed