Pitting corrosion of offshore water injection steel pipelines

Robert E. Melchers & Mukshed Ahammed
Centre for Infrastructure Performance and Reliability, The University of Newcastle.
Newcastle, NSW, Australia.

ABSTRACT

The internal corrosion and pitting of water injection pipelines (WIP) is of much interest in the oil and gas industry. Water injection is used to aid the recovery of oil or gas from reservoirs that are nearing depletion. Most pipelines are low alloy high strength steels, many kilometres in length, not cathodically protected and placed on the seafloor. In some cases after some years service very severe internal corrosion, mainly pitting and channeling corrosion is observed, typically at the 6 o’clock position and sometimes at transverse welds. Various causes have been proposed. However, a critical issue is the depth of corrosion pitting that is likely to occur as the pipeline continues in use. Data extracted from intelligent pigging records for a number of water injection pipelines is presented. It is examined in the framework of conventional Extreme Value analysis. The data do not follow a Gumbel EV distribution as would be expected from fundamental theory and from (some, short-term) past experience. All the pipelines considered show similar trends for departure from the ideal, theoretical Gumbel distribution. As a result, extrapolation to longer pipelines or longer exposure periods is problematic. The reasons for these observations are considered and recommendation made as to how the data can be used in the most productive way for estimation of likely future maximum pit depth.

KEY WORDS: Pipelines, offshore, water-injection, pitting, corrosion, steel.

INTRODUCTION

Particularly for older gas and oil reservoirs nearing depletion, enhanced recovery of the remaining oil and gas can often be achieved by injecting water under high pressure (e.g. 200-250 bar) into the reservoir, usually at several different locations. The water injected often is seawater, or produced water (the water separated from the oil produced from a reservoir) or other available water sources, such as local aquifers (Fig. 1). Often combined sources are used. In all cases the water is filtered to remove sands and other particulate matter and also degassed with the aim to reduce the oxygen content in the water (typically to a nominal 20 ppb oxygen) and thereby attempt to reduce internal corrosion of the steel pipelines on the basis that oxygen starvation reduces the corrosion process. The water is supplied from a processing plant that may be some considerable distance above and away from the reservoir(s) and steel pipelines (water injection pipelines - WIPs) are used to convey the water from the plant to the injection points. Typically the WIPs are many kilometres in length and when used offshore are placed on the seafloor. For obvious reasons pipeline leakage or rupture is not desirable. Often severe pitting leads to cracking and likely pipeline rupture [Bai & Bai 2012]. For this reason the industry is very concerned about the severity of pitting corrosion as well as the severity of channeling corrosion.

Figure 1. Schematic water injection system showing reinjection of produced water or injection of seawater and aquifer water into an oil reservoir (based on Comanescu et al. 2015).

Conventionally the WIPs are constructed from conventional pipeline carbon steel (grades X50, X52 and X65) made in spools with a longitudinal weld and welded together with transverse welds. Higher-grade steels and various stainless steels have been tried but not adopted generally in the industry because of their (much) higher cost and the lack of clear evidence that their corrosion behaviour is better than for the conventional steels. Also because of economics, it is not common practice in industry to provide cathodic protection for WIPs used offshore, although CP is common onshore (Bai & Bai 2012). However, for offshore applications the WIPs usually are provided with a protective coating and this appears in most cases to be adequate for the expected lifetime of a pipeline. The main concern is with internal corrosion [ICEOC 2012].

Many WIPs show no evidence of serious internal corrosion even after many years operation. However, in some cases very severe corrosion has been observed, sometimes after only a few years service. In these latter cases corrosion tends to be most severe at the 6 o’clock