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Failure analysis of buried piping and cold drain vessel

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ABSTRACT

This paper describes the failure analysis of a cold drain vessel used to collect hydrocarbon fluids off liquefied natural gas through a network of buried piping. The analysis deals with (i) the corrosion of the buried piping and (ii) the cracking of the head plate of the vessel. The analysis comprises visual inspection, chemical and mechanical testing, and finite element thermo-mechanical stress analysis. Corrosion of the buried pipe was found to result from the combined effect of saline ground water, defective coating, ineffective cathodic protection, and stray current. Improper corrosion treatment led to stress corrosion cracking which ultimately caused complete fracture of the vessel head plate at a nozzle attachment. It is recommended to improve coating and cathodic protection, and to enhance welding quality and employ better design considerations to reduce the local stresses.

1. Introduction

1.1. Problem description

A gas processing plant located on the Mediterranean Sea shore uses a cold drain vessel to separate both butane and propane in the liquefied natural gas (LNG) from offshore platforms through a network of buried piping. Fig. 1 depicts a schematic of the cold drain vessel under investigation, which was fabricated in 2004 from 304L (18Cr–8Ni) stainless steel according to ASME section VIII-Div. 1 [1]. The vessel is located 8 m below sea level and is fed by the hydrocarbon liquids collected through a network of buried drain piping. The four millimeter thick tape-coated buried piping is made of 316L (16Cr–12Ni–2Mo) stainless steel. The pipe is 50.8 mm thick. A heating coil inside the vessel is used to evaporate the collected liquids to the flare. The coil utilizes hot oil, which is fed through the inlet nozzle connected to the 10 mm thick ellipsoidal head plate as shown in Fig. 1.

The nominal operating data of the vessel are: internal pressure $P_v = 1.5$ barg. and temperature range of −5/69 °C, and for the heating coil are: internal pressure $P_n = 16$ barg. and temperature range of 250/150 °C between oil inlet and outlet, respectively. Actual pressure and temperature histories were not available. The operation of this vessel is intended to be intermittent since these liquids are collected during a plant shutdown/startup. No data is available on the liquid levels which may trigger the vessel operation. However, vessel operation was more frequent than expected.

The piping connected to the hot oil inlet nozzle has experienced severe corrosion after 2 years in service, which ultimately penetrated its full thickness. This has eventually led to through-thickness cracking in the ellipsoidal head at the hot oil inlet nozzle weldment and hazardous leakage of flammable hydrocarbons was reported. This study presents the results of the failure analysis of both the buried piping and the vessel.

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