Available online at www.sciencedirect.com
ScienceDirect

Desalination 201 (2006) 35–45

DESALINATION

www.elsevier.com/locate/desal

Corrosion resistance and performance of steel alloys in MSF distillation plants

Ali Al-Odwani, Essam E.F. El-Sayed*, Mohamed Al-Tabtabaei, Mansour Ahmed

Water Technologies Department, Water Resources Division, Kuwait Institute for Scientific Research, P.O. Box 24885, Safat 13109, Kuwait
Tel. +965 4878122/4878124; Fax +965 4879238; email: esayed@kisr.edu.kw

Received 18 October 2005; accepted 12 January 2006

Abstract

Material performance and corrosion resistance in multistage flash (MSF) plants are considered among the most important drives and central issues in promoting the advancement of this technology. This study was aimed at testing materials of construction of high, medium, and low temperature stages of the heat recovery sections in MSF plants. Three ferric-based materials, namely carbon steel alloy UNS G10080 and stainless steel alloys UNS S31603 and S31254 were included in the study along with other materials. Specimens of these three materials were exposed to both liquid and vapor environments under well controlled conditions at three different temperatures; 90, 70, and 50^{o}C for durations ranging from 30 to 300 days. Performances and corrosion behavior of the specimens were analyzed and evaluated using weight loss measurements and electrochemical testing. This is the second paper in a series of three. The paper describes testing conditions and discusses results obtained from weight loss analysis. Highest corrosion rate of 0.4 mm/y was measured for carbon steel UNS 10080 in the vapor phase at 90°C after 300 days. Corrosion rates less than 0.0003 mm/y were obtained for stainless steel alloys and this had produced scatter in the results as the results approached the resolution limit of the experimental technique.

Keywords: Material performance; Corrosion resistance; Steel alloys; Copper alloys; Titanium

1. Introduction

Selection of materials of construction of multi-stage flash (MSF) distillation plants have evolved through the years as operational data and experience continued to accumulate with the extensive construction and operation of MSF plants during the last four decades of the twentieth century. At the time first-generation MSF plants were constructed, materials used were dominated by carbon steel, especially for shells, supporting structures, and many internal components. Knowledge of process dynamics and data on the performance of

*Corresponding author.

doi:10.1016/j.desal.2006.01.033

materials used was either limited or non-existent, and hence little was done to prevent corrosion. Instead, large allowances for corrosion were considered by increasing thicknesses well beyond design values for the components that are exposed or in contact with corrosive substances. This practice had resulted in over designed/over weight MSF units, and consequently restricted unit capacity, which contributed to keeping the prices of installed unit volume in the high range of $2,500–$3,000/m^3 [1]. In addition MSF units of that generation required more than usual down-time for maintenance, which had lead to lower operational performance and even higher overall production cost. By the beginning of the eighties of the past century, a new generation of MSF plants had emerged as a result of better understanding of the MSF process dynamics, and hence its consequence on the corrosion behavior of materials exposed or in contact with liquid and vapor environments. Development of higher grade alloys had meant and pushed for adoption of corrosion resistance way of design rather than the previous way of making allowance for corrosion. Stainless steel alloys had replaced carbon steel and became the dominant material in the new generation MSF plants, hence resulting in much better engineered units of lighter weight, larger size, and with a price of installed unit volume as low as $1,200/m^3 by the end of the 1990s [1].

Hence, the present study was initiated with the primary object to experimentally examine the corrosion behavior of a number of materials that are commonly used, or have the potential to be used, in the construction of MSF plants, with focus on the heat recovery section. The study included testing of a total of three steel alloys: carbon steel alloy UNS G10080, and two stainless steel alloys UNS S31603 and S31254. These materials are commonly used in the construction of flash chambers and deaerator shells, supporting structure, demisters, pumps, valves, piping, tanks, etc. Testing of these materials was conducted under controlled liquid and vapor environments similar to those of MSF plants at three different thermal levels; namely 90, 70, and 50ºC. Testing procedures have been designed to allow weight loss analysis of the various test specimens, which were exposed to the typical testing environments for different intervals running from one to ten months. Detailed descriptions of the test unit used in this study, test procedures, and process performance results over the extended period of the study are presented in a Part I paper [2] in a series of three parts.

2. Corrosion testing plan

A total of 108 steel test coupons were used in this study; 36 coupons for each of the three materials subject of the investigation. Each test coupon of the 36 from each of the three materials was subjected to a specific test condition in the following manner:

- Variable exposure environments: submerged in liquid brine or exposed in flashed vapor.
- Various temperatures: typical average test temperatures of 50, 70, and 90ºC.
- Variable exposure time: typically, 30, 90, 150, 210, 270, and 300 days.

The various combinations of these test conditions result in 36 case studies; each of these is represented by one coupon from each of the materials under investigation, which are identified in Table 1 in accordance with UNS standards and trade names. The chemical composition of the materials under investigation is presented in Table 2.

Table 1
The UNS number and the commercial/trade name of the steel materials under investigation

UNS	Commercial/trade name
G10080	Carbon steel C1008
S31603	Stainless steel SS316L
S31254	Stainless steel SS254SMO®