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# Failure analysis of type 304 stainless steel amine exchanger sheets in a gas sweetening plant

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ABSTRACT

Amine exchangers are widely used in gas sweetening plants for amine solution regeneration process. This study is investigates cracking and leakage of a 304 type stainless steel plate in an amine exchanger unit, used between absorption and stripper towers. In this regard, micro and macro examinations were performed on the plate, and solution was analyzed. Micro cracks were observed on both sides of the plate, especially under the gasket region of the plate. Results showed that the main reason of cracking was intergranular corrosion accompanied by stress. High concentration of Formate in amine solution, and also high level of stress under gasket region, had initiated the intergranular corrosion and cracking.

## 1. Introduction

Nowadays amine treating is one of the most common methods for removing acid gases from natural gas due to advantages like high efficiency, high acid gas absorption rate and, recyclability [1]. Popularity of amine solutions generally comes from its recyclability, therefore each equipment used for solution recycling is important from both financial and process points of view. Amine exchanger is a vital equipment since it is placed between absorber and regenerator (stripper) tower, and it exchanges the heat between lean and rich amine and finally prepares the solutions for absorbing and stripping process. Fig. 1 shows a simplified schematic of the gas sweetening process, with the position of an amine exchanger unit shown in the figure [2].

Corrosion is one of the most known problems in amine gas sweetening plants, mainly due to presence of $CO_2$ and $H_2S$ in natural gas stream [3,4]. Carbon steels suffer general corrosion more than other types of steels, while stainless steels are more commonly exposed to local forms of corrosion.

Leakage of MDEA amine solution occurred in a plate type amine exchanger in a gas sweeting plant. The amine exchanger consisted of 504 pieces stainless steel plates which were fixed with a through bolt, and between each plate gaskets were used in order to seal the plates from one another. The plates were made from ASTM 304 stainless steel, while other parts of exchanger were made from ASTM A516 carbon steel. One side of the sheet plates were in contact with lean amine solution while the other sides were in contact with semi-lean amine solution. Fig. 2. shows a schematic of a plate type amine exchanger unit.

## 2. Process description

Lean amine solution first enters the absorber tower while it is not very hot. Lean amine solution temperature increases during absorption of acidic gases from top towards the bottom of the tower. At the bottom of the tower the lean amine solution is saturated

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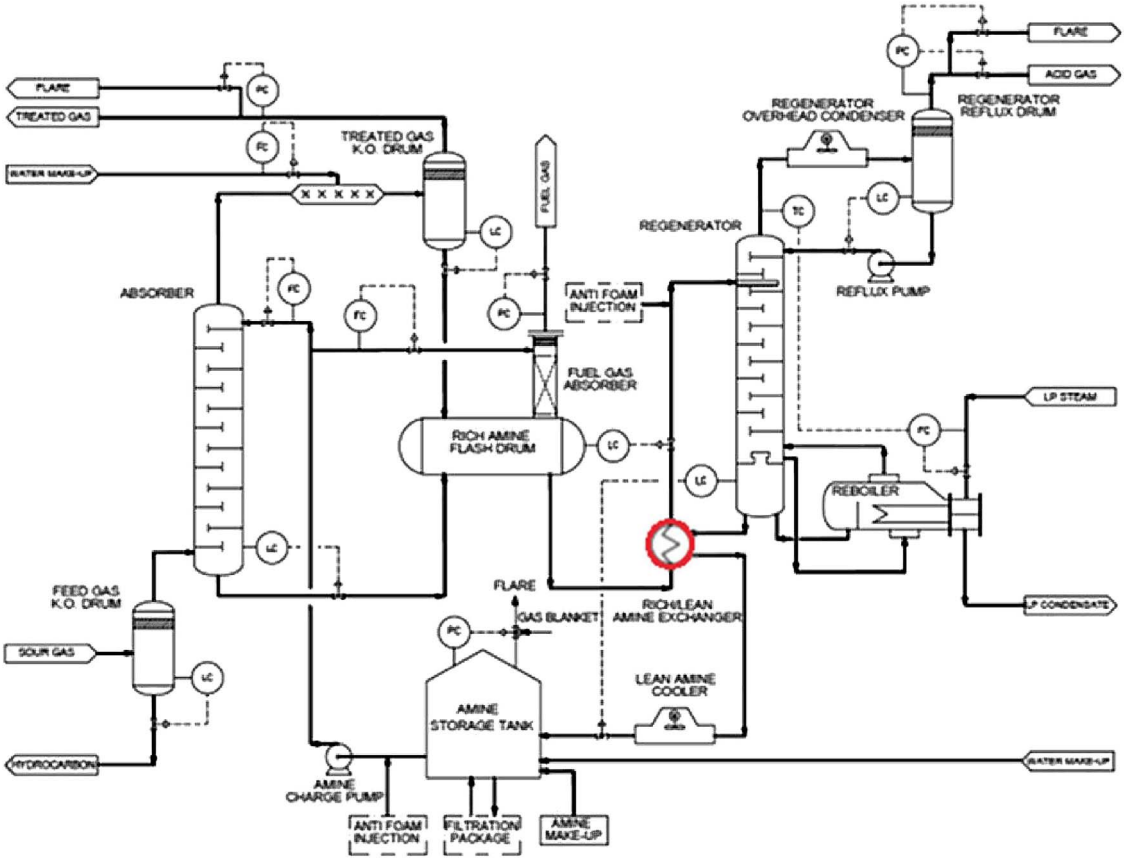


**Fig. 1.** Schematic of a amine gas sweetening unit. Red circle indicates the position of an amine exchanger unit [2].

from $CO_2/H_2S$ gases (acidic gases), which is called rich amine solution. The rich amine solution is heated and then enters a stripper tower in order to separate acidic gases from the solution, and converted to semi-lean and then to lean amine solution. When the lean amine solution exits the stripping tower it is hot and should be cooled prior to transformation to the absorption tower. Therefore, in this regard a heat exchanger unit is placed between the absorber and stripper tower, as shown by red circle in Fig. 1.

The working condition of the amine exchanger unit is summarized in Table 1. As can be seen from this table, lean amine solution has higher temperature and lower pressure in comparison to semi-lean solution, which is mainly used for the stripping (regeneration) process.

## 3. Experimental procedure

Specimens with different dimensions were cut from various regions of an amine exchanger sheet. The surface of samples was then examined by visual, non-destructive Dye Penetrant Test (PT), Stereo Microscope, and Scanning Electron Microscope techniques. Also, for metallographic examinations some samples were mounted in epoxy, grind to 1200 grit paper, polished and etched for a period of 30 sec in HCL-$HNO_3$-$H_2O$ solution. Amine solution composition was analyzed by Ion Gas Chromatography (IGC). pH of both semi-

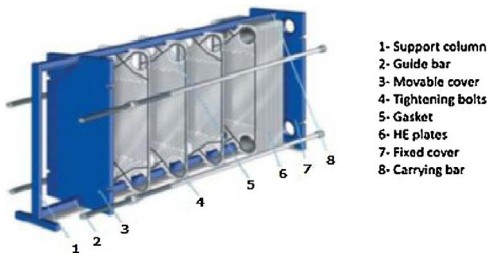


**Fig. 2.** Schematic of a plate type amine exchanger unit [5].