

## **Hydrochloric Acid Corrosion of a Venturi Gas Scrubber in a Continuous Catalyst Regeneration (CCR) Unit**

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### **ABSTRACT**

A venturi gas scrubber (ejector) made of Nickel-Chromium-Molybdenum (Ni-Cr-Mo) alloy UNS N06200 located in a Continuous Catalyst Regeneration (CCR) unit. failed prematurely after 1.5 years in operation. The scrubber was used to neutralize hydrochloric acid (HCl) and chlorine present in the regeneration tower vent gas using caustic injection (1 wt.% NaOH). A metallurgical failure analysis investigation concluded that the scrubber had failed due to hydrochloric acid (HCl) corrosion. In general, many alloys are susceptible to HCl corrosion at different acid concentrations. Originally, the scrubber was made of alloy UNS N10665 but was changed to alloy UNS N06200 after multiple failures. Recommendations are provided to prevent similar damage recurrence.

Key words: Hydrochloric Acid, HCl Corrosion, UNS N06200, CCR, Venturi Scrubber

### **INTRODUCTION**

Two of the most common acid gases produced by the refining industry are chloride compounds such as hydrogen chloride (HCl) and chlorine (Cl<sub>2</sub>). These compounds can react with water to form solutions of hypochlorous and hydrochloric acid. Droplets that condense are often highly concentrated, and acid concentrations in excess of 10% can be expected.<sup>1</sup> A common source of these gaseous compounds is the overhead exhaust/vent of regeneration tower within a Continuous Catalytic Reforming (CCR) unit. Chloride compounds in the regenerator vent gas are absorbed in 1 wt.% caustic (NaOH) by subsequent contact in a venturi scrubber (ejector), before venting chloride free gas to atmosphere through a wash tower.

At the venturi scrubber as shown in Figure 1, the gas stream enters the converging section and gas velocity increases as the area decreases. At the throat, liquid (caustic) is introduced. In other words, the inlet gas is forced to flow at very high velocity through the small throat section.

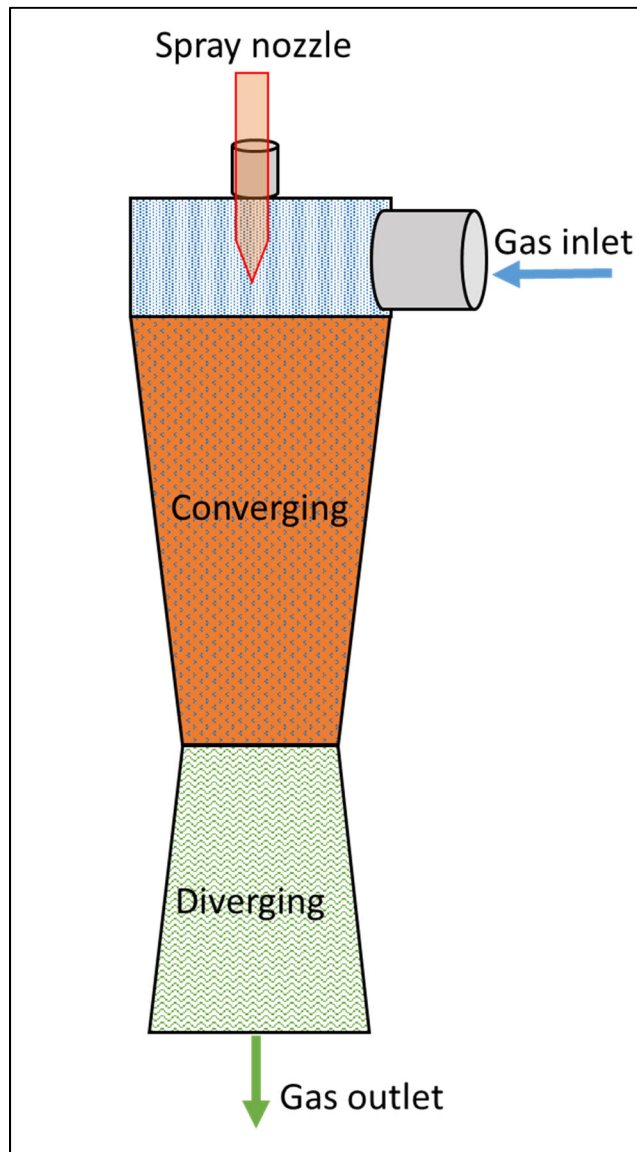


**Figure 1: Venturi scrubber (ejector) principal of operation.**

Many nickel alloys containing chromium and molybdenum have useful resistance to HCl in all concentrations up to approximately, 150 °F (65 °C) and in very dilute acid up to the boiling point. This is true in non-aerated acid in the absence of oxidizing agents (e.g. Cl<sub>2</sub>). Alloy N10665 and N10675, are particularly well suited for handling hydrochloric acid at all concentrations and temperatures (including the boiling point) but are attacked if exposed to oxidizing agent or aerated environments which can destroy passivity of the alloy and lead to high corrosion rates. Corrosion resistance in these environments increases with molybdenum content. Other resistant alloys, such as alloy UNS N10276, also contain tungsten. These Ni-Cr-Mo alloys are also very resistant to chloride SCC. Resistance to pitting and crevice corrosion in acid chloride solutions improves with increasing chromium and molybdenum contents.<sup>22</sup>

## BACKGROUND

During operation, after only 18 months, a leak was observed at the venturi scrubber (ejector) of Continuous Catalyst Regeneration (CCR) unit at a Refinery as shown in Figure 2. This ejector was used for caustic injection (1 wt. % NaOH) to neutralize HCl present in the regeneration tower vent gas, before sending the vent gas to a wash tower. Table 1 shows the design specifications and operating conditions.

**Table 1**  
**Design Specifications and Operating Conditions**

|                                          |                                        |                                                                                                                        |
|------------------------------------------|----------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| Equipment Venturi Gas Scrubber (Ejector) | Material of fabrication                | UNS N06200                                                                                                             |
|                                          | Service environment                    | Vent Gas (72.95% N <sub>2</sub> , 10.06% O <sub>2</sub> , 8.71% H <sub>2</sub> O, 0.19% HCl, 0.0056% Cl <sub>2</sub> ) |
|                                          | Length of service                      | ~18 months                                                                                                             |
| Gas                                      | Design gas inlet/outlet temperature    | 907 °F (486 °C) / 120 °F (48 °C)                                                                                       |
|                                          | Operating gas inlet/outlet temperature | ~150 °F (66°C) / no transmitter                                                                                        |
|                                          | Operating gas inlet pressure           | 44 psig (303 Kpa)                                                                                                      |
|                                          | Design flow rate                       | 7,209 lb/hr (3,270 kg/hr)                                                                                              |
| Caustic injection                        | Injection concentration                | 1 wt. %                                                                                                                |
|                                          | Design inlet /outlet temperature       | 108 °F (42°C) / 120 °F (48°C)                                                                                          |
|                                          | Inlet temperature                      | 135 ± 10 (57±6 °C)                                                                                                     |
|                                          | Design pressure inlet                  | 92 psig (634 Kpa)                                                                                                      |
|                                          | Design flow rate                       | 111,708 lb/hr (50,670 kg/hr)                                                                                           |
|                                          | Removal Efficiency:                    | 90% HCl / 65% Cl <sub>2</sub>                                                                                          |



**Figure 2: General photographs of the leaked venturi scrubber (ejector) after cutting.**