



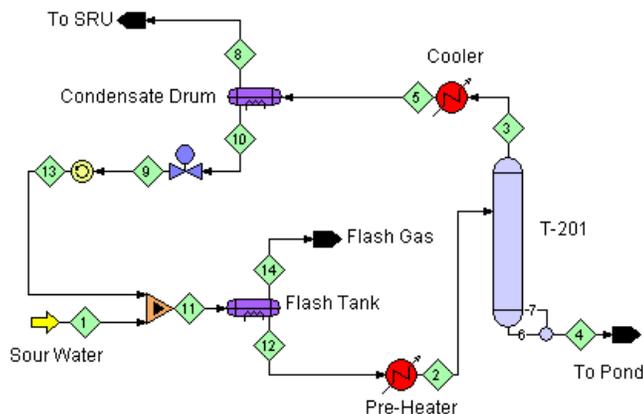
# The CONTACTOR™

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## HCN and Phenol in a Refinery Sour Water Stripper

Phenol is a component picked up in water washing various refinery streams, and it ends up in the sour water going to the stripper and ultimately to a biological waste water treatment facility. Can it be removed in the sour water stripper (SWS) and to what extent?

Figure 1 is a simplified PFD of a SWS in which the overhead condenser has been removed and replaced with a cooler and condensate drum arrangement. One should expect that in the condensate drum, the condensed water will capture a good part of the gases and other contaminants already removed in the SWS. This condensate (which is itself a sour water) is mixed with the fresh sour water coming into the unit and reprocessed.



**Figure 1 Simplified SWS Flowsheet**

To make this case completely specific, the sour water analysis shown in Table 1 was used in the simulation. As far as the removal of phenol is concerned, the results are unequivocal.

With the column top pressure at 22 psig and the reboiler using 1.4 lb of 60 psig steam per gallon of sour water (Stream 1), the stripping column itself removes 21.5% of the phenol in the sour water feed

(0.646 lbmol/h phenol in Stream 1) but the Cooler and Condensate Drum drop out most of this and return it to the SWS. Thus, the overall process is able to remove only 0.33% of the phenol in the original sour water. The stripped water has virtually all the phenol, almost none of the H<sub>2</sub>S and HCN, and 33 ppmw ammonia. As far as stripping phenol is concerned, condensation of steam from the stripper overhead results in “recovery” of most of the stripped phenol and ruins any prospect of removing phenol from sour water using a SWS (unless the stripper wet-overhead can be sent directly to the sulfur plant).

**Table 1 Sour Water Conditions**

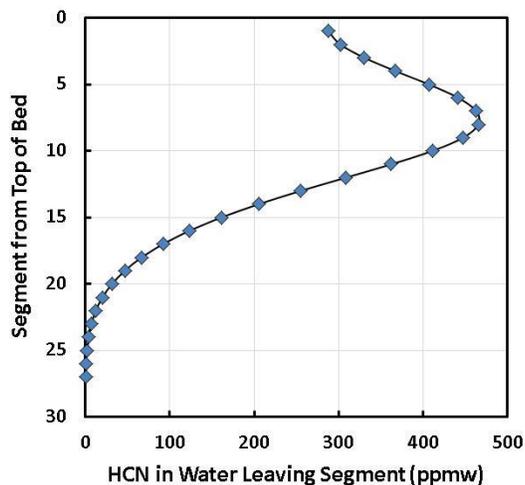
|                   |       |
|-------------------|-------|
| Temperature (°F)  | 100   |
| Pressure (psig)   | 20    |
| Flow (bbl/d)      | 1500  |
| Composition: ppmw |       |
| CO <sub>2</sub>   | 50    |
| H <sub>2</sub> S  | 8,000 |
| HCN               | 100   |
| Phenol            | 250   |
| Ammonia           | 4,500 |
| Thiocyanate       | 30    |
| Chloride          | 35    |

Table 2 shows that whether or not the sour water contains HCN and phenol, the residual ammonia level in the stripped water is largely unaffected. H<sub>2</sub>S isn’t listed in Table 2 since it is completely stripped.

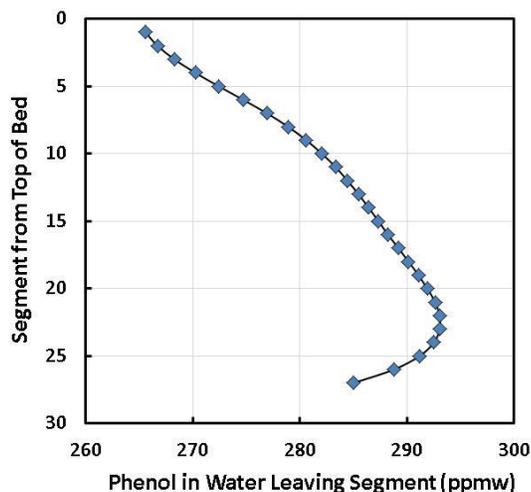
Looking at composition profiles in the stripper itself can be both interesting and informative. Figure 2 shows the HCN profile in the water phase. This is very similar to the behavior discussed in the September issue of *The Contactor* and is just another example of how HCN accumulates in the upper part of the stripper, below the feed segment.

**Table 2 Effect of HCN and Phenol in Sour Water on Residual Ammonia**

| HCN (ppmw) in sour water | Phenol (ppmw) in sour water | NH <sub>3</sub> (ppmw) in stripped water |
|--------------------------|-----------------------------|--|
| 0                        | 0                           | 29.4                                     |
| 0                        | 250                         | 30.3                                     |
| 100                      | 0                           | 32.8                                     |
| 100                      | 250                         | 33.9                                     |



**Figure 2 HCN Profile in Water**

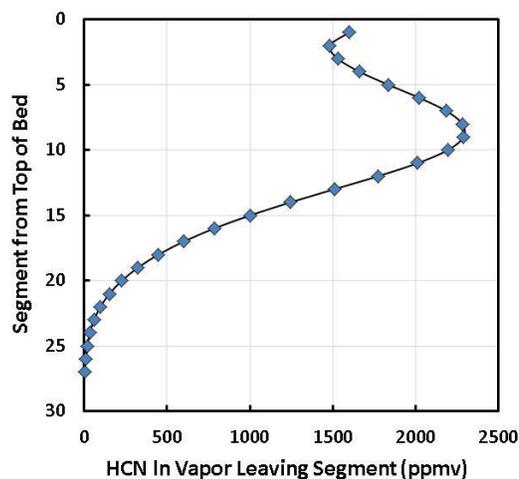


**Figure 3 Phenol Profile in Water**

As shown in Figure 3, phenol, although not highly volatile, accumulates to some extent in the bottom part of the stripper. As the sour water descends through the column, phenol which was stripped out in the reboiler and which, therefore, is present in the stripping steam, gradually condenses

with the condensing steam, and so finds its way back into the reboiler.

The reason for HCN accumulation is its entrapment by ammonia with which it reacts. The same sort of thing can happen with both ammonia and H<sub>2</sub>S, for the same reason, namely reaction (see *The Contactor*, Vol. 6, No.3, May, 2012). In the present case, however, the ammonia level in the sour water far exceeds that of HCN — ammonia will be dragged downwards, too, but the amount is masked by the inherently high ammonia concentration. The reason for the phenol bubble is its relatively low volatility — not so low that it cannot enter the stripping steam phase by vaporization, but not so high that it can be cleanly stripped either. Its preferred residence is the water phase.



**Figure 4 HCN Profile in Vapor**

Here again we see the value of a mass transfer rate-based approach to separations. ProTreat® has revealed very detailed information on the distribution of trace components in a SWS. Phenol is probably not a component of huge interest but it's worthwhile understanding why it cannot be stripped from sour water, at least using a conventional approach. Of greater importance, Figure 4 shows that HCN is far more concentrated in the vapor near the top of the stripper that one might have had any reason to expect. This may have significant implications for corrosion, and it requires a rate model such as ProTreat to reveal.

To learn more about this and other aspects of gas treating, plan to attend one of our seminars. Visit [www.protreat.com/seminars](http://www.protreat.com/seminars) for details.

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