HOW MEA PLANTS HAVE PERFORMED

Survey results on 13 plants give insight into problems and solutions of various operators.

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In 1965, MEA (monoethanolamine) corrosion was briefly discussed in relationship to the reboiler. It became evident at that time that more information was needed, and a survey was planned, with ammonia producers primarily being the ones eventually contacted. We did cross reference the results with those from gas plant experience.

We tried to pick small plants; the smallest was one designed for 60 ton day and which operated at 90 ton/day. The largest plant surveyed had a capacity of 600 ton/day. We did not survey the operators with extremely large units because of the lack of operational experience with such units.

There were 13 MEA plants

There were 16 plants total included in the survey. 13 of these operated MEA systems. One was operating a sulfanol process, one hot potassium carbonate and one the copper liquor scrubbing process. My discussion will be limited to MEA.

Figure 1 is a simplified schematic diagram of the Girbotol or MEA system. I first want to refer to the MEA reboiler shown on the right hand side. Notice that it is being heated by steam. Of course, many different heating medias are used, steam being common, the process gas also being a common heating medium.

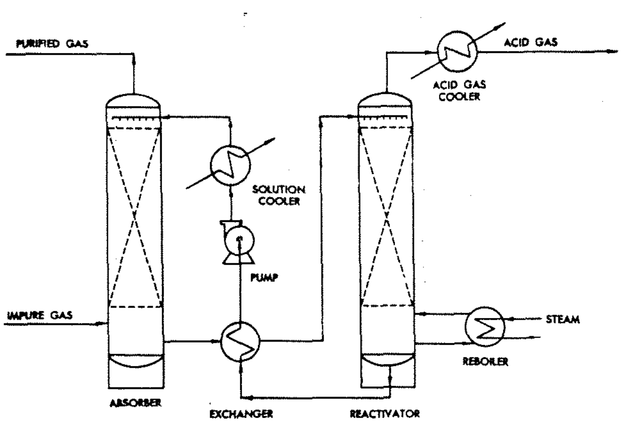

Figure 1. Simplified schematic of the Girbotol or monoethanolamine system.

Of the 13 plants surveyed, a total of one to five MEA reboilers were in the plants for a total of 22 units. One of these was carbon steel, 16 were using type 304 stainless steel, three were using type 304 ELC tubes, one was type 316 and one was Monel alloy 400.

The carbon steel reboiler was being used on the smaller of the plants surveyed. Interestingly enough, however, it was also being used on the highest heating media involved. It was being heated with process gas coming in at 380 F. The MEA, however, was only 240 F. This unit had been in service since January of 1964 with no operating difficulties. A little later we will find out why a unit like this does operate successfully.

Company G in the survey had three separate MEA systems for a total of five 304 stainless steel reboilers. Two of these units had been in since 1954, one since 1958, one since 1959 and one since 1963. There had been no problems in any of the five units. The point to note here, however, was that the process gas used for heating was limited to 330 F. and this was pretty standard. In other words, they did not permit the operating department to go higher. The MEA was limited to 230 F.

We had Plant F where the process gas entered the reboiler at 340 F. The MEA temperature was 255 . The service life on the 304 stainless steel had averaged 12 months. This plant was currently on its third stainless steel reboiler bundle. Here failures were occurring due to pitting under fouling deposits and the fouling was caused by too tight a design, a triangular pitched type facing, therefore, you increased the heat transfer across the tube, increased the erosion-corrosion, and also left pitting to occur under the deposits.

The highest MEA temperature reported was by Company J of the survey. They had MEA temperatures of 265 and up. They had 304 ELC stainless steel tubes; the original bundles lasted five months. The cause of failure was reported as stripping occurring in the reboiler and an extremely high loading factor.

Repeated tube failures on five

Of the 11 companies using stainless steel reboilers, five reported repeated tube failures. It can best be said that the service experience with stainless in this service is erratic and depends upon the operating variables.

We had one company which reported the successful use of Monel alloy 400. It had been in service for 12 years. This by the way is not Shell Chemical which was discussed in the Minneapolis meeting last year. This is a different plant.

Let us discuss now the stripper column itself. Only 11 companies reported here. All 11 were using stress-relieved carbon steel stripper columns. Two of the units were built with stainless steel cladding on the top section as a part of the original equipment. Two others went to stainless steel cladding as a result of excessive corrosion. In one case the customer went to 430 stainless which had been his tray material, and since it was holding up, he went to it for the sidewall linings. In another case, the customer went to 304 stainless steel.

There were two units that had been built with carbon steel trays

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and hardware but had corroded and were replaced with 304 stainless steel.

Three of the units used packed columns and not trays. In this case, the distribution systems on the top of the tower were 304 stainless steel.

We found one unit using 316 stainless steel trays and hardware. We also found another using cast iron trays with success.

The main type of corrosion here occurred primarily on carbon steel and is corrosion-erosion in nature. Therefore, you must eliminate all sharp turns. All baffles should be stainless steel. All bolting within these trays should be a minimum of 304 stainless steel. We have even seen 304 stainless steel boltings go out as well as 316. The reason for this is they use a machinable grade of stainless steel which does not have the corrosion resistance of the parent grade. In other words, they use 316 with sulphur in it and it does not have the same corrosion resistance that the regular 316 does.

The acid gas cooler

Now the acid gas cooler or overhead condenser: Twelve companies reporting, a total of 15 exchangers. Seven were using 304 stainless steel; six were using carbon steel; one, aluminum clad tubing and one a bi-metallic tube with steel on the OD, admiralty on the ID. The cooling water was on the ID side.

All of the stainless steel units were operating without difficulty. Three of the seven units had been used for replacement of carbon steel tubes which were part of the original equipment. The bi-metallic tube installation was also a replacement of plain carbon steel on the original equipment. The aluminum clad tubes had been in service for some five years and were being replaced on a two year interval. Two of the existing six carbon steel units are experiencing excessive corrosion and plans are to go to stainless upon complete failure of the bundles.

It is interesting to note here, however, that most of the failures of carbon steel have been due to water-type corrosion and not from the acid gas.

Lean-to-rich exchangers

Now we turn to the lean-to-rich exchanger and here there was some confusion in the survey. For example, we requested lean solution temperatures into this bundle and lean solution temperatures out. There may be two, three or four of these units in series. Some people call the first two, lean-to-rich exchangers; they call the latter two, solution coolers. It varies with plants. We weren't too clear on the terminology here but the results are quite evident as far as which way corrosion is occurring and what the solution is.

We had lean solution coming in varying from 230 to 265 which corresponds with the reboiler temperatures on the MEA. We had temperatures going out from 115 to 225. We had rich solutions temperatures coming in varying from 115 to 190 F. We had rich solution temperatures going out varying from 190 to 230.

The 12 companies which reported, had a total of 38 exchangers -- 24 were 304 stainless steel; 10 were carbon steel, three were Monel alloy 400, one was bi-metallic, steel on the lean solution and admiralty on the rich solution.

Most of the 10 carbon steel units were on the low temperature side of the series of exchangers. If there were three exchangers carbon steel was used only in the third. If there were four, it was the fourth. Very seldom was carbon steel used as the only exchanger.

Ten of the 304 stainless steel exchangers were replacements for carbon steel equipment on the original construction. One Monel alloy 400 bundle had been in service for 12 years, the other two were placed in service in 1958 and 1961, as replacements for carbon steel. This unit has four exchangers in series, the fourth bundle is now being replaced with Monel.

One company reported failure of an aluminum tube after three years of service and it was replaced with stainless.

No safe limits for carbon steel

There appear to be no safe limits for carbon steel in this service. Even those operating at 115 on the lean solution have experienced trouble. 304 stainless steel appears to be a satisfactory answer here.

We did have one customer report pitting of 304 stainless. He went to Incoloy alloy 800 on a trial installation. It also pitted. This would be expected. Incoloy 800 would not have any better pitting resistance than 304. In that case, he would have to upgrade to a much more expensive alloy system such as Carpenter 20 or Incoloy alloy 825. We feel that the solution there is to improve his operating conditions rather than solve his problem metallurgically.

The gas plant people have proven that you can operate these units with all carbon steel equipment if you do two things:--size the equipment properly and run it properly. Unfortunately, ammonia producers are a different breed of cat. You size them small and push them hard. So you have two choices. On the initial construction you can design corrosion out of these units. You can either eliminate it or reduce it. Once you have exceeded design capacity, once you have gone to those variables which affect corrosion -- these are MEA solution strength, acid gas loading, dripper pressure, and heating media -- (those are the four most important). Once you exceed the recommended values here, there is only one way you can solve your corrosion problem and that is by metallurgy. Sometimes it can be expensive, so the choice is up to you.

Discussion

Nort Walton (SunOlin): The remarks on MEA are very interesting. I would like to suggest that in some respects MEA systems and the operation of them and the corrosion problems relating to them vary from unit to unit, and in some cases the solution of these problems is more of an art than being able to determine just what causes it.

For example, you have heard me detail some of the corrosion problems in our MEA system and yet when we go back and look at the loadings that we have, they are well within the recommended loadings. The analysis of the solution for contaminants, for alkalinity, etc., shows nothing which could contribute to the corrosion. In most all respects, the operation of our unit falls within the recommended safe guidelines for variables, but we have severe corrosion problems. So I think in many respects these MEA systems are peculiar and the solution of the corrosion problems are not always susceptible to following general guidelines and rules.

Q. We have a plant that encompasses two categories: it is a gas treating plant, in itself, but it was being pushed as an ammonia plant. We were not able to reach the capacity production we would have liked to. We did have some success using inhibitors. Were any of the plants surveyed using inhibitors?

Speed: Of the 13 MEA plants, three were using inhibitors.

Q. Successfully?

Speed: They thought so.