How efficient are refinery amine units?

Refiners' survey investigates current industry design and operating practices

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What are the operating parameters of an efficient, well-operated amine unit? How do refiners know if their units are performing at peak levels? Lack of real-world data prompted an industry initiative to develop and draft a best practices manual for amine operations. Survey results of small and large refiners including major and independent operators lists current operating data for amine units. Analysis of responses suggests that amine operations can be improved. Key suggestions are: reduce amine losses, minimize amine-solution contamination, decrease sulfur plant upsets, etc.

Benchmark performance. When discussing best practices for refinery amine units, a small group of refiners, engineers and consultants discovered there was no real-world data available that related performance to plant design and operating practices. To close this informational gap, an industry-survey questionnaire was developed to focus on amine-unit operating data. **Its goal:** Obtain data to characterize unit operation and to establish a performance-measure database. Table 1 lists the goals and performance measures, defined for the survey questions.

The database. Respondents sent confidential data from large and small facilities operated by major and independent refiners, using monethanolamine (MEA), diethanolamine (DEA), methyl diethanolamine (MDEA) and diglycolamine (DGA) solvents. Data from tail gas units were excluded from the database because it represents a special class. The database represents survey participants' responses. However, data analysis suggests general problems are present in amine unit operations.

Ranking unit performance. Respondents were rated and separated into quartiles based on operating efficiencies. The first quartile represents efficient, well-running units, while the fourth quartile represents poorer-running plants. Fig. 1 summarizes average quartile data for some performance measures. No survey participant was first quartile or last quartile in *all categories*. But some plants were first or last in several measures. Some participants were more successful at meeting Table 1 goals than others.

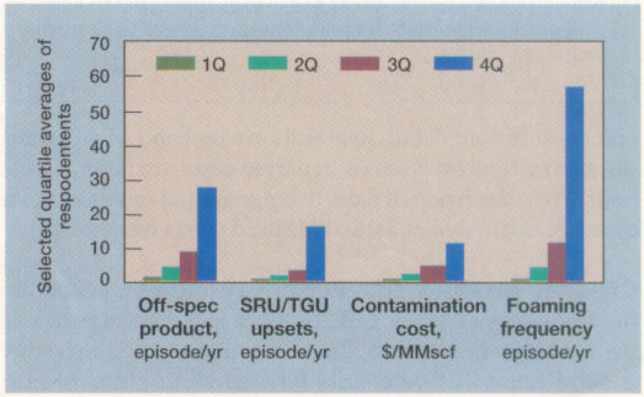

Fig. 1. Survey responses by quartile averages.

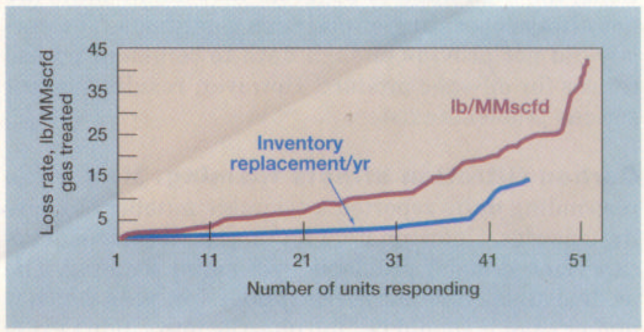

Fig. 2. Amine loss rate.

Refiners lose too much amine. On average, refiners replace their entire circulating amine inventory three times each year! A median refinery replaces its amine over twice per year. Expressing this on a volume basis would put the average at 18 lb of amine per MMscf of gas treated. First quartile units experience textbook losses, i.e., 2 to 4 lb amine per MMscf, while bottom quartile refiners had losses exceeding 25 lb. Allowing $0.75/lb replacement amine, the difference could cost an average refiner, treating 60 MMscfd of gas, over $350,000 annually. Fig. 2 shows the range of amine losses as annual percent of inventory and as pounds of amine per MMscfd equivalent gas treated.

Contamination costs money. The survey asked about the cost of contaminated amine solutions. Cost data covered annual costs for filter replacement, amine reclaiming (seven respondents reclaim amine), spent amine disposal (five participants dispose of it) and additives like caustic, antifoam and corrosion inhibitor. The sum of these factors was defined as contamination cost; unfortunately, contamination-cost data is incomplete. For example, 32 responders reported additive costs, while 43 reported using antifoam. Hence, not all refiners monitor total operating costs for amine

Amine national working meeting

A symposium is planned for Oct. 2–3, 1995, Dallas, Texas, where amine operators can discuss in more detail problem areas revealed by the survey. For information on the October Symposium, contact:

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To participate in the survey and receive a copy of the database, contact: Mr. Bruce Scott, Bruce Scott, Inc., phone/fax:415-485-5626. Please mark your request: "Amine survey questionnaire." This is a not-for-profit conference dedicated to helping refiners establish "best practices" procedures to improve amine operations.

units in sufficient detail. Real costs are probably higher than the survey figures. Even so, reported costs are not insignificant. From the reported data, average annual contamination costs are estimated at $1,500/MMscfd of gas treated.

Off-spec product. Another survey question asked for the frequency of gas or LPG product H_2S content exceeding the refinery's targets. The annual number of episodes is significant at five events for a median plant. While these may not be reportable incidents or permit violations, the high number suggests that amine units are not always operating at optimum conditions. The survey did not provide enough data to comment on the causes for off-spec product. However, results suggest serious problems exist.

Carbon filtration affects foaming. Most of the responding units reported a tolerable number of foaming episodes. Unfortunately, lower quartile respondents experienced major problems with amine foaming. The median amine unit had seven episodes per year, which is higher than it should be. Top quartile units didn't experience foaming, while the bottom quartile fought foaming almost daily. Because foaming is usually related to contaminated amine, this factor is an unstated part of contamination costs discussed earlier. Survey results suggest that the more amine is carbon filtered, the less foaming is experienced.

Sulfur plant upsets. As in foaming, most of the responding amine operators keep their sulfur plant operators happy. Median refiners had two upsets per year. Bottom quartile refiners caused their sulfur unit operators many headaches. This is a concern. The frequency of sulfur-plant emergency trips mirrors the distribution of upsets. Any sulfur-plant emergency trip presents a potential refinery hazard and loss of revenue.

Table 1. Goals and performance measures for amine units

Goals of a well-run amine unit	Performance measures
Provide on-spec gas and LPG	Frequency of off-spec products
Provide high quality acid gas	Frequency of SRU upsets
Operate reliably	Frequency of unscheduled downtime
	Frequency amine unit limits other refinery units
Perform at minimum cost	Regenerator heat input
	Amine circulation/MMscf gas
	Cost of amine contamination
	Regenerator reflux ratio
	Amine makeup (loss) rate

Heat stable salts standardization. The survey asked for the heat stable salt (HSS) level in the amine. The answers varied so widely that it is difficult to decide if the numbers are expressed as percent of solution or as percent of amine in the solution. This is an area where the industry needs to standardize reporting methods. The Amine Best Practices Group strongly recommends reporting HSS as percent of the amine in the solution.

Regenerator heat input. Another survey question inquired about heat input to the regenerator, as well as asking if the cost of heat was a factor in setting the regenerator heat input. Of the 62 responders, 47 replied that heat cost was not a factor, compared to 15 who replied that it was. Interestingly, DEA users who said NO used less heat per unit of amine flow than did the DEA users who said that cost was a factor. The median unit used less than 1 lb steam/gal, as expected.

Amine type isn't a factor. The survey data suggest no significant difference between operating units using MEA, DEA and MDEA. Circulation rates, heat inputs, foaming frequency, upsets to the SRU and loss rates are about the same. Both first and last quartile units show about the same solvent usage range. MDEA data show a distinct difference in the solvent's selectivity for H_2S over CO_2.

After the survey. The Amine Best Practices Group presented a summary of the survey data, along with a draft of its *Good Practices Manual* at an amine conference, Dallas, Texas, May 1994. The manual, for each equipment item within the amine unit, lists the purpose and normal operating range, typical instrumentation and monitoring and outlines deviations from normal operation. Each deviation lists causes, consequences and suggested actions. ■

The authors

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