Online Chemical Engineering Information

Boil-Off in Refrigerated Ammonia Tanks

Measuring and quantifying ammonia boil off from storage or transfer tanks is important in an overall material balance and to minimizing expensive losses. Understanding how boil-off occurs and measuring it's impact is key to minimizing it's affect.

For this case study, we'll examine a storage tank with a capacity of 5,000 metric tons. The tank is constructed on low temperature carbon steel (SA 537, class 1) which has a design temperature of -45 °C (-49 °F). The piping leading to the tank is also constructed of low temperature carbon steel and is insulated with polyurethane foam. The polyurethane foam on the tank is 150 mm (6") thick. The insulation is covered with thin gauge aluminum. The bottom of the tank is protected from heat ingress with 200 mm (8") thick foam glass. The entire tank is elevated about 1.5 m (5 feet) above ground level to ensure free ventiliation at the bottom.

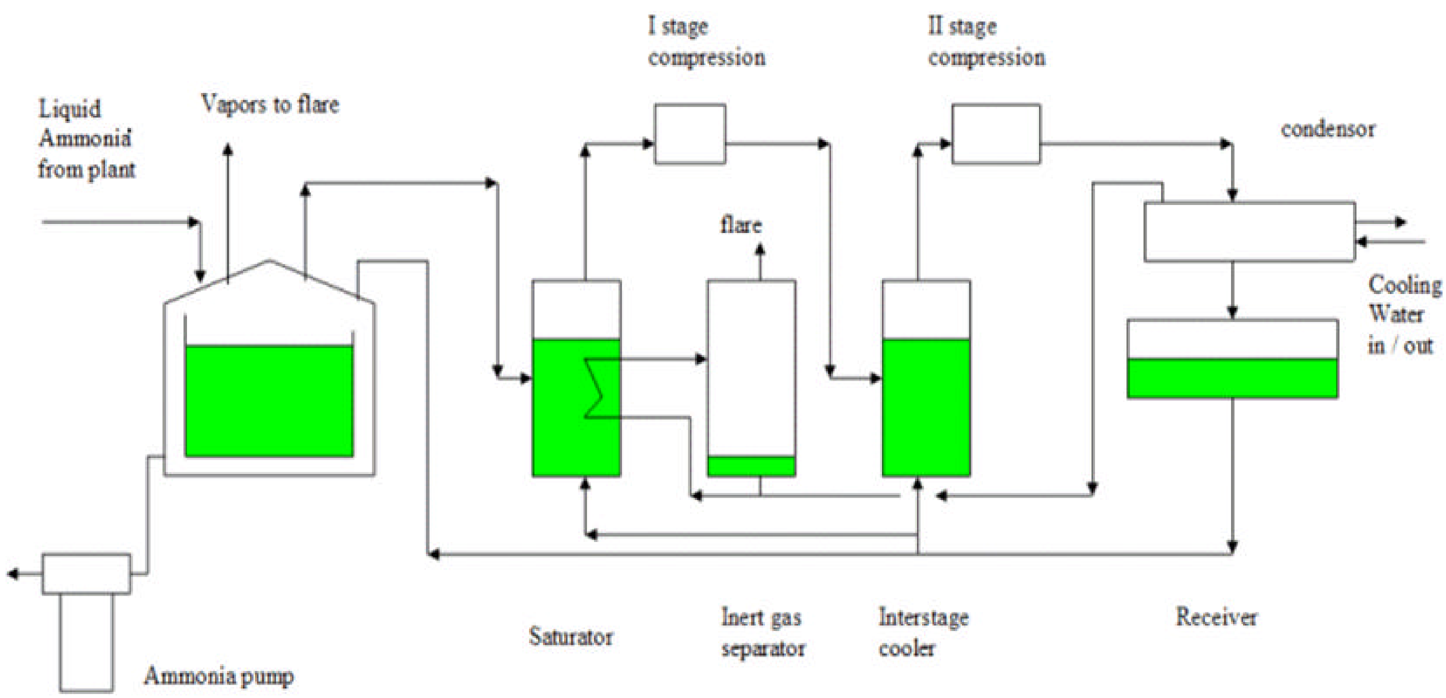

Figure 1 – Flow diagram of ammonia storage system with compressor and pump

Boil-Off in Refrigerated Ammonia Tanks, by V.C. Belapurkar
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Figure 1 shows a typical ammonia storage facility. The ammonia storage tank has a domed-style roof, double wall construction per API 620, and insulation as described previously. The storage tank is designed to store liquid ammonia at atmospheric pressure and -33 °C (-27 °F). The storage system includes the liquid ammonia storage tank, compressor, saturator, inter-stage cooler, condenser, surge vessels, and the associated piping and instrumentation. The compressor used is typically a reciprocating type with two stages for vapor compression. This compressor recylces vapors back to the storage tank. ***Vapor are formed by liquid ammonia transfer to the tank and boil-off due to heat gained from the environment.***

Defining Boil-Off

Even with insulation, heat is transferred to the ammonia in the tank from the environment. This heat, combined with the low heat of vaporization of ammonia, causes vapor to form. Insulation is designed to keep boil-off to a benchmark of less than 0.04% by weight of the tank's content. Tests are conducted to monitor performance against this objective.

Boil-Off (%) = (Vapors Generated in 24 hours [weight]) / (Capacity of the tank [weight]) x 100

Measuring Boil-Off

Before measuring boil-off, it's necessary to properly isolate the tank. No liquid or vapor should be transferred to the tank. Boil-off vapors should be captured in a separate tank after the refrigeration unit. Breather valves and flare lines should be closed. Use this spreadsheet to help in your calculation and form a chart as shown below (**spreadsheet available for download online at http://www.cheresources.com/refnh3tanks.xls)**.

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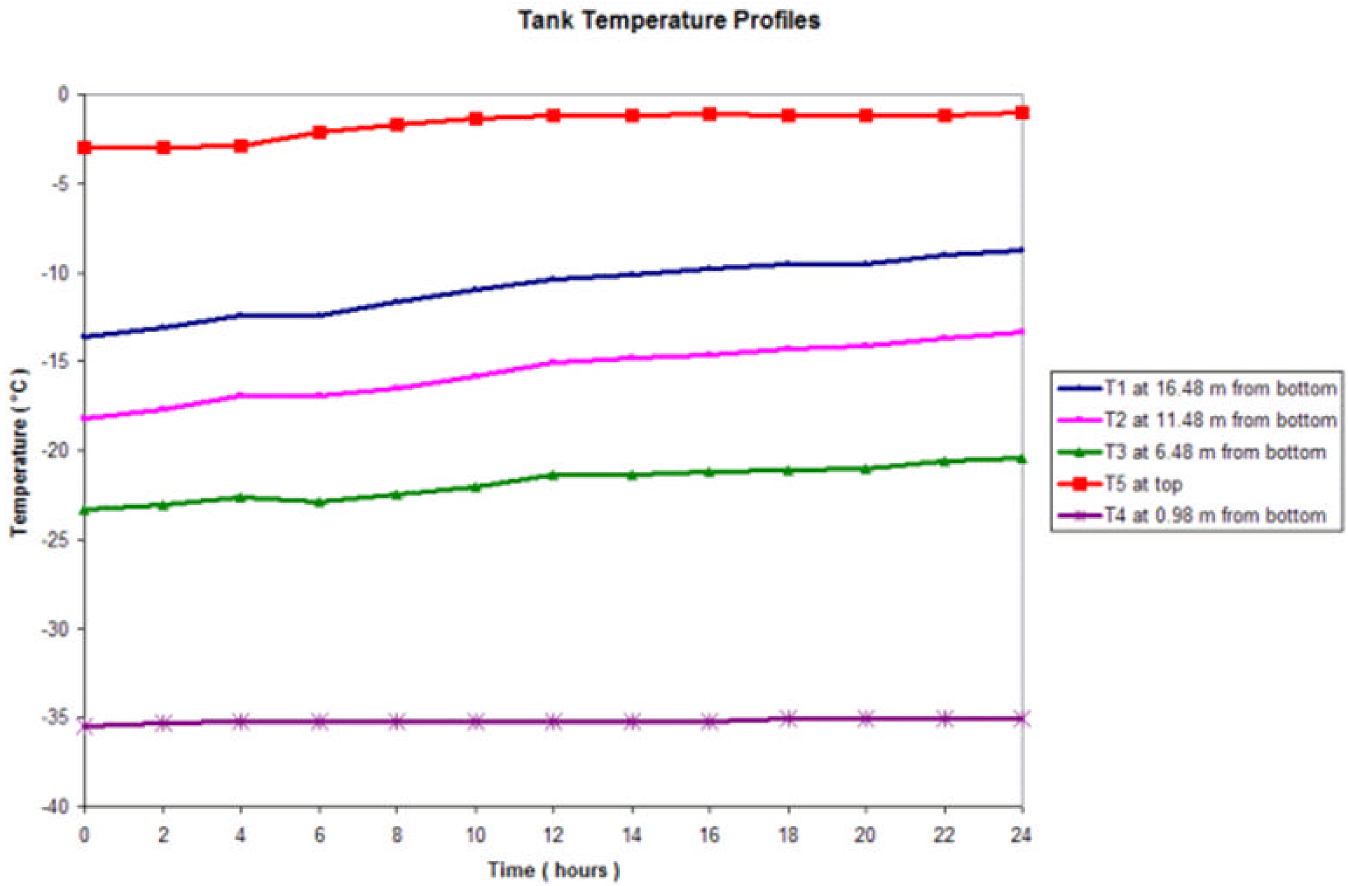

As shown in the calculation spreadsheet supplied with this article, 92.2% of the available heat is absorbed by the ammonia for vaporization. Approximately 4.4% is absorbed by the outgoing vapors and 3.4% by the static vapors in the tank. Also, note that the maximum seasonal temperature may not be experienced during test, so it is accounted for in the calculation to estimate a final result. Extrapolation of data can be minimized by conducted testing during the warmest seasonal temperatures.

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