*Left: Inflating clamp-on cooling panels. Right: Top of existing 5275 kW (1,500 ton) $NH_3$ separator to be retrofitted to 12 309 kW (3,500 ton) separator.*

# Ammonia System Fix

This project won the 2009 Milton W. Garland Commemorative Refrigeration Award for Project Excellence, which is presented by ASHRAE's Refrigeration Committee to recognize the designer and owner of a non-comfort cooling refrigeration application that highlights innovation and/or new technologies.

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When temporarily fixing a refrigerant leak is cheaper than permanently repairing the leak, a problem can last for a long time. In this case, at a brewery run by the San Miguel Corporation in the Philippines, the problem lasted for nearly a decade at a cumulative cost of $648,000 for the monthly charging of the tanks with refrigerant.

The problem began in 1989 when an expansion project at the brewery called for the installation of 12 jacketed beer fermenter/storage steel cylindro-conical tanks (CCT), each measuring at least 8 m (26 ft) (diameter) by 20 m (66 ft) (height). Each tank was enveloped with a metal jacket where ammonia flows continuously to maintain a –7°C (19.4°F ) temperature.

The tanks were fabricated and installed sometime in March 1989, but after only three months in operation, the ammonia cooling jackets showed signs of refrigerant leaks. The fabricator repaired the leaks, but the plant had to repair the jackets every three months thereafter. This repair work for the 12 tanks was done continuously for nine years because the company did not want to sustain a longer shutdown or extensive capital expense to change the vessels to fix minor leaks.

***Left: Dismantling of $NH_3$ cooling jackets. Right: Installation of laser-welded cooling panel with heat transfer paste.***

However, production volume increased and by 1998 the need for trouble-free tanks for stable production became necessary. By this time, the plant had been spending $6,000 per month, charging the vessels with ammonia at the rate of 6 metric tons daily at an annual cost of $72,000.

This amount was considered to be minuscule compared to repairing each tank. Every time a tank was decommissioned and repaired per month, the loss in beer sales was 3.1 million bottles or an annual loss of $7.6 million.

## Retrofitting Procedure

- Remove the old cladding and insulation of the tank.
- Fill the tank with tap water at 35°C (95°F) and cool it down to 20°C (68°F) using a water chiller to prevent damage to the epoxy lining of the tank. This lining is an aseptic coating for food and beverage applications.
- Remove the leaking cooling jackets using a plasma cutter and grind it to a smooth finish.
- Weld the stud support of the clamp-on laser-welded cooling panel.
- Paint the tank with epoxy primer.
- Apply the heat transfer paste mastic (non-setting) into the cooling panel.
- Lift and then set and clamp the cooling panel into the tank.
- Install the supply and return ring headers and connect it to the cooling panel, ammonia liquid supply and wetted return line.
- Pressure test the tank cooling panel and piping with 1,379 kPa (200 psig) compressed air and let it stand for 24 hours. If the pressure did not change, release the pressure.
- Charge the system with 2,413 kPa (350 psig) bone dry nitrogen and let it stand for 24 hours. If no leaks are found, release the nitrogen gas.
- Vacuum the system up to 500 microns, and let it stand for 24 hours. If no leaks are found, charge the system with 34 kPa (5 psig) ammonia gas and conduct the leak testing using lighted sulfur stick.
- If no leaks are found, fully charge the tank cooling panel with refrigerant grade ammonia (99.98% purity) and commission the CCT.

After nine years, the brewery's management finally decided to retrofit or replace the problematic vessels (see sidebar). The first option was to replace the 12 CCTs at a cost of $7 million. The second option was to convert from direct ammonia-cooled to glycol-cooled by retrofitting the tanks with new cooling jackets. However, this alternative increases operating cost by as much as 15% because the tanks are cooled with a secondary refrigerant. The cost of retrofitting to glycol cooling amounted to $4.2 million. The third option was to retrofit using ammonia refrigerant as the cooling medium, which has a lower cost than the other two options.

I previously worked at an appliance manufacturer in the 1970s that made chest freezers and refrigerators. I remembered that to insulate the food compartment box where products are frozen, heat transfer non-setting mastic is applied between the evaporator coil and this box, it is then crimped and insulated with foam-in-place polyurethane. Based on this knowledge, I tested this theory by working with a British tank fabricator to jointly design and fabricate the cooling panels to replace the leaking cooling jackets of the tanks. With this technical collaboration, the company approved the retrofit work.

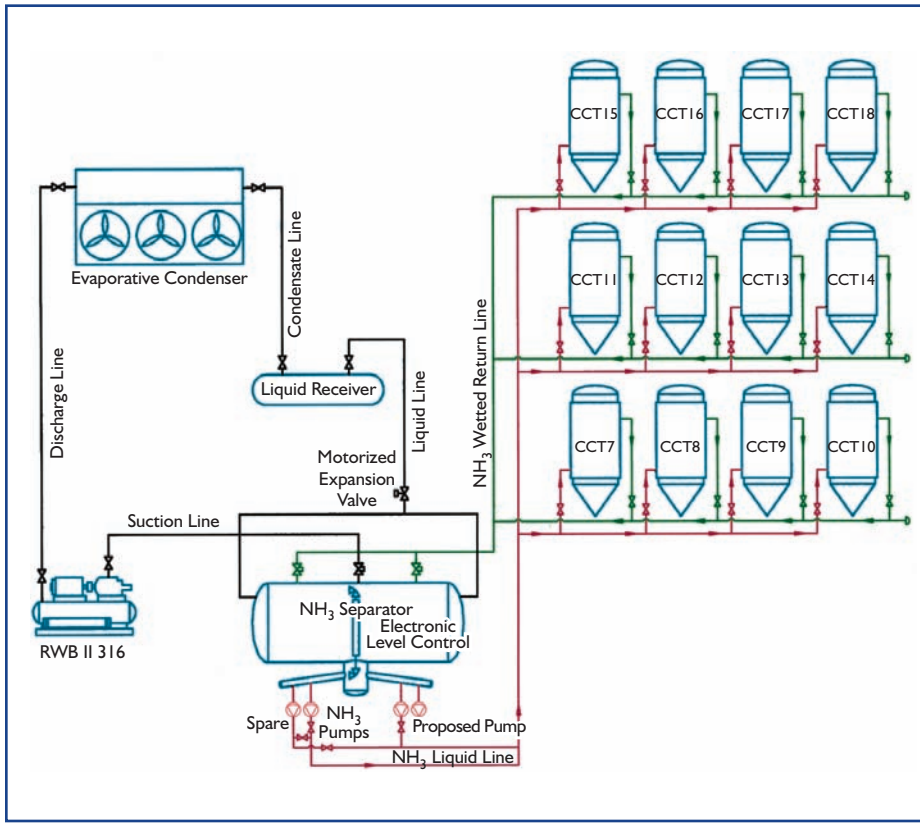


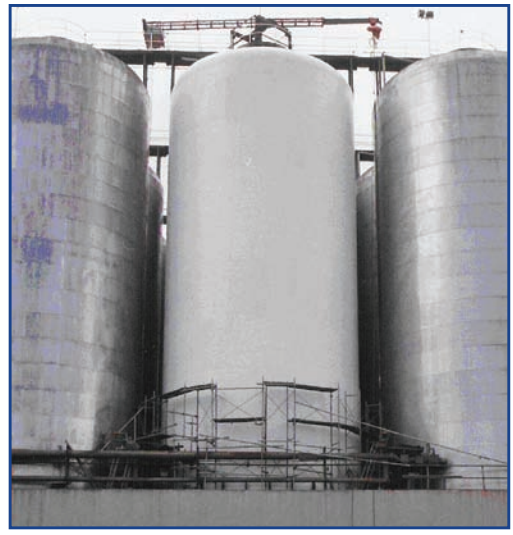

***Figure 1: Refrigeration flow diagram of the retrofitted cylindro-conical tank with clamp-on laser-welded cooling panels into the tank shell using non-setting heat transfer paste.***

We decided to use clamp-on, laser-welded cooling panels in retrofitting the CCTs and convert all flooded heat exchangers to liquid overfeed, increasing its capacity by 20% due to fully wetted heat exchanger surface area. The accumulator with cycle center and pumper drum were removed and replaced

with one retrofitted 12 309 kW (3,500 ton), low-temperature ammonia separator –10°C (14°F) and one 4572 kW (1,300 ton), high-temperature ammonia separator –4°C (24.8°F).

During the retrofitting and modernization process, the brewery was operating at full capacity and work was done piecemeal.

The plant now operates the retrofitted cylindro-conical tanks efficiently, and environmental problems were solved by eliminating the leaks using the clamp-on laser welded cooling panels while using direct ammonia refrigerant cooling. The plant attains the required temperature needed to ferment and store the beer and has eliminated the frequent ammonia charge of 6 metric tons per month. This resulted in a monthly gain of production capacity of 3.1 million bottles. The project was completed in January 2005.



***Retrofitted conical tank with laser cooling panel.***

The project cost was $3.24 million providing a payback of only 0.29 years. The process of retrofitting was done one tank at a time and was completed in four years.


### Acknowledgments

The associates involved in this undertaking were MPP Group (UK), fabricator of the welded cooling panels, its partner, Omega of Enchede, the Netherlands for fabricating the stainless steel clamp-on laser-welded cooling panels and their distributor and installer in the Philippines, GNQ Industrial & Contracting Corporation.



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