Outside the Lackland commissary. Photo courtesy of CTA Architect Engineers.

LOW-GWP ALTERNATIVES IN COMMERCIAL REFRIGERATION

Name of the Store:
Lackland Air Force Base Commissary

Location:
San Antonio, Texas, United States

Contact Information:
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Type of Facility:
Commissary, Store Area = 117,000 sq ft

Technology Transition:
R-404A direct expansion system to an ammonia/carbon dioxide cascade system

STORE OVERVIEW

The Defense Commissary Agency (DeCA) currently operates a 117,000-square foot commissary in San Antonio, Texas. The store is located in the community service area of the Lackland Air Force Base and is surrounded by other retail stores, banks, schools, and housing. The previous refrigeration system, which contained more than 7,000 pounds of R-404A—a greenhouse gas refrigerant blend with a global warming potential (GWP) of 3,922[1]—was over 13 years old and was ready for retirement. With help from Hillphoenix and CTA Architect Engineers, DeCA replaced the old refrigeration system with an ammonia (NH_3)/carbon dioxide (CO_2) cascade system, which uses a refrigerant with a negligible GWP. The store remodel, which is being implemented by Summit Construction, began in January 2014 and is expected to be completed by August 2015, during which time the store has remained open to the public. The installation of the refrigeration system was completed in December 2014. As part of the remodel, all cases, piping, controls, and the HVAC system are also being replaced.

[1] Meaning that it is 3,922 times more damaging to the climate system than CO_2 on an equal mass basis.

[2] Federal mandates (i.e., Executive Order 13423 on Strengthening Federal Environmental, Energy, and Transportation Management, as well as the Energy Policy Act of 2005) require that energy consumption be reduced by 30% in new buildings and 20% in remodeled buildings.

PROJECT BACKGROUND

DeCA chose to adopt a NH_3/ CO_2 cascade system for two main reasons: (1) to control future capital and operating costs, and (2) to meet the energy and sustainability goals the U.S. Government has established for all public buildings.[2]

Prior to their decision, DeCA reviewed the possible refrigeration systems that could be used to meet their goals. DeCA wanted to use a refrigerant with low or no GWP to eliminate climate risk and address the regulatory uncertainty around climate policies, which could impose future penalties on the use or emissions of high-GWP refrigerants or even force a refrigerant conversion. DeCA also wanted to adopt a system that is more energy efficient than standard industry rack systems that typically use R-404A refrigerant, and eliminate safety concerns. They also aimed to adopt equipment that can be easily serviced and wanted to keep costs reasonable.

With these criteria in mind, DeCA considered installing either a transcritical CO_2 system or an NH_3/CO_2 cascade system. Due to the hot climate of southern Texas, the NH_3/CO_2 cascade system was deemed the most suitable choice for the Lackland Air Force Base commissary.[3]

SYSTEM DESCRIPTION

The NH_3/CO_2 cascade system that has been installed at the Lackland commissary consists of three key pieces: (1) an NH_3 direct expansion system, (2) a CO_2 secondary loop system, and (3) a CO_2 direct expansion system. The NH_3 system, which is contained in an outdoor enclosure on the roof of the building, relies on a condenser water loop to connect the NH_3 compressors with the evaporative fluid cooler, and is used to condense vapor CO_2 into a liquid. The liquid CO_2, which is stored in a tank adjacent to the NH_3 system, is circulated throughout the store to remove heat from both the low and medium temperature cases. On the medium temperature side, the liquid CO_2 passes through a coil to remove heat from the refrigerated space and then returns directly to the liquid CO_2 tank prior to being condensed again by the NH_3 system (utilizing a secondary loop design). On the low temperature side, the liquid CO_2 first passes through an expansion valve, evaporates into a gas as it removes heat from the refrigerated space, and then is compressed prior to returning to the roof.

In total, the system has a low temperature cooling capacity of 304 MBTUs/hr and a medium temperature cooling capacity of 1,233 MBTUs/hr. The system consists of nine ammonia modules, each

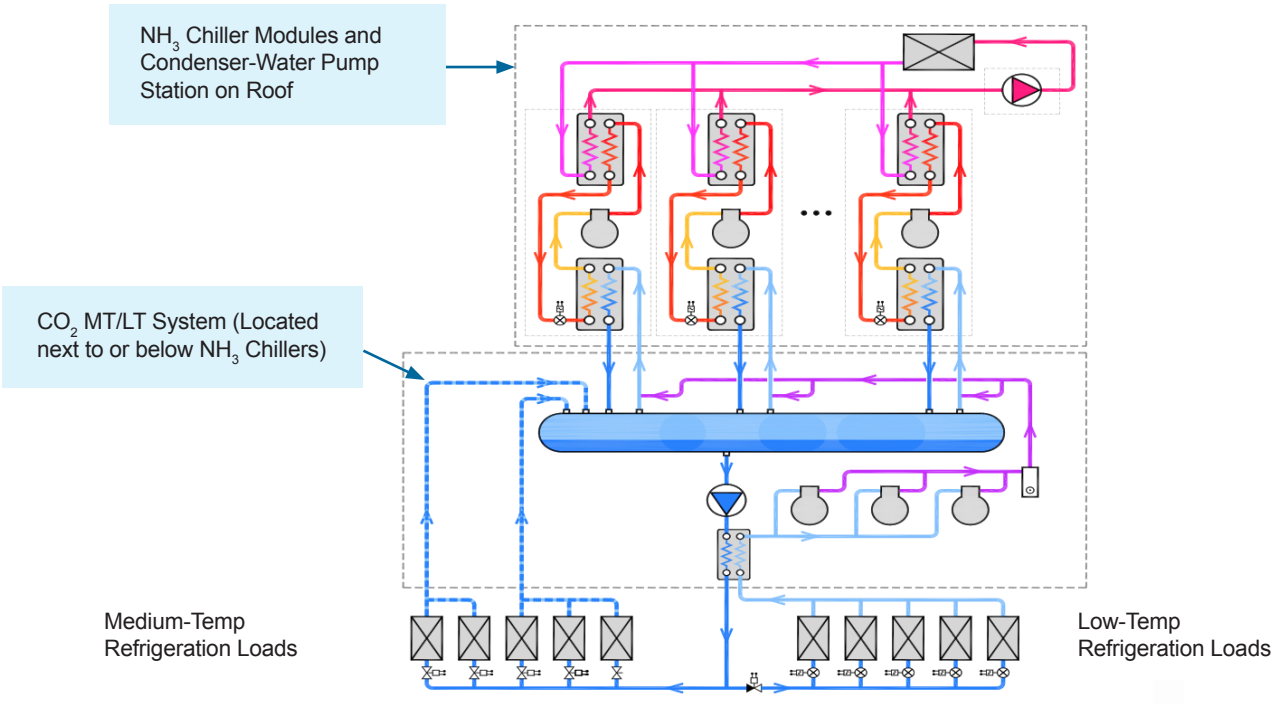

Diagram of the NH_3/CO_2 cascade system to be installed at the Lackland commissary. FMI Energy & Store Development Conference presentation, September 2012, Phoenix, Arizona.

[3] According to DeCA analysis, transcritical CO_2 systems are the preferred option for use in cooler climates.

containing nine pounds of refrigerant, for a total of 81 pounds of NH_3 as well as roughly 1,800 pounds of CO_2. To increase energy efficiency, LED lighting is used in all refrigerated cases and cold storage rooms. Additionally, display cases with glass doors are used for the majority of products (except produce and fresh meat).

PERFORMANCE AND COSTS

Compared to the existing R-404A rack system, it is expected that compressor energy use of the new system will be reduced by 8%, resulting in a system-wide energy reduction of roughly 3%. Additionally, due to the avoided leakage of more than 600 pounds of refrigerant each year[4]—equivalent to roughly 1,100 metric tons of CO_2—refrigerant costs are expected to be over 90% lower. Maintenance costs are also expected to be almost 40% lower.

While upfront costs of the NH_3/CO_2 cascade system were roughly 15% higher than a standard system—an incremental cost of roughly $334,000—operational savings from energy use, refrigerant use, and maintenance costs will greatly offset these costs, likely resulting in only a small overall cost increase over the estimated 20-year lifetime of the system. Once the technology reaches large scale commercialization, it is expected that the life cycle cost of future systems will be equal to or less than a typical R-404A rack system.

CHALLENGES AND LESSONS LEARNED

The greatest challenge DeCA faced in implementing the NH_3/CO_2 cascade system at the Lackland commissary was public acceptance of using NH_3 in a building near sensitive areas, such as day care facilities and schools. To address this concern, the National Renewable Energy Lab (NREL) and the Environment Protection Agency (EPA)—with technical assistance from CTA Architects Engineers and Hillphoenix—conducted an ammonia plume study, which analyzed the potential effects of ammonia being released from the system into the community. Results of the study showed that the system poses minimal threat to human health, with impacts mainly limited to short-lived unpleasant odors. The risk of public health impacts can be mitigated through the use of a continuous leak monitoring system. In addition to conducting the study, DeCA also conducted public outreach to community leaders to effectively communicate the results of the study and alleviate concerns. While DeCA is confident that concerns over the use of NH_3 will fully dissipate, a key lesson learned is the need to actively engage the community from the start in order to proceed with an ammonia system.

Other key lessons learned include the need to prepare maintenance teams and maintain spare parts on hand. For instance, because the NH_3/CO_2 cascade system is designed differently than conventional systems, DeCA's personnel must be trained on how to service and maintain them. To address this important issue, Hillphoenix will conduct training sessions over the course of several days to educate DeCA maintenance teams on how to handle the system. These training sessions are incorporated into the Hillphoenix service contract. In addition, DeCA recommends having spare system components on hand (e.g., ammonia compressor) to allow for timely repairs, since parts delivery may take several days until the technology is more widely in use. As more NH_3/CO_2 cascade systems are adopted across the United States and more technicians are trained on how to service these systems, personnel training and component availability will pose less of a challenge for users.

Moving forward, DeCA anticipates adopting NH_3/CO_2 cascade systems as the standard technology at other commissaries located in warm climates. NH_3/CO_2 cascade systems will also be considered for installation in other types of facilities such as DeCA's cold storage and central distribution center at Sagami General Depot in Japan. In addition, transcritical CO_2 systems will be considered for use at commissaries in cooler climates, such as at the facility at the U.S. Air Force Base in Spangdahlem, Germany and in the commissary in Newport, Rhode Island.[5] Worldwide, there are approximately 250 U.S. commissaries.

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[4] Based on the average leak rate of the existing R-404A system during 2012 and 2013.

[5] Construction began at the Spangdahlem commissary in February 2014. The new commissary, which will use a transcritical CO_2 refrigeration system, is expected to be complete by the spring of 2016.