FORANE® REFRIGERANTS BY ARKEMA

CASE STUDY

Arkema's Forane® 427A Refrigerant – The Easy Retrofit™

Modena Terminal, Modena, Italy

BACKGROUND

HCFC-22 refrigerant has been banned from use in servicing cooling systems in Europe, starting on January 1, 2010. This European legislation has implications for all participants in the cooling industry, especially those involved in Cold Food Chain.

The case examined here is that of a cold storage facility located in Modena, Italy, a few miles north of Bologna. The company, Modena Terminal, stores the local cheese (Parmesan) as well as other food staples that require much lower storage temperatures, such as meat. Its refrigerated warehouse is one of the largest in Italy.

Modena Terminal has been directly affected by this legislation because its refrigerated warehouse operates exclusively with HCFC-22. Modena Terminal belongs to an association of cold storage professionals, Assologistica, which has educated its members on the penalties that could arise from a failure to respond to this legislation.

The problem was a simple one. Modena Terminal could choose to use a conversion product that would allow it to continue operating for years to come - or it could shut down its business.

Naturally, *Tecnoimpianti,* the company that services Modena's systems, recommended the use of Forane® 427A. Tecnoimpianti's many positive experiences with the product helped to convince Modena Terminal to use it for the conversion of its systems.

- Five polyvalent cold rooms between 0 and -20°C: capacity of 3,000 tons of meat for a total volume of about 8,800 m^3; one direct expansion evaporator per cold room; a corridor connecting the various cold rooms to the outside at a temperature of 14°C maximum (volume: 5,880 m^3)
- A large cold room, called the *Cellone* capacity of over 6,000 tons of meat frozen at 18°C to -20°C; volume exceeding 54,400 m^3, height of 25 m; 10 direct expansion evaporators

Project
Modena Terminal

Location
Modena, Italy

Application
Cold Food Chain

Refrigerant
Forane® 427A (R-427A)

Lubricant
Polyolester (POE)

CLASSIFIED UL®

- Dedicated area for loading and unloading temperature of 14°C (volume 5,450 m^3)
- A tunnel for freezing/deep-freezing fresh meat at -40°C: Capacity of 20 tons/ 18 hours; flooded evaporator with four heat exchangers; tunnel antechamber to cool the beef quarters before freezing and packaging for storage in the cold rooms

The assembly runs mainly at night, when electricity is cheapest, and is shut down during the day.

RETROFIT APPLICATION

One week before the retrofit, the cold rooms were filled to the maximum load capacity and the temperature was lowered to its minimum.

The rooms subsequently remained closed for the 36 hours of the system's shutdown:

- 24 hours before, two of the four compressors were shut down, their filters changed and the mineral oil replaced with a POE lubricant POE
- System shutdown = start of the 36-hour shutdown
- Recovery of R-22 load (3,600 kg)
- Removal of oil from the two remaining compressors, filter change-out, and replacement of oil
- The seals were not replaced. A variety of seals were used, including Teflon®, Viton®, and neoprene
- Change-out of filters with new, equivalent filters: Seven filters on every oil separator, compressor oil filters, dehydrating filters at the receiver outlet
- Verification of the system's water-tightness
- System under vacuum test for about 10 hours

COMPARISON OF R-22 & FORANE® 427A PROPERTIES	R-22	R-427A
Fluid Flow		Higher
Discharge Temperature	70 to 75°C	65°C
Condensing Pressure	9.6 Bars	10.6 Bars
Subcooling	3°C	7 - 10°C (use of subcooler)
COLD ROOM		
Evaporation Pressure	0.2 Bar	0.3 - .0.4 Bar
Temperature Increase	10 to 12°C	10 to 12°C
Temperature in the Cold Room	-23 to -24°C	-27 to -28°C
Rate of Temperature Drop		Faster
CELLONE		
Evaporation Pressure	0 Bar	0.2 Bar
Temperature Increase	10 to 12°C	10 to 12°C
Temperature in the Cold Room	-17°C	-18°C
Rate of Temperature Drop		Faster
FREEZING TUNNEL		
Evaporation Pressure	about 0 bar (between 0.2 and +0.2 bar)	about 0 bar
Evaporation Temperature	-38°C	Liquid = -40°C
Temperature in the Separator		Gas = -37°C
Temperature in the Tunnel	-32/-33°C after 9-11 hours	-27°C after 6 hours
Rate of Temperature Drop		Faster - depends on the load, type of packaging
Valve Setting	After being completely opened (about 13 turns), closure of 3 turns	After complete closure, opening with 3 turns

- Charging with Forane® 427A through the bottom of the receiver one compressor was started
- System start-up: addition of fluid in order to adjust the receiver level
- Adjustment of expansion valves

After 36 hours of shutdown, the temperature in the *cellone* went from -22°C to -20.5°C.

Oil Change

Mineral oil (Mobil Gargoyle Arctic 300) was replaced by a POE lubricant (Frosyn SE170):

- 500 L of mineral oil was removed, as the oil level was low
- 600 L of the new oil was loaded to have a high level in the compressors

After various periods of tunnel operation, the liquid separator was drained (fluid sent back to the receiver), and the oil was drained through the bottom: about 50 kg the first time, 50 kg the second time, and 10 kg the third time. This oil was analyzed and found to be almost exclusively mineral oil. This showed that the mineral oil that had been blocked in the tunnel's heat exchangers was progressively recovered here.

Fluid

The fluid is roughly distributed as follows in the system:

- 800 kg in the *cellone*
- 800 kg in the five cold rooms
- 800 kg in the tunnel
- 400 kg in the condensers
- 800 kg in the receiver

The remainder is found throughout the lines.

With HCFC-22, at least 3,600 kg of fluid were needed to operate the entire system at once.

With Forane® 427A, it takes at least 4,000 kg of product for the whole system to run without the tunnel. The subcooler that is currently running requires 150 kg of product. Thus, 250 kg of additional fluid is needed, compared to operation with HCFC-22 (4,000 - 150 - 3,600). This may be related to the fact that oil is no longer drawn into the circuit as with HCFC-22: up to 300 L of oil was circulating in the system; this volume must now be filled by fluid.

The fact that the system requires more fluid is also related to the adjustments made:

- Greater flow of fluid, which causes a higher level of liquid in the evaporators
- Greater high and low pressures

Comments

- With HCFC-22, oil flowed evenly throughout the system. It could, therefore, cover the surface of the heat exchangers and, because of its insulating nature, limit the exchange of heat. The oil level with Forane® 427A remains stable after the start-up, which shows that oil is not being drawn into the circuit. There is no oil in the expansion valves or at the entrance of the tunnel evaporators, thus, improving the transfer of heat in the exchangers. Therefore, for the same degree of temperature increase, the refrigerant flow is higher.
- This resulted in a increase in pressure drop in the lines (the loss is proportional to the square of the flow rate). This is particularly apparent in the line between the receiver and the expansion valves of the *cellone*, which are 25 m high. Initially, there was a temperature difference between top and bottom of the horizontal inlet tube in the *cellone's* evaporators. The subcooler was employed to increase subcooling and avoid this partial vaporization upstream of the expansion valves.
- There was a higher level of liquid in the evaporators.The higher liquid level and greater flow explained the increase in cooling capacity. Conversely, the amount of fluid required in the system is higher.
- It is not possible to compare current energy consumption to what was required with HCFC-22 because the company installed solar panels this year, which supply a portion of the electricity requirement.

RESULTS

The cold chambers, equipped with dry expansion evaporators, work better since this retrofit: higher cooling power and then temperature drop in the cold chambers is faster (time is halved) and the temperature reached is lower: from -23 / -24°C with HCFC-22 to -27 / -28°C with Forane® 427A.

When fresh products are placed in the cold rooms, they freeze more rapidly than before, making it possible to freeze goods without using the freezing tunnel.

The freezing tunnel equipped with a flooded evaporator was tested: despite the reluctance to use a high glide blend in a flooded evaporator, the set point of -40°C was reached within a few hours.

The customer was content with the new system.

Ultimately, the system works better since the retrofit with Forane® 427A.

For answers to your refrigerant related questions or retrofit concerns, please contact Arkema's Technical Service Team at (800) 738-7695. More information on R-427A and our other retrofit solutions is available through our website, www.r22retrofits.com.

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PPC/SDC/04-2019

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Customer Service: 800 245 5858

Technical Service: 800 738 7695

ARKEMA
INNOVATIVE CHEMISTRY

Arkema Inc. (Americas)
900 First Avenue
King of Prussia, PA 19406
Tel.: +1 610 205 7000
Fax: +1 610 205 7497
arkema-americas.com

Headquarters: Arkema France
420, rue d'Estienne d'Orves
92705 Colombes Cedex – France
Tel.: +33 1 49 00 80 80
Fax: +33 1 49 00 83 96
arkema.com

forane.com