Figure 1: Kloosterboer under construction

Kloosterboer Delta Terminal BV expands its Maasvlakte cold store by adding a refrigeration and freezer system manufactured by Nijssen Koeling BV.

Kloosterboer Delta Terminal BV has been part of the Kloosterboer Group since 2003. Their cold store is equipped with an ammonia/CO_2 freezer system that was built in 2003. Nijssen Koeling BV of Leiden expanded the system when the company decided to increase its storage capacity. The new storage facilities added include facilities suitable for both refrigerated storage and deep-frozen storage. To achieve this, the central freezer system was expanded and modified to incorporate the new facilities.

Introduction

When Kloosterboer Delta Terminal built its Maasvlakte cold store, the decision to install an ammonia/CO_2 freezer system had already been made. Kloosterboer made the decision to install an environmentally-friendly and energy-efficient type of system that used natural refrigerants back in 2003. At that time, the freezer system was designed with a number of provisions to enable the capacity to be expanded, such as an over-sized ammonia separator and connection points for additional heat exchangers.

A start was made on expanding the refrigeration and freezer facilities in 2012, when an additional refrigeration and freezer store with a floor area of approximately 8,500 m^2 and a total storage capacity of 72,000 pallet spaces was added. Nijssen Koeling BV supplied and installed the refrigeration and freezer systems in the new storage facilities.

In a number of rooms, both refrigerated and deep-frozen storage facilities had to be provided, along with a facility to freeze fresh products. This led to a number of substantial adjustments to the system. This also provided an opportunity to carry out modifications to the system, adjusting it in line with the latest developments in technology.

Kloosterboer considers innovation and sustainable business practices to be of paramount importance. On account of this vision, Kloosterboer chose to base the new system's design and assessment on the **BREEAM** method.

During construction, efforts will be made to achieve the rating of **'Very Good'**.

Multifunctional use

In the new refrigeration and freezer facility, a number of rooms had to be suitable both for keeping products cool at a temperature of up to +10°C and for storing deep-frozen products at a temperature of -25°C. For this reason, a number of cells were equipped with refrigerators suitable for both cooling applications and freezing. The refrigerators in these rooms are designed with widely spaced fins in order to prevent the system from freezing up. For efficient defrosting during deep-freezing, the refrigerators are equipped with a defroster coil and defrost socks were fitted on the discharge and one suction cup.

Summary

By expanding its activities, Kloosterboer has enlarged its Maasvlakte freezer facility with approximately 8,500 m^2 of storage space. In view of the multifunctional use of the conditioned rooms, they had to be suitable for both keeping products cool to a temperature of +10°C and for storing deep-frozen products at a temperature of -25°C. The refrigeration and freezer systems are connected to the existing central system. The requirements led to a substantial expansion and modification of the current ammonia/CO_2 system. **Nijssen Koeling BV** of Leiden took on this considerable task, and was able to provide innovative solutions thanks to the creativity of its designers. Energy-saving components and environmentally-friendly options helped towards the achievement of a high BREEAM classification that underscores Kloosterboer's corporate social responsibility.

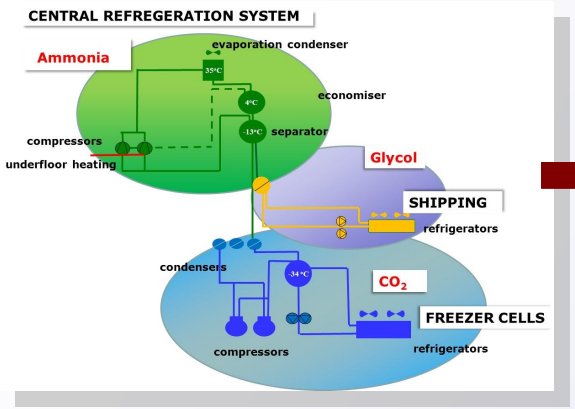

Figure 2: Existing system

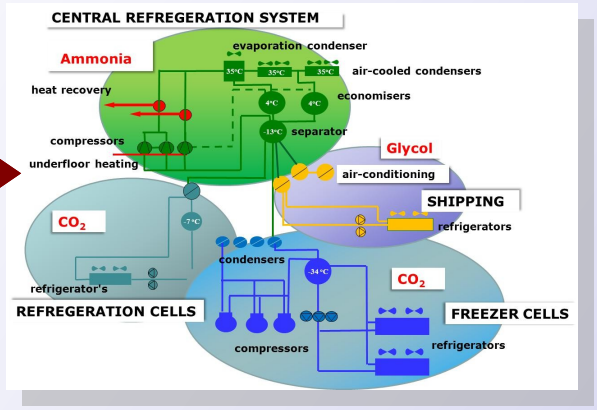

Figure 3: System after expansion

The defrost socks prevent heat from being released into the room during defrosting and ensures that it is only used to melt the ice.

On order to be able to both keep products cool at +10°C and freeze products at -25°C, the refrigerators are connected to **two refrigeration circuits that use CO_2 as a refrigerant**. The control system can be used to select refrigeration or freezer mode for each individual room.

Besides being suitable for refrigerating and freezing fruit products, three rooms also had to be suitable for **storing potato, vegetable and fruit products**. Because these are live products, heat is produced during storage. It is essential to ensure that there is a constant flow of air circulating around the stacks of products in order to allow this heat to be discharged effectively. In order to do this, the rooms are fitted with additional fans that are able to achieve an **air circulation rate of approximately 20 times** the capacity of the room.

By choosing special refrigerators, providing additional connections and control equipment and using supporting fans it was possible to create multifunctional rooms, thus facilitating a wide temperature range and various product applications.

Expansion of the refrigeration facility

Substantial modifications had to be carried out in order to provide a storage facility with two possible temperature levels. The figures above show a schematic representation of the systems before and after the expansion.

The primary ammonia system was expanded by adding an industrial screw-type compressor manufactured by Sabroe. The **variable Vi-regulation** facilitates the optimum utilisation of low condensation pressure with a low outside temperature. The compressor is also fitted with a continuously variable speed controller. An open economiser has been installed in order to produce the highest possible COP. By using all these facilities, the energy consumption of this compressor has been reduced by more than 15%.

As is customary for Nijssen systems, the Sabroe compressor is equipped with a Unisab control system manufactured by Sabroe, which is connected to the Nijssen computer controller.

Besides the two existing CO_2 compressors, an additional suction compressor manufactured by Sabroe has been installed for expanding the freezer capacity. In order to be able to divert the hot gas heat from this compressor to the ammonia section, an additional heat exchanger manufactured by Vahterus has been fitted to the ammonia separator.

Additional CO_2 circuit

In order to facilitate the multifunctional use of these rooms, an additional refrigeration circuit has been installed that uses CO_2 as a refrigerant. The design temperature in this circuit is -7°C. In order to produce this circuit, an additional CO_2 tower was installed, consisting of a heat exchanger, separator, CO_2 circulation pumps and ammonia pumps.

In the heat exchanger, the circulating CO_2 is cooled by the ammonia from the primary circuit.

Sophisticated choice of condenser

It was necessary to expand the capacity of the condenser in order to be able to discharge the heat from the system. The current system already included an evaporation condenser. One of the advantages of an evaporating condenser is that it is possible to maintain a relatively low condensation temperature at high outside temperatures. However, a drawback is that it has a high water consumption as heat is extracted by means of water evaporation. Also, chemicals are needed to prevent lime scale build-up and the growth of bacteria, which makes this design less environmentally friendly. These two aspects led Kloosterboer to opt for air-cooled condensers for the expansion.

Figure 4 : Separator for additional CO_2 circuit

By installing condensers with a large surface area, a relatively low condensation pressure can also be achieved. And by choosing a sophisticated weather-dependent control system, optimum use can be made of a low condensation pressure, with minimal consumption of water and chemicals. The fans are equipped with continuously variable DC motors in order to keep electricity consumption to a minimum as well. These choices fit in perfectly with the efforts to achieve a **high BREEAM classification**.

The condensers are designed with stainless steel tubes and fins made of seawater-resistant aluminium in order to guarantee the long service life of the system. In addition, the condenser batteries have a corrosion-resistant coating.

Figure 5 : Extra CO_2-compressor

Modification of the ammonia/CO_2 system

Development in this field has not stopped since the construction of the ammonia/CO_2 system back in 2003. As a result, the system's expansion created a perfect opportunity for carrying out a number of modifications based on the latest knowledge and experience.

As part of this modification, the system for injecting CO_2 from the cascade condenser into the CO_2 separator was adapted. This was achieved by installing an insulated buffer tank with the necessary regulating components.

A second modification involved fitting heat exchangers for superheating the CO_2 gases drawn through the freezer compressors. This expansion prevents slugging in the compressors and the damage that this can cause.

Free heat

In order to be able to utilise as much of the heat from the refrigeration and freezer system as possible, heat exchangers have been installed in the hot gas pipes from both the existing ammonia compressors and the new compressor. The heat that is extracted from the system using this method is used to heat the offices, the underfloor heating system in the shipping rooms and underneath the refrigeration cells and to defrost the refrigerators. There is also an additional benefit to be gained by using the heat from the hot gases. As the condensers have less heat to discharge, additional energy savings are achieved as a result of the lower condensation pressure.

Beet juice as a heating medium

A water/glycol solution is often used as a heat recovery medium. In the case of extra low temperatures, a high concentration of glycol is needed. This provides a mixture with a high viscosity.

Because a considerable amount of additional energy is required to pump this fluid around, this part of the heat recovery circuit is filled with a heat transfer fluid based on **beet juice (betaine)** in this system. As this is a natural product, this choice has also contributed towards the achievement of a high BREEAM rating.

Corrosion-resistant pipework

All of the pipework used for the ammonia-carrying section is designed in high-grade stainless steel. The CO_2 pipes are also designed in high-grade stainless steel or pressure-resistant copper.

Plastic has been used for the heat recovery circuit and the cold water/glycol circuits so that its good mechanical properties are also retained in the case of low temperatures.

The main expansion components:

- Expansion with a refrigerator, pipework, etc. for 8,500 m^2 of refrigeration and freezer facilities, connected to the existing system;
- Additional ammonia screw-type compressor with speed controller, automatic Vi-regulation and economiser;
- Condenser capacity increased by adding two air-cooled condensers;
- Additional CO_2 suction compressor;
- Additional CO_2 condenser for the freezer circuit;
- Expansion with another CO_2 cooling circuit for the refrigeration facilities;
- Expansion with a water/glycol circuit for air-conditioning;
- Modification of the CO_2 freezing circuit;
- Expansion of heat recovery capacity.

Figure 6: Ammonia screw compressor

The advantages of using plastic pipes include their insulating properties and the fact that the pipes will not become corroded. **A very long service life is guaranteed for the pipe system as a result.**

Effective insulation

The tanks, economiser and heat exchangers have been insulated using PIR shells and, after fitting a damp-proof layer, clad with aluminium sheeting. All the pipes in the machine room and the pipes installed in the outside air are also clad with aluminium sheeting. If the damp-proof protective layer is damaged, moisture can penetrate the insulation which can prove fatal for the effectiveness of the insulation.

Not only will the amount of cold lost increase, resulting in a higher energy consumption, but it will also cause the corrosion of the tanks and pipes. Therefore, the aluminium cladding serves not only to help make the system look professional but, above all, guarantees a **long service life for the system** and **limited energy losses**. This is why Nijssen makes every effort to optimise the design and finishing of the insulation in all its refrigeration systems.

Project details for the expansion carried out at Kloosterboer

Original system:

• Freezer facility	-23 °C	8,800 m^2
• Shipping room	0 °C	1,300 m^2
• Total freezing capacity		1,300 kW
• System design, freezer		ammonia/CO_2 cascade system
• Total primary capacity		2,000 kW
• Design of indirect system		water/glycol circuit

Expansion with refrigeration/freezer facilities:

• 3 freezer cells	-25 °C	2,000 m^2
• Naked Products cell	-20 °C	48 m^2
• Refrigeration/freezer cells	-25/+10 °C	3,000 m^2
• 6 other refrigeration rooms	0/+10 °C	440 m^2
• 2 shipping rooms	+5/+10 °C	3,000 m^2
• Total freezing capacity		1,942 kW
• System design, freezer		ammonia/CO_2 cascade system
• Total refrigeration capacity		2,880 kW
• Design of indirect system		water/glycol circuit

Replacement of the control system

This project also involved modernising the facility's entire control system. The outdated PLCs were replaced with modern Siemens systems. A new control system was also chosen. After modification, the entire system is now managed and controlled by the **Nijssen Freezingmaster®** control program developed in-house by Nijssen. This includes the **Nijssen Power Saving©** system, which provides a weather-dependent and capacity-dependent control system.

As a result, the control system makes an important contribution towards ensuring the energy-efficient use of the systems.

The **Freezingmaster®** software package only serves as a base for the overall control programme, however. Specialists at Nijssen designed and custom-built the entire advanced control and monitoring system for Kloosterboer. As a result, the control of this system is guaranteed to be fault-free and energy-efficient while also meeting all of the customer's special user requirements.

BREEAM CERTIFICATION

BREEAM-NL is a method of assessment used to determine the environmental performance of buildings. BREEAM stands for 'Building Research Establishment Environmental Assessment Method'. BREEAM sets the standard for a sustainable building and then specifies the level of performance achieved by the building being assessed, with the aim of analysing and improving buildings. The system uses qualitative weighting: a new building is awarded 1 to 5 stars as a total score (Pass, Good, Very Good, Excellent or Outstanding). BREEAM-NL can be used for buildings subject to a single standardised assessment guideline. All other types must be assessed using a customised method known as BREEAM-NL 'Bespoke'. For further information, please contact DGBC by sending an e-mail to helpdesk@dgbc.nl.

Aspects of Nijssen Koeling BV's expansion of the refrigeration and freezer system that **helped to achieve a high BREEAM score** include:

- The use of ammonia and CO_2 as natural refrigerants;
- A screw-type compressor fitted with a frequency regulator for increased efficiency;
- An economiser for saving energy;
- The use of energy-efficient air-cooled condensers;
- Saving on water consumption by using hybrid condensers;
- The recovery of heat from the oil cooling system and hot gases;
- Energy savings by using weather-dependent and capacity-dependent regulation.

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