



Multilateral Fund

for the Implementation of the Montreal Protocol

OBJECTIVE

To demonstrate the suitability of ammonia/CO₂ technology as a viable replacement for HCFC-22 in the manufacture of two-stage refrigeration systems for cold storage and freezing applications



DEMONSTRATION OF AMMONIA/CO₂ TECHNOLOGY IN THE MANUFACTURE OF TWO-STAGE REFRIGERATION SYSTEMS FOR COLD STORAGE AND FREEZING APPLICATIONS

Project title	Demonstration project for conversion from HCFC-22 technology to ammonia/CO ₂ technology in the manufacture of two-stage refrigeration systems for cold storage and freezing applications at Yantai Moon Group Co. Ltd.
Country	China
Agency	UNDP
Sector	Industrial and commercial refrigeration and air-conditioning (ICR)
Subsector/application	Cold storage and freezing applications
Enterprise/systems house	Yantai Moon Group Co. Ltd.
Baseline technology	HCFC-22
Alternative technology	Ammonia/CO ₂
GWP (alternative technology)	Negligible
Potential safety issues	Ammonia: toxic; CO ₂ : high pressure
ODS phase-out (mt)	250
ODS phase-out (ODP tonnes)	13.75

DESCRIPTION

The project consisted of:

- Product and process redesign: including design of three compressors for CO₂ for the low stage of the refrigeration system; three compressors for ammonia for the high stage; and design of high-pressure vessels to operate with CO₂
- Conversion of one manufacturing line with an annual capacity of 100 HCFC-22-based units (average refrigerant charge of 2.5 tonnes) to systems based on ammonia/CO₂. It included the modification of the compressor manufacturing line and the vessel manufacturing line
- Modification of test devices for product performance
- Manufacturing of prototypes, including two types of compressor and sample products
- Personnel training and technology dissemination

RESULTS

The project has been successfully completed, the converted manufacturing facilities have been certified for compliance with the safety regulations and are commercially running.

Three prototypes for each of the three sizes considered in the project were built and tested, and delivered a refrigeration capacity of up to 1 megawatt (MW) at -55°C.

The resulting products have significant advantages in terms of environmental benefits and energy efficiency. The energy efficiency of the systems was over 20% higher than the existing HCFC-22 system. At the same time, HCFC-22 leakage, which had been substantial due to the use of an open compressor, has been eliminated.

As the characteristics of CO₂ are different from conventional low-temperature refrigerants, the key points of this technical conversion were:

1. Development of an intermediate-pressure CO₂ compressor
2. Design and manufacture of a mid-pressure vessel for higher pressure
3. Development of CO₂ heat exchangers which match the large unit volume refrigeration capacity and high latent heat of CO₂
4. Design of heat exchangers on the low-temperature side which can withstand high pressures and low temperature
5. Development of a fully automatic, safe, efficient and reliable control system.

A total of 734 personnel were trained, including staff in research and development, manufacturing, engineering, marketing and equipment maintenance. Technology dissemination was done through several channels including participation in exhibitions.

Operating NH₃/CO₂ system in customer



COST ANALYSIS

The incremental capital cost incurred amounted to US \$4.1 million (or 36% higher than the original budget). The main cost items were the modification of the compressor manufacturing lines (28%), the manufacturing of prototypes (27%), the modification of test devices for product performance (22%), and the modification of production lines for pressure vessels (11%). The product and process redesign amounted to 8% of the overall cost, and the training and technology dissemination amounted to 5%.

Preliminary data indicates that the incremental operating cost of the ammonia/CO₂ cascade systems is US \$84,793, against the cost of US \$72,720 for the HCFC-22-based system.

CONCLUSION

This project demonstrated that ammonia/CO₂ is a viable alternative technology to HCFC-22 in two-stage refrigeration systems for cold storage and freezing applications. This technology is also suitable for a number of other applications, among them smaller-scale storage and freezing systems, and supermarkets.

The technology is innovative, the resulting product has significant advantages in terms of environmental friendliness and energy efficiency, and ammonia/CO₂ cascade refrigeration systems can overcome the disadvantages of pure CO₂ systems and the toxicity of ammonia.

The conversion will fully eliminate the use of 250 mt of HCFC-22 per year in the charging of these systems. Since the replacement technology has virtually no GWP, it avoids the emission of 441,000 tonnes of CO₂ equivalent every year.

FINAL REPORT AND SECRETARIAT'S COMMENTS

<http://www.multilateralfund.org/72/English/1/7211a1.pdf>
(paragraphs 26 to 36 and Annex in page 33)