

**UEE11 Electrotechnology
Training Package**

**UEENEEJ103A
Establish the
basic operating conditions
of vapour compression systems**

**Learner workbook
Version 1**

**Training and Education Support
Industry Skills Unit
Meadowbank**



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Section 1: Refrigeration Industry

Purpose

In this topic you will learn about the various areas of specialisation in the Refrigeration Industry. Many mechanics and technicians will only ever work in one of these specialised areas throughout their working lives.

Topics

- The history of the refrigeration industry
- Applications, classifications and equipment used in the refrigeration industry.

Learning Objectives

At the end of this section you should be able to:

- List examples of early cooling methods
- List important events in the history of refrigeration throughout the world
- Identify important events in the introduction and development of refrigeration in Australia
- Briefly describe the development and introduction of the vapour compression concept
- Identify the major applications in the refrigeration industry
- Describe the four main classifications of refrigeration equipment, that is domestic, commercial, industrial and transport
- Describe the main features of some of the equipment used in various classifications (areas of specialisation).

References

The following references will be of assistance with this topic:

- ARAC, 4th edition, Volume 1, Chapter 1 - History of refrigeration
- ARAC, 4th edition, Volume 1, Chapter 1 - Scope of the industry
- ARAC, 4th edition, Volume 1, Chapter 1 - Classification of applications
- Trade magazines, e.g. Celsius, AIRAH Video, AIA News, Road News, Truck and Bus Transportation, ASHRAE, Industrial Heating, Refrigeration and Air Conditioning, etc
- ARAC, 4th edition, Volume 1, Chapter 7 - Domestic, commercial and industrial systems
- ARAC, 4th edition, Volume 2, Chapter 20 - Air conditioning systems
- Learner exercises.

Learner exercises

Skill Practice 1.1: Assignment - Classifications and Applications

1.1 History of refrigeration

- ARAC, 4th edition, Volume 1, Chapter 1 – History of refrigeration.

Early cooling methods used to preserve food

Primitive man discovered, in the course of time, that coldness slowed down the rate of deterioration of meat and other organic substances. It was eventually realised that this was due to the lower ambient temperature.

In ancient times, refrigeration was achieved by the use of snow and ice. The Old Testament and Chinese sources going back to the 11th century B.C. give hints of such early refrigeration.

In countries that lacked snow and ice, such as Egypt and India, evaporation of water in unglazed vessels during the cold nights was an early method of refrigeration.

In reality, the surrounding temperature affects all living matter somehow. The first defence against heat was when primitive man retreated to deep natural caves. Old natural caves and caverns have been discovered which were used like refrigerated stores. Some date back fifty centuries B.C.

Other examples of early refrigeration used in ancient times were:

- In 356 B.C. Alexander the Great supplied his army with refrigerated wine by utilising the use of natural ice.
- The emperor Nero in 68 A.D. used ice to cool and control the room temperature.
- In the Gironde region of France a particularly cold cave was discovered which was used as a refrigerated store 3000 years B.C.
- The Roman Catacombs, originally quarries, were used as food stores.

Certain tribes in Africa and Asia used refrigerated water, kept cool by porous earthenware vessels. These vessels were subjected to intense evaporation. Cooling by evaporation has further developed into, for example the desert water bag of modern days. The bags are made of a material that allows water to seep through so that the surface is always moist. The hot and dry ambient temperature evaporates the surface moisture, thus removing heat from the water inside the bag and therefore, the contents is always cooler than the ambient temperature.

The properties of coldness in slowing down natural biological processes were known in ancient times but were forgotten for many centuries. Attention was drawn to it again, when in 1799 a perfectly frozen mammoth was discovered by an explorer called Palles in Siberia.

In the 19th century, blocks of ice were distributed for use in purpose built containers called iceboxes. At the time, iceboxes were sufficient for the keeping of foodstuffs but towards the end of the 19th century new inventions were being developed for the storage of food. New technology using chemicals were the forerunner of modern preservation. All these together form the basis of modern refrigeration techniques.

Important events in Australia

- 1845 Australia had a recognised meat canning industry.
- 1848 Export of meat to England.
The rinderpest plague created a meat shortage in England.
The export of canned meat to England continued up to 1855.
- 1851 **James Harrison** sets up the world's first ice manufacturing plant in Geelong Victoria and secured patents to cover his invention. He used the compression and expansion of Ether. This system was a dangerous system because of the flammability of the Ether. He was successful in freezing meat in his refrigerator at a Melbourne Exhibition in 1872-73. He attempted to export frozen meat to England on board the vessel 'Norfolk' in 1873 but failed and he was financially ruined.
- 1855-1866 Gold rush in Australia, no activity in refrigeration area.
- 1860 Sydney/Victoria have several operating ice works. The steam driven refrigeration plant used Ethyl Ether as the refrigerant.
The patent for this refrigeration plant actually specified ammonia.
- 1861 The first meat freezing works was erected in Sydney by Thomas Sutcliffe Mort and Frenchman Eugene Dominique Nicolle.
- 1872 Largest canned meat exports to Britain (Franco-Prussian war boosted the export trade).
- 1873-77 Transport of meat and milk from country NSW to Sydney in refrigerated (iced) containers.
- 1879 34.5 tonnes of refrigerated meat was transported on board the vessel 'Strathleven' to England. Meat temperatures vary between -20°C through to -12°C . The refrigeration system used was a Direct Air Expansion unit powered by steam from the ship's boiler. The refrigerated hold was insulated using powdered charcoal.

Development of the vapour compression system in mid 19th century

While the employment of natural refrigerants continues to this day, the development of mechanical refrigeration had to await progress in the physical sciences. This included a clear concept of the nature of gases and liquids, the relationship between heat and other forms of energy, the behaviour of vapours, etc. The systematic use of various processes enabled the artificial production of cold applications, which we now lump together under the term refrigeration.

Thermodynamics

The branch of physics that forms the scientific basis of all modern refrigeration is of course, thermodynamics.

The first law of thermodynamics

Heat and mechanical work were equivalent and stood in a fixed relationship to each other.

The first law of thermodynamics in refrigeration is attributed to Robert Mayer, a German and Joule, an Englishman.

The second law of thermodynamics

Wherever there is a temperature difference, a moving force can be generated.

The second law of thermodynamics in refrigeration is attributed to Sadi Carnot, a Frenchman (who first introduced the term 'entropy') and Rudolph Clausius, a German.

Gas laws

An understanding of the behaviour of what we call refrigerants is equally as important.

- | | |
|-----------|---|
| 1662-1802 | Boyle, Gay-Lussac, Dalton, Charles and Mariotte were credited with formulating the Gas Laws. They showed the exact way in which volume, pressure and temperature are connected in behaviour of ideal gases. |
| 1895 | Richard Mollier calculated the first exact vapour tables for CO ₂ and introduced a graphic representation of the properties of steam, air and refrigerants, which still bear his name. |

Other major events

- | | |
|-----------|--|
| 1672 | Otto von Guericke, a German, invented the air pump. Water can boil under low pressure, at ordinary temperatures. |
| 1780 | Two Frenchmen succeeded in liquefying the gas Sulphur Dioxide, by compression and subsequent cooling. |
| 1799 | The first liquefaction of Ammonia at atmospheric pressure is achieved. |
| 1842-1852 | This decade can be regarded as the classical birth of this discipline – refrigeration. |
| 1860-1875 | This is the beginning of the refrigeration industry. |

The scene was now set for the development of refrigeration machinery. The three main methods of artificial production of cold, which still form the main basis of our industry:

- Cold air machines
- Vapour compression system
- Absorption systems.

All have their beginnings at approximately the same time and all developed simultaneously, even if the relative importance of one of the three systems overshadowed others at various times.

Vapour compression system

When we come to discussing the history of the vapour compression system, it becomes necessary to pay attention to the historically important choice of refrigerant and the basic division between positive displacement (reciprocating or rotary) piston types and centrifugal systems.

All the early development was concerned with reciprocating piston compressors and the other versions a much later development.

Important events in the history of refrigeration

- 1834 Jakob Perkins, filed a patent as follows:
'An arrangement of apparatus or means as above described where by I am enable to use volatile fluids for the purpose of producing the cooling or freezing of fluids and yet at the same time constantly condensing such volatile fluids and bring them again and again into operation without waste.' This is the principle of the closed system. The refrigerant was Ether.
- 1848 James Harrison sets up the world's first ice manufacturing plant in Geelong Victoria and secured patents to cover his invention. He used the compression and expansion of Ether. This system was a dangerous system because of the flammability of the Ether. He was successful in freezing meat in his refrigerator at a Melbourne Exhibition in 1872 – 73.
- 1861 The first meat freezing works was erected in Sydney by Thomas Sutcliffe Mort and Eugene Dominique Nicolle. The refrigeration plant used Ether as the refrigerant.
- 1862 Ferdinand Carre, a Frenchman, built a continuous absorption machine producing 250 kgs of ice per hour.
- 1872 First frozen meat shipped to England (cargo was spoilt due to machinery breaking down). This is the first attempt by James Harrison to ship refrigerated meat to England. He used the compression and expansion of Ether as the refrigerant in the system.
- 1874 The first Sulphur Dioxide (SO₂) refrigeration machines appear in the U.S.A. and Europe. Large skating rinks use SO₂ as the refrigerant in the refrigeration system.
- 1876 The first Ammonia compressor was built in Germany by Carl von Lindie.
- 1874 The first artificially refrigerated skating rink appears in Chelsea, London, using SO₂ as the refrigerant.
- 1877 Steamer Paraguay transports meat and fish successfully. The steamer Paraguay is fitted with Ammonia compressors. The cargo is shipped from the River Plate to Le Havre.
- 1881 The first large cold stores built in England using Ammonia type compressors.