INTRODUCTION

This book is based on Bill Noe's Cryo 101 HyperCard program.

The word cryogenics means the science and art of producing cold(Scurlock 1). This is a simple definition and doesn't adequately describe its most frequent process, liquefying gasses.

This manual will cover what an Operator should generally know about cryogenics in order to operate the systems. History and other information will be added to round an Operator's overall knowledge.

If you are interested in further readings on cryogenics, please refer to the books used to create this document listed on the bibliography page.

DEFINITION

Cryogenics — how cold is cold?

"The cryogenic state has been described not as a fixed or definite temperature, but as a realm that begins below -150°C (-238°F)."

To an engineer, designing a cryogenic system, these temperatures present another problem:

> "[Below -150°C] the effects and reactions on system materials and components become important design considerations."
>
> The most significant consideration is the effect on carbon steel at cold temperatures. This material becomes brittle and can fail due to fracture. (from introduction, *Cryogenics Desks Guide*)

HISTORY

In the 1860's, research into the theories of cryogenics identified the concepts of phase separation and critical phenomena. These concepts were identified before gas liquefaction was accomplished. This early research discovered that "common gasses such as O_2 and N_2 have similar behavior when cooled to temperatures near their critical points"(Van Sciver, P3).

By 1877, Cailletet in France and Pictet in Switzerland were both liquefying oxygen. Their work proved that when permanent gases neared the gas's boiling point both liquid and vapor coexisted. Further, Pictet's process of cascade cooling and heat exchanging is today's preferred method of efficient refrigeration systems(Van Sciver, P4).

In 1892, Dewar developed a storage container that "consisted of a glass double-walled vacuum vessel with inner walls silvered to reduce radiation heat transfer"(Van Sciver, P4). An early schematic of a helium storage vessel showed that he used liquid nitrogen to further block thermal radiation.

The practical theory behind mechanical refrigeration came from a 28-year-old professor by the name of Carl von Linde. In 1870, Linde published a paper entitled, "The use of mechanical methods for the extraction of heat at low temperature." The Austrian brewery put his refrigeration designs to use immediately. Over the next eleven years a company he headed produced 1000 commercial refrigeration units. Linde continued to study the principles of thermodynamics and the work of Thomson and Joule. In 1895, Linde invented the first continuous process for air liquefaction, which allowed for the generation of bulk quantities of liquid oxygen(Baker 217).

Linde's liquefaction process relied on high-pressure gas and the Joule-Thomson effect. Unfortunately, this process had a high rate of energy consumption.

In 1902, the French scientist George Claude developed a piston expansion engine that liquefied air by exporting mechanical work. This process was much more energy efficient and worked at lower pressures. L'Air Liquide was founded to exploit this process. Later, the American branch of this company changed its name to Airco(Baker 212-223).