MarsSpaceConstruction. LLC
Montgomery, TX 77356
All we have to do is
SCIENCE the HELL out if this

Texas Registered Engineering Firm F-XXX
Work by Mars Space Construction, LLC

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REV	Description	Eng	Date	Appr	Date

REVISION HISTORY

Doc. I.D.	DES-Starship-010	Page 1 of 3		REV.	A
Job No.	XXXXXXXX	By:	GJR	Date	6/26/2021

Request for Quotation

REV.	DATE	BY	APPR.	NO.	FIRM
X	X	X	X	X	X

Title: Starship Module - MSC Liquid / Gas Oxygen Generation Plant

Design Variables need to be defined:

Amount of oxygen needed per person?

Amount of oxygen needed extract oxygen?

Oxygen sources will include carry from Earth, by product from using fuel cells usage, recycle waste from Human Urine, extraction ice from Mars ore. Carrying on Oxygen from Earth requires expensive storage.

Water/Oxygen Extraction Equipment can extract water and oxygen from ice with H2O (ice) water from soil

Humidity? Some days 100%, water can be extracted from air at this time

MOXIE - (Oxygen Generation Module)

The Mars Oxygen In-Situ Resource Utilization Experiment is better known as MOXIE. NASA is preparing for human exploration of Mars, and MOXIE will demonstrate a way that future explorers might produce oxygen from the Martian atmosphere for propellant and for breathing.

Humidity on Mars (9.00) – extract water from air

Packing for Mars 2018 (41.00)– Documentary includes closed loop system for generating oxygen from waste

Project Moxie (10.0) extract oxygen from air, scalable to a factor of 100

(link to Water Module)

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Cyrogenic Society of America, Inc. (web link)

Air Separation

This article, written by Dr. John Weisend, was originally published in the Volume 31 Number 2 issue of Cold Facts as part of his series, Defining Cryogenics.

Air separation is one of the largest, as well as earliest, industrial applications of cryogenics. In this process, cryogenic temperatures are used to separate air into its constituent gases: nitrogen (78.08%), oxygen (20.95%), argon (0.93%) and carbon dioxide (0.3%). Trace gases such as krypton, neon, xenon and helium total far less than 1%. Water vapor can also be a significant fraction of air but it is removed along with carbon dioxide at the start of the separation process.

The components of air have many applications in industry and research, and the separation, transport and selling of these gases is a multibillion dollar industry. **Air separation is a principal part of the business of large industrial gas firms such as Air Products, Air Liquide, Linde and Praxair.**

There are essentially two production models used in the air separation industry. In the first, centralized plants separate the air and the resulting components are then shipped to customers offsite, frequently in the form of cryogenic liquids. In the second, an air separation plant is located at the customer site itself to produce, for example, oxygen for a chemical plant or steel mill or nitrogen for use in pressurizing oil fields to increase recovery. The remaining gases not of direct interest to the customer are either sold to other customers or vented to the atmosphere, depending on the economic case. Air separation plants are quite large, with typical capacities being thousands of tonnes per day of oxygen and nitrogen produced.

Cryogenic air separation is based on the principle of rectification, which is defined in Barron as “the cascading of several evaporations and condensations carried out in counterflow.” A simple version of this is shown in Figure 1. Air is compressed and all of the water, hydrocarbons and carbon dioxide are removed. The resulting air is cooled down via heat exchange with colder flows of nitrogen and oxygen and then expanded via both expansion engines and valves to near the saturation temperature of oxygen and nitrogen. This cold, near-saturated mixture is then fed into the rectification column. Since oxygen has a higher boiling temperature than nitrogen, as the mixture progresses through the trays or plates of the column, the liquid portion, which flows down, becomes progressively richer in oxygen, while the gas portion, which flows up, becomes progressively richer in nitrogen. The liquid oxygen at the bottom of the column still contains significant amounts of nitrogen, while the gas at the top is almost pure nitrogen, with small fractions of argon, xenon, helium, etc. In the example given, the plant was designed only to produce crude oxygen and the nitrogen flow is vented. Many complicated variations on this technique exist. One of the most common uses two rectification columns placed on top of each other, operating at different pressures. This arrangement (known as the Linde double-column system) results in the production of much higher purity oxygen and nitrogen. Additional columns can be added to remove argon, xenon, krypton and neon.

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AIR SEPARATION

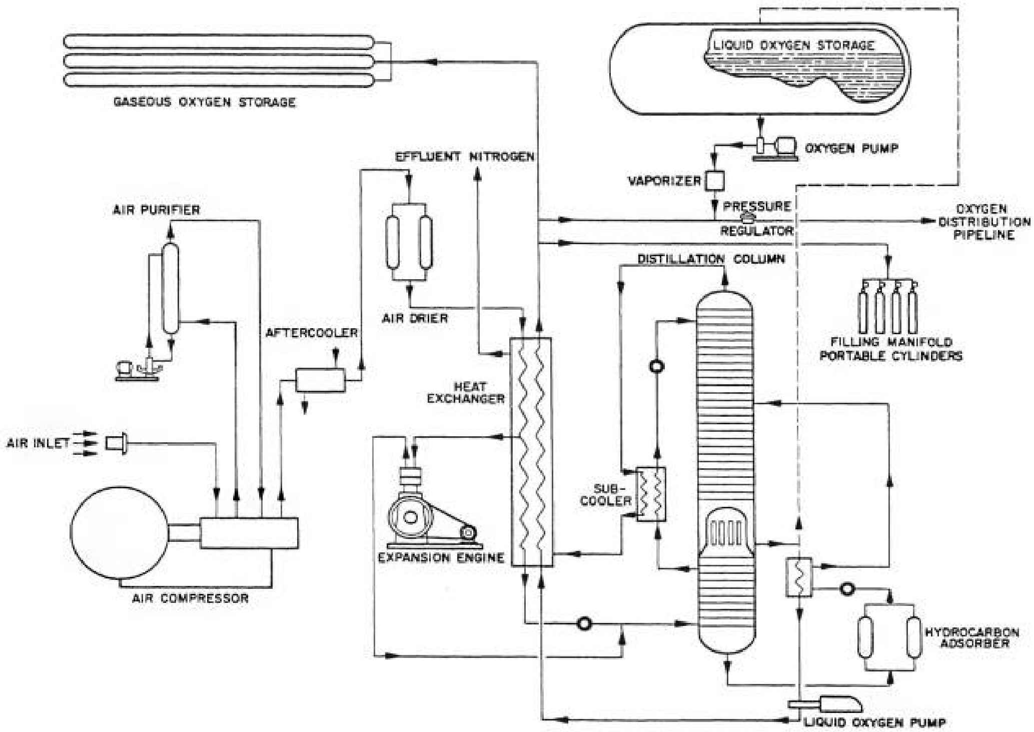

Figure 1: Schematic of a liquid oxygen plant. Image: Mechanical Engineers' Handbook, Vol. 4, M. Kutz (Ed). Copyright © 2015 Air Liquide. Reproduced with permission of John Wiley & Sons, Inc.

The need for air separation plants to compress and move thousands of tonnes of air a day means that they require significant amounts of energy. Thus, a number of energy recovery schemes are typically used, including using the work done by the gas on the expansion engines to help power the compressors. Research on modeling and optimizing the rectification columns and heat exchangers to improve the product purity while reducing energy consumption is ongoing.

Additional details on cryogenic air separation may be found in Cryogenic Engineering, R. Barron, McGraw-Hill (1966); Separation of Gases, W. H. Isalski, Oxford University Press (1989); and “Air Separation Plant Design,” D. J. Hersh and J. M. Abrado, Cryogenics (July 1977). Examples of modeling of air separation plant components include “Simulation of Multistream Plate-Fin Heat Exchangers of an Air Separation Unit,” R. Boehme et al., Cryogenics 43 (2003) and “Hybrid Model of Structured Packing Column for Cryogenic Air Separation,” Z. Wu et al. Proc. ICEC 24 (2013). An example of using heat recovery to reduce energy use in air separation plants is presented in “A Novel Cryogenic Air Separation Process Based on Self-Heat Recuperation,” Y. Kansha et al., Separation and Purification Technology 77 (2011). The relative merits of cryogenic air separation and pressure temperature swing adsorption techniques are discussed in “Comparative Analysis of Cryogenic and PTSA Technologies for Systems of Oxygen Production,” T. Banaszkiewicz et al. in Adv. Cryo. Engr. Vol 59b (2014). A description of the Air Liquide helium liquefier built in Qatar may be found in “Ras Laffan Helium Recovery Unit HeRUII Project,” R. Ali Said et al., Proc ICEC 2014 (at press).

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