CGA P-8—2020

GUIDELINE FOR SAFE PRACTICES FOR CRYOGENIC AIR SEPARATION PLANTS

SIXTH EDITION

CGA
Compressed Gas Association
The Standard For Safety Since 1913

PREFACE:

As part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has published CGA P-8, *Guideline for Safe Practices for Cryogenic Air Separation Plants*, jointly produced by members of the International Harmonization Council.

This publication is intended as an international harmonized standard for the worldwide use and application of all members of the Asia Industrial Gases Association (AIGA), Compressed Gas Association (CGA), European Industrial Gases Association (EIGA), and Japan Industrial and Medical Gases Association (JIMGA). Each association's technical content is identical, except for regional regulatory requirements and minor changes in formatting and spelling.

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1 Introduction

This publication provides guidance on the safe operation of cryogenic air separation plants. It is based on the experience of CGA member companies that operate cryogenic air separation units (ASUs).

Industrial cryogenic air separation has some potential hazards that must be recognized and addressed. The hazards include electricity, gases under pressure, very low temperatures, the ability of oxygen to accelerate combustion, and the asphyxiant properties of nitrogen, argon, and the rare gases [1].[1]

Cryogenic air separation technology is not static; it has been progressing for decades and will continue to do so because of engineering development efforts. Consequently, plant process cycles, equipment, and operating conditions can be and are of varying kinds. Therefore, this publication includes generalized statements and recommendations on matters for which there is a diversity of opinion or practice. Users of this guide should recognize that it is presented with the understanding that it cannot take the place of sound engineering judgment, training, and experience. It does not constitute, and should not be construed to be, a code of rules or regulations.

2 Scope

This publication serves the interest of those associated or concerned with air separation plant operations and applies to safety in the design, location, construction, installation, operation, and maintenance of cryogenic air separation plants. Emphasis is placed on equipment and operational and maintenance features that are specific to cryogenic air separation processes. Limited coverage is given to plant equipment such as air compressors, which are used in other industrial applications and for which safe practices in design, installation, and use have already been established elsewhere. Further, as this publication is not intended as a universal safe practice manual for specific design and safety features, it is also important to refer to the operating manuals of the equipment suppliers.

The following are excluded from this publication:

- cylinder filling facilities;
- rare gas purification systems; and
- product transmission piping outside the plant boundaries.

3 Typical ASU features

Cryogenic ASUs have these features:

- air compression;
- air contaminant removal;
- heat exchange;
- distillation; and
- expansion (or other refrigeration sources).

Figure 1 is an example of a flow diagram for separating air by cryogenic distillation producing oxygen, nitrogen, and argon products. Air is compressed in the main air compressor (MAC) to between 4 atm and 10 atm. It is then cooled to ambient temperature. Trace contaminants such as water, carbon dioxide, and heavy hydrocarbons are removed using systems such as a prepurification unit (PPU) or a reversing heat exchanger (REVEX). The main heat exchanger cools the air to near its liquefaction temperature before entering the high pressure distillation column. Some of the air is reduced in pressure in the expander to produce refrigeration, overcoming heat leak and process inefficiencies. Gaseous nitrogen from the top of the high pressure column is condensed by the reboiler and the liquid used to reflux both columns. Condensing nitrogen releases heat to vaporize liquid oxygen

[1] References are shown by bracketed numbers and are listed in order of appearance in the reference section.

in the low pressure column sump, which is then taken as product or sent as stripping gas to the low pressure column.

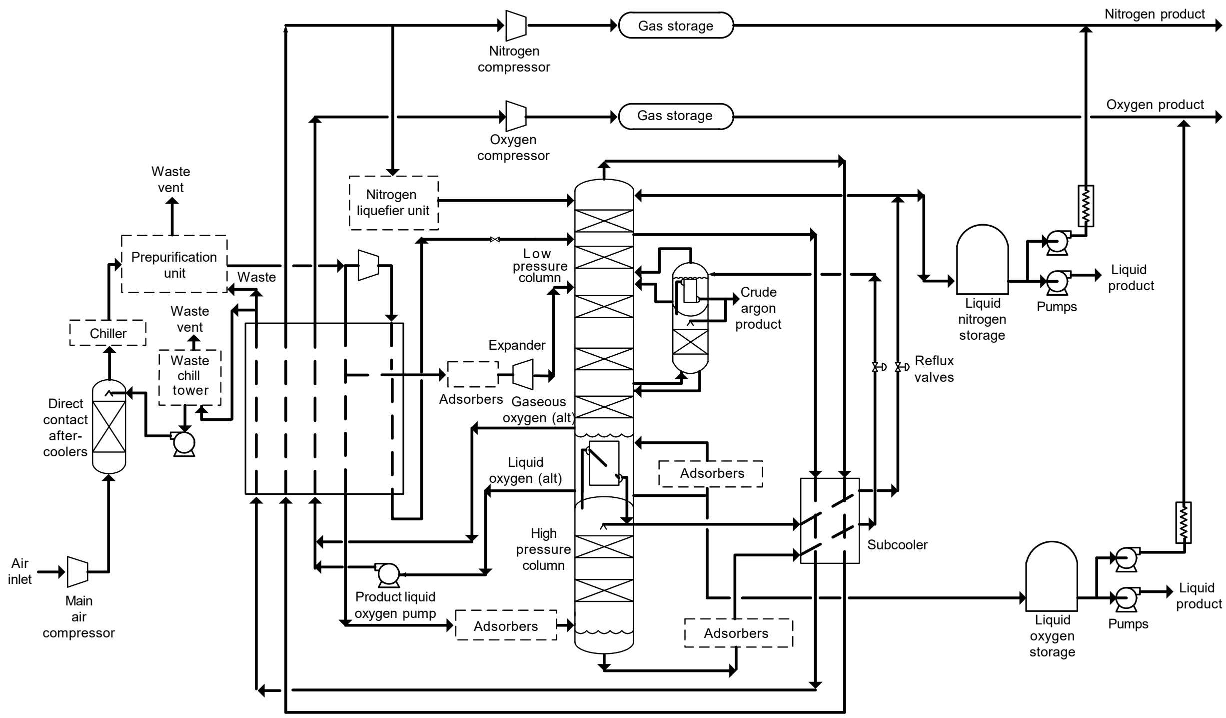

Figure 1—Example of an air separation plant flow diagram

Oxygen has the highest boiling point of the three main components and is taken from the bottom of the low pressure column. Nitrogen is taken from the top of the low pressure or high pressure columns. An argon-rich stream can be withdrawn from the middle of the low pressure column and refined to a pure product in other distillation columns. The product streams are warmed to ambient temperature against incoming air in the main heat exchanger to recover the refrigeration. It is also possible to remove the products from the distillation system as liquid, if sufficient refrigeration is available. Producing large quantities of liquid products requires extra refrigeration, often supplied by a nitrogen liquefier unit. Liquid may be stored for pipeline backup or merchant sales.

There are two typical ASU configurations for producing pressurized oxygen. In the gas plant configuration (also called gaseous oxygen process or classic gas process), oxygen is taken as a vapor from the bottom of the low pressure column and warmed by incoming air in the main heat exchanger. If a high pressure oxygen product is needed, it is compressed to the required pressure. A liquid oxygen purge stream is taken from the sump of the low pressure column to prevent the trace contaminants from concentrating above allowable safety limits. In the pumped liquid oxygen process (also known as the internal compression process), oxygen is taken as a liquid from the low pressure column sump, pumped to the required pressure, and vaporized in the main exchanger against high pressure air from the booster air compressor. The pumped oxygen stream removes trace contaminants from the low pressure column sump, so a separate liquid oxygen purge stream from the low pressure column sump may be eliminated.

There are many other configurations of the ASU process that are specifically tailored for different products mixes and customer needs. A detailed discussion of these is beyond the scope of this publication.

4 Definitions

4.1 Publication terminology

4.1.1 Shall
Indicates that the procedure is mandatory. It is used wherever the criterion for conformance to specific recommendations allows no deviation.

4.1.2 Should
Indicates that a procedure is recommended.

4.1.3 May
Indicates that the procedure is optional.

4.1.4 Will
Is used only to indicate the future, not a degree of requirement.

4.1.5 Can
Indicates a possibility or ability.

4.2 Technical definitions

4.2.1 Acid gas
Air contaminants such as chlorine, NO_x, and SO_x that can form acid when combined with water.

NOTE—Acid gases can create corrosive conditions in brazed aluminum heat exchangers (BAHXs) and other equipment.

4.2.2 Adsorption
Purification process in which one or more components from a gas or liquid is preferentially adsorbed onto a solid desiccant or other adsorbent.

NOTE—Typical adsorbents include:

- molecular sieve—granular adsorbent (typically 13X) used in air PPUs for water, carbon dioxide, and hydrocarbon removal;
- alumina—granular adsorbent typically used in air PPUs or dryers for water removal; and
- silica gel—granular adsorbent typically used in cryogenic adsorbers for carbon dioxide and hydrocarbon removal.

4.2.3 Asphyxiation
To become unconscious or die from lack of oxygen.

4.2.4 Blow out
Maintenance or commissioning procedure in which a fluid, typically dry air, is blown through piping and equipment to eliminate dirt, moisture, or other contaminants.

4.2.5 Brazed aluminum heat exchanger (BAHX)
Aluminum plate and fin heat exchanger consisting of corrugated sheets separated by parting sheets and an outer frame consisting of bars with openings for the inlets and outlets of fluids, equipped with headers and nozzles to connect to external piping.

NOTE—The approximate thickness of the corrugated sheets is 0.2 mm to 0.5 mm, while the parting sheets have thicknesses between 1.0 mm and 2.4 mm. More information is provided in CGA G-4.9, *Safe Use of Brazed Aluminum Heat Exchangers for Producing Pressurized Oxygen* [2].

4.2.6 Casing
Outside walls of a coldbox or cryogenic piping duct. The cross section can be circular or rectangular.

4.2.7 Catalyst
Material that helps promote a reaction but is not changed itself.