



CGA P-8.6—2022

UNMANNED AIR GAS PLANTS: DESIGN AND OPERATION

THIRD EDITION

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PREFACE

As part of a program of harmonization of industry standards, the Compressed Gas Association (CGA) has issued CGA P-8.6, *Unmanned Air Gas Plants—Design and Operation*, jointly produced by members of the International Harmonization Council and originally published by the European Industrial Gases Association (EIGA) as EIGA Doc 132, *Unmanned Air Gas Plants—Design and Operation*.

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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NOTE—Technical changes from the previous edition are underlined.

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1 Introduction

This publication has been written to address issues relating to the increasing number of air gas production facilities that are run unmanned or remotely operated.

There are many similarities in the operation of manned, unmanned, and remotely operated plants; however, there are some differences. These differences are not only in how the plant is operated and maintained but also how the plant is designed. In particular, designing new unmanned plants or converting existing plants from manned to unmanned or remote operation requires specific design considerations to ensure an equivalent level of safety to that of a manned operated plant.

2 Scope and purpose

The purpose of this publication is to provide guidelines for the design, operation, and maintenance of a plant that has unmanned or remote operations.

Unmanned or remotely operated plant functionality can range from a plant with full remote functionality i.e., satellite plant controlled by a remote operating center (ROC) to a plant with autonomous operation.

The installations that are included in this publication are:

- cryogenic air separation plants;
- cryogenic nitrogen generators;
- noncryogenic plants (pressure swing absorption, vacuum pressure swing absorption, membrane, etc.) for oxygen and nitrogen;
- pipeline compression stations;
- compressed dry air facilities; and
- back-up systems and site storage, if existing and integrated with the production unit.

Specifically excluded are product supply tanks installed at a customer's premises, home care units (for example, concentrators), and noncryogenic plants with a capacity of 5 ton (5 000 kg) per day or less. For noncryogenic plants from 5 ton to 20 ton (5 000 kg to 20 000 kg) per day, a risk assessment shall be carried out to identify which requirements of this publication apply.

3 Definitions

For the purpose of this publication, the following definitions apply.

3.1 Publication terminology

3.1.1 Shall

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

3.1.2 Should

Indicates that a procedure is recommended.

3.1.3 May

Indicates that the procedure is optional.

3.1.4 Will

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

3.1.5 Can

Indicates a possibility or ability.

3.2 Technical definitions

3.2.1 Personnel roles

3.2.1.1 Local operator

Person who is on site and has control of the plant. Personnel who are working at the plant but are not in control of the plant are not considered to be local operators.

3.2.1.2 Remote operator

Person remotely located that has control of the plant.

3.2.2 Remote control/remote monitoring

Two-way communication from the plant to or from the ROC, (for example, receiving plant alarm/trip signals and the ability to remotely start/stop machinery, etc.).

Remote monitoring implies one way communication from the plant to the ROC, (for example, receive only plant alarm/trip signals, plant data, etc.).

3.2.3 Remote operating center (ROC)

Any location that remotely monitors and/or controls a plant or multiple plants from outside of the plant boundary. It can be a dedicated center, be located at a plant site, or any other remote location.

The ROC can also provide specialist operations support (maintenance, engineering, control systems, etc.).

3.2.4 Remote operation

Condition where a plant operates for period of time with operational control of a plant performed at a location other than the plant site.

Such a condition can exist whether or not there are personnel (for example, performing trailer filling or maintenance tasks) at the plant site.

Remote operation does not necessarily imply continuous communication with the plant.

3.2.5 Unmanned operation

Condition where a plant operates without the physical presence of personnel qualified to respond to a plant process or safety emergency, either independently or with direction from a qualified operator.

3.2.6 Unmanned plant

Plant that operates for any period of time without the physical presence of personnel qualified to respond to a plant process or safety emergency, either independently or with direction from a qualified operator.

4 Safety aspects of plant design

4.1 General considerations

This section briefly introduces the complex subject of safety in plant design and the reader is referred to Section 9 for more detailed information.

The starting point for evaluation of safety systems is always a review that is focused on safety. This can typically be a hazard and operability (HAZOP) review for new plant designs or a "What If" analysis for retrofits. Either type of analysis will lead to a hazard identification and risk assessment. The objective of these assessments is to identify the safety features necessary to reduce the risk to the as low as reasonably practicable (ALARP) threshold—the necessary safety target set by each country/company.

Safety related features can prevent, contain, or mitigate the hazard and comprise the following categories:

- passive engineering systems (for example, selection of pipeline materials to eliminate the hazard, secondary leak containment system, etc.);

- active engineering systems (for example, a device, safety valve, nonreturn (check) valve, or instrumentation (alarms and trips); and
- procedural controls/human actions (for example, operating instructions, emergency response—plant shutdown, isolation, etc.).

Plants should be designed to incorporate controls in the first category (which eliminate or reduce the risk) as these are inherently more reliable than those in the other two categories.

Certain safety related features that rely on instrumentation are called safety instrumented systems (SIS) and the following design standards give a systematic approach that is internationally recognized as best practice:

- IEC 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems – All Parts* [1].¹ This standard is focused towards manufacturers and suppliers of devices; and
- IEC 61511, *Functional safety—Safety instrumented systems for the process industry sector – All Parts* [2]. This standard is focused towards system designers, integrators, and users.

Both standards give guidance on how to achieve suitable reliability for these SIS (risk graph, layer of protection, etc.). This reliability is called the safety integrity level (SIL) (which is numbered 1 to 4) and such systems are usually considered to be safety critical.

A high SIL rating means a more demanding safety function requiring more sophistication in the equipment (for example, SIL 4 is usually used in the nuclear industry) and requires duplication/redundancy/diversity in the instrumentation so that no single component could cause the overall system to fail.

Typically, air separation plants have only a few SIS. Most are passive systems (material selection, location, etc.) or active engineering systems (safety valves, etc.). The instrumentation elements of the SIS may be specified with SILs. Where applied, these are usually specified to SIL 1 or SIL 2 (i.e., 1 dangerous failure every 100 000 hours to 1 million hours for SIL 1 and 1 dangerous failure every 1 million hours to 10 million hours for SIL 2).

See 5.8.4 for typical examples.

Having established the required design reliability, there is also guidance on how to establish suitable hardware reliability. The key message here is an overall life cycle requirement for SIS so that the control function operates with the correct reliability over the whole life of the plant.

See CGA P-8, *Guideline for Safe Practices for Cryogenic Air Separation Plants* for more information regarding plant design and operation [3].

4.2 Requirements and recommendations for unmanned and remotely operated air gas plants

A risk assessment paying particular attention to the consequences of unmanned and remote operation shall be made for all unmanned and remotely operated plants. For new projects, the authorities normally require a risk assessment as part of the operating license.

If the general risk assessment has not been done before, it shall be done prior to implementing unmanned or remote operation.

For retrofits, the existing risk assessment shall be reviewed in detail and updated where necessary.

The risk assessment for an operating plant shall be reviewed whenever a significant change is made to the process, see 4.4. The objective of the review should be to ensure that changes in operating conditions, connected supplier and customer processes, and surrounding communities have not created an unacceptable risk or altered safety features that were originally built into the design.

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

Whenever an unmanned or remotely operated plant is acquired from a third party, the risk assessment documentation for that process shall be reviewed to confirm compliance with company and industry standards. If there is no existing risk assessment documentation or the existing documentation is incomplete, a new formal risk assessment shall be conducted.

4.3 Plant location risk

For unmanned or remotely operated plants, detection and mitigation of off-site risks becomes more important since human intervention cannot be assumed.

Typical questions that shall be considered are:

- How could the installation and the total stored volume of products affect the surrounding area;
- How could the surrounding area affect the safety of the plant;
- Can planned future developments in the surrounding area or within the plant area have a negative influence on safety; and
- Can the local firefighters handle a major release of products from the plant?

See EIGA Doc 75, *Methodology for Determination of Safety and Separation Distances* [4].

4.4 Management of change review

Management of change (MOC) is the procedure used to ensure that changes are implemented correctly and safely and are documented. These documents shall be maintained at the plant. Any proposed change to equipment, controls, software, procedures, and facilities shall require a documented review by technically competent personnel and approval by authorized personnel before implementation. This review and authorization shall apply to all proposed modifications or changes whether they are permanent, temporary, or emergency in nature. All appropriate plant documentation such as a process and instrument diagram, equipment specifications and drawings, and operating and maintenance procedures shall be updated.

Replacement-in-kind is an exact replacement or design alternative that meets all design specifications of the item being replaced. Replacement-in-kind does not require MOC approval, see EIGA Doc 51, *Management of Change* [5].

5 Plant design and retrofit considerations

5.1 Compliance with permits and regulations

All applicable regulations shall be followed and appropriate permits acquired.

Delegation of responsibility for compliance with permits and regulations shall be defined in the company management system for each unmanned or remotely operated plant.

5.2 Shutdown systems

Manned, unmanned, and remotely operated plants are subject to different needs for shutdown systems. A risk assessment shall be performed to determine the type and methodology of shutdown systems and should account for the staff available to respond to an emergency at an unmanned or remotely operated facility.

The requirements for manual and automated shutdown systems for unmanned and remotely operated plants are described below.

5.2.1 Plant emergency shutdown system

All unmanned or remotely operated plants shall be provided with an emergency shutdown system that, when activated, will put the plant into a safe condition. Where multiple emergency shutdown systems are present, the systems should control logical segments of the site (i.e., the storage areas, trailer filling areas, production units, etc.).

Emergency shutdown systems are hardwired stop buttons strategically located around the plant and include:

- machine stop buttons;
- switch gear stop buttons; and
- plant stop button.

At least one of the stop buttons shall be safely accessible by the initial responder, see 8.1.

Manually operated hardwired stop buttons shall be strategically located around the plant. At least one of the stop buttons shall be safely accessible by the initial responder, see 8.1.

The plant emergency shutdown system can also be manually activated from the plant control system, the ROC, or other locations such as the customer control room.

The storage and trailer filling emergency shutdown system shall isolate all storage tank liquid valves and cease filling operations. If the main storage tank is used to directly feed the back-up vaporization system to a pipeline customer, a risk evaluation shall be made covering the case for isolating the liquid outlet valve.

Remote or automatic reset of the emergency shutdown system shall not be possible. It is potentially hazardous to remotely or automatically reset the emergency shutdown system because it may not be possible to determine the complete nature of the emergency.

5.2.2 Plant shutdown system

All unmanned or remotely operated plants shall be provided with an automated shutdown system that, when activated, will put the equipment or plant into a safe condition.

The plant shutdown system will normally be activated by various trip signals, for example:

- critical safety devices identified during the risk assessment phase (for example, liquid leak detectors, hydrocarbon detectors, etc.);
- process safety devices (for example, pressure switch);
- quality control devices (for example, analyzers);
- machine protection devices (for example, vibration, low oil pressure); and
- local or remote manual inputs.

Provisions to allow for remote reset of the plant shutdown system shall be documented.

5.2.3 Remote shutdown

The ability to trip the plant from a remote location (for example, ROC) provides additional operational safety, but this ability might not be available for all facilities. Remote shutdown shall not be the primary means of emergency shutdown or plant shutdown, as communication with the remote location can be interrupted.

5.3 Fire and gas alarm system

Subject to a risk assessment, unmanned and remotely operated plants may be provided with an automatic fire/smoke detection system. Examples of areas that could require protection are the control room, the electrical switchgear room, and compressor areas.