



SAFE START UP AND SHUT DOWN PRACTICES FOR STEAM REFORMERS

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SAFE START UP AND SHUT DOWN PRACTICES FOR STEAM REFORMERS

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As part of a programme of harmonisation of industry standards, the European Industrial Gases Association, (EIGA) has published EIGA Doc 185, *Safe Start Up and Shut Practices for Steam Reformers*, jointly produced by members of the International Harmonisation Council and originally published by the Compressed Gas Association as CGA H-11-2020, *Safe Start Up and Shut Practices for Steam Reformers*.

This publication is intended as an international harmonised 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, 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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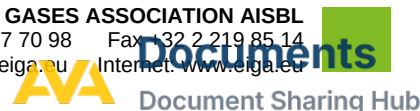


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Amendments to 185/14

Section	Change
4.1	The PPE bullet list has been deleted
5.1.1	Added: e.g., no fault signals, limit switches are cleared
5.1.3	Add the Note
5.2.2	Footnote: EIGA do not have a document on metric practice
5.2.4	Add bullet (j) and changed bullet (k) Added the Note
5.4.2	Added 2 nd paragraph
5.4.3	Added 2 nd paragraph
5.4.5	More detailed paragraph
5.7.1.2	More detailed paragraph
5.7.2	More detailed paragraph

NOTE Technical changes from the previous edition are underlined

1 Introduction and purpose

1.1 Introduction

Large scale hydrogen production has been commercially practiced for decades and the demand for such production has grown over that period. In the last several years, developments in crude oil processing, such as the increased use of hydrogen to remove sulfur and the refinement of heavier crude oil stocks, has driven significant growth in the demand for hydrogen supply.

In response to this demand, industrial gas companies operate and maintain large scale hydrogen production facilities worldwide and have done so with an exemplary safety record for many years. However, it should be noted that large scale hydrogen production involves potential personnel and process safety hazards that shall be addressed in design and operation. Such hazard potential is inherent to the processing of toxic and flammable gases via high temperature reforming as practiced in hydrogen production.

The steam reformer represents the core operating unit of most large scale hydrogen production facilities. Therefore, steam reformer furnace combustion safety is fundamental to the overall safe operation of these large scale hydrogen plants. The startup and shutdown of the reformer can create transitional periods of increased risk to the operation of the facility. The operating procedures and practices employed during startup and shutdown shall effectively address the potential hazards of such transitions to ensure plant safety.

The need to specifically consider and address the startup and shutdown of industrial processes is well recognized as a cornerstone to safe operation. Requirements to ensure startup and shutdown safety are addressed in operating procedures and are included in process safety regulations in Title 29 of the U.S. *Code of Federal Regulations* (29 CFR) Part 1910.119, *Process safety management of highly hazardous chemicals*, referred to as OSHA Process Safety Management (PSM), and in Europe, Seveso III Directive 2012/18/EU, *Control of Major Accident Hazards Involving Dangerous Substances*, among other regulatory bodies [1, 2].¹

Guidelines for the safe startup and shutdown of industrial production units are technology specific. Industry-wide publications addressing startup and shutdown practices exist for many technologies, including industry publications such as EIGA Doc 147, *Safe Practices Guide for Cryogenic Air Separation Plants*, which addresses startup and shutdown of air separation plants [3].

It should be noted that there are other industries such as ammonia and methanol production, that operate large steam reformers. Therefore, it can be instructive to consider the learning and experiences from those industries through organizations such as the American Institute of Chemical Engineering: Ammonia Plant Safety Symposium and the International Methanol Producers and Consumers Association (IMPCA).

Steam reformer furnace design will continue to develop along with methods to implement combustion safety in these furnaces. A wide variety of steam reformer designs, configurations, and component equipment exists today. Therefore, this publication includes generalized statements and recommendations on matters which there may be diversity of opinion or practice. Users of this publication should recognize that it is presented with the understanding that it can supplement, but not take the place of, sound engineering judgment, training, and experience. It does not constitute, and should not be construed to be, a code or rules or regulations.

1.2 Purpose

The purpose of this publication is to inform and guide interested parties on the procedures and practices fundamental to combustion safety in the operation of steam reformers. This publication presents a baseline for safe reformer operation which, if followed, assures our customers that the hydrogen they receive from member companies has been produced according to accepted industry-

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

wide safety guidelines. This publication provides a technical basis that can be used to present a common viewpoint to government and regulatory authorities, ensuring proper application of rules and regulations.

2 Scope

This publication applies to steam reformers that are operated with natural gas, refinery off gas, naphtha, and other light hydrocarbon streams. It specifically applies to large volume hydrogen production plants, defined for this publication as a production capacity of 10 000 Nm³/h (380 000 scfh) (240 000 Nm³/D or 9 MMSCFD) or greater. This publication may be applied to smaller reformers depending on the technology used.

This publication covers operational safety of steam reformer startup and shutdown. Emphasis is placed on operational guidance and features that provide safeguards against the hazards associated with the transition and infrequent nature of startups and shutdowns. The publication is not intended to address the details of design, installation, construction, and initial startup (commissioning) of steam reformers.

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 Boiler

Closed vessel in which water is heated and steam is generated by heat input from combustible fuels in a self-contained or attached furnace.

3.2.2 Burner

Device for the introduction of fuel and air into a combustion chamber at the velocity, turbulence, and concentration required to maintain ignition and combustion of fuel.

3.2.3 Burner management system (BMS)

Control system dedicated to combustion safety and operator assistance in the starting and stopping of fuel preparation and combustion equipment and for preventing improper operation of and damage to fuel preparation and burning equipment.

3.2.4 Bypass

Means used to temporarily deactivate an alarm, control, or protection system including, but not limited to: jumper wires, control system overrides, forced values, modified setpoints, modification of the normal lock open or closed valve positions, taking the device offline, or running temporary hoses.

NOTE—Based on the type of bypass, it can also be referred to as an override, shunt, or jumper.

3.2.5 Bypass log

Formal document used to track the approval, installation, management, and removal of bypasses.

3.2.6 Cold collector

Refractory lined piping system wherein the exit of the catalyst tubes is directly connected to a refractory lined piping manifold.

3.2.7 Combustion air

Air used to react with the fuel in the combustion process.

3.2.8 Convection section

Portion of the reformer, downstream of the furnace, where flue gas passes over heat exchangers and heat transfer occurs via radiation and convection.

3.2.9 Damper

Valve or plate for controlling draft or the flow of gases, including air.

3.2.10 Dead leg

Section of a piping system that normally has no significant flow (one end blocked or restricted) with a length greater than 3 to 6 pipe diameters.

3.2.11 Double block and bleed (DB&B)

Piping or instrument arrangement that combines two block (or isolation) valves in series with a vent valve in between the block valves as a means of releasing pressure between the block valves with the intent to provide positive isolation.

3.2.12 Draft

Negative pressure (vacuum) measured at any point in the furnace, typically expressed in inches of water column (mm of water column).

3.2.13 Excess oxygen

Flue gas oxygen measurement, typically on a wet gas basis (e.g., 1.5% excess oxygen approximately corresponds to 10% excess air, depending on fuel composition).

3.2.14 Extended outage

Period of time after a plant shutdown that can range from several weeks to months.

3.2.15 Forced draft (FD) fan

Device used to pressurize and supply ambient air to the combustion chamber to support combustion.

3.2.16 Flame

Body or stream of gaseous material involved in the combustion process and emitting radiant energy at specific wavelength bands determined by the combustion chemistry of the fuel. In most cases, some portion of the emitted radiant energy is visible to the human eye.

3.2.17 Flame detector

Device that senses the presence or absence of flame and provides a usable signal.

3.2.18 Furnace

Portion of the reformer where the combustion process takes place.

3.2.19 Header

Pipe or duct through which liquid or gas is conveyed and supplied to or received from multiple branches.

3.2.20 Induced draft (ID) fan

Device used to remove the products of combustion from the reformer furnace by introducing a negative pressure differential.

3.2.21 Interlock

Device or an arrangement of devices, in which the operation of one part or one mechanism of the device or arrangement controls the operation of another part of another mechanism.

3.2.22 Lower explosive limit (LEL)

Lowest concentration of a flammable gas in an oxidant that will allow a flame to propagate when ignited.

NOTE—LEL is sometimes referred to as lower flammability limit (LFL).

3.2.23 Lock closed valve

Manual valve that is closed in its safe position during normal operation. The valve is locked in the closed position by means of a plastic strip, a cage around the valve, a key locked chain, or another suitable device.

3.2.24 Lockout/Tagout (LOTO)

Safety procedure used to ensure that sources of energy are properly shut off, isolated, and labeled prior to the start of maintenance work. This condition is maintained during the work, and reversed when preparing for restart.

3.2.25 Monitor

To sense and indicate a condition without initiating automatic corrective action.

3.2.26 Permissive

Condition that shall be met before a piece of equipment can be operated or a step in a sequence can be completed. After the equipment is operated or sequence step is completed the permissive is ignored.

3.2.27 Prereformer

Reactor, located upstream of the reformer, that primarily converts heavy hydrocarbons (e.g., ethane, propane, butane) to methane.

3.2.28 Pressure swing adsorption (PSA)

Multiple fixed bed gas purification process that uses materials that selectively adsorb one or more gas species from a mixture. Regeneration of the adsorbent is accomplished with a pressure reduction or swing.

3.2.29 Purge

Flow of air or an inert medium at a rate that will effectively remove any gaseous or suspended combustibles and replace them with the purging medium.

3.2.30 Pyrophoric

Capable of igniting spontaneously in air.

3.2.31 Radiant section

Portion of the furnace in which the heat is transferred to the tubes, primarily by radiation.

3.2.32 Refinery off-gas

Gas stream removed as a by-product or purge from various crude oil processing units; typically consisting of a mixture of hydrogen, olefins, and alkanes.

3.2.33 Safety instrumented system (SIS)

Independent system composed of sensors, logic solvers, and final elements designed for the purpose of:

- automatically taking an industrial process to a safe state when specified conditions are met; and/or
- permitting a process to move forward in a safe manner when specified conditions allow (permissive functions).

3.2.34 Startup

Series of steps to initiate process flows, increase process temperatures, and start production.

3.2.34.1 Hot restart

Startup occurring shortly after an instantaneous shutdown from a no-hydrocarbon feed flow and near operating temperature condition to an operating flow condition at operating temperature.

3.2.35 Shutdown

Series of steps to stop production, feed, and fuel flows in a safe and controlled manner.