NFPA® 56 (PS)

Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems

2012 Edition

NFPA, 1 Batterymarch Park, Quincy, MA 02169-7471
An International Codes and Standards Organization

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NFPA® 56 (PS)

Standard for

Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems

2012 Edition

This edition of NFPA 56 (PS), *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, was prepared by the Technical Committee on Gas Process Safety. It was issued and made effective by the Standards Council on August 11, 2011.

This edition of NFPA 56 (PS) was approved as a Provisional American National Standard on August 11, 2011. NFPA 56 (PS) will now be processed as a regular NFPA document in accordance with the NFPA *Regulations Governing Committee Projects*. NFPA 56 (PS) shall only be in effect for a two-year period following the date of approval.

Origin and Development of NFPA 56 (PS)

In February 2010, an explosion occurred at a power plant construction site as the result of an uncontrolled release of flammable gas that was being used to clean the interior of the fuel piping system. The incident investigation resulted in urgent recommendations being issued by the U.S. Chemical Safety Board (CSB) for NFPA to develop requirements for the "safe conduct of fuel gas piping cleaning operations." In response, the NFPA Standards Council established the Technical Committee on Gas Process Safety and tasked that committee with developing a standard to address piping system cleaning and purging operations. As a result of the CSB's urgent recommendation, NFPA issued NFPA 56 (PS), *Standard for Fire and Explosion Prevention During Cleaning and Purging of Flammable Gas Piping Systems*, which prohibits the use of flammable gas as an agent for the interior cleaning of piping systems. NFPA 56 (PS) expands on the CSB recommendations by including cleaning and purging of all flammable gas piping systems at any inlet pressure for electric-generating plants and industrial, commercial, and institutional applications.

NFPA 56 (PS) addresses training requirements for personnel as well as notification of hazards for personnel not directly involved in cleaning or purging procedures. In addition, the new standard requires development of written procedures for cleaning and purging activities. It also requires that all written procedures for cleaning and purging undergo a safety validation performed by a competent person. The definition of *competent person* is extracted directly from federal Occupational Safety and Health Administration (OSHA) regulations. NFPA 56 (PS) also adopts terminology commonly used by the petrochemical industry for those procedures: *purging into service* for the process of replacing air in a piping system with inert or flammable gas and *purging out of service* for the process of replacing flammable gas in the piping system with inert gas or air.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This committee shall have primary responsibility for documents on the commissioning and maintenance of flammable gas piping systems in commercial, industrial, and power plant applications, extending from the point of delivery to the equipment isolation or shutoff valve except for those already covered by the NFPA National Fuel Gas Technical Committee and/or the NFPA Hydrogen Technologies Technical Committee.

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex D. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex D.

Chapter 1 Administration

1.1 Scope.

1.1.1* Applicability. This standard shall apply to fire and explosion prevention during cleaning and purging activities for new and existing flammable gas piping found in electric-generating plants and in industrial, institutional, and commercial applications.

1.1.1.1* Coverage of piping systems shall extend from the point of delivery to the gas-consuming equipment isolation valve.

1.1.1.1.1 For other than undiluted liquefied petroleum gas (LP-Gas) systems, the point of delivery is the outlet of the customer meter or at the connection to a customer's piping, whichever is farther downstream, or if there is no meter at the connection to customer piping.

1.1.1.1.2 For undiluted LP-Gas, the point of delivery is the outlet of the final pressure regulator, exclusive of line gas regulators, in the system.

1.1.1.1.3 For facilities that produce flammable gas for consumption on site, the point of delivery is the discharge isolation valve for the gas-producing equipment.

1.1.2 Nonapplication of Standard. This standard shall not apply to the following items:

(1)*Piping systems covered by NFPA 2
(2)*Piping systems covered by NFPA 54
(3)*Piping systems covered by NFPA 58
(4)*LP-Gas (including refrigerated storage) at utility gas plants *(see* NFPA 59*)*
(5)*LNG facilities covered by NFPA 59A
(6) LP-Gas used with oxygen for cutting, welding, or other hot work
(7)*Vehicle fuel dispensers
(8) Commissioning and maintenance of appliances or equipment
(9) Vent lines from pressure relief valves
(10) Systems regulated by U.S. Department of Transportation (DOT) 49 CFR 191 and 192

1.2* Purpose. This standard provides minimum safety requirements for the cleaning and purging of flammable gas piping systems, including cleaning new or existing piping systems, purging piping systems into service, and purging piping systems out of service.

1.2.1 For the purposes of this document, a piping system shall be understood to mean a complete piping system, including valves, regulators, and other appurtenances, and any segment thereof that can be isolated from the system.

1.3 Retroactivity. The provisions of this standard reflect a consensus of what is necessary to provide an acceptable degree of protection from the hazards addressed in this standard at the time the standard was issued.

1.3.1 Unless otherwise specified, the provisions of this standard shall apply to facilities, equipment, structures, or installations that existed or were approved for construction or installation prior to the effective date of the standard.

1.3.2 The retroactive requirements of this standard shall be permitted to be modified if their application clearly would be impractical in the judgment of the authority having jurisdiction and only where it is clearly evident that a reasonable degree of safety is provided.

1.4 Equivalency. The provisions of this code are not intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this standard.

1.4.1 Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.4.2 The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 2, *Hydrogen Technologies Code,* 2011 edition.

NFPA 31, *Standard for the Installation of Oil-Burning Equipment,* 2011 edition.

NFPA 51B, *Standard for Fire Prevention During Welding, Cutting, and Other Hot Work,* 2009 edition.

NFPA 54, *National Fuel Gas Code,* 2012 edition.

NFPA 58, *Liquefied Petroleum Gas Code,* 2011 edition.

NFPA 59, *Utility LP-Gas Plant Code,* 2012 edition.

NFPA 59A, *Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG),* 2009 edition.

NFPA 69, *Standard on Explosion Prevention Systems,* 2008 edition.

NFPA 70®, National Electrical Code®, 2011 edition.

2.3 Other Publications.

2.3.1 ASME Publications. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.

ANSI/ASME B31.1, *Power Piping,* 2010.

ANSI/ASME B31.3, *Process Piping,* 2010.

2.3.2 U.S. Government Publications. U.S. Government Printing Office, Washington, DC 20402.

Title 29, Code of Federal Regulations, Part 1926, "Safety and Health Regulations for Construction," Definitions.

Title 49, Code of Federal Regulations, Part 191, "Transportation of Natural and Other Gas by Pipeline: Annual Reports, Incident Reports, and Safety-Related Condition Reports," and Part 192, "Transportation of Natural and Other Gas by Pipeline: Minimum Federal Safety Standards."

2.3.3 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 54, *National Fuel Gas Code,* 2012 edition.

NFPA 55, *Compressed Gases and Cryogenic Fluids Code,* 2010 edition.

NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids,* 2006 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary,* 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Should. Indicates a recommendation or that which is advised but not required.

3.3 General Definitions.

3.3.1 Closed Piping System. Interconnected piping that is designed to contain the flammable gas under pressure during normal operations and incorporates provisions for controlled release of contents.

3.3.2* Competent Person. One who is capable of identifying existing and predictable hazards in the surroundings or working conditions which are unsanitary, hazardous, or dangerous to employees, and who has authorization to take prompt corrective measures to eliminate them. **[29 CFR 1926, 32(f)]**

3.3.3* Detection Equipment. Monitoring equipment necessary for detecting and/or measuring the volume of flammable gas or oxygen present in air.

3.3.4 End Point. Attainment of concentration (percent by volume) of inert substance in the closed system being purged such that subsequent admission of air, if purging out of service, or admission of gas or vapor, if purging into service, will not result in formation of a flammable mixture.

3.3.5 Equipment Isolation Valve. A manual shutoff valve for shutoff of the flammable gas to each piece of equipment.

3.3.6* Inert Gas. A nonreactive, nonflammable, noncorrosive gas such as argon, helium, krypton, neon, nitrogen, and xenon. [**55,** 2010]

3.3.7* Line Gas Regulator. A pressure regulator placed in a gas line between the service regulator and the appliance regulator.

3.3.8 Pig. A device inserted into a pipeline and that travels freely through it, pulled by a cable tow; propelled by air, water, or another medium; or driven by the product flow and that performs a specific task within the pipeline.

3.3.9 Purge. To free a gas conduit of air or gas, or a mixture of gas and air. [**54,** 2012]

3.3.9.1 ***Purge into Service.*** To replace the air or inert gas in a closed system by a flammable gas.

3.3.9.2 ***Purge out of Service.*** To replace the normal flammable content of a closed system by inert gas, air, or water.

Chapter 4 General Requirements

4.1 Piping System Construction. Flammable gas piping systems shall be constructed in accordance with ANSI/ASME B31.1, ANSI/ASME B31.3, or NFPA 54, as applicable.

4.2 Notification of Hazards. Personnel in the affected area(s), as determined by the cleaning or purging procedure, shall be informed of the hazards associated with the activity prior to the initiation of any such activity.

4.3* Cleaning and Purging Procedures. Written cleaning and purging procedures shall be developed and implemented by a competent person.

4.3.1* The written procedure for each cleaning and purging activity shall address, as a minimum, the following items:

(1) Scope of work and site-specific purge procedure development
   (a) Cleaning and purging method
   (b) Piping and instrument diagrams (PIDs)
   (c) Chemical and physical properties of flammable gas, purge media, and discharge gas
   (d) Determination of purge end point introducing flammable gas, inert gas, or air
   (e) Assessment and control of purge inlet and discharge locations
   (f) Temporary piping system design
   (g) Personal protective equipment (PPE)
   (h) Training and qualifications
   (i) Management review and approval
   (j) Restoration of service
   (k) Target design, launcher/receiver venting review for pigging operations
   (l) Regulatory permits
   (m) Evaluation of engineering controls to limit potential unintended ignition of gases (controlled oxidation, "flaring")
   (n) Written stand-down instructions to stop activity in a controlled manner
   (o) Hazards

(2)*Environmental conditions and work locations
   (a) Establishment and clear identification of exclusion zones where flammable gas-air mixtures are likely to exist
   (b) Limited access for personnel not directly involved with purge operations
   (c) Assessment of potential for gas migration (building openings, adjacent structures)
   (d) Prohibition of hot work within exclusion zones
   (e) Lockout/tagout
   (f) Impact of environmental conditions (wind speed and direction, temperature, barometric pressure) on purge operations
   (g) Vehicular and air traffic, if applicable
   (h) Topography
   (i) Noise control/monitoring

(3) Communication plans
   (a) Pre-job briefings
   (b) Work permits
   (c) Roles and responsibilities
   (d) Emergency response plan
   (e) Facility alarm, alert and warning systems
   (f) General facility notification prior to start of purge operations
   (g) General facility notification at the conclusion of purge operations
   (h) Notification of regulatory authorities as required (local emergency responders, utility operators, community officials, environmental authorities, etc.)

(4)*Control of ignition sources
   (a) Bonding and grounding considerations
   (b) No smoking or spark-producing work within exclusion zones
   (c) Elimination of hot work within exclusion zone
   (d) Static electricity ignition sources at discharge point

(5) Pre-purge piping system assessment
   (a) Assessment of piping system for trapped liquids, pyrophoric solids, and other flammable or combustible deposits within the piping system
   (b) Ensuring that the piping system is properly isolated
   (c) Limiting site conditions that impact the safety of the activity

(6)*Purge monitoring and instrumentation
   (a) Ensuring that monitoring instruments are appropriate for gas being purged
   (b) Training
   (c) Calibration
   (d) Monitoring frequency and reporting
   (e) Appropriate selection of sample point(s)
   (f) General atmosphere checks in vicinity of purge gas release

4.3.2 Stand-Down. If the conditions during the purging or cleaning activity deviate from those indicated in the written procedure, resulting in a safety hazard, the purging or cleaning activity shall be discontinued according to the stand-down instructions.

4.4* Safety Validation. A written safety validation shall be performed for cleaning and purging procedures.

4.4.1* The safety validation shall be conducted independently after the procedure has been written and shall evaluate hazards, errors, and malfunctions related to each step in the procedure to validate the measures prescribed in the procedure or make recommendations for additional hazard mitigation measures if necessary.

4.4.2* Recommendations (also called "action items") resulting from the safety validation shall be resolved prior to the activity being conducted.

4.4.3 Prior to initiation of a cleaning or purging activity, the safety validation shall be approved by a designated individual who is competent and knowledgeable in the procedure and hazards and who is authorized to provide such approval.

4.5* Management of Change. Written procedures to manage change to process materials, technology, equipment, procedures, and facilities shall be established and implemented. [**654:**4.3]

4.5.1 The management-of-change procedures shall ensure that the following issues are addressed prior to any change:

(1) The technical basis for the proposed change
(2) The safety and health implications
(3) Whether the change is permanent or temporary
(4) Modifications to cleaning and purging procedures
(5) Employee training requirements
(6) Authorization requirements for the proposed change

4.5.2* Implementation of the management-of-change procedures shall not be required for replacements-in-kind.

4.5.3 The written cleaning and purging procedure, as required by Section 4.3, shall be updated to incorporate the change.

4.6 Documentation.

4.6.1 Cleaning and purging procedures shall be documented and available at the job site.

4.6.2 The safety validation documentation shall include the following items:

(1) Names, company names, and addresses of the primary developer and other principal team members responsible for the safety validation
(2) Name, company name, and address of the principal operational personnel representing the plant owner or operator
(3) Date of preparation and any applicable modification dates
(4) The completed safety validation in accordance with Section 4.4
(5) Any procedures related to the safety validation and any limiting conditions identified in the management of change assessment required by Section 4.5

4.6.3 The safety validation and the cleaning and purging procedures shall be retained for at least 2 years following completion of the activity.

4.7 Notification of Hazards. Personnel in the affected area(s), as determined by the cleaning or purging procedure, shall be informed of the hazards associated with the activity prior to the initiation of any such activity.

4.8 Evacuation of Affected Area. Personnel not involved in cleaning or purging activities shall be evacuated from the affected area(s) as determined by the procedure.

4.9 Segment Cleaning. Piping system segments that can be isolated for cleaning prior to completion of the entire piping system shall be permitted to be cleaned, tested, and secured in a clean condition in accordance with Section 6.7.

4.10 Hangers and Supports. Hangers, supports, or other means capable of restricting the movement of piping shall be installed prior to initiating cleaning or purging activities in accordance with the procedure.

4.11* Nonflammable Atmosphere. Fluid media for testing or cleaning shall not introduce a flammable atmosphere into or create a fire hazard in the piping system being tested or cleaned.

4.12 Utility Coordination. Where utilities such as steam, water, or compressed air are used in quantities or duration that can disrupt distribution or operations internal or external to the facility, cleaning or purging activities shall be coordinated with the managing authority of the utility.

4.13 Restricted Access. Access to all parts of the piping system during cleaning or purging activities shall be restricted in accordance with the procedure.

4.14* Pressure Testing and Inspection. Prior to cleaning or purging, piping systems shall be inspected and pressure tested to determine that the materials, design, fabrication, and installation practices comply with the requirements of this standard and the intended application.

4.14.1 Pressure testing and inspection procedures shall be documented.

4.14.2 Where piping is designed and installed in accordance with NFPA 54, pressure testing and inspection shall be in accordance with NFPA 54, Chapter 8.

4.14.3 Where piping is designed and installed in accordance with ANSI/ASME B31.1, pressure testing and inspection shall be in accordance with Chapter VI of ANSI/ASME B31.1.

4.14.4* Where piping is designed and constructed in accordance with ANSI/ASME B31.3, leak testing and inspection shall be in accordance with Chapter VI of ANSI/ASME B31.3.

4.14.5* Where pneumatic testing is conducted in accordance with ANSI/ASME B31.1, paragraph 137.5.2, or with ANSI/ASME B31.3, paragraph 345.5.3, the test medium shall be air, carbon dioxide, or an inert gas. Oxygen shall never be used.

4.15 Hot Work Safety. Cutting, welding, and allied processes shall be in accordance with NFPA 51B.

4.15.1 Hot work shall not be permitted within the affected area determined by the procedure until the piping system or segment has been purged out of service.

Chapter 5 Training Requirements

5.1 Training. Persons whose duties fall within the scope of this standard shall be provided with training that is consistent with the scope of their job activities.

5.1.1 Such training shall include hazards of flammable gas, hazards of any compressed gas used for cleaning or purging, safe handling practices of flammable gas and compressed gas as applicable, emergency response procedures and equipment, and company policy.

5.1.2 Personnel training shall be conducted by a competent person knowledgeable in the subject matter and shall be documented.

5.1.3 Training records shall be maintained for a period not less than 5 years from the date of completion of the activity.

Chapter 6 Cleaning

6.1 Cleaning of Flammable Gas Piping.

6.1.1 General.

6.1.1.1 Flammable gas shall not be used for internal cleaning of piping.

6.1.1.2 An alarm shall precede the start of cleaning in accordance with the written cleaning procedure.

6.2* Acceptable Fluid Media. Air, inert gas, steam, and water shall be acceptable cleaning media.

6.3 Temporary Power/Fuel Supply.

6.3.1 Where electric power is used to power the equipment necessary to implement the pipe cleaning, it shall be connected in accordance with *NFPA 70*.

6.3.2 Where fuel gas is used to power the equipment necessary to implement the pipe cleaning, it shall be piped and connected in accordance with NFPA 54 or NFPA 58, as applicable.

6.3.3 Where fuel oil is used to power the equipment necessary to implement the pipe cleaning, it shall be piped and connected in accordance with NFPA 31.

6.4 Temporary Piping (Including Hose Assemblies). Temporary piping systems, including hose assemblies, used to connect the cleaning media supply source to the piping system shall be in accordance with ANSI/ASME B31.1, paragraph 122.10.

6.5 Pig Cleaning. Pigs shall be permitted to be used to clean piping systems.

6.5.1 Prior to placing a piping system into service, the fluid used to propel the pig through the piping system shall be water, steam, air, or inert gas.

6.5.2* A pig shall be permitted to be used to accomplish cleaning and purging into service simultaneously in accordance with 6.5.2.1 through 6.5.2.4.

6.5.2.1* Pig cleaning using flammable gas as the propellant shall utilize a closed piping system.

6.5.2.2* Where a pig is used to accomplish cleaning and purging simultaneously, the pig shall be sized to minimize unintended commingling of flammable gas and air.

6.5.2.3* A pig shall be permitted to be used to clean a piping system that is filled with flammable gas where the flammable gas in the piping system is being consumed by end-use equipment or flares and the residual flammable gas in the launcher or receiver is discharged in accordance with 8.3.2.

6.5.2.4 Where flammable gas is used as the pig propellant, the residual gas from the launcher or receiver shall be discharged in accordance with 8.3.2.

6.6* Target. Where a target is used to indicate debris during the cleaning process, it shall be designed and secured to withstand the velocity and pressure of the exiting media and debris without breaking or failing.

6.7 Isolation and Protection of Clean Piping Systems or Segments. Where piping systems are cleaned in stages during fabrication or field assembly, the clean piping shall be isolated and protected against infiltration of contaminants.

Chapter 7 Purging into Service

7.1 Charging Piping System with Flammable Gas.

7.1.1 Where gas piping containing air is placed in operation, the air in the piping first shall be displaced with an inert gas, which then shall be displaced with flammable gas in accordance with Section 7.2.

7.1.2* If the plant is owned or operated by the serving natural gas supplier, natural gas piping between the point of delivery and the plant shall be permitted to be purged into service in accordance with the serving natural gas supplier's written procedures.

7.1.2.1 The natural gas supplier's written procedures shall include a safety validation in accordance with Section 4.4.

7.1.2.2 The natural gas supplier's written procedures and process shall be coordinated with the plant operational personnel.

7.2 Discharge of Purged Gases.

7.2.1 The vent discharge from a piping system being purged into service shall discharge directly to a safe outdoor location as determined by the written purge procedure.

7.2.2 Purging operations shall comply with the requirements in 7.2.2.1 through 7.2.2.5.

7.2.2.1 The vent line from a piping system being purged into service shall be equipped with a readily accessible or remotely actuated shutoff valve.

7.2.2.2 During discharge, the discharge gases from the permanent piping system shall be monitored on a continual basis with appropriate detection equipment that complies with Section 7.3.

7.2.2.3* Purging operations introducing inert gas shall be continuous until the oxygen concentration detected at the discharge end of the permanent piping system or in the vent line is less than 60 percent of the limiting oxidant concentration as determined in accordance with 7.2.3 of NFPA 69.

7.2.2.4* Purging operations that introduce flammable gas shall be continuous until at least 90 percent flammable gas by volume or the minimum concentration established by the purging procedure is detected at the discharge end of the permanent piping system or in the vent line.

7.2.2.5 Where a piping system containing inert gas is purged into service, it shall be permitted to isolate the piping system in lieu of venting in accordance with the following:

(1) The piping system design can accommodate the activity.
(2) The end-point concentration of inert gas does not prevent complete combustion or consumption of the flammable gas in the end-use equipment or process.
(3) The inert gas–flammable gas mixture is released in a controlled manner to end-use equipment, process equipment, or flares.

7.3 Detection Equipment.

7.3.1* Sense of smell shall not be used to detect the presence of flammable gas.

7.3.2* Detection equipment shall be designed and listed for the gas being monitored and the environment where it is used and calibrated in accordance with the manufacturer's instructions.

7.3.3* Combustible gas indicators shall numerically display the gas concentration by volume scale from 0 to 100 percent in measurement increments determined by the procedure.

7.3.4* Lower flammability limit (LFL) monitors shall numerically display the gas concentration as a percentage of the LFL from 0 to 100 percent in measurement increments determined by the procedure.

7.3.5 Oxygen monitors shall numerically display the oxygen concentration by volume from 0 to 25 percent or higher in measurement increments determined by the procedure.

Chapter 8 Purging Out of Service

8.1 Isolation. Flammable gas piping shall be isolated from the flammable gas supply and downstream piping and equipment prior to purging out of service.

8.2 Charging with Inert Gas. Where existing gas piping is purged out of service, the residual flammable gas in the piping shall be displaced with an inert gas.

8.2.1* If owned or operated by the serving natural gas supplier, natural gas piping between the point of delivery and the plant shall be permitted to be purged out of service in accordance with the serving natural gas supplier's written procedures.

8.2.1.1 The natural gas supplier's written procedures shall include a safety validation in accordance with Section 4.4.

8.2.1.2 The natural gas supplier's written procedures and process shall be coordinated with the plant operational personnel.

8.3 Discharge of Purged Gases.

8.3.1* Pressurized flammable gas systems shall be depressurized prior to being purged out of service in accordance with the written purge procedure.

8.3.2 The vent discharge from a piping system being depressurized or purged out of service shall discharge directly to a safe outdoor location as determined by the written purge procedure.

8.3.3 Purging operations shall comply with the requirements in 8.3.3.1 through 8.3.3.4.

8.3.3.1 The vent line from a piping system being purged out of service shall be equipped with a readily accessible or remotely actuated shutoff valve.

8.3.3.2 During discharge, the discharge gases from the permanent piping system shall be monitored on a continual basis with detection equipment in accordance with Section 7.3.

8.3.3.3* Purging operations that introduce inert gas shall be continuous until the flammable gas concentration detected at the discharge end of the permanent piping system or in the vent line is such that the inert gas–flammable gas mixture is not ignitible when released in air.

8.3.3.4 Purging operations that introduce air to displace inert gas shall be continuous until at least 19.5 percent oxygen by volume is detected at the discharge end of the permanent piping system or in the vent line.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1.1 Industrial applications encompass a wide variety of manufacturing and other operations such as, but not limited to, petroleum refining and petrochemical and chemical applications.

A.1.1.1.1 The piping system includes segments located between pieces of equipment, such as gas conditioning or compressing equipment. This document does not cover the commissioning or maintaining of that equipment but does cover the commissioning or maintaining of those piping segments and equipment as a system as it relates to the flow or displacement of flammable gas. The equipment isolation valve is intended to be the final isolation valve prior to the manufacturer's or supplier's equipment gas train. For some common pieces of equipment in NFPA standards, the isolation valve is identified and referenced as follows:

(1) NFPA 37 uses the term *equipment isolation valve* in 5.2.1.
(2) NFPA 85 uses the term *manual shutoff valve* in Figure A.5.3.2.3 for single burner boilers; in Figure A.6.6.5.1.5.4(a) and Figure A.6.6.5.1.5.4(b) for multiple burner boilers; and in Figure A.8.8.5.8(a), Figure A.8.8.5.8(b), and Figure A.8.8.5.8(c) for heat recovery steam generators.
(3) NFPA 86 uses the term *equipment isolation valve* in 6.2.4.1.
(4) NFPA 87 uses the term *equipment isolation valve* in 6.2.4.3.

A.1.1.2(1) The application of NFPA 2 is included here for the convenience of the user:

1.3 Application.

1.3.1 This code shall apply to the production, storage, transfer, and use of hydrogen in all occupancies and on all premises.

1.3.2 The use of hydrogen shall include stationary, portable, and vehicular infrastructure applications.

1.3.3 The fundamental requirements of Chapters 1 through 8 [of NFPA 2] shall apply in addition to the use-specific requirements provided in Chapters 9 through 20, as applicable.

1.3.4 Exemptions.

This code shall not apply to the following:

(1) Onboard vehicle or mobile equipment components or systems, including the onboard GH_2 or LH_2 fuel supply
(2) Mixtures of GH_2 and other gases with a hydrogen concentration of less than 95 percent by volume when in accordance with NFPA 55
(3) The storage, handling, use, or processing of metal hydride materials outside of metal hydride storage systems defined in Chapter 3 [of NFPA 2]

[**2:**1.3]

A.1.1.2(2) The scope of NFPA 54 is included here for the convenience of the user:

1.1 Scope.

1.1.1 Applicability.

1.1.1.1 This code is a safety code that shall apply to the installation of fuel gas piping systems, appliances, equipment, and related accessories as shown in 1.1.1.1(A) through 1.1.1.1(D) [of NFPA 54].

(A) Coverage of piping systems shall extend from the point of delivery to the appliance connections. For other than undiluted liquefied petroleum gas (LP-Gas) systems, the point of delivery shall be considered to be the outlet of the service meter assembly or the outlet of the service regulator or service shutoff valve where no meter is provided. For undiluted LP-Gas, the point of delivery shall be considered to be the outlet of the final pressure regulator, exclusive of line gas regulators, in the system.

(B) The maximum operating pressure shall be 125 psi (862 kPa).

Exception No. 1: Piping systems for gas–air mixtures within the flammable range are limited to a maximum pressure of 10 psi (69 kPa).

Exception No. 2: LP-Gas piping systems are limited to 20 psi (140 kPa), except as provided in 5.5.1(6) [of NFPA 54].

(C) Requirements for piping systems shall include design, materials, components, fabrication, assembly, installation, testing, inspection, operation, and maintenance.

(D) Requirements for appliances, equipment, and related accessories shall include installation, combustion, and ventilation air and venting.

[**54:**1.1]

A.1.1.2(3) The scope of NFPA 58 is included here for the convenience of the user:

1.1 Scope. This code applies to the storage, handling, transportation, and use of LP-Gas.

1.2 Purpose. (Reserved)

1.3 Application.

1.3.1 Application of the Code. This code shall apply to the operation of all LP-Gas systems, including the following:

(1) Containers, piping, and associated equipment, when delivering LP-Gas to a building for use as a fuel gas.
(2) Highway transportation of LP-Gas.
(3) The design, construction, installation, and operation of marine terminals whose primary purpose is the receipt of LP-Gas for delivery to transporters, distributors, or users, except for marine terminals associated with refineries, petrochemicals, gas plants, and marine terminals whose purpose is the delivery of LP-Gas to marine vessels.
(4) The design, construction, installation, and operation of pipeline terminals that receive LP-Gas from pipelines under the jurisdiction of the U.S. Department of Transportation (DOT) whose primary purpose is the receipt of LP-Gas for delivery to transporters, distributors, or users. Coverage shall begin downstream of the last pipeline valve or tank manifold inlet.

[**58:**1.1]

A.1.1.2(4) The scope of NFPA 59 is included here for the convenience of the user:

1.1 Scope.

1.1.1 This code shall apply to the design, construction, location, installation, operation, and maintenance of refrigerated and nonrefrigerated utility gas plants. Coverage of liquefied petroleum gas systems at utility gas plants shall extend to the point where LP-Gas or a mixture of LP-Gas and air is introduced into the utility distribution system.

1.1.2 When operations that involve the liquid transfer of LP-Gas from the utility gas plant storage into cylinders or portable tanks (as defined by NFPA 58) are carried out in the utility gas plant, these operations shall conform to NFPA 58.

1.1.3 Installations that have an aggregate water capacity of 4000 gal (15.14 m^3) or less shall conform to NFPA 58.

[**59:**1.1]

A.1.1.2(5) The scope of NFPA 59A is included here for the convenience of the user:

1.1 Scope.

1.1.1 This standard shall apply to the following:

(1) Facilities that liquefy natural gas
(2) Facilities that store, vaporize, transfer, and handle liquefied natural gas (LNG)
(3) The training of all personnel involved with LNG
(4) The design, location, construction, maintenance, and operation of all LNG facilities

1.1.2 This standard shall not apply to the following:

(1) Frozen ground containers
(2) Portable storage containers stored or used in buildings
(3) All LNG vehicular applications, including fueling of LNG vehicles

[**59A:**1.1]

A.1.1.2(7) Vehicle fuel dispensers are covered by NFPA 2, NFPA 30A, NFPA 52, and NFPA 58.

A.1.2 Any activities related to the introduction of flammable gas into a piping system are included in the scope of this standard, regardless of the project phase or operational status.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase "authority having jurisdiction," or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.2 Competent Person. On the OSHA website, guidance material states additionally that "by way of training and/or experience, a competent person is knowledgeable of applicable standards, is capable of identifying workplace hazards relating to the specific operation, and has the authority to correct them. Some standards add additional specific requirements which must be met by the competent person."

A.3.3.3 Detection Equipment. Detection equipment can include combustible gas indicators, lower flammability limit (LFL) monitors, and oxygen monitors. The LFL is sometimes called the lower explosive limit, or LEL. There can also be devices capable of monitoring and displaying gas concentration, oxygen concentration, percent of LFL, or any combination thereof.

A.3.3.6 Inert Gas. Inert gases do not react readily with other materials under normal temperatures and pressures. For example, nitrogen combines with some of the more active metals such as lithium and magnesium to form nitrides, and at high temperatures it will also combine with hydrogen, oxygen, and other elements. The gases neon, krypton, and xenon are considered rare due to their scarcity. Although these gases are

commonly referred to as inert gases, the formation of compounds is possible. For example, xenon combines with fluorine to form various fluorides and with oxygen to form oxides; the compounds formed are crystalline solids. [**55**, 2010]

A.3.3.7 Line Gas Regulator. The service regulator in an undiluted LP-Gas system can include any one of the following:

(1) The second stage regulator or integral two-stage regulator
(2) A 2 psi (14 kPa) service regulator or integral 2 psi (14 kPa) service regulator

A.4.3 A sample written procedure, for informational purposes only, is included in Annex C.

A.4.3.1 It is recognized that purging as part of routine maintenance of small piping segments can be accomplished safely, provided that the written procedure (standard practice) is incorporated into a plant or facility operations and maintenance (O&M) manual that addresses the potential hazards occurring at the time of the purging operations. Purging should be conducted by competent personnel trained in purging operations, including recognition of potential hazards associated with purging. It is not intended that a new written procedure and/or safety validation be required each time the activity occurs within a facility.

A.4.3.1(2) There are many factors that should be used to identify an exclusion zone. During a purging into or out of service, the procedure should address gas migration and dispersion based on wind direction, wind speed, and physical characteristics of the gas.

A.4.3.1(4) Bonding requirements can be found in *NFPA 70* and NFPA 77. Users should consider grounding of the piping system to dissipate any electrical charge on the piping.

A.4.3.1(6) The procedure for monitoring the discharge gases and nearby areas should recognize that the response time of the sampling system could result in a time delay between a hazardous situation developing and being detected by detection equipment. Where sampling systems are used, the response time should be short relative to the expected period of time in which a hazard could develop.

Detection equipment selection should consider possible sample contamination by other commingled gases, moisture, or debris. The sampling system and/or detection equipment selection should consider appropriate mitigation measures such as filtration.

In some cases, gas release processes require the sampling of end points. In such cases, breathing air could be required for working in and around inert materials that have been released or that can create an exposure hazard. It is also important that personnel working in and around releases of gas understand the hazards of inert materials such as nitrogen. All workers should be trained in the use and handling of the gases involved, proper PPE, and all the risks. Further information on risks of inert gas asphyxiation is available from the U.S. Chemical Safety Board, www.csb.gov.

A.4.4 A safety validation is an independent, systematic analysis of a procedure to ensure that foreseeable hazards, errors, and malfunctions have been addressed by appropriate measures. Safety validations can be conducted using known techniques. The intent of the safety validation is to identify deficiencies in the procedure and make appropriate recommendations for correcting them. For further information on hazard analyses, users can reference the AIChE Center for Chemical Process Safety publication *Guidelines for Hazard Evaluation Procedures*.

A.4.4.1 The safety validation should not be performed solely by the same person or group responsible for developing the procedures. It can be performed or reviewed by an independent person or group within the company or department or by a third-party consultant.

A.4.4.2 The recommendations can be resolved by changes made to the written cleaning and purging procedures prior to the activity being conducted. If the person(s) responsible for developing or implementing the procedures disagrees with the recommendations of the safety validation, the facility owner/operator or a designated representative (such as a facility manager or, for facilities under construction, a construction manager) should evaluate technical documentation to resolve the disagreement. The designated representative should be a competent person as defined in 3.3.2 and should have the authority to modify or reject the procedure or the recommendation.

A.4.5 Where physical, operational, or personnel changes are made to a plant or facility, the cleaning and purging procedures should be re-evaluated. Such changes can include, but are not limited to, physical changes to piping system design, change to the cleaning or purging media, changes in responsibility for personnel, changes in local conditions such as encroachment by new equipment or nearby development, or changes in the chemical composition of the gas being purged.

A.4.5.2 *Replacement-in-kind* refers to a situation in which a piece of equipment is replaced with equipment of the same design and service.

A.4.11 Compressors can introduce lubricating oil or other flammable constituents into the compressed gas supply. Care should be taken to ensure that these flammable constituents are not introduced into the piping system in concentrations that could lead to a flammable atmosphere within the pipe. This can include the use of "100 percent oil-free compressors" or filtering systems that remove residuals prior to introduction into the piping system.

A.4.14 Where pressure testing is completed before the piping system is cleaned of dirt and debris, operators should release the media and debris in such a way that does not pose a risk to personnel. Operators can consider the following methods to discharge the pressure test media:

(1) Releasing test media at a rate that prevents the ejection of debris or liquids at high velocity
(2) Providing means to capture debris or liquids exiting the system
(3) Locating the discharge point a safe distance from any person, vehicle, or structure

A.4.14.4 ANSI/ASME B31.3 requires a "leak test" wherein piping systems are subjected to pressures at least 1.5 times the design operating pressure and such pressure is held for at least 10 minutes. NFPA 54 and ANSI/ASME B31.1 require a similar test procedure and parameters but refer to the test as a "pressure test."

A.4.14.5 ANSI/ASME B31.1 and ANSI/ASME B31.3 require the use of a "nonflammable and nontoxic" gas as the test medium for pneumatic testing. NFPA 56 (PS) specifically limits the acceptable media further to air, carbon dioxide, or inert gas. Oxygen is specifically prohibited because of the possible

subsequent introduction of flammable gas and the risk of developing a flammable atmosphere.

A.6.2 This is not intended to exclude specialized cleaning chemicals used in solution with water in accordance with the manufacturer's instructions by competent personnel.

A.6.5.2 Pigging using flammable gas as the propellant can be considered where the system has been designed to accommodate the activity and it is beneficial to accomplish cleaning and purging simultaneously. The pig is designed to fit tightly inside the pipe and will effectively push the air out of the piping system as the volume behind the pig is filled with gas. When the pig reaches the receiver, the pig is isolated within the receiver and the discharge valve is closed to ensure that a minimal amount of flammable gas is released. While there can be some small amount of fuel gas released due to seepage around the pig, the result is generally a smaller release than traditional purging into service. The purge procedure should identify safe disposal of the residual gas. The use of flammable gas as the propellant also eliminates the hazards associated with the intermediate purging step using inert gas in a traditional purge into service. See Figure A.6.5.2 for an example of a pig launcher/receiver arrangement.

A.6.5.2.1 Pigging using the flammable gas as the propellant is limited to defined, closed systems. Open-ended systems where no receiver is installed are permitted where a nonflammable propellant is used. However, users should carefully consider environmental factors and other safety factors associated with open-ended pigging.

A.6.5.2.2 The use of a pig to accomplish cleaning and purging into service simultaneously should be carefully reviewed by competent persons who are knowledgeable and experienced in the use of pigs in flammable gas systems. The pig should be sized to fit tightly in the piping system. Factors to be considered in pig selection include, but are not limited to, pipeline size, wall thickness, minimum bend radius, length of piping to be pigged, propelling media, flow rate/velocity, side connections, and valve type.

A.6.5.2.3 Pigging where the piping is already filled with flammable gas is often referred to as "on-line" or "in-service" pigging. In-service pigging is not limited to cleaning processes, and 6.5.2.3 is not intended to prohibit or prevent other pigging processes. Other in-service pigging processes can include various types of inspection pigs.

A.6.6 Targets are devices used for identifying the amount of debris that might remain within a piping system. Targets are installed at the discharge end in such a manner as to receive impacts from debris. The design and installation of targets can divert gases discharging from the end of the piping systems in directions that were not intended. If targets are placed too close to the end of the pipe, they can also create a restriction and accentuate tangential velocities of gas flows.

A.7.1.2 There are instances where a plant is located on a much larger piece of land where the point of delivery may be on or beyond the perimeter of the property and travel a significant distance before reaching any piece of equipment associated with the plant or process and where the serving natural gas supplier

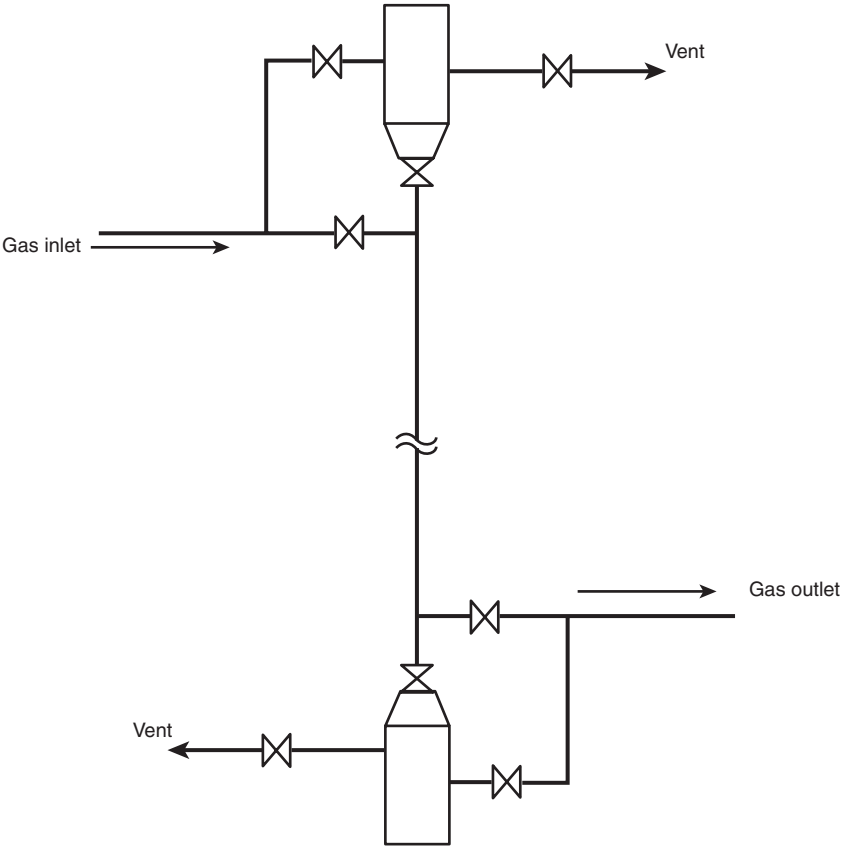


FIGURE A.6.5.2 Simplified Pig Launcher and Receiver System for Piping Segment.

operates the pipeline between the point of delivery and the plant. The serving natural gas supplier generally has specialized procedures for purging and operating transmission and distribution lines.

A.7.2.2.3 When purging with an inert gas, it is generally acceptable to use an oxygen detector to measure the absence of oxygen. When flammable gas is being introduced, an appropriate gas detection device that can operate in the absence of oxygen should be used. Catalytic combustion–type indicators should not be used for purging into service in an oxygen-free environment.

Subsection 7.2.3 of NFPA 69 is extracted here for the convenience of the user [Table C.1(a) and Table C.1(b) of NFPA 69 are reprinted here as Table A.7.2.2.3(a) and Table A.7.2.2.3(b), respectively]:

7.2.3 Limiting Oxidant Concentrations (LOCs).

7.2.3.1 Table C.1(a) and Table C.1(b) shall be permitted to be used as a basis for determining LOCs of flammable gases or suspensions of combustible dusts.

7.2.3.1.1 For gases and vapors, if the LOC values according to ASTM E 2079 are available, then these shall be used.

7.2.3.1.2 For gases and vapors, if the LOC values according to ASTM E 2079 are not available, then the LOC values obtained in flammability tubes shall be used after adjustment by subtracting 2 percent by volume oxidant as indicated in the adjusted columns in Table C.1(a).

7.2.3.2 For fuel, inert, and oxidant combinations not listed in Table C.1(a) or Table C.1(b) or for situations when the process conditions differ from the conditions under which the existing data were obtained, the test methods described in ASTM E 2079 shall be permitted to be used.

7.2.3.3 The extent of oxidant reduction shall be determined by testing where conditions vary significantly from the test conditions under which the data were obtained.

[**69:**7.2.3]

Table A.7.2.2.3(a) Limiting Oxidant Concentrations for Flammable Gases When Nitrogen or Carbon Dioxide Is Used as a Diluent

	Adjusted LOC (Volume % O_2 Above Which Deflagration Can Take Place) per 7.2.3 [of NFPA 69]			Original LOC (Volume % O_2 Above Which Deflagration Can Take Place)	
Gas/Vapor	N_2–Air Mixture	CO_2–Air Mixture	Reference*	N_2–Air Mixture	CO_2–Air Mixture
Methane	10.0	12.5	1	12.0	14.5
Ethane	9.0	11.5	1	11.0	13.5
Propane	9.5	12.5	1	11.5	14.5
n-Butane	10.0	12.5	1	12.0	14.5
n-Butyl acetate	9.0	—	9	9.0	—
Isobutane	10.0	13.0	1	12.0	15.0
n-Pentane	10.0	12.5	1	12.0	14.5
Isopentane	10.0	12.5	2	12.0	14.5
n-Hexane	10.0	12.5	1	12.0	14.5
n-Heptane	9.5	12.5	2	11.5	14.5
Ethanol	8.7	—	9	8.7	—
Ethylene	8.0	9.5	1	10.0	11.5
Propylene	9.5	12.0	1	11.5	14.0
1-Butene	9.5	12.0	1	11.5	14.0
Isobutylene	10.0	13.0	4	12.0	15.0
Butadiene	8.5	11.0	1	10.5	13.0
3-Methyl-1-butene	9.5	12.0	4	11.5	14.0
Benzene	10.1	12.0	1, 7	11.4	14.0
Toluene	9.5	—	7, 9	9.5	—
Styrene	9.0	—	7	9.0	—
Ethylbenzene	9.0	—	7	9.0	—
Vinyltoluene	9.0	—	7	9.0	—
Divinylbenzene	8.5	—	7	8.5	—
Diethylbenzene	8.5	—	7	8.5	—
Cyclopropane	9.5	12.0	1	11.5	14.0
Gasoline					
(73/100)	10.0	13.0	2	12.0	15.0
(100/130)	10.0	13.0	2	12.0	15.0
(115/145)	10.0	12.5	2	12.0	14.5
Kerosene	8.0(150°C)	11.0(150°C)	5	10.0(150°C)	13.0(150°C)
JP-1 fuel	8.5(150°C)	12.0(150°C)	2	10.5(150°C)	14.0(150°C)
JP-3 fuel	10.0	12.5	2	12.0	14.5
JP-4 fuel	9.5	12.5	2	11.5	14.5

(continues)

Table A.7.2.2.3(a) *Continued*

Gas/Vapor	Adjusted LOC (Volume % O_2 Above Which Deflagration Can Take Place) per 7.2.3 [of NFPA 69]		Reference*	Original LOC (Volume % O_2 Above Which Deflagration Can Take Place)	
	N_2–Air Mixture	CO_2–Air Mixture		N_2–Air Mixture	CO_2–Air Mixture
Natural gas (Pittsburgh)	10.0	12.5	1	12.0	14.5
n-Butyl chloride	12.0	—	3	14.0	—
	10.0(100°C)	—	3	12.0 (100°C)	—
Methylene chloride	17.0 (30°C)	—	3	19.0 (30°C)	—
	15.0 (100°C)	—	3	17.0 (100°C)	—
Ethylene dichloride	11.0	—	3	13.0	—
	9.5 (100°C)	—	3	11.5 (100°C)	—
1,1,1-Trichloroethane	12.0	—	3	14.0	—
Trichloroethylene	7.0(100°C)	—	3	9.0(100°C)	—
Acetone	9.5	12.0	4	11.5	14.0
n-Butanol	NA	14.5(150°C)	4	NA	16.5(150°C)
Carbon disulfide	3.0	5.5	4	5.0	7.5
Carbon monoxide	3.5	3.5	4	5.5	5.5
Ethanol	8.5	11.0	4	10.5	13.0
2-Ethyl butanol	7.5(150°C)	—	4	9.5(150°C)	—
Ethyl ether	8.5	11.0	4	10.5	13.0
Hydrogen	3.0	3.2	4	5.0	5.2
Hydrogen sulfide	5.5	9.5	4	7.5	11.5
Isobutyl acetate	9.1	—	9	9.1	—
Isobutyl alcohol	9.1	—	9	9.1	—
Isobutyl formate	10.5	13.0	4	12.5	15.0
Isopropyl acetate	8.8	—	9	8.8	—
Isopropyl alcohol	9.5	—	10	9.5	—
Methanol	8.0	10.0	4	10.0	12.0
Methyl acetate	9.0	11.5	4	11.0	13.5
Propylene oxide	5.8	—	8	7.8	—
Methyl ether	8.5	11.0	4	10.5	13.0
Methyl formate	8.0	10.5	4	10.0	12.5
Methyl ethyl ketone	9.0	11.5	4	11.0	13.5
n-Propyl acetate	10.1	—	10	10.1	—
n-Propyl alcohol	8.6	—	9	8.6	—
UDMH (dimethylhydrazine)	5.0	—	6	7.0	—
Vinyl chloride	13.4	—	7	13.4	—
Vinylidiene chloride	15.0	—	7	15.0	—

Notes:

1. See 7.7.2 [of NFPA 69] for the required oxygen level in equipment.
2. Data were determined by laboratory experiment conducted at atmospheric temperature and pressure. Vapor–air–inert gas samples were placed in explosion tubes and ignited by electric spark or pilot flame.

*References:

1. J. F. Coward and G. W. Jones (1952).
2. G. W. Jones, M. G. Zabetakis, J. K. Richmond, G. S. Scott, and A. L. Furno (1954).
3. J. M. Kuchta, A. L. Furno, A. Bartkowiak, and G. H. Martindill (1968).
4. M. G. Zabetakis (1965).
5. M. G. Zabetakis and B. H. Rosen (1957).
6. Unpublished data, U.S. Bureau of Mines.
7. Unpublished data, Dow Chemical Co.
8. U.S. Bureau of Mines.
9. L. G. Britton (2002).
10. Unpublished data, Dow Chemical Co., 2002.

[**69:** Table C.1(a)]

Table A.7.2.2.3(b) Limiting Oxidant Concentrations for Combustible Dust Suspensions When Using Nitrogen as a Diluent

Dust	Median Particle Diameter by Mass (μm)	LOC (Volume % O_2 Above Which Deflagration Can Take Place), N_2–Air Mixture
Cellulosic Materials		
Cellulose	22	9
Cellulose	51	11
Wood flour	27	10
Food and Feed		
Pea flour	25	15
Corn starch	17	9
Waste from malted barley	25	11
Rye flour	29	13
Starch derivative	24	14
Wheat flour	60	11
Coals		
Brown coal	42	12
Brown coal	63	12
Brown coal	66	12
Brown coal briquette dust	51	15
Bituminous coal	17	14
Plastics, Resins, Rubber		
Resin	<63	10
Rubber powder	95	11
Polyacrylonitrile	26	10
Polyethylene, h.p.	26	10
Pharmaceuticals, Pesticides		
Aminophenazone	<10	9
Methionine	<10	12
Intermediate Products, Additives		
Barium stearate	<63	13
Benzoyl peroxide	59	10
Bisphenol A	34	9
Cadmium laurate	<63	14
Cadmium stearate	<63	12
Calcium stearate	<63	12
Methyl cellulose	70	10
Dimethyl terephthalate	27	9
Ferrocene	95	7
Bistrimethyl-silyl-urea	65	9
Naphthalic acid anhydride	16	12
2-Naphthol	<30	9
Paraformaldehyde	23	6
Pentaerythritol	<10	11
Metals, Alloys		
Aluminum	22	5
Calcium/aluminum alloy	22	6
Ferrosilicon magnesium alloy	17	7
Ferrosilicon alloy	21	12
Magnesium alloy	21	3
Other Inorganic Products		
Soot	<10	12
Soot	13	12
Soot	16	12
Others		
Bentonite derivative	43	12

Source: R. K. Eckhoff, *Dust Explosions in the Process Industries*, 2003.
Note: The data came from 1 m^3 and 20 L chambers using strong chemical igniters.
[**69:** Table C.1(b)]

A.7.2.2.4 This is not intended to prohibit discontinuation of a purging process if there is a danger to personnel or if another emergency condition is detected. Annex B contains material from AGA XK0101 which discusses purging end points for many common flammable gases.

A.7.3.1 Odor fade, odor masking, olfactory fatigue, an individual's inability to smell the flammable gas, or the fact that a flammable gas is not odorized can reduce safety and lead to an inadequate warning of a flammable gas–air mixture. Calibrated detection equipment should be used by trained workers whenever the presence of flammable gas is being monitored.

A.7.3.2 Any detection equipment should be listed not only for the specific gas or gases being sensed in the process but also for the type of environment they might be subjected to or used in. Detectors for use in hazardous locations as defined in *NFPA 70* should be listed for such use. This is particularly important for detection equipment used to monitor areas where flammable gas is being discharged. Detection equipment specifications such as response time, limits of measurement range, operating temperature, and gas pressure limitations should be known, and the procedure should developed such that these factors will not negatively impact the safety of the activity.

A.7.3.3 Combustible gas indicators for fuel gases should display increments of 1 percent or smaller. The procedure and the safety validation should indicate the maximum increment based on gas being detected and the response time. Selection and use of the combustible gas indicator should be appropriate to ensure that a hazard is detected in a timely manner.

A.7.3.4 LFL gas monitors for fuel gases should display increments of 1 percent or smaller. The procedure and the safety validation should indicate the maximum increment based on gas being detected and the response time. Selection and use of the LFL gas monitor should be appropriate to ensure that a hazard is detected in a timely manner.

A.8.2.1 There are instances where a plant is located on a much larger piece of land where the point of delivery may be on or beyond the perimeter of the property and travel a significant distance before reaching any piece of equipment associated with the plant or process and where the serving natural gas supplier operates the pipeline between the point of delivery and the plant. The serving natural gas supplier generally has specialized procedures for purging and operating transmission and distribution lines.

A.8.3.1 Generally, depressurization results in the piping system being brought down to approximately atmospheric pressure. However, some processes require maintaining slightly higher pressure prior to purging. The final pressure in the piping system following depressurization should be determined by the purge procedure.

A.8.3.3.3 Annex B contains material from AGA XK0101, which discusses purging end points for many common flammable gases. Other resources that provide flammability limits for purging into and out of service include Bureau of Mines Bulletin 680 and the AIChE publication *Understanding Explosions*.

Annex B Purge End Points for Common Flammable Gases

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 The material in this annex is extracted in part from AGA XK0101, *Purging Principles and Practices*, copyright 2001, American Gas Association, and is reprinted here with permission.

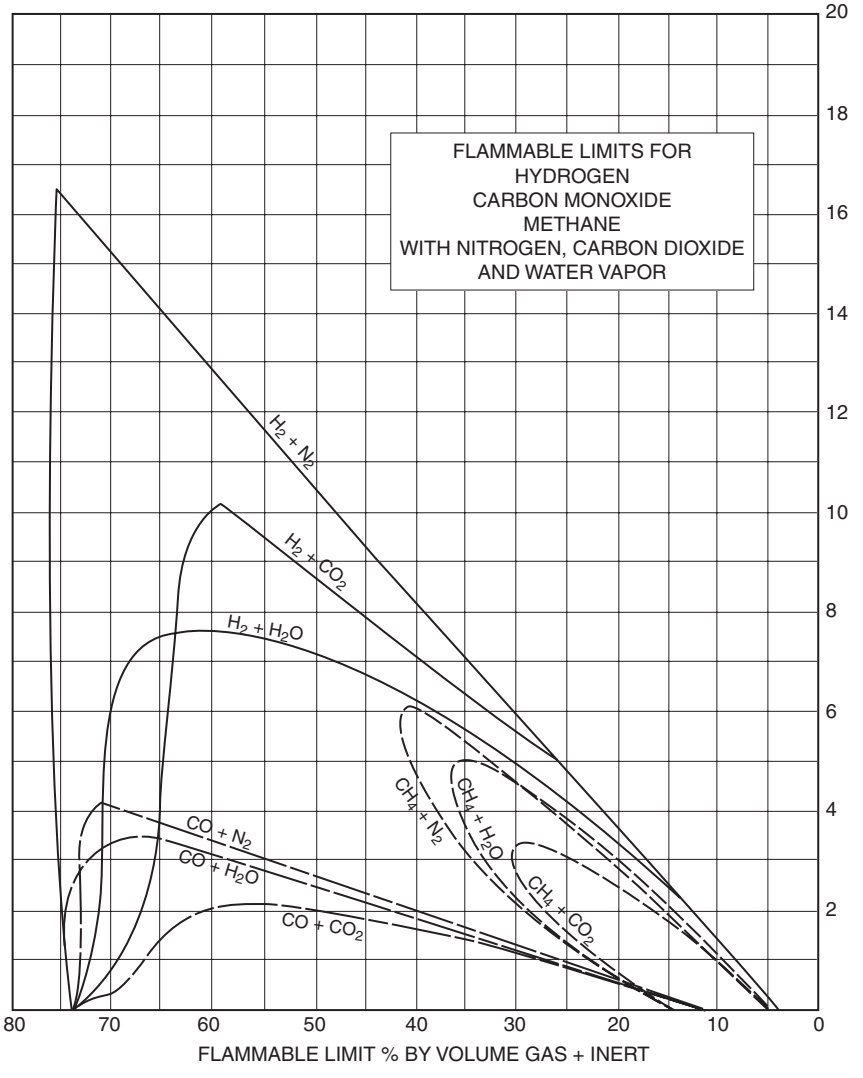


FIGURE 2-1 Flammable limits for hydrogen, carbon monoxide, methane, with nitrogen, carbon dioxide and water vapor.

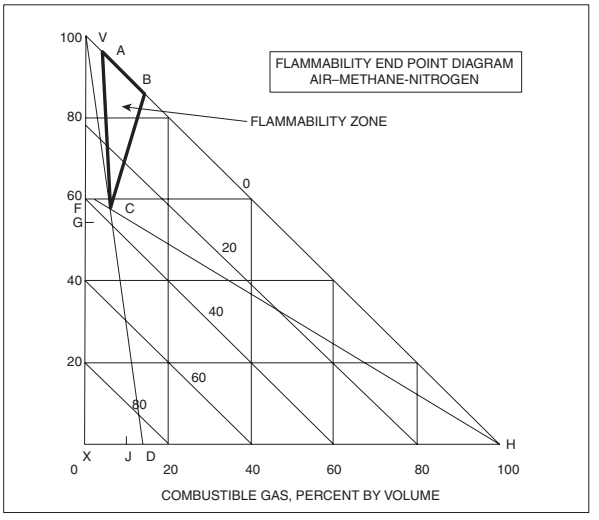


FIGURE 2-2 Flammability end point diagram for the purging of methane with nitrogen at 70° F. The A and B coordinates are 5 and 14 percent methane, and 0-percentage nitrogen, respectively. The C coordinate is a mixture of approximately 6 percent methane, 36 percent nitrogen and 58 percent air. The triangle formed by the coordinates of A, B and C represent the flammability zone at 70 degrees F. Note: the flammability zone area will increase as the temperature increases.

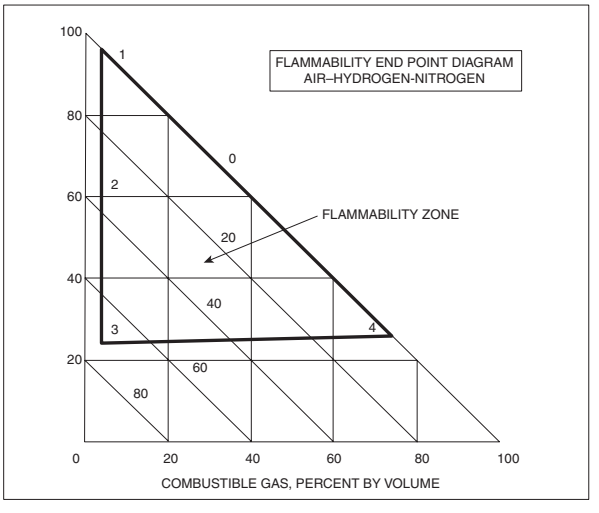


FIGURE 2-3 Flammability end point diagram for the purging of hydrogen with nitrogen can be approximated from Figure 2-1. The approximate concentration of hydrogen, nitrogen and air have been estimated at points 1, 2, 3 and 4 in Figure 2-1. Those same concentrations points are represented as points 1, 2, 3 and 4 above. Note: this method approximates the flammability zone since the interior lines forming the triangle may not be precisely linear.

2.5 PURGING FACILITIES INTO SERVICE

A safe purging operation of air from a container subsequently to be filled with natural gas may be indicated in Figure 2-2. As an inert gas is added, the air concentration drops along ordinate VX to any point G below F. Subsequent addition of natural gas causes the mixture composition to change along line GH (not shown), which crosses no part of the flammable zone ABC. In the example shown in Figure 2-2, inert gas should be added until the purged atmosphere contains at least 42 percent inert gas, thereby reducing the air content in the purged atmosphere to 58 percent, or an oxygen concentration of about 12 percent.

To render a given combustible-air mixture nonflammable it is desirable to know what percentage of inert gases is required. Table 2-3 gives the values for a number of combustibles investigated by the U.S. Bureau of Mines. To ensure safety, purging should be continued to a point at least 20 percent beyond the flammable limit. These purging end-points are given on the right side of Table 2-3.

Sometimes it is more convenient to control the purging by determining the oxygen content of the purged gases. In purging into service, inert gas is added to the container until the oxygen concentration of the mixture is decreased to the point where no mixture of this with the combustible gas would be flammable. This data, also presented by the U.S. Bureau of Mines, is given in Table 2-4. Suggested purging end-point data with a 20 percent safety factor are given on the right half of Table 2-4 in terms of percent of oxygen for the purging of containers in preparation to receive the various combustibles shown. Note: NFPA 69 requires that oxygen end-points be calculated at 60% of the limiting oxidant concentration. The reader is urged to review both sources for the applicable standard to their operation.

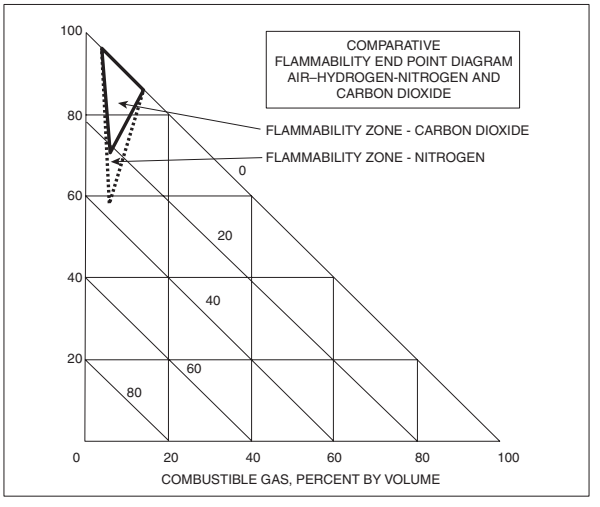


FIGURE 2-4 The comparative flammability end point diagram for the purging of methane with carbon dioxide and nitrogen.

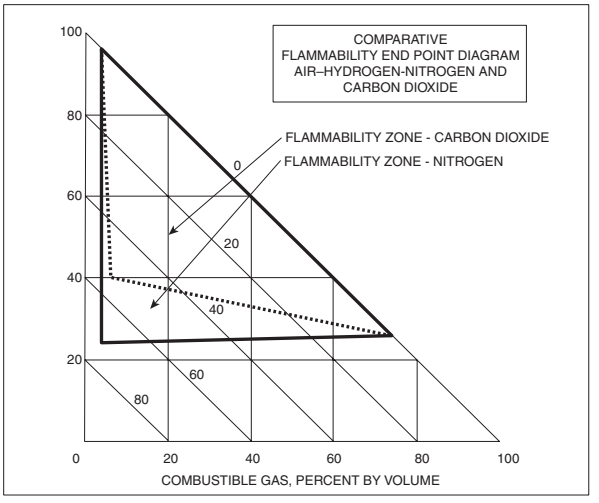


FIGURE 2-5 The comparative flammability end point diagram for the purging of hydrogen with carbon dioxide and nitrogen.

Purge Medium	CO_2	N_2*	CO_2	N_2*
Combustible	Percent required to render mixtures non-flammable		Purging End Points with 20% Safety Factor	
Hydrogen	57	71	66	77
Carbon Monoxide	41	58	53	66
Methane	23	36	38	49
Ethane	32	44	46	55
Propane	29	42	43	54
Butane	28	40	42	52
Iso-butane	26	40	41	52
Pentane	28	42	42	54
Hexane	28	41	42	53
Gasoline	29	43	43	55
Ethylene	40	49	52	59
Propylene	29	42	43	54
Cyclopropane	30	41	44	53
Butadiene	35	48	48	49
Benzene	31	44	44	55

** Nitrogen percentages do not include nitrogen of the air in mixtures.*

TABLE 2-3 Inert Gas End Points for Purging Into Service.

Purge Medium	CO_2	N_2	CO_2	N_2
Combustible	Percent of oxygen below which no mixture is flammable		Purging End Points with 20% Safety Factor	
Hydrogen	5.9	5.0	4.7	4.0
Carbon Monoxide	5.9	5.6	4.7	4.5
Methane	14.6	12.1	11.7	9.7
Ethane	13.4	11.0	10.7	8.8
Propane	14.3	11.4	11.4	9.1
Butane	14.5	12.1	11.6	9.7
Iso-butane	14.8	12.0	11.8	9.6
Pentane	14.4	12.1	11.5	9.7
Hexane	14.5	11.9	11.6	9.5
Gasoline	14.4	11.6	11.5	9.3
Ethylene	11.7	10.0	9.4	8.0
Propylene	14.1	11.5	11.3	9.2
Cyclopropane	13.9	11.7	11.1	9.4
Butadiene	13.1	10.4	10.5	8.3
Benzene	13.9	11.2	11.1	9.0

TABLE 2-4 Oxygen End Points for Purging Into Service.

2.6 PURGING FACILITIES OUT OF SERVICE

The operation of purging natural gas from a container to be filled subsequently with air may also be illustrated using Figure 2-2. As inert gas is added, the natural gas concentration decreases from point H (at the right) along abscissa HX to a point J beyond D. Subsequent addition of air results in a change in the mixture composition along line JV (not shown), which crosses no part of flammable zone ABC. In the example shown in Figure 2-2, at least 88 percent of the natural gas should be replaced by inert gas when the container is purged out of service.

To render a given combustible nonflammable should air be added to it in any amount, it is desirable to know what percentages of inert gases are required. Table 2-5 gives the data for a number of combustibles investigated by the U.S. Bureau of Mines. To ensure safety, purging should be continued to a point at least 20 percent beyond the flammable limit. These purging end-points are given on the right side of Table 2-5. Again the requirements NFPA 69 implies that U.S. Bureau of Mines oxygen end-points listed in these tables do not meet the safety margins of a 60% limiting oxidant concentration. The reader is urged to research the appropriate standard that applies to their operation.

It is sometimes more convenient to control the purging by determining the combustible content of the purged gases. In purging out of service, inert gas is added to the container until the combustible gas concentration of the mixture is decreased to the point where no mixture of this with any amount of air would be flammable. These data are given on Table 2-6. Suggested purging end-point data with a 20 percent safety factor are given on the right side of Table 2-6 in terms of the percent of combustible in a mixture which will remain nonflammable regardless of any amount of air which may be added to it.

Purge Medium	CO_2	N_2	CO_2	N_2
Combustible	Percent required to render mixtures non-flammable when air is added in any amount		Purging End Points with 20% Safety Factor	
Hydrogen	91	95	93	96
Carbon Monoxide	68	81	74	85
Methane	77	86	82	89
Ethane	88	93	91	95
Propane	89	94	91	95
Butane	91	95	93	96
Iso-butane	91	95	93	96
Pentane	96	97	97	98
Hexane	96	97	97	98
Gasoline	93	96	95	97
Ethylene	90	94	92	95
Propylene	94	96	95	97
Benzene	93	96	95	97

TABLE 2-5 Inert Gas End Points for Purging Out of Service

Purge Medium	CO_2	N_2	CO_2	N_2
Combustible	Percent of combustible below which no mixture is flammable when air is added in any amount		Purging End Points with 20% Safety Factor	
Hydrogen	9	5	7	4
Carbon Monoxide	32	19	26	15
Methane	23	14	18	11
Ethane	12	7	9	5
Propane	11	6	9	5
Butane	9	5	7	4
Iso-butane	9	5	7	4
Pentane	4	3	3	2
Hexane	4	3	3	2
Gasoline	7	4	5	3
Ethylene	10	6	8	5
Propylene	6	4	5	3
Benzene	7	4	5	3

TABLE 2-6 Combustible Gas End Points for Purging Out of Service

Annex C Sample Purge Procedure

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 The sample purge procedure in this annex is reprinted here with permission from National Grid and is intended only to provide an example showing the implementation of the cleaning and purging procedures defined in Section 4.3. It should not be used as a procedure applicable to any specific site or facility.

Sample Site Specific Purge Procedure

Electricity Generation Operations— Operating Procedure For Purging Main and Ignition Gas Lines

Authorized by: Date:

_____ _____

Plant Manager

Operating Procedure for Purging Main and Ignition Gas Lines
Amendments Record

	Date	Summary of Changes/ Reasons	Author(s)	Approved by (Name/Job Title)
1	3/1/2010			
2	3/15/2010	Typographical corrections and procedural alterations		
3	4/1/2010	Typographical corrections and procedural alterations		
4	4/2/2010	Typographical corrections and procedural alterations		
5	6/17/2010	Change to procedure number		

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 These Operating Procedures have been compiled to provide a ready reference and guide for the Operations Section at the xxxxxx Power Station required to accomplish both routine and non-routine tasks.

1.2 These Operating Procedures have been designated as divisional procedures.

1.2.1 Some of the Procedures may require notification of departments outside the Electric Production Department and/or organizations outside the Company.

1.2.2 Some of the actions detailed in these Procedures may be in response to local, state or federal regulations.

1.2.3 Training for implementation of these Procedures is given during on-the-job training at the plant.

1.2.4 This procedure will be reviewed and revised every seven years. If revision is called for during the interim, it will be handled as a partial revision and issued promptly.

2.0 PURPOSE AND SCOPE

2.1 The purpose of these Operating Procedures is to provide a standardized method for the Operations Section to accomplish both routine and non-routine tasks by the use of clearly written, comprehensive procedures which avoid confusion.

2.2 The Operating Procedures are meant to complement the training previously received and the general information provided in the instruction books.

3.0 RESPONSIBILITY

3.1 The Shift Supervisor is directly responsible to see that the procedures covered in these Operations Section Procedures are properly carried out.

3.2 All Operations Section personnel are responsible to be familiar with and understand the procedures covered in these Procedures. Clarification, if necessary, of any procedure is available from your Supervisor.

4.0 DEFINITIONS

4.1 Blowdown Operation: The act of releasing the displaced gas within the pipeline, into the atmosphere.

4.2 Controlled Operation: The process of safely containing and directing the flow of natural gas.

4.3 Gassing-In: The process of introducing natural gas into a gas *main* under a controlled, safe operation.

4.4 Inert Gas: For the purpose of this procedure, the gas utilized to displace (or replace) gas within a pipeline in order to safely control the purge operation (e.g., nitrogen or carbon dioxide.)

4.5 Inerting: The act of replacing air or gas within a pipeline, with a non-combustible substance. The inert operation is performed in such a manner as to prevent the formation of explosive air/gas mixtures.

4.6 M&C Station: Refers to the xxxxxx Power Station Gas Metering and Control Station. This area is located inside the plant at elevation 27'.

4.7 M&R Station: Refers to the xxxxxx Power Station Gas Metering and Regulator Station. This area is located outside the plant at elevation 15'.

4.8 Maximum Allowable Operating Pressure (MAOP): The maximum pressure at which a pipeline or segment of a pipeline may be operated under compliance with 16 NYCRR 255 (for Gas System) or ASME B31.1 Power Piping Code (for Generation.)

4.9 Purging: The act of displacing either air or gas from within a pipeline. The purge operation must be performed in a manner to minimize the mixture of air and natural gas so as to prevent formation of an explosive mixture.

4.10 Slug Purge: during the purge operation, a small amount of inert gas is inserted into a pipeline to form a “slug” (or piston effect) between the natural gas or air within the pipeline and the natural gas or air being introduced into the pipeline. The slug and the already existing gas or air within the pipeline are pushed along the pipe by the pressure of the gas or air being introduced into the pipeline.

4.11 Specific Gravity: The ratio of a gas to an equal volume of air under prescribed conditions of temperature and pressure. (Ex. The specific gravity of natural gas = 0.65, nitrogen = 0.9694, air = 1.0, and carbon dioxide = 1.532. Therefore, nitrogen and natural gas are lighter than air and carbon dioxide is heavier than air.

5.0 COMMUNICATIONS AND TRAINING

5.1 The purge and gas-in principles and practices discussed herein are methods for safely changing the atmosphere in a pipeline. Since many variables are involved (pipe size, length of pipe to purge, pressure, etc.) common sense and good judgment should be exercised during all purging operations.

5.2 Purging new or existing gas piping into buildings can be highly hazardous due to the possible accumulation of gas above the lower explosive limit and the associated danger of fire and explosion. Wherever practical, directly vent purged gases to

a safe location outdoors, away from people and *ignition* sources. This can be done using a temporary hose or piping or permanently installed vent pipes, depending on the facility design.

5.3 Employees shall be trained in and familiar with the safety related work practices, safety procedures and other safety requirements that pertain to their respective job assignment. Employees shall also be trained in and familiar with any other safety practice, including applicable emergency procedures that are related to their work (i.e.: scaffolding, confined space, etc.) and are necessary for their safety.

5.4 Qualified Employees shall be trained and competent in:

5.4.1 The proper use of the special precautionary techniques, personal protective equipment (PPE), insulating and shielding materials and insulated tools for working on or near exposed energized parts of electric equipment.

5.4.2 Supervision shall determine, through regular inspections that each employee is complying with safety related work practices. Retraining and possible discipline will be initiated if an employee is not complying.

5.5 The training required shall be classroom and on-the-job type. The training shall establish employee proficiency in work practices and shall introduce the necessary procedures. Employment records shall be maintained that certify the required training has been received by each qualified individual.

6.0 BACKGROUND

6.1 The purpose of this procedure is to formalize a methodology to safely and efficiently replace unit #3 and 4 “E” valves, *ignition* gas v-cone flow measuring devices and *main* gas v-cone flow measuring devices.

6.2 Implementation of this procedure will result in the isolation of all main and ignition gas to the steam station. This procedure covers the necessary steps to perform work on either or both units’ main and ignition gas systems.

6.3 Nitrogen will be used to purge the piping for both the *main* and *ignition* gas lines using the M&R station purge connections and v-cone taps, respectively. The M&C normal high point vent at elevation 65' and the burner corner vent piping on unit #3 and 4 will be used to vent displaced gases and to monitor the combustible gas content. Both vents expel gas outside of the building. The volume of *main* gas to be purged is about 934 cubic feet.

7.0 SAFETY AND PROTECTIVE EQUIPMENT

7.1 Prior to performing any maintenance or operation, each employee shall refer to and comply with Office of Generation procedures, OEG-28, Personal Protective Clothing Policy and OEG-29, Personal Protective Equipment Requirements.

7.2 A job briefing shall be given to all personnel prior to implementing this procedure.

7.3 During the safety briefing at the beginning of the procedure, all personnel on site will be accounted for and recorded. Security shall be requested to inform the Shift Supervisor of any personnel entering or exiting the site during the course of the procedure.

7.4 Any existing safety red tags on the M&C gas system piping must be administratively accounted for. Boundaries may be moved to allow for all work related to this procedure.

7.5 This outage will prevent the package boiler from operation. In addition, the gas powered emergency battery charger diesel will be out of service while the *ignition* gas system is purged and tagged.

7.6 “No Smoking” signs shall be placed nearby all gas vents and drains.

7.7 A periodic public address (PA) system announcement shall be made inform all employees not to smoke on unit #3 and 4 and to avoid potential sources of ignition.

7.8 Verify that all windows, specifically in the coal tower, and building openings are closed and remain closed during the duration of the procedure to prevent vented gas from entering the building.

7.9 Gas Instrument and Regulation (I&R) shall shut down the chromatograph for the duration of the procedure.

7.10 Alert all personnel of the dangers of nitrogen gas. Provide material properties.

7.11 Combustible Gas Indicator (CGI) Instruments shall be used to monitor gas concentrations during purging operations. Never rely on odor alone to detect releases of fuel gases.

7.12 Before use, verify that all CGI’s are properly calibrated and have not exceeded their calibration expiration date.

7.13 Plant and Gas I&R personnel shall continuously monitor for combustible gas throughout the duration of the work procedure. If gas is detected at the M&C station, the area will be evacuated and the procedure will be stopped.

7.14 All purging equipment shall be electronically bonded to the metallic pipe to dissipate static charges. An electrical bond shall be made between the purge cylinder and the gas *main,* using a minimum bonding wire size of 14 AWG. Use an alligator clip or magnetic jumper.

7.15 Personnel should be wearing fire retardant clothing. In addition, approved fire extinguisher should be located in the immediate vicinity of each purge site.

7.16 During purging operations, the removal or neutralization of all potential sources of *ignition* is required, prior to starting the purging operation.

7.16.1 Extinguish all open flames (e.g. pilot lights, cutting torches, cigarettes, etc.)

7.16.2 Eliminate or remove all potential sources of sparks or arcs (e.g. non-approved flashlights, hand lights, engines and motors, hand tools, cutting and grinding equipment, static electricity, and welding equipment.)

7.16.3 Allow heated metals and lights time to cool down (e.g. electric lights, glowing metals and flowing filaments.)

7.17 Establish and maintain communications between all personnel during the purging procedure.

7.18 All hand-held radios in use during the procedure must be intrinsically safe. Indentifying features of intrinsically safe radios include a green dot at the bottom of the device or battery, or the words “Factory Mutual Approved” or “Intrinsically Safe” printed on the device.

7.19 Ensure personnel involved in gas purging operations are fully trained and knowledgeable about safe gas venting practices, the proper use of Baskum Turner GMI’s (combustible gas detectors provided by Gas I&R,) and the danger of relying on the sense of smell alone to detect gas releases.

7.20 Gases shall not be vented within the building. Connect hoses to all drains that are to be used on the M&C station during the procedure. The other end of the hose shall be brought outside.

7.21 Use suitable nitrile green gasket. All removed gaskets shall be replaced and not reused.

8.0 PROCEDURE

8.1 PHASE I — PREREQUISITES

8.1.1 Confirm nitrogen bottle inventory at the M&R and M&C stations before commencing procedure.

8.1.2 Electric System Operations (ESO) and Gas System Operations (GSO) must be notified that a duel unit outage is required to conduct this procedure.

8.1.3 Refer to section 11.1 for familiarization with valve locations at the M&R station.

8.1.4 Refer to section 11.2 for familiarization with valve location for *main* gas piping at the M&C station.

8.1.5 Refer to section 11.3 for familiarization with valve location for *ignition* gas piping at the M&C station.

8.1.6 Six separate hold-offs will be required to perform this operation safely. The necessary hold-offs are as follows:

8.1.6.1 The M&R *main* gas systems (five *main* isolation valves: V-102, V-202, V-103, V-203, and V-303.) See section 11.1 for reference.

8.1.6.2 The M&R *ignition* gas system isolation valves (V-401 and V-402) and *main* system *ignition* gas backup (V-403.) See section 11.1 for reference.

8.1.6.3 The (16) unit #3 *main* gas cock block valves at the burner corners on elevation 52' for the M&C Station *main* gas system. See section 10.7 for reference.

8.1.6.4 The (16) unit #4 *main* gas cock block valves at the burner corners on elevation 52' for the M&C Station *main* gas system. See section 10.8 for reference.

8.1.6.5 The M&C station unit #3 *ignition* gas system valves (the ignition gas control valve outlet isolation valve and the control valve bypass valve.) See section 10.9 and 11.3 for reference.

8.1.6.6 The M&C station unit #4 *ignition* gas system valves (the ignition gas control valve outlet isolation valve and the control valve bypass valve.) See section 10.10 and 11.3 for reference.

8.2 PHASE II—MAIN AND IGNITION GAS PURGE PROCEDURE

8.2.1 Gas I&R shall isolate the *main* gas system at the M&R station. Close and tag the two isolation valves (V-102 and V-202) located past the gas meters at the M&R station.

8.2.2 Open unit #3 and 4 6" and 8" *main* gas inlet and outlet manual isolation valves on the M&C station.

8.2.3 Gas I&R shall isolate the *ignition* gas piping by closing the isolation valve (V-401) located upstream of the *ignition* gas meter at the M&R station.

8.2.4 On the M&C station, close and tag unit #3 *ignition* gas control valve outlet isolation valve, and control valve bypass valve.

8.2.5 On the M&C station, close and tag unit #4 *ignition* gas control valve outlet isolation valve, and control valve bypass valve.

8.2.6 Gas I&R shall open the *main* gas system backup supply to the *ignition* gas piping valve V-403. During the process of operating valve V-403, be sure to throttle the valve adequately so not to release safety valve on the *ignition* gas piping. The safety valve is set for 115 PSI.

8.2.7 If available, allow the package boiler to burn the remaining gas from the *ignition* and *main* gas piping. Manually trip the package boiler when gas has been exhausted to about 3 PSI. If the package boiler is not available, continue to 8.2.9.

8.2.8 Considering the weather conditions, drain package boiler steam piping to prevent damage due to freezing.

8.2.9 With assistance from Controls, open all control and trip valves associated with *main* gas piping on the M&C station.

8.2.10 Throttle and vent the *ignition* gas and *main* gas piping to 0 PSI using the high point vent at elevation 65' and at the burner corner vent piping on unit #3 and 4. Note that the high point vent at elevation 65' is a manual vent and the vents at the burner corner vent piping are controlled by motor operated valves at the burner corners. Ensure that the *main* system backup supply to the *ignition* gas piping valve (V-403) is cycled open and then tagged and closed by Gas IR during this step.

8.2.11 Gas I&R shall close and tag the *main* gas system backup supply to the *ignition* gas piping valve (V-403.)

8.2.12 Gas I&R shall close and tag the main gas three isolation valves (V-103, v-203, and V-303) and the ignition gas isolation valve (V-402) at the M&R station.

8.2.13 On the M&C station, close and tag isolation valves for the package boiler and the emergency battery charger diesel.

8.2.14 Gas I&R shall purge unit #3 and 4 *main* gas piping with nitrogen once prior steps are completed. Nitrogen shall be injected into the piping at the M&R station.

8.2.15 Gas I&R shall purge unit #3 and 4 *ignition* gas piping with nitrogen. Nitrogen shall be injected at the M&R station and into the v-cone taps at the M&C station. The high point vent at elevation 65' shall be used as a flow path for both purges.

8.2.16 Gas samples will be monitored at the high point vent located on elevation 65' and at the burner corner vent piping on unit #3 and 4.

8.2.17 Secure all nitrogen bottles when purge is completed.

8.3 PHASE III—UNIT #3 WORK PERMITS AND PROCEDURES

8.3.1 Work permits may be issued to complete the following tasks if applicable to the work plan:

8.3.1.1 The removal and installation of unit #3 *ignition* gas v-cone meter.

8.3.1.2 The removal and installation of unit #3 *main* gas v-cone meter.

8.3.1.3 The removal and installation of unit #3 “E” valve.

8.4 PHASE IV—UNIT #4 WORK PERMITS AND PROCEDURES

8.4.1 Work permits may be issued to complete the following tasks if applicable to the work plan:

8.4.1.1 The removal and installation of unit #4 *ignition* gas v-cone meter.

8.4.1.2 The removal and installation of unit #4 *main* gas v-cone meter.

8.4.1.3 The removal and installation of unit #4 “E” valve.

8.5 PHASE V—IGNITION GAS GAS-IN PROCEDURE

8.5.1 Secure all vents and drains and introduce air into the *ignition* gas piping. Pressurize to 80 PSI and test all new fittings for leaks.

8.5.2 After testing all new fittings for leaks, slowly open the high point vent on elevation 65' associated with *ignition* gas piping. Vent piping to 0 PSI.

8.5.3 Gas I&R shall inert *ignition* gas system with nitrogen to evacuate system of air in order to prevent mixture with oxygen before natural gas is reintroduced.

8.5.4 While pushing nitrogen through, close the high point vent on elevation 65' associated with the *ignition* gas piping and pressurize. Open drains and close again when all remaining air has been pushed out of the system.

8.5.5 Secure all nitrogen bottles when purge is completed.

8.5.6 Gas I&R shall open valves V-401 and V-402 at the M&R station while keeping valve V-403 closed to allow gas into the *ignition* gas piping while purging nitrogen through vent.

8.5.7 Once gas-in is completed, clear all hold-offs associated to *ignition* gas piping and open the *ignition* gas control valve outlet isolation valves associated with unit #3 and 4 on the M&C station.

8.5.8 Return the emergency battery charger diesel and the package boiler to service.

8.5.9 Perform a test run of the emergency battery charger diesel.

8.6 PHASE VI—MAIN GAS GAS-IN PROCEDURE

8.6.1 Upon completion of work permits related to *main* gas piping, gas-in procedure may commence.

8.6.2 Secure all vents and drains and introduce air into the *main* gas piping. Pressurize to 80 PSI and test all new fittings for leaks.

8.6.3 After testing all new fittings for leaks, slowly open the high point vent on elevation 65' associated with *main* gas piping and at the burner corner vent piping on unit #3 and #4. Vent piping to 0 PSI.

8.6.4 Gas I&R shall inert with nitrogen to evacuate system of air and prevent mixture with oxygen when natural gas is reintroduced.

8.6.5 While pushing nitrogen through, close the high point vent on elevation 65' associated with the *main* gas piping and at the burner corner vent piping on

unit #3 and 4. Pressurize with nitrogen. Open drains and close again when all remaining air has been pushed out of the system.

8.6.6 Secure all nitrogen bottles when purge is completed.

8.6.7 Gas I&R shall open valves V-102, V-202, V-103, V-203, and V-303 at the M&R station to allow gas into the *main* gas piping.

8.6.8 Ensure that nitrogen has been fully vented and the *main* gas system is fully gassed-in.

8.6.9 Clear all hold-offs associated with *main* gas piping.

9.0 ACCEPTANCE CRITERIA

9.1 All ignition and main v-cone gas meter bolted joints and "E" valve bolted joints verified to be leak tight.

10.0 REFERENCES

10.1 xxxxx Power Station Unit #3 & #4—Addition or Gas Firing System Familiarization Manual.

10.2 Gas Operations PURG-5010: Purge and Gas-In Mains and Services.

10.3 Chemical Safety Board Safety Bulletin—September 2009.

10.4 U.S. Chemical Safety and Hazard Investigation Board: Urgent Recommendations—February 4, 2010.

10.5 AGA Purging Principles and Practice.

10.6 Gas I&R Work Instruction for xxxxx Steam Plant Gas Header Purge.

10.7 xxxxx Power Station Unit #3 Gas Conversion, P&I Diagram, Main Fuel Gas System (Drawing PJPS3-MM-04000-00.)

10.8 xxxxx Power Station Unit #4 Gas Conversion, P&I Diagram, Main Fuel Gas System (Drawing PJPS4-MM-04000-00.)

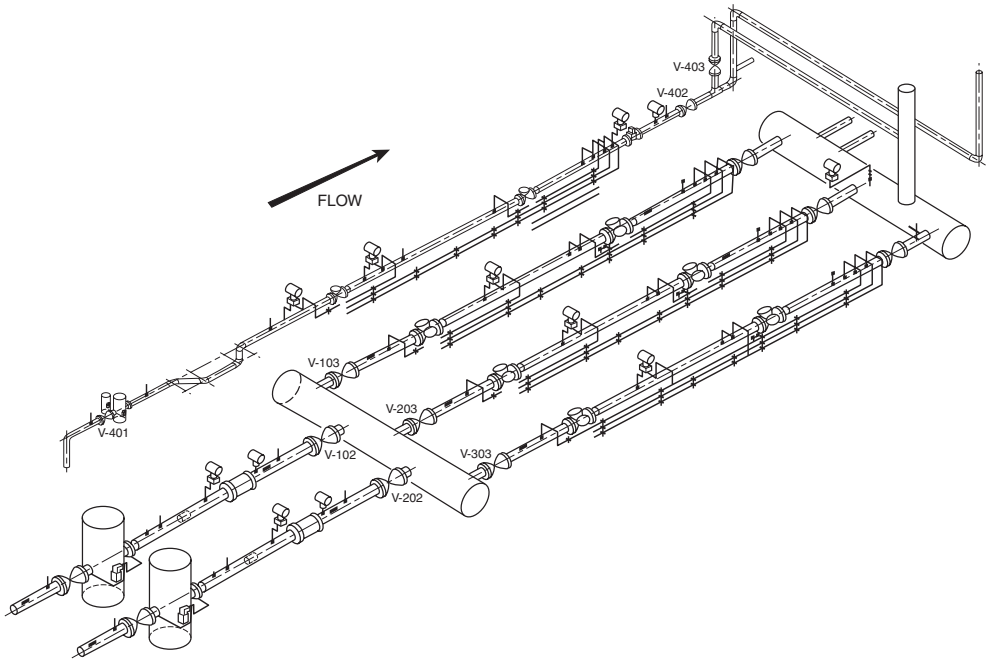
10.9 xxxxx Power Station Unit #3 Gas Conversion, P&I Diagram, Ignition Gas System (Drawing PJPS3-MM-04001-2.)

10.10 xxxxx Power Station Unit #4 Gas Conversion, P&I Diagram, Ignition Gas System (Drawing PJPS4-MM-04001-00.)

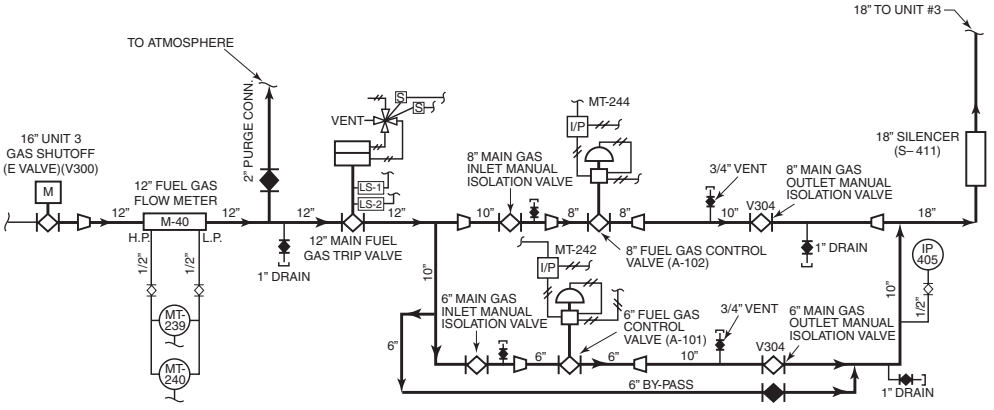
10.11 Natural Gas Meter and Regulation Station for Unit 3 & 4 Gas Firing, Piping Plan, Sections, and Details (Drawing PJMRY-MM-02000-3.)

11.0 ATTACHMENTS

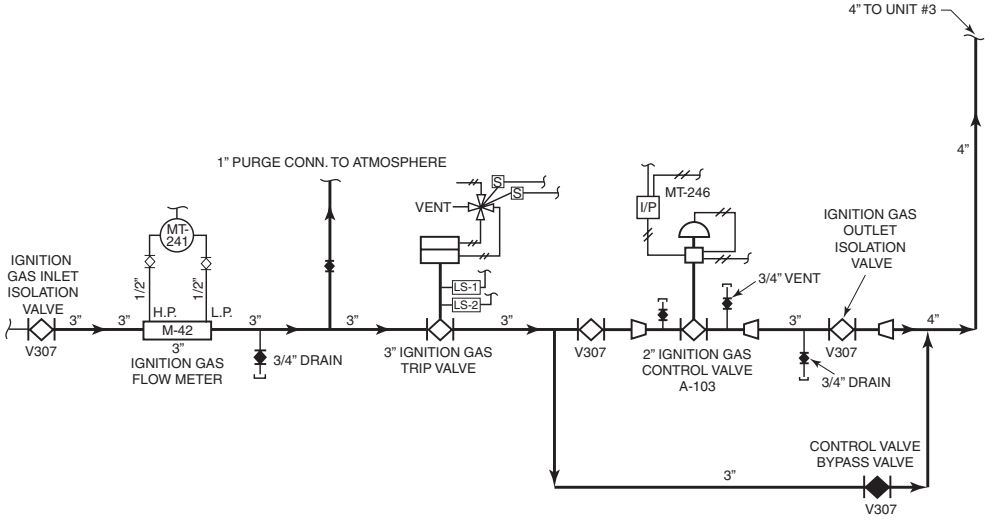
11.1 xxxxx Power Station Gas Metering and Regulator Station.



11.2 xxxxx Power Station Main Fuel Gas Metering and Control Station.0



11.3 xxxxx Power Station Ignition Gas Metering and Control Station.



11.4 Inert Amounts Table.

Pipe Size and Minimum Amount of Inertant Needed When Purging by Completely Filling Line

Nominal Pipe Size (in.)	*Volume (V) of Inerts (cu. ft.) Per 100 ft. of Pipe
6	40
8	70
10	140
12	160
16	280
20	440
24	630
30	1000
36	1500

** This data includes a 2.0 safety factor adjustment.*

11.5 Full Cylinder Data.

	Volume (cu. ft.)	Pressure (psig)
N2	220	2200
CO2	520	830

11.6 Slug Volume Requirements.

VOLUME OF SLUG OF CARBON DIOXIDE/NOTROGEN REQUIRED FOR VARIOUS PIPE SIZES AND PIPE LENTHS CHART

Purging Velocity 200 Lineal Pipe Feet per Minute or Higher
Pipe Diameter Nominal – Inches

Pipe Length (ft.)	4"	6"	8"	10"	12"	16"	18"	20"	22"	24"	30"
	Volume of Nitrogen Slug—Cubic Feet										
1,000 or less	7	24	54	107	184	430	588	806	1,070	1,390	2,722
1,000–2,000	8	28	73	126	216	580	686	940	1,250	1,624	3,390
2,000–4,000	11	36	83	165	282	632	902	1,240	1,640	2,142	4,180
4,000–6,000	13	44	103	200	368	784	1,118	1,540	2,000	2,580	5,100
6,000–8,000	15	52	123	236	418	936	1,334	1,840	2,380	3,120	6,080
8,000–10,000	18	60	143	270	484	1,088	1,550	2,040	2,790	3,620	7,060
10,000–15,000	24	82	188	372	640	1,530	2,046	2,800	3,720	4,860	9,520
15,000–20,000	30	102	238	468	808	1,800	2,580	3,540	4,680	6,120	12,000
20,000–25,000	36	124	288	528	976	2,170	3,014	4,280	5,640	7,400	14,400
25,000–30,000	42	146	338	588	1,144	2,540	3,448	5,020	6,600	8,620	16,900
30,000–40,000	55	186	432	1,042	1,470	3,280	4,680	6,420	8,520	11,120	21,800
40,000–50,000	67	228	530	1,234	1,820	4,000	5,720	7,960	10,440	13,680	26,800
50,000–60,000	80	270	630	1,426	2,170	4,720	6,760	9,500	12,320	16,200	31,700
60,000–70,000	92	312	730	1,618	2,520	5,440	7,900	11,040	14,300	18,700	36,500
70,000–80,000	101	354	830	1,812	2,870	6,160	8,940	12,580	16,200	21,220	41,400

General Notes:

1. The same volume of a slug applies for nitrogen usage.
2. For exhaust gases, add 20%.
3. The number of large cylinders of nitrogen required can be obtained be dividing the volume required by 224 cubic feet.

For total displacement: locate the length of pipe and the size of the pipe, look up the intersecting volume (cubic feet) and divide by 224 cubic feet to establish the number of cylinders required.