

Burners for Fired Heaters in General Refinery Services

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Contents

	Page
1 Scope.....	1
2 Normative References	1
3 Terms, Definitions, and Abbreviations.....	1
3.1 General Terms and Definitions.....	1
3.2 Specific Definitions	2
3.3 Symbols and Abbreviations	8
4 Proposals and Documentation.....	8
4.1 Purchaser's Responsibilities.....	8
4.2 Vendor's Responsibilities.....	9
4.3 Documentation Requirements	9
4.4 Performance Tests and Guarantees	11
5 Functional Requirements—Burners.....	11
5.1 Airside Design.....	11
5.2 Basis of Flame Shape and Dimension Requirements	12
5.3 Burner Ignition	12
5.4 Flame Detection Requirements	13
5.5 Required Stable Operating Envelope	13
5.6 Optional Stability Requirements	14
6 Functional Requirements—Pilots	14
6.1 General.....	14
6.2 Airside Design.....	14
6.3 Flame Ignition Requirements.....	14
6.4 Flame Detection Requirements	15
6.5 Stable Operating Envelope.....	15
6.6 Transient Operations	15
7 Mechanical Requirements—Burners	15
7.1 General Requirements.....	15
7.2 Tiles	16
7.3 Manifold Gas Distribution Systems.....	16
7.4 Tip-Riser Assembly Systems	17
7.5 Air Plenums/Individual Windbox	18
7.6 Ports and Connections	20
8 Mechanical Requirements—Pilots.....	20
8.1 General.....	20
8.2 Flame Detection.....	21
9 Fabrication	21
9.1 Welding.....	21
9.2 Flange Face.....	21
9.3 Piping.....	21
9.4 Paint.....	21
9.5 Tiles	22
10 Inspection and Component Testing.....	22

Contents

	Page
10.1 Visual Inspection.....	22
10.2 Dimensional Inspection.....	22
10.3 Mechanical Function Inspection	23
10.4 Materials Inspection	23
10.5 Additional Checks	23
11 Identification, Handling, Storage, and Shipment.....	24
11.1 General	24
12 Burner Testing	24
12.1 General	24
12.2 Test Furnace Requirements.....	24
12.3 Test Fuels	25
12.4 Air Supply	25
12.5 Ignition and Flame Detection Devices	26
12.6 Burner Test Points.....	26
12.7 Optional/Exploratory Test Points.....	26
12.8 Test Instrumentation	27
12.9 Measurements	27
12.10 Acceptance Criteria	29
Annex A (informative) Equipment Datasheets	30
Annex B (informative) Burner Test Procedure	53
Annex C (informative) Purchaser's Checklist	58
Annex D (normative) Oil/Liquid Fuel Firing.....	60
Bibliography.....	64

Tables

1 Fuel Gas Burner Components	17
2 Burner Casing and Burner Damper/Register	20
C.1 Purchaser's Checklist for Burners for Fired Heaters in General Refinery Services.....	58
D.1 Liquid Burner Materials of Construction.....	62
D.2 Liquid Burner Testing	63

Introduction

Burners are devices that mix air and fuel to provide stable combustion and hot gas for the transfer of heat to process fluids in general refinery services. A burner design basis is developed in consideration of the specified performance expectations, functional requirements, and mechanical details required to fulfill the operating goals established for each application. This standard provides the basis for design, functional and mechanical requirements, and burner testing requirements to provide safe, reliable, and efficient combustion of fuel to enable the heater to satisfy its operating requirements.

The burner types addressed in this standard are commonly used and available in a variety of configurations and sizes. Burner types generally include premix, raw gas, staged air, staged fuel, and others. Most types are available in either natural-draft or forced-air arrangements, or both. The burner types listed are not intended to imply that other burner types are not available or applicable. Many of the individual features described in this standard are applicable to most burner types.

Burners designed to this standard are used in a wide range of petrochemical and refinery applications, and are influenced by the fired heater design. These burners may need to be capable of handling a large variation in fuel composition, be subjected to different ignition methods, and be monitored by a variety of different flame-detection techniques. Generally, burners built to this standard are engineered for the specific application while addressing the owner specifications/standards and the jurisdictional regulatory requirements to which the owner's facility is subjected.

For new designs, the development of a design can be advanced using the direction and examples of good engineering practice identified in this standard.

Users of this standard should be aware that further or differing requirements may be needed for individual applications. This standard is not intended to inhibit a vendor from offering, or the purchaser from accepting, alternative equipment or engineering solutions for the individual application. This may be particularly applicable where there is innovative or developing technology. Where an alternative is offered, the vendor should identify any variations from this standard and provide details.

In API standards, the International System of Units (SI) is used. In this standard, where practical, U.S. Customary (USC) units are included in brackets for information.

A bullet [•] at the beginning of a clause or sub-clause indicates that either a decision is required, or further information is to be provided, by the purchaser. This information should be indicated on the purchaser's checklist (see [Annex C](#)) or stated in the inquiry or purchase order.

Burners for Fired Heaters in General Refinery Services

1 Scope

This standard provides requirements and direction for the selection, specification, materials, and testing of burners for fired heaters in general refinery services designed in accordance with API 560. Details of fired heater and related equipment designs are considered only where they interact with the burner selection.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

API 556, *Instrumentation, Control, and Protective Systems for Gas Fired Heaters*

API 560, *Fired Heaters for General Refinery Services*

3 Terms, Definitions, and Abbreviations

For the purposes of this document, the following terms and definitions apply.

3.1 General Terms and Definitions

The following general definitions are provided to better define and distinguish the multidisciplined workforce and the typical areas of responsibility involved in the specification, design, and supply work processes required in the overall procurement process for burners in fired heaters in general refinery services. These definitions are intended to build upon the typical definitions of “purchaser” and “vendor” normally used in API standards.

Recognizing that the work process and areas of responsibility may differ between projects and owner organizations, the terms and definitions contained in the purchaser’s procurement documentation take precedence over definition of parties of the multidisciplined workforces and their respective areas of responsibility.

3.1.1

owner

purchaser

The owner or purchaser is the party with responsibility for all or part of the process and thermal design/definition, the mechanical specification, procurement, and installation of the purchased equipment.

NOTE The owner or purchaser may, at times, work through an engineering contractor (contractor) as an agent undertaking the owner’s requirement for the engineering, procurement, and/or construction phases of work, including representation of the owner on decisions related to operation and maintenance as may be required. The term “purchaser” within this document will be considered synonymous with the terms “contractor” or “owner.”

3.1.2

vendor

The party that supplies the design, manufacturing, equipment, and any services required as specified by the purchaser.

NOTE 1 The vendor typically has the prime responsibility for the detailed engineering, material procurement, project management, and manufacturing processes involved in the physical supply of the burner, including all aspects of quality assurance and quality control for work of their own and others whom they qualify for providing work, products, or services on their behalf.

NOTE 2 The vendor, whether they directly produce the materials or are agents in supply of such components, have responsibility for the quality of the product to either recognized industry or other standards as directed by the purchaser, whomever they may be.

NOTE 3 A vendor may also provide specialty engineering services, such as finite element analysis (FEA). Within the context of this standard, the vendor has prime responsibility for the products and services provided by the vendor.

3.2 Specific Definitions

3.2.1

adiabatic flame temperature

Temperature that results from a complete combustion process without any heat transfer or changes in kinetic or potential energy.

3.2.2

air register

air damper

The part of a burner that permits/adjusts/directs combustion air through openings into or around the burner assembly.

3.2.3

burner throat

A restriction in the air flow path formed by the burner block and other burner components that may be used to initiate turbulence for the mixing of the fuel and air.

3.2.4

CO breakthrough

combustible breakthrough

The point at which the trend of carbon monoxide (CO) and/or combustibles measured in the firebox, when plotted on a time scale, begins to increase rapidly upon reduction of the air/fuel ratio when the firebox is above the autoignition temperature of CO.

NOTE 1 This breakthrough will vary depending upon the fuel composition, the type of burner, and the mechanical condition of the burner.

NOTE 2 CO breakthrough is different than excessive CO produced in the presence of high excess air conditions. High CO in the presence of high excess air is more an issue of cool temperatures resulting in incomplete oxidation.

NOTE 3 A typical definition for the CO breakthrough rate of increase is when the CO value increases by a factor of 3 within the span of 10 seconds. This would be considered CO breakthrough as the CO value has "spiked," even if the target value has not been reached. A true breakthrough is shown with a sustained spike.

NOTE 4 For most refinery fuel gases, the typical CO breakthrough value is considered as 285 mg/Nm³ (250 ppm).

3.2.5

cold ignition

Initial burner ignition when the fired heater is near ambient conditions.

3.2.6

combination burner

A burner capable of burning gas and liquid fuel individually or simultaneously.

3.2.7

combustion products

Resultant components of the combustion process, such as carbon dioxide, water vapor, and additional components (such as sulfur dioxide and ash).

3.2.8**design heat release (burner)**

The heater design heat release, divided by the number of burners and multiplied by the burner design margin.

3.2.9**double drop orifice**

A drilled plate or union upstream of the firing ports to reduce fuel gas pressure at the tips.

3.2.10**excess air**

The amount of air above the stoichiometric requirement, expressed as a percentage.

3.2.11**flame envelope**

The volume in which combustion reactions take place, liberating heat and usually visible light.

NOTE The generally accepted limit (flame boundary) of the volume is based on a CO concentration of 2499 mg/Nm³ (2000 ppmv(d)).

3.2.12**flame front**

The boundary of the flame that separates fresh fuel and air from the combustion process envelope.

3.2.13**flame length**

The linear distance from the exit of the burner tile to the furthest edge of the flame envelope.

3.2.14**flame liftoff**

The lifting of a flame when the fuel stream velocity exceeds the flame velocity, resulting in the flame front moving away from the flame stabilization point and ultimately being extinguished.

3.2.15**flame speed**

The rate at which a flame front propagates through a combustible mixture.

3.2.16**flame stabilization point**

The location in the burner at which the flame front anchors.

3.2.17**flame stabilizer****flame holder**

A bluff body restriction in the combustion air stream that creates an internal recirculation zone with low velocity regions where flame stabilization points can form.

3.2.18**flame temperature**

The average temperature within the flame envelope during sustained combustion.

3.2.19**flashback**

The phenomenon that occurs when a flame front instantaneously propagates back into the direction of the fuel-air mixture flow.

NOTE 1 This occurs in premix burners or pilots when the flame velocity exceeds the velocity of the fuel-air mixture through a burner nozzle.

NOTE 2 Fuels that contain high amounts of hydrogen have a greater propensity to flashback.

3.2.20

forced draft

The difference in pressure produced by mechanical means that delivers air into a burner at a pressure greater than atmospheric.

3.2.21

fuel bound nitrogen

Nitrogen (N) atoms that are chemically bonded within fuel molecules.

3.2.22

fuel gas

A gas phase mixture of various chemicals that can sustain combustion without the addition of supplemental gas firing at the burner.

NOTE 1 Other terms for this mixture include the following, but are not limited to, process gas, refinery gas, and off-gas.

NOTE 2 Typically, a mixture of methane, ethane, and other light hydrocarbons; hydrogen; and possibly inerts.

3.2.23

fuel NO_x

Nitrogen oxide molecules that are formed predominantly due to chemically bonded nitrogen in fuel.

NOTE 1 Components like ammonia (NH₃), hydrogen cyanide (HCN), and nitric oxide (NO) can also be contained in the fuel and can contribute to NO_x formation.

NOTE 2 A large fraction of the fuel-bound nitrogen follows this reaction path, which can result in hundreds of ppm of NO_x.

3.2.24

heat release

firing rate

The heat liberated from the fuel, expressed as units of energy over time (e.g. MW, kcal/hr, Btu/hr).

3.2.25

higher heating value

HHV

gross heating value

The total heat obtained from the combustion of a specified fuel at 15.5 °C (60 °F), expressed as a unit of heat per mass or volume, which includes the latent heat of vaporization of water.

3.2.26

ignition

Initial burning of a fuel.

3.2.27

ignition device

Equipment used to provide enough energy within a flammable gas mixture to initiate the combustion reaction process.

NOTE Examples include sparking devices, a pilot burner, and a portable flame device.

3.2.28

induced draft

The difference in pressure (between inside and outside of the heater) produced by mechanical means downstream of the combustion zone resulting in a negative pressure inside the heater.

3.2.29**initial ignition port(s)**

The orifice(s) in the burner tip(s) that is designed to achieve the first flame from the ignition device, subsequently igniting the other burner tips/orifices.

3.2.30**instability****burner instability**

An unwanted operating condition present if any of the following phenomena occur:

- 1) flame detaches from the flame stabilization point;
- 2) visually observable or audible pulsation of burner flame, burner, or heater or test furnace;
- 3) uncontrollable or erratic fluctuations in the flame shape;
- 4) flashback into a venturi.

NOTE If flame liftoff occurs, the flame may or may not reattach to the flame stabilization point, which creates movement or pulsations, resulting in pressure waves created by the energy of the oscillations.

3.2.31**low NO_x burner**

A burner that is designed to reduce the formation of nitrogen oxides (NO_x).

3.2.32**lower heating value****LHV****net heating value**

The higher heating value minus the latent heat of vaporization of the water formed by combustion of hydrogen in the fuel, expressed as a unit of heat per mass or volume.

NOTE LHV is the more common term used in the industry.

3.2.33**minimum heat release (burner)**

The lesser of 1/3 the design burner heat release or the minimum heat release condition specified on the burner datasheet.

3.2.34**natural draft**

The differential pressure that serves to draw combustion air into the burner when there are no mechanical means for providing air flow.

3.2.35**normal heat release (burner)**

The heater design heat release, divided by the number of burners.

3.2.36**NO_x**

A general term used describe oxides of nitrogen, including nitric oxide (NO) and nitrogen dioxide (NO₂).

NOTE For the purpose of emission calculations, NO_x is assumed to be nitrogen dioxide with a molecular weight of 46.01.

3.2.37**operating envelope**

The range of parameters (heat release, temperature, pressure, fuel heating value, heater draft, excess air level) in which operating within will result in stable and acceptable burner performance.

3.2.38**pilot**

An installed small burner that acts as a burner ignition device that provides energy to ignite a mixture of fuel gas, exiting the initial ignition port(s), and combustion air.

3.2.39**pilot orifice****spud**

A device with one or more small gas orifices that often has an internal orifice used to reduce the pressure before the exit orifices (also see “tip”).

NOTE Typically used in reference to premix burners and placed outside the heat-affected zone.

3.2.40**plenum****windbox**

A chamber surrounding the burner(s) used to distribute air to the burner(s) and/or to reduce combustion noise.

3.2.41**pre-fired**

A controlled thermal drying procedure of refractory before it is used in continuous/normal service.

3.2.42**premix burner**

A burner where fuel and air are mixed prior to entering the initial combustion zone.

3.2.43**pressure loss**

The non-recoverable difference in pressure measured between upstream and downstream points.

NOTE For fired equipment, as measured through the process tubes, through air or flue gas ducting, or across the burner (fuel and/or air side).

3.2.44**primary air**

That portion of the combustion air that first mixes with the fuel.

3.2.45**primary fuel**

The fuel used to generate a flame that in turn provides energy to stabilize the combustion of any remaining fuel during steady operation of the burner.

3.2.46**primary tile****regen (regeneration) tile**

An additional refractory block that is located in the throat of the burner to act as a stabilization device.

NOTE Primary tiles are more commonly seen in liquid fuel fired burners as opposed to fuel gas fired burners.

3.2.47**radiant wall burner**

A burner where the flame does not project into the firebox but spreads out alongside the wall on which it is installed.

3.2.48**raw gas burner**

A gas burner in which combustion takes place as the fuel is mixed with the combustion air downstream of the fuel tips.

3.2.49**riser****fuel gun**

Piping within the burner that takes the fuel from the distribution manifold to the burner tip.

3.2.50**secondary air**

A portion of the combustion air that is delivered downstream of the primary combustion zone.

3.2.51**secondary fuel**

The remaining portion of fuel that is injected downstream of the primary fuel in a staged fuel burner.

3.2.52**sound power level****PWL**

The energy of the transferred sound, $PWL = 10 \log(P/P_0)$, with the relative changes expressed in decibels (dB) with the reference value $P_0 = 10^{-12}$ W.

3.2.53**sound pressure level****SPL**

The level of air pressure fluctuations in a fluid, $SPL = 20 \log(p/p_0)$, with changes in SPL expressed in decibels (dB) with the reference value $p_0 = 2 \times 10^{-5}$ N/m².

NOTE If the frequency spectrum is corrected using an "A-weighting" to account for the human ear response, the SPL is reported in dBA or dB(A).

3.2.54**stability****burner stability**

The ability of a burner to adhere a flame to the flame stabilization point, occurring when the fuel stream velocity is equal to the flame velocity, to produce and maintain reliable combustion without showing signs of instability.

3.2.55**staged air burner**

A low NO_x burner in which a portion of the combustion air is introduced downstream of the primary combustion zone.

3.2.56**staged fuel burner**

A low NO_x burner in which a portion of the fuel is introduced downstream of the primary combustion zone.

3.2.57**tile****muffle block****quarl**

A refractory block that segregates the burner internals from the surrounding heater, often used to anchor the flame, and designed to control the mixing of air, fuel, and recirculating flue gas.

3.2.58**tip**

A device with one or more small fuel orifices, usually without an internal orifice.

NOTE Typically used in reference to nozzle mix burners and placed inside the heat-affected zone.

3.2.59**turndown**

The minimum rate at which a burner is designed to operate with stable combustion, typically expressed as a percentage of the maximum operating rate.

NOTE It can also be expressed as a ratio that is the inverse of the percentage. For example, 25 % turndown is the same as a 4-to-1 turndown.

3.3 Symbols and Abbreviations

For the purposes of this document, the following symbols and abbreviations apply.

APH air preheat system

HHV higher heating value

IOM installation and operation manual

ITP inspection test plan

NO_x oxides of nitrogen

PM particulate matter

PMI positive material identification

ppm parts per million

UHC unburned hydrocarbons

VOC volatile organic compounds

4 Proposals and Documentation**4.1 Purchaser's Responsibilities**

4.1.1 The purchaser's inquiry shall include burner datasheets ([Annex A](#)), checklist ([Annex C](#)), and other applicable information outlined in this standard. This information shall include any special requirements or exceptions to this standard from the purchaser's perspective.

4.1.2 The purchaser is responsible for the **correct** design specification to enable the vendor to prepare the burner design.

NOTE 1 The purchaser should complete, at a minimum, those items on the datasheet that are designated by an asterisk (*). Refer to [Annex A](#).

NOTE 2 The purchaser should refer to the checklist in [Annex C](#) for purchaser's decisions or further information to be provided by the purchaser in the inquiry documents or during design development.

NOTE 3 Some sections of the burner datasheets should be duplicated if the number of design requirements extends beyond the capacity of the template. The duplicatable sections of the burner datasheets are designated by a double asterisk (**).

4.1.3 The purchaser's inquiry shall define the vendor's scope of supply and responsibilities relative to application of this standard.

4.1.4 The purchaser's inquiry shall specify the number of copies of drawings, datasheets, specifications, data reports, operating manuals, installation instructions, spare-parts lists, special testing requirements (when applicable), and other data to be supplied by the vendor.

4.1.5 Changes in referenced standards, codes, and specifications shall be mutually agreed to by the owner and the vendor.

4.1.6 [•] When purchasing equipment capable of oil/liquid fuel firing, the purchaser shall specify whether the requirements contained in [Annex D](#) shall be used directly, with or without modification, or alternate specifications and requirements shall be provided.

4.2 Vendor's Responsibilities

4.2.1 The vendor's proposal shall include:

- a) completed datasheets for each burner design and the associated equipment;
- b) a burner sales drawing outlining burner external dimensions;
- c) detailed description of any exceptions to the specified requirements or normative references;
- d) schedule for submission of all required drawings, data, and documents.

4.3 Documentation Requirements

4.3.1 Proposals

4.3.1.1 The burner vendor shall provide completed burner datasheets with information not provided by the purchaser.

4.3.1.2 The burner vendor shall provide a preliminary burner general arrangement drawing, including any mechanical clearance dimensions.

4.3.1.3 The burner vendor shall provide a sketch showing the proposed burner layout, expected flame pattern (including dimensions at design heat release), and number of burners.

4.3.1.4 The burner vendor shall provide a list of spare parts recommended for construction, startup, and a two-year run.

4.3.1.5 The burner vendor shall provide the expected plenum surface temperature for preheated air service.

4.3.1.6 The burner vendor shall provide and clearly define the basis for emissions guarantees.

4.3.1.7 The burner vendor shall provide a typical maintenance procedure for the purchaser's review.

4.3.1.8 [●] When specified, the burner vendor shall provide estimated weights and dimensions of the proposed burner.

4.3.1.9 [●] When specified, the vendor shall provide a completed noise datasheet representative of the vendor's experience and reference list for the applicable burner(s).

4.3.2 Design Information and Documentation for Purchaser's Review

4.3.2.1 The burner vendor shall provide a burner general arrangement drawing showing the major dimensions of the burner. Any critical dimensions, and their tolerances, shall be shown on the burner drawing. Any special features requested by the purchaser shall also be shown.

NOTE Critical dimensions and tolerances should be validated by the purchaser after final installation of the burner assembly.

NOTE 2 The following burner component and assembly dimensions are typically considered critical:

- a) burner tile diameter;
- b) burner tile concentricity (out of roundness);
- c) tip port angles;
- d) bolting dimensions;
- e) gas tip locations (horizontal and vertical);
- f) gas tip orifice size.

4.3.2.3 The burner vendor shall list the materials of construction on the burner general arrangement drawing.

4.3.2.4 The burner vendor shall provide a nameplate drawing that includes the following information.

- a) vendor name and phone number;
- b) burner model number;
- c) vendor's reference number and general arrangement drawing number;
- d) name or equipment number of heater for which the burner is being supplied;
- e) manufacturing date.

4.3.2.5 The burner vendor shall provide completed burner datasheets.

4.3.2.6 The burner vendor shall provide capacity curves for both the fuel side and air side.

4.3.2.7 The burner vendor shall provide a burner combustion test procedure when specified on the datasheet.

4.3.2.8 The burner vendor shall provide an inspection and test plan (ITP).

4.3.2.9 The burner vendor shall provide installation, operation, and maintenance (IOM) instructions.

4.3.2.10 The burner vendor shall provide any wiring diagrams, instrumentation catalog sheets, and instructions for any electrical/instrumentation provided with the burner or pilot assembly.

4.3.3 As-built Documentation

4.3.3.1 After receipt of the purchaser's comments on the burner general arrangement drawings and requested information and documentation, the vendor shall furnish the following:

- a) as-built detailed dimensional drawings;
- b) performance curves/tables of heat release vs. fuel pressure and heat release vs. airside pressure loss (see [Annex A](#));
- c) completed and updated burner datasheets supplied with the inquiry (see [Annex A](#));
- d) report of factory test results;
- e) a separate drawing highlighting dimensional and alignment tolerances of the burner assembly;
- f) vendor's data book with QC information.

4.4 Performance Tests and Guarantees

4.4.1 [●] When specified by the purchaser, witnessed burner performance tests shall be performed that include and adhere to, at a minimum, the test protocols as specified in [Section 12](#).

4.4.2 Any specific guarantees shall be contained in exhibits or attachments to the purchaser's requisition.

5 Functional Requirements—Burners

5.1 Airside Design

5.1.1 General

5.1.1.1 The burner shall be designed to use 90 % to 100 % of the available airside pressure loss with the burner air register fully open on the most limiting combustion case, e.g. the combustion case with the highest airside pressure loss.

5.1.1.2 The vendor shall be responsible for distribution of the available airside pressure loss within the burner to achieve the specified performance requirements.

NOTE Oversizing the burner by specifying a lower-than-expected burner airside pressure loss, or with higher-than-expected ambient air humidity, can have negative impacts on combustion performance, airside controllability, and emissions control. A margin for burner sizing is already considered by specifying a burner design heat release.

5.1.1.3 [●] The purchaser shall specify the primary source of combustion air used for the burner sizing, e.g. natural draft, forced draft, or forced draft with an air preheater.

5.1.1.4 The burner shall be designed such that there is no more than 2 % open area for combustion air to flow through the burner with the burner air register in the closed position.

NOTE Sealing strips on the inside edge of the burner air register housing are the most common way to control the air leakage through the air register when in the full closed position.

5.1.2 Natural Draft and Induced Draft

5.1.2.1 The air register shall have enough range and resolution to achieve ± 5 % of the air flow for each combustion case listed on the burner datasheet.

5.1.2.2 All burners shall operate with the same level of excess air at normal heat release, with air registers set at the same position.

5.1.3 Forced Draft

5.1.3.1 When the purchaser specifies a natural draft burner airside pressure loss and burner heat release, the burner vendor shall provide the required forced draft pressure loss to achieve the burner heat release at the specified combustion air temperature.

5.1.3.2 When the purchaser specifies the forced draft burner airside pressure loss and burner heat release, the burner vendor shall provide the highest achievable heat release for the natural draft case(s).

5.1.4 Air Distribution Requirements

[●] In applications where the air is supplied to the burners through ducting, or a common plenum, the purchaser shall provide the expected variation of air to each burner.

5.2 Basis of Flame Shape and Dimension Requirements

5.2.1 [●] The purchaser shall specify a burner test maximum and minimum allowable flame length and flame width (round flame burners). For flat flame burners, the purchaser shall also specify the minimum and maximum allowable flame depth.

NOTE A basis for flame dimension requirements can be found in API 560.

5.3 Burner Ignition

5.3.1 [●] The purchaser shall specify the method for burner ignition.

5.3.2 The burner vendor shall specify the range of energy (or heat release) from the burner ignition device, location of the burner ignition device, flame volume/flame shape, and the tolerance of the burner ignition device placement required for burner ignition.

5.3.3 [●] When portable ignition devices are used, the purchaser shall specify if positioning brackets are required.

5.3.4 The burner vendor shall provide the diameter, quantity, and location of the initial ignition port(s) and note their location on the burner datasheet and burner drawings.

NOTE Where a burner has a single initial ignition port, special precautions should be taken to address the increased preventive maintenance frequency required on the gas tip as a function of probability of failure on demand.

5.3.5 The burner vendor shall provide maintenance criteria for burner and ignition devices (when supplied by burner vendor).

5.3.6 [●] The purchaser or heater vendor shall specify the following conditions for burner ignition:

- a) heat release or burner fuel pressure;
- b) burner air register setting;
- c) combustion air conditions;
- d) heater draft or burner airside pressure loss;
- e) fuel compositions.

5.3.7 Unless otherwise specified, the following conditions establish the minimum requirements for burner ignition in a cold ignition scenario:

- a) at or below the minimum heat release of the burner up to 50 % of the design heat release of the burner;
- b) with the burner air register set from 25 % to 100 % open;
- c) at the ambient air conditions on the burner datasheet;
- d) between 1.27 mmH₂O and 7.62 mmH₂O (0.05 in.H₂O and 0.3 in.H₂O) fired heater draft at the burner installation plane or burner airside pressure loss;
- e) the fuel compositions that are specified to be available at burner ignition.

NOTE Conditions a), b), and d) are not prescriptive setpoints, and these conditions can be combined at different ranges, as indicated above.

5.4 Flame Detection Requirements

5.4.1 [●] When flame detection is required, the purchaser shall specify the make and model of flame detection technology that will be mounted on the burner.

5.4.2 [●] The specific flame detection requirements for the burner assembly shall be defined by the purchaser as one of the following:

- a) burner;
- b) pilot and burner;
- c) pilot only.

5.4.3 When flame detection is specified by the purchaser, the burner shall be designed to accommodate the installation of the specified type of detection instrument.

NOTE 1 A common practice for the application of optical flame detection is to sight a location of the burner flame that is going to remain relatively constant and not change drastically in transparency or size depending on the operating condition. In staged fuel burners, it is considered best practice to sight the stabilization zone of the burner instead of the staged fuel zone.

NOTE 2 A common practice measure is to test the burner using the specified flame detection technology to demonstrate the functionality of the flame detection device with respect to the application.

NOTE 3 See API 556 for additional information on flame detection devices.

5.5 Required Stable Operating Envelope

5.5.1 The burner shall be stable at the minimum, normal, and design heat release conditions specified on the burner datasheet.

5.5.2 The burner shall be stable without an ignited pilot on at all burner datasheet operating conditions.

5.5.3 The burner shall be stable at the design and normal burner heat release rates specified on the burner datasheet with the stoichiometric amount of air.

5.5.4 [●] The burner shall be stable through purchaser-specified transient operational requirements.

NOTE Transient cases may be described by the purchaser by referring to the time required to transition between two defined steady state combustion cases, such as changes in fuel gas composition or specified air supply.

5.6 Optional Stability Requirements

NOTE The optional stability requirements were compiled from common industry practices to establish an enhanced operating envelope outside the defined conditions from the burner datasheet.

5.6.1 [●] The purchaser shall specify the applicable operational stability requirements from the following:

- a) the burner shall be stable on natural gas throughout the stable operating envelope, as specified in [5.5](#);
- b) the burner shall be stable with an additional 30 % excess air from the design excess air for the design and normal heat release conditions specified with the burner air register fully open;
- c) the burner shall be stable at 33 % of design heat release with the burner air register set to design heat release position at the design burner airside pressure loss;
- d) the burner shall be stable at 70 % of minimum burner heat release with the burner air register set to normal heat release position at the design burner airside pressure loss.

6 Functional Requirements—Pilots

6.1 General

6.1.1 [●] The purchaser shall specify if burners are to be equipped with pilots.

NOTE The purpose of the pilot is to:

- a) ignite the gas coming from the initial ignition ports in the defined burner ignition conditions in [5.3.6](#), or as defined on the burner datasheet;
- b) allow use of the hot restart procedure (see API 556).

6.1.2 Pilots shall be gas fueled.

6.1.3 Pilot flames and shields, if present, shall be positioned so that both are clearly visible from a burner sight port in all operating conditions.

6.1.4 The pilot shall be fired parallel to the burner combustion air flow to minimize shear stresses unless testing is performed to demonstrate that a pilot subjected to shear stress remains stable.

6.1.5 Unless otherwise specified, pilot heat release shall comply with the burner vendor requirements according to information provided as prescribed in [5.3.2](#) for all pilot fuels indicated on the burner datasheet.

6.2 Airside Design

6.2.1 The pilot shall be provided with an independent and continuous supply of combustion air under all operating conditions.

NOTE 1 This requirement includes operation of the pilot with the burner in or out of service regardless of burner air register position.

NOTE 2 This requirement includes pilot spuds or mixer bodies located outside or inside of the burner plenum.

6.3 Flame Ignition Requirements

6.3.1 [●] The purchaser shall specify the type of pilot flame ignition required.

NOTE Manual ignition of pilots may be accomplished with gas or electric portable igniters. Alternatively, pilots may be equipped with an integrated electric ignition system.

6.3.2 The ignition device shall ignite the pilot under the pilot and burner specified ignition conditions.

6.4 Flame Detection Requirements

6.4.1 [●] The purchaser shall specify when instrumented pilot flame detection is required.

6.4.2 [●] The purchaser shall specify the type of instrumented flame detection.

NOTE Common methods of instrumented flame detection include flame rods, UV scanners, IR scanners, and UV+IR scanners.

6.4.3 [●] The purchaser shall specify when the pilot detection is required to be independent of main burner flame detection.

NOTE When independent pilot flame sensing is required, positioning and design of the flame detection device needs to be carefully considered to ensure that pilot flameout is detected while the burner flame is still on.

6.4.4 The pilot flame detection device shall be capable of detecting a flame across the operating envelope of the pilot.

6.5 Stable Operating Envelope

6.5.1 The vendor shall provide the maximum and minimum fuel pressure required to maintain pilot stability.

6.5.2 The pilot shall be stable within a range of 50 % to 150 % from the target pilot gas pressure.

6.5.3 The pilot shall be stable independent of the burner air register setting (including rapid rates of air register change).

6.5.4 The pilot shall remain stable when the burner fuel valve is opened or closed quickly, e.g. one to two seconds.

NOTE Premised on the expectation that the burner fuel valve operation does not affect the pilot fuel gas pressure.

6.5.5 The pilot shall be stable with a back pressure at the pilot tip of 25.4 mmH₂O (1 in.H₂O).

6.5.6 The pilot shall be stable with 50.8 mmH₂O (2 in.H₂O) over the burner design draft or airside pressure loss.

NOTE When pilot testing is required, testing of the conditions specified in [6.5.5](#) and [6.5.6](#) may need to be conducted in a separate test furnace than used for the burner test.

6.6 Transient Operations

6.6.1 [●] The purchaser shall specify any abnormal transient operational requirements.

7 Mechanical Requirements—Burners

7.1 General Requirements

7.1.1 All components subject to fuel gas fouling shall be removable from outside the burner assembly without crossing the plane of any burner opening, thereby avoiding confined-space entry.