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**Erdöl-, petrochemische und Erdgasindustrie –
Fackeln für den allgemeinen Betrieb in Raffinerien und petrochemischen
Service (ISO 25457:2008);
Englische Fassung EN ISO 25457:2008**

Petroleum, petrochemical and natural gas industries –
Flare details for general refinery and petrochemical service (ISO 25457:2008);
English version EN ISO 25457:2008

Industries du pétrole, de la pétrochimie et du gaz naturel –
Détails sur les torches d'usage général dans les raffineries et dans les usines
pétrochimiques (ISO 25457:2008);
Version anglaise EN ISO 25457:2008

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Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) im DIN

Nationales Vorwort

Dieses Dokument (EN ISO 25457:2008) wurde vom Technischen Komitee CEN/TC 12 „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ (Sekretariat: AFNOR, Frankreich) erstellt. Es handelt sich dabei um die unveränderte Übernahme von ISO 25457:2008, erarbeitet von ISO/TC 67 „Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries“.

Für Deutschland hat hieran der NA 109-00-01 AA „Materialien, Ausrüstungen und Offshore-Bauwerke für die Erdöl-, petrochemische und Erdgasindustrie“ im Normenausschuss Erdöl- und Erdgasgewinnung (NÖG) mitgearbeitet.

Diese Europäische Norm enthält unter Berücksichtigung des DIN-Präsidialbeschlusses 1/2004 nur die englische Originalfassung der EN-ISO-Norm.

Diese Norm enthält neben den gesetzlichen Einheiten auch die Einheiten „BTU/h“, „BTU/scf“, „°F“, „ft“, „in (inch)“, „lb“, „lb/ft²“, „mph“, „NPS“, „PS (HP)“, und „psig“, die im Deutschen Normenwerk nicht zugelassen sind. Es wird jedoch ausdrücklich darauf hingewiesen, dass die Anwendung dieser Einheiten im nationalen amtlichen und geschäftlichen Verkehr aufgrund des Gesetzes über Einheiten im Messwesen nicht zulässig ist.

Umrechnung:

Nicht-SI-Einheit	SI-Einheit	Umrechnung
BTU/h	kJ/h	1 BTU/h = 1,055 kJ/h
BTU/scf	kJ/Nm ³	1 BTU/scf = 37,25 kJ/Nm ³
°F	°C	°C = [(5/9) · (°F – 32)]
ft	m	1 ft = 0,304 8 m
in (inch)	mm	1 inch = 25,4 mm
lb (pound)	kg	1 lb = 0,453 592 37 kg
lb/ft ²	kg/m ²	1 lb/ft ² = 4,882 kg/m ²
mph	km/h	1 mph = 1,6 km/h
NPS	DN	1 NPS = DN 25
PS (HP)	kW	1 PS = 0,74 kW
psig	kPa	1 psig = 6,894 757 kPa

English Version

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Erdöl-, petrochemische und Erdgasindustrie —
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petrochemischen Service
(ISO 25457:2008)

This European Standard was approved by CEN on 11 December 2008.

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Foreword

This document (EN ISO 25457:2008) has been prepared by Technical Committee ISO/TC 67 “Materials, equipment and offshore structures for petroleum and natural gas industries” in collaboration with Technical Committee CEN/TC 12 “Materials, equipment and offshore structures for petroleum, petrochemical and natural gas industries” the secretariat of which is held by AFNOR.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2009, and conflicting national standards shall be withdrawn at the latest by June 2009.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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Endorsement notice

The text of ISO 25457:2008 has been approved by CEN as a EN ISO 25457:2008 without any modification.

Introduction

Users of this International Standard should be aware that further or differing requirements may be needed for individual applications. This International 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 International Standard and provide details.

In International Standards, the SI system of units is used. Where practical in this International Standard, US Customary units are included in brackets for information.

A bullet (●) at the beginning of a clause or subclause indicates that either a decision is required or further information is to be provided by the purchaser. This information should be indicated on data sheets (see examples in Annex E) or stated in the enquiry or purchase order.

1 Scope

This International Standard specifies requirements and provides guidance for the selection, design, specification, operation and maintenance of flares and related combustion and mechanical components used in pressure-relieving and vapour-depressurizing systems for petroleum, petrochemical and natural gas industries.

Although this International Standard is primarily intended for new flares and related equipment, it is also possible to use it to evaluate existing flare facilities.

Annexes A, B and C provide further guidance and best practices for the selection, specification and mechanical details for flares and on the design, operation and maintenance of flare combustion and related equipment.

Annex D explains how to use the data sheets provided in Annex E; it is intended that these data sheets be used to communicate and record design information.

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.

ISO 1461, *Hot dip galvanized coatings on fabricated iron and steel articles — Specifications and test methods*

ISO 2408:2004, *Steel wire ropes for general purposes — Minimum requirements*

ISO 8501-1:2007, *Preparation of steel substrates before application of paints and related products — Visual assessment of surface cleanliness — Part 1: Rust grades and preparation grades of uncoated steel substrates and of steel substrates after overall removal of previous coatings*

ISO 10684, *Fasteners — Hot dip galvanized coatings*

ISO 13705:2006, *Petroleum, petrochemical and natural gas industries — Fired heaters for general refinery service*

ISO 15156 (all parts), *Petroleum and natural gas industries — Materials for use in H₂S-containing environments in oil and gas production*

ISO 23251, *Petroleum, petrochemical and natural gas industries — Pressure-relieving and depressuring systems*

EN 1092-1:2007, *Flanges and their joints — Circular flanges for pipes, valves, fittings and accessories, PN designated — Part 1: Steel flanges*

EN 10264-2:2002¹⁾, *Steel wire and wire products — Steel wire for ropes — Part 2: Cold drawn non alloy steel wire for ropes for general applications*

EN 12385-10, *Steel wire ropes — Safety — Part 10: Spiral ropes for general structural applications*

API RP 2A WSD:2000²⁾, *Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms — Working Stress Design*

ASME B16.5-2003³⁾, *Pipe Flanges and Flanged Fittings*

1) Comité Européen de Normalisation, 36, rue de Stassart, B-1050 Brussels, Belgium.

2) American Petroleum Institute, 1220 L Street, N.W., Washington, D.C. 20005, USA.

ASME STS-1, *Steel Stacks*

ASTM A 123/A123M⁴⁾, *Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products*

ASTM A 143/A143M, *Standard Practice for Safeguarding Against Embrittlement of Hot-Dip Galvanized Structural Steel Products and Procedure for Detecting Embrittlement*

ASTM A 153/A153M, *Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware*

ASTM A 384/A384M, *Standard Practice for Safeguarding Against Warpage and Distortion During Hot-Dip Galvanizing of Steel Assemblies*

ASTM A 385, *Standard Practice for Providing High-Quality Zinc Coatings (Hot-Dip)*

ASTM A 475-03, *Standard Specification for Zinc-Coated Steel Wire Strand*

ASTM A 586-04, *Standard Specification for Zinc-Coated Parallel and Helical Steel Wire Structural Strand*

ASTM B 633, *Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel*

NACE MR0103:07⁵⁾, *Materials Resistant to Sulfide Stress Cracking in Corrosive Petroleum Refining Environments*

SSPC SP 6/NACE No. 3⁶⁾, *Joint Surface Preparation Standard: Commercial Blast Cleaning*

3 Terms and definitions

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

3.1

air seal

purge reduction device

device used to minimize or eliminate the intrusion of air back into the riser from the exit

EXAMPLE Buoyancy seal, orifice seal, velocity seal.

3.2

assist gas

fuel gas that is added to relief gas prior to the flare burner or at the point of combustion in order to raise the heating value

NOTE In some designs, the assist gas can increase turbulence for improved combustion.

3.3

back blowing

procedure by which the dry air seal drain line is blown back from the base of the drain into the buoyancy seal to ensure the line is clear

3) American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10017, USA.

4) American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA.

5) NACE International, P.O. Box 218340, Houston, TX 77218-8340, USA.

6) The Society for Protective Coatings, 40 24th Street, 6th Floor, Pittsburgh, PA 15222-4643, USA.

3.4

blowoff

loss of a stable flame where the flame is lifted above the burner, which occurs when the fuel velocity exceeds the flame velocity

3.5

buoyancy seal

diffusion seal

dry vapour seal that minimizes the required purge gas needed to protect from air infiltration

NOTE The buoyancy seal functions by trapping a volume of light gas in an internal inverted compartment that prevents air from displacing buoyant light gas in the flare.

3.6

burnback

internal burning within the burner

NOTE Burnback can result from air backing down the flare burner at purge or low flaring rates.

3.7

burn-pit flare

open excavation, normally equipped with a horizontal flare burner that can handle liquid as well as gaseous hydrocarbons

3.8

burning velocity

flame velocity

speed at which a flame front travels into an unburned combustible mixture

3.9

coanda flare

flare burner that is designed to employ the aerodynamic effect where moving fluids follow a curved or inclined surface over which they flow

NOTE Flares of this type generally use steam or pressure to achieve smokeless performance.

3.10

combustion air

air required to combust the flare gases

3.11

combustion efficiency

percentage of the combustible fluid totally oxidized in the burner

NOTE In the case of hydrocarbons, combustion efficiency is the mass percent of carbon in the original fluid that oxidizes completely to CO₂.

3.12

condensable gas

vapour that can condense at the temperature and pressure expected in a flare header during or after a flaring event

3.13

cryogenic service

systems that may be called upon to handle waste gas below -40 °C (-40 °F)

3.14

derrick support

support system for the elevated flare riser, normally used for very tall flares or when plot space is limited

NOTE Various derrick-supported arrangements are available: a fixed system has its riser permanently supported to the derrick; a demountable derrick has multiple riser sections that are designed such that they can be lowered and removed to permit lowering of the flare burner to grade; a demountable derrick with one fixed riser provides for a single-piece design that can be lowered to grade as a single component.

3.15

design flare capacity

maximum design flow to the flare

NOTE The design flare capacity is normally expressed in kilograms per hour (pounds per hour) of a specific composition, temperature, and pressure.

3.16

destruction efficiency

mass percent of the combustible vapour that is at least partially oxidized

NOTE In the case of a hydrocarbon, destruction efficiency is the mass percentage of carbon in the fluid vapour that oxidizes to CO or CO₂.

3.17

detached stable flame

flame that is not in contact with the flare burner itself but burns with a stable flame-front in the vicinity of the flare burner

3.18

direct ignition

ignition of a flare flame by a high-energy source rather than by a pilot flame

3.19

dispersion

scattering of the products of combustion over a wide area to reduce ground-level concentrations of the combustion products

3.20

enclosed flare

flare enclosure with one or more burners arranged in such a manner that the flame is not directly visible

3.21

endothermic flare

flare that utilizes outside energy, usually assist or enrichment gas, to maintain the combustion reaction

3.22

enrichment

process of adding assist gas to the relief gas

3.23

elevated flare

flare where the burner is raised high above ground level to reduce radiation intensity and to aid in dispersion

3.24

excess air

air provided to a flame in excess of stoichiometric requirements

3.25

exit velocity

velocity at which the design flare capacity exits the burner

NOTE The exit velocity is usually expressed as metres per second (feet per second) or as a fraction of the Mach number for the fluid.

3.26

flame detection system

flame monitor

system that verifies a flame is present

3.27

flame front generator

device used for lighting a pilot by means of a flame front

NOTE A combustible gas-air mixture is created and allowed to fill an ignition line connecting the flame front generator and the pilot. Igniting the mixture allows the flame front to travel through the ignition line to the pilot.

3.28

flame retention device

physical device meant to prevent flame blowoff from a flare burner

3.29

flare

device or system used to safely dispose of relief fluids in an environmentally compliant manner through the use of combustion

3.30

flare burner

flare tip

part of the flare where fuel and air are mixed at velocities, turbulence and concentration required to establish and maintain proper ignition and stable combustion

NOTE The name "flare burner" is considered more appropriate than "flare tip" given the engineered nature of design and inclusion of measures for flame stabilization, most often of proprietary design.

3.31

flare header

piping system that collects and delivers the relief gases to the flare

3.32

flare stack

flare boom

flare tower

mechanical device upon which an elevated flare burner is mounted

3.33

flashback

phenomenon occurring in a flammable mixture of air and gas when the local velocity of the combustible mixture becomes less than the flame velocity, causing the flame to travel back to the point of mixture

3.34

ground flare

non-elevated flare

NOTE A ground flare is normally an enclosed flare but may also refer to a ground multi-burner flare or a burnpit.

3.35

guyed flare

elevated flare with the riser kept from overturning using cables

NOTE A typical guyed flare is shown in Figure A.2.

3.36

heat release

total heat liberated by combustion of the relief gases based on the lower heating value

NOTE The heat release is expressed in kilowatts (British thermal units per hour).

3.37

higher heating value

HHV

gross heating value

total heat obtained from the combustion of a specified fuel at 16 °C (60 °F)

NOTE The higher heating value includes the latent heat of vaporization of water in the combustion products (including the water already present in the flare gas).

3.38

lower heating value

LHV

net heating value

higher heating value minus the latent heat of vaporization of the water (both the water formed in the combustion products and that already present in the flare gas)

3.39

knockout drum

vessel in the flare header designed to remove and store condensed and entrained liquids from the relief gases

3.40

liquid seal

water seal

device that directs the flow of relief gases through a liquid (normally water) on their path to the flare burner, used to protect the flare header from air infiltration or flashback, to divert flow or to create backpressure for the flare header

3.41

Mach number

ratio of a fluid's velocity, measured relative to some obstacle or geometric figure, divided by the speed at which sound waves propagate through the fluid

3.42

manifold

device for the collection and/or distribution of a fluid to or from multiple flow paths

3.43

multi-burner flare

group of burners designed to burn all or a portion of the design flow capacity, which are often arranged in stages to facilitate better burning

NOTE Multi-burner flares are capable of smokeless combustion at high flow rates with lower radiation levels.

3.44

muffler

device that mitigates noise

3.45

multi-point flare

single flare burner with multiple separate exits

3.46

opacity

degree of non-transparency to rays of light

NOTE The opacity is quantified by the Ringelmann number.

3.47

pilot

small, continuously operating burner that provides ignition energy to ignite and/or stabilize combustion of the flared gases

3.48

pin-actuated device

non-reclosing pressure-relief device actuated by static pressure and designed to function by buckling or breaking a pin that holds a piston or plug in place; upon buckling or breaking of the pin, the piston or plug instantly moves to its full open position

3.49

pressure design code

recognized pressure equipment standard specified or agreed by the purchaser

EXAMPLES ASME VIII or EN 13445 (all parts) for pressure vessels; ISO 15649, EN 13480 (all parts) or ANSI/ASME B31.3 for piping.

3.50

purge gas

fuel gas or non-condensable inert gas added to the flare header to mitigate air ingress and burnback

3.51

radiation intensity

radiant heat transfer rate from the flare flame

NOTE The rate is usually considered at grade level.

3.52

relief gas

waste gas

flared gas

waste vapour

gas or vapour vented or relieved into a flare header for conveyance to a flare

3.53

Ringelmann number

visually comparative scale used to define levels of opacity, where clear is 0, black is 5 and 1 through 4 are increasing levels of gray as used in describing smoke from combustion of hydrocarbons

NOTE The Ringelmann number is often used to describe the intensity of smoke.

3.54

riser

pipe or other conduit that conveys the relief gas, combustion air, etc. to the flare burner of an elevated flare

3.55

smokeless capacity

range of flow to a flare burner that can be burned without smoke

NOTE The term without smoke can be quantified using the **Ringelmann number** (3.53).

3.56

staged flare

group of two or more flares or burners that are controlled so that the number of flares or burners in operation is proportional to the relief-gas flow

3.57

stoichiometric air

chemically correct quantity of air, i.e., a quantity capable of perfect combustion with no unused fuel or air

3.58

structural design code

recognized structural standard specified or agreed by the purchaser

EXAMPLES AISC S302, ASCE 7, AWS D1.1/D1.1M.

3.59

supplemental gas

fuel gas burned external to a flare burner in order to facilitate the burning of low-heating-value relief gas

3.60

thermocouples

temperature-measuring devices used to detect whether the pilot is in operation

3.61

velocity seal

orifice seal

dry vapour seal that minimizes the required purge gas needed to protect against air infiltration into the flare burner exit

3.62

wind fence

structure surrounding a flare at ground level to modify the effect of crosswinds on the combustion process, to prevent unauthorized access, limit the radiation to the surroundings and/or make the flame non-visible to the neighbors

See Figure A.7.

3.63

windshield

device used to protect the down-wind side of an elevated flare burner from direct flame impingement

NOTE Windshields are also integral to the design of pilots to avoid flame-outs during bad/stormy weather.

4 Design

4.1 Introduction

A flare is a critical mechanical component of a complete system design intended for the safe, reliable and efficient discharge and combustion of hydrocarbons from pressure-relieving and vapour-depressurizing systems. Being critical to the safety of an operating plant, a flare shall be continuously available with high reliability and capable of its intended performance through all operating-plant emergency conditions, including a site-wide general power failure. The flare and related mechanical components shall be designed to operate and properly perform for the specified service conditions for a minimum of five years without the need for an outage of the operating facility.

Although flare availability and reliability are strongly dependent on the design of the related mechanical equipment, proper training, installation, commissioning, and operating and maintenance practices are critical to ensuring the safety of plant personnel, the operating facility and the general public. Management systems shall be in place which

- a) clearly document the intended capacity, performance and operational limitations of the pressure-relieving and vapour-depressurizing systems and flare,
- b) provide operating procedures and operator training, and
- c) provide planned and routine maintenance of components critical to the safety and operating goals.

The high-level safety and operating goals of a flare are summarized as follows:

- to provide safe, reliable and efficient discharge and combustion of hydrocarbons with a high combustion efficiency;
- to ensure that the discharged hydrocarbons burn with stable combustion over the entire defined operating range;

- to ensure a continuity of the flare flame under severe weather conditions;
- to ensure that ground level concentrations of specified compounds do not exceed environmental limits;
- to ensure that the back pressure does not exceed the maximum allowable;
- to ensure that velocity throughout the flare piping and the flare burner does not exceed the maximum specified;
- to ensure that the opacity limit at the smokeless flow rate range does not exceed that defined;
- to ensure that the flare radiation intensity does not exceed the maximum allowable;
- to ensure that noise levels do not to exceed the maximum permissible.

For new designs, the development of a design can be advanced by using the guidance and examples of good engineering practice that are identified in this document.

A flare design basis is developed in consideration of the performance expectations, the functional requirements and mechanical details required to achieve the safety and operating goals established for each application. In 4.2 to 4.11, objectives are identified that establish the safety and operating goals together with the functional requirements that enable the objectives to be achieved. Clauses 5 and 6 provide functional requirements more specific to the arrangement and mechanical details of design.

The functional requirements in this International Standard are supported by the technical guidance provided in Annexes A, B and C. The technical guidance provided in the informative annexes addresses alternative designs or techniques and provides good practices on the basis of which, through sound engineering judgment, the practitioner can make appropriate design decisions and selections.

The finalized basis of design shall be recorded on data sheets (e.g., those provided in Annex E) in order to properly communicate requirements and preserve design information. Annex D provides instructions for completing the flare data sheets in Annex E.

4.2 System design

4.2.1 Objective

The objective is to identify fundamental requirements, specific design criteria and information consistent with the delivery of the critical safety and operating goals of the specific flare under design.

4.2.2 Functional requirements

Fundamental system design requirements are established primarily in accordance with ISO 23251, from which the following aspects shall be defined on the data sheets:

- design-flow cases from the pressure-relieving and vapour-depressurizing system, including maximum continuous case and maximum intermittent case;
- flare staging requirement and method;
- allowable flare-burner exit velocity;
- system hydraulics with respect to allowable pressure drop, static pressure and diameter of the flare;
- environmental performance requirements related to smokeless capacity, opacity limits and permissible noise limits;

- operating performance, such as peak radiation intensity at grade;
- functional description of the intended system operation;
- selection of major system components that can be integral to the flare, such as a knockout drum, liquid seal, buoyancy seal, purge-reduction device, etc.;
- site and ambient design conditions; and
- utilities available.

4.3 Process definition

4.3.1 Objective

To provide a clear process definition for the flare ensuring all capacity and process stream characterization information relevant to the system performance and mechanical design considerations are provided.

4.3.2 Functional requirements

In addition to the functional system design requirements as defined in 4.2, complete composition, range of temperature and hydrocarbon characterization information of the process stream(s) shall be provided. In consideration that various operating or pressure-relieving cases can individually define various aspects of the design, i.e. hydraulic capacity, ground-level radiation, aeration requirement for the defined smokeless capacity, requirement for dilution gas, design metal temperature, thermal expansion, etc., multiple cases together with expected duration and frequency should be provided to permit the designer to determine which cases control the design.

The potential for liquid introduction or the condensation of hydrocarbons, or the formation of hydrates in the flare header or flare riser, which can be carried to the combustion zone, shall be considered by both the user and the flare designer. Hydrocarbon droplets entrained in the gas stream that are carried into the flame usually burn incompletely, can produce burning liquid droplets, form soot and decrease the smokeless capacity of the flare. The maximum liquid-droplet size that can enter the combustion zone and can be handled within achievable measures for smokeless control depends on the burner design. ISO 23251 gives further guidance on the maximum droplet size for different types of burners.

Flare-system knockout-drum design and heat-tracing systems downstream of the knockout drum shall be designed in consideration of these potential problems.

Process definition is primarily established in ISO 23251.

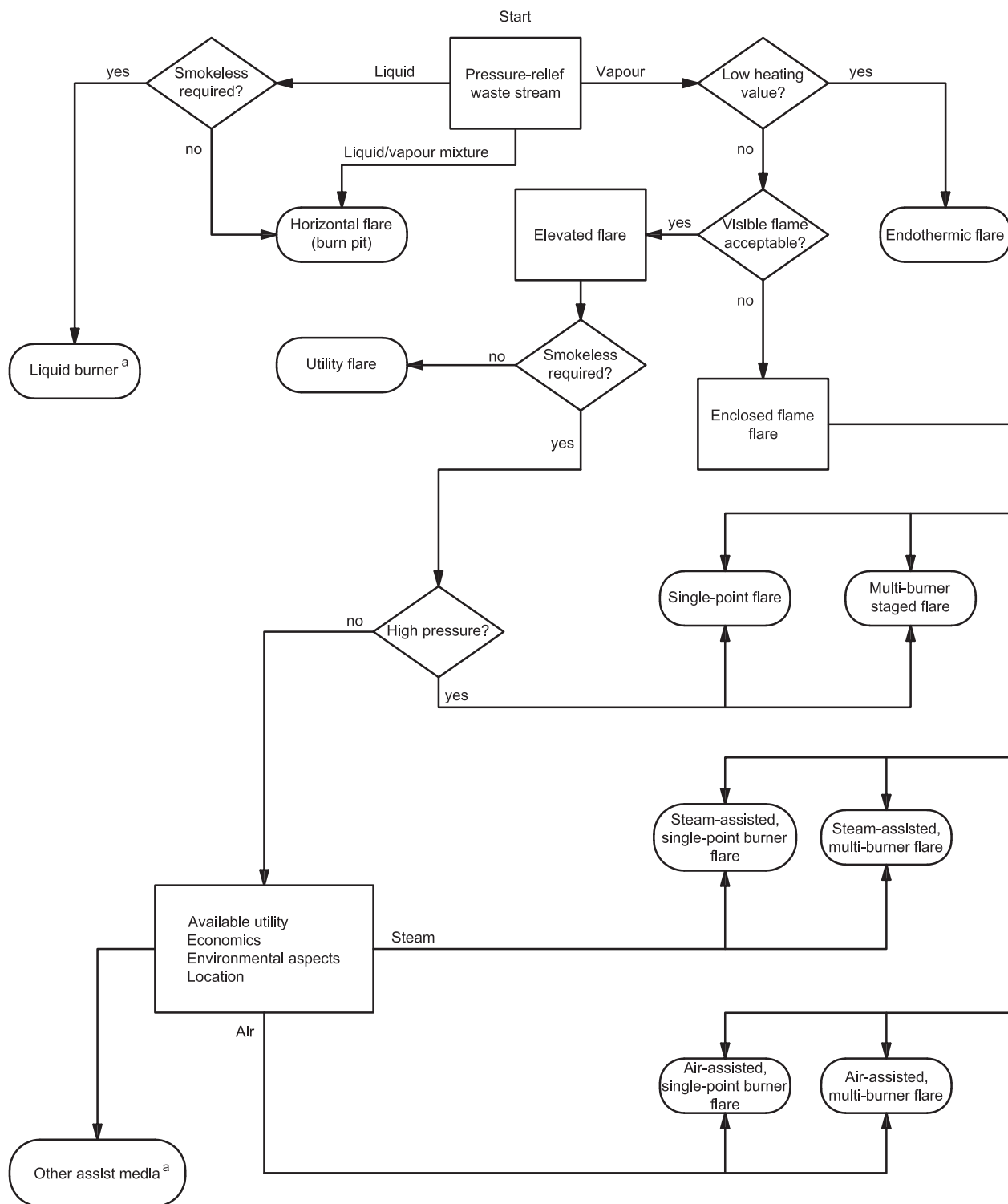
4.4 Types of flares

4.4.1 Objective

To identify and select the most appropriate type and configuration of a flare.

4.4.2 Functional requirements

Through an understanding of the process, performance and operability needs requirements for the flare, and with consideration of the mechanical, operability and maintenance implications for each, the designer shall specify the most appropriate type of flare, configuration and components to meet the safety, operability and the functional requirements established through use of this International Standard. Refer to Figure 1 for a general flare type selection guide. Within each general type of flare, various alternatives and proprietary design aspects can exist. An understanding of alternatives and/or proprietary design aspects can be obtained and evaluated using the data sheets in Annex E and instructions on their use in Annex D.



^a Liquid burners and other assist media, such as high-pressure gas or water, are not typically used in refinery and petrochemical plant services but have been used in production facilities. These technologies are outside the scope of this International Standard.

Figure 1 — Flare type selection

For further guidance on the types of flares, the mechanical details and the requirements of design for each, refer to Clauses 5 and 6 and Annexes A, B and C. Decisions on functional requirements shall be documented in the data sheets.

4.5 Flare burners

4.5.1 Objective

The objective is to identify the critical performance attributes for a flare burner.

4.5.2 Functional requirements

The type of flare and configuration is primarily established through consideration and application of the procedures, practices and recommendations of this International Standard. The most critical mechanical component integral to all flare types is the flare burner, with which all aspects of safe, reliable and efficient discharge and combustion of relief gases from the flare system are associated. The integrity and reliability of this component has a direct effect on the operability and run length between maintenance intervals for the facility. A flare burner supplied in accordance with this International Standard shall perform as specified under the defined service conditions for a minimum of five years when installed and operated in accordance with the manufacturer's recommendations. Although many design alternatives for flare burners exist, including those of a proprietary nature, the following are the functional requirements that shall be met.

a) For all flare burners:

- Flare burners shall incorporate flame-retention devices or aerodynamic methods with proven capability to provide stable combustion and protection from flame blow-off.
- Air or steam injection, if applied, shall not disrupt the basic flame stabilization mechanisms of the flare burner.
- Flare burners in combination with their system of pilot(s)/ignition system(s) shall be capable of maintaining stable combustion of the main flame for the specified service conditions, including the environmental conditions as specified for pilots in this International Standard.

b) For flare burners with internal steam injection to induce air:

- Steam condensate shall be drained from the internal steam/air injection point and from any muffler surrounding these tube assemblies.

4.6 Mechanical design

4.6.1 Objective

To define the requirements for the design, fabrication, inspection and testing of the mechanical components of the flare.

4.6.2 Functional requirements

There are numerous physical arrangements and mechanical designs available from which to select the most appropriate for the application, in accordance with the local codes and regulations. Whichever selection is made, the following shall apply.

- a) The pressure design code shall be specified or agreed by the purchaser. Pressure components shall comply with the pressure design code and the supplemental requirements in this International Standard.
- b) The structural and mechanical design codes shall be specified or agreed by the purchaser. Structural components shall comply with the structural design code and the supplemental requirements in this International Standard.
- c) The purchaser and the vendor shall mutually determine the measures required to comply with any local or national regulations applicable to the equipment.

If the flare mechanical design involves both pressure and structural design codes (e.g. self-supported or guyed flares), then the more severe shall govern.

- d) The purchaser shall specify the design temperature and design pressure.

For uninsulated flare risers, it is not necessary to consider that the maximum design temperature and wind loads apply simultaneously because of the cooling effect of the wind. For the design wind case, a credible metal temperature under design wind conditions shall be established, listed on the data sheet and used in the design.

For insulated or shielded flare risers, design temperature and wind loads shall be considered to apply simultaneously.

Further guidance on metal temperature considerations is given in D.3.3, Form Elev 4.

The following shall be taken into account in the mechanical design:

- flared stream temperature, pressure and composition;
- corrosive nature and liquid content of the flared stream;
- ambient conditions;
- site conditions;
- wind, snow and ice loading;
- seismic loading;
- jet loads associated with high-velocity flare burners;
- cyclic loading, vibration (fatigue);
- hydraulic forces, as are possible with blow-dry liquid seals;
- pressure waves, as are possible with staged flares;
- proximity to equipment, structures, thoroughfares and site boundaries;
- maintenance and inspection criteria;
- contraction/expansion of stack due to ambient or process changes;
- pressure due to flashback, if specified by the purchaser.

NOTE The use of a reliable purge can preclude the requirement to design for flashback pressure.

4.7 Pilots

4.7.1 Objective

The objective is to reliably light the flare burner and maintain stable combustion throughout the full range of process conditions, including under severe weather conditions, without the requirement for maintenance for at least five years of operation, unless the pilot is accessible for on-stream maintenance.

NOTE It is recognized that in some extreme services, such as burn-pit flares, this five-year lifetime might be unachievable.

4.7.2 Functional requirements

There are numerous pilot designs available from which to select the most appropriate for the application. Although design alternatives exist, the following are the functional requirements that shall be met.

- Pilots shall be continuously burning.
- Pilots shall reliably light the flare flame on single- and multi-burner flares.
- Minimum pilot heat release shall be 13,2 kW (45 000 Btu/h).
- Pilots shall remain lit even if the flaring gases are not flammable.
- Pilots shall remain lit and capable of being relit at wind speeds up to 160 km/h (100 mph) under dry conditions and 140 km/h (85 mph) when combined with at least 50 mm (2 in) of rainfall per hour. This performance shall be verified by type testing in accordance with a documented test protocol and documented results. A typical test protocol is given in Clause A.6.
- The minimum number of pilots shall be in accordance with Table 1.

Table 1 — Number of pilots for a single-point flare

Minimum number of pilots	Flare burner outlet diameter (DN)	Flare burner outlet diameter (NPS)
1 ^a	≤ 200	≤ 8
2	> 200, ≤ 600	> 8, ≤ 24
3	> 600, ≤ 1 050	> 24, ≤ 42
4	> 1 050, ≤ 1 500	> 42, ≤ 60
b	> 1 500	> 60
^a For toxic gas, the minimum number shall be two. ^b To be agreed with the purchaser.		

- Pilot tip and components exposed to flame shall be constructed of a heat-resistant material, e.g. AISI 309, 310, 310H, etc.
- For self-aspirating pilots, the air inlet shall be located so that it has uninterrupted air access and shall be at least 1,8 m (6 ft) or 125 % of the actual burner diameter (whichever is greater) from the top of the flare.
- For self-aspirating pilots, a strainer shall be installed at grade for protection of the pilot regulator. A strainer or settling chamber shall also be installed just upstream of the gas orifice unless the piping between the grade strainer and the gas orifice is stainless steel.
- Individual fuel-supply lines shall be installed to each pilot, if required, to improve operability and reliability of the pilots.
- Piping and components between the pilot tip and the air mixer shall be constructed of austenitic stainless steel.
- Pilots shall be designed for the specified fuel gas supply.
- A continuous source of clean fuel, which is regulated in pressure and has a defined range of heating value and composition (e.g. natural-gas quality), shall be supplied to the pilot.
- Each pilot shall have at least one dedicated means of ignition and one dedicated means of pilot-flame detection.

For guidance on pilot selection, maintenance and troubleshooting, refer to Clause A.3.

4.8 Pilot-ignition systems

4.8.1 Objective

The objective is to reliably light the pilot.

4.8.2 Functional requirements

There are numerous pilot ignition system designs available from which to select the most appropriate for the application. Although design alternatives exist, the following are the functional requirements that shall be met.

- The pilot ignition system shall be able to reliably light the pilot, including at wind speeds of up to 160 km/h (100 mph) under dry conditions and 140 km/h (85 mph) when combined with at least 50 mm/h (2 in/h) of rainfall. This performance shall be verifiable by type testing in accordance with a documented test protocol and documented results. A typical test protocol is given in Clause A.6,
- The pilot ignition system shall be able to light the pilot during all defined operating and emergency relief cases, including a site-wide general power failure.
- It shall be possible to ignite each pilot independently of the other pilots without depending on the flare flame for ignition.

For guidance on pilot ignition equipment selection, maintenance and troubleshooting, refer to Clause A.4.

4.9 Pilot-flame detection

4.9.1 Objective

The objective is to confirm that pilots are lit.

4.9.2 Functional requirements

There are numerous pilot-flame detection system designs available from which to select the most appropriate for the application. Although design alternatives exist, the following are the functional requirements which shall be met.

- The pilot-flame detection system shall be able to distinguish between pilot flame and flare-burner flame.
- The pilot-flame detection system shall be able to detect the pilot flame, including at wind speeds of up to 160 km/h (100 mph) under dry conditions and 140 km/h (85 mph) when combined with at least 50 mm/h (2 in/h) of rainfall. This performance shall be verifiable by testing in accordance with a documented test protocol and documented results. A typical test protocol is given in Clause A.6.
- Each pilot shall have at least one dedicated means of pilot-flame detection.

For guidance on pilot-flame detection equipment selection, maintenance and troubleshooting, refer to Clause A.5.

4.10 Piping

4.10.1 Objective

The objective is to specify the requirements for piping attached to the flare riser or support structure.

4.10.2 Functional requirements

Design criteria of the pipe shall be in accordance with the pressure design code. The material of the piping shall be selected on the basis of the fluids being transported in the piping, temperature and pressure of the fluids and potential ambient temperature impact.

Flanges shall be kept to a minimum since they can be a source of leakage.

Piping shall be evaluated for expansion due to the difference in temperature between the piping and the support structure. If necessary, expansion loops shall be used in the piping on the stack and, in particular, on steam lines. Expansion joints should be avoided due to their tendency to leak and the difficulties in their maintenance. It is recognized, however, that they are sometimes unavoidable but should be limited to steam lines only. Movement of the piping interface point should be specified by the flare system designer and accommodated in the inlet piping.

All piping shall be considered in the structural analysis of the wind and earthquake loads, including any insulation (whether applied before shipment or applied on site).

Piping shall be designed for all operating and test loads, including water-filled steam piping.

4.11 Auxiliary components

4.11.1 Objective

The objective is to provide a clear definition for the auxiliary components included with the flare and their effect on the design of the flare.

4.11.2 Functional requirements

There are numerous auxiliary components available from which to select those that are appropriate for the mechanical design considerations of the flare. The following are the functional requirements that shall be met.

- The flare-stack structural design shall consider the loads due to any auxiliary component directly attached to or incorporated into the design flare stack, e.g. ladders and platforms, axial blower and ducting, buoyancy seal, seal drum, etc.
- For parallel flares, at least one liquid seal or some other means of automatic isolation shall be provided downstream of the branch between the two flares.
- Flares in cryogenic service shall be equipped with means to prevent blockage that can be caused by the freezing of trapped water during a cryogenic relief. Special attention shall be given to liquid seals and buoyancy seals.
- Where there is the potential for solids formation, hydrates or liquid freezing under cold-climate conditions, heat-tracing system requirements shall be considered.

5 Mechanical details — Elevated flares

5.1 Mechanical design — Design loads

Clause 5 covers the support structure and includes both single-burner and multi-burner elevated flares.

General descriptions of several methods that can be used to support a vertical flare are given in Clause A.1.

The design of a support structure for a vertical, elevated flare shall consider, as a minimum, the design loads given below, as appropriate. The designer shall review the intended application and may ignore loads that are not applicable.

a) Wind loadings

These shall take into account the riser and all of its appurtenances such as, but not limited to, piping (including insulation, if any), access platforms and ladders. When appropriate, the wind loading on supporting derrick structures shall be included. Wind loads shall be based on the local regulations, e.g. ASCE 7.

b) Earthquake-induced loads

These shall be based on the local regulations, e.g. ICBO or ASCE 7. Structural design shall be based on wind loads and earthquake loads occurring separately.

c) Wind-induced vibration loads

The structural design for wind-induced vibration shall be in accordance with the ISO limit-state method in ISO 13705:2006, Annex H, or ASME STS-1.

d) Internal pressure

Flare stacks are generally operated at near-atmospheric pressure and are not specifically designed as pressure equipment. Exceptions to this include conditions when the flare burner creates a backpressure in the flare riser that causes the pressure design code to become applicable. In some cases, the bottom portion of the stack incorporates a knockout drum or liquid seal, or both. When specified in the data sheets, the stack portion containing the knockout drum or liquid seal may be designed as a pressure vessel including, if specified, hydrostatic testing and code stamping. In such cases, the design of the pressure-vessel portion shall be in accordance with the pressure design code and shall be based on the design pressure stated in the data sheets or at least 105 kPa (ga) [15 psig]. It is common practice that the riser section of the stack be designed for structural loads and the anticipated maximum operating pressure when the base section of the stack is designed as a pressure vessel. For design purposes, the riser section is deemed to start at the pressure vessel outlet. The design of a stack base section that is a pressure vessel shall include provision for internal pressure loads and for simultaneous wind loads based on 70 % of the design wind velocity. The design pressure (maximum allowable working pressure) of a stack-base section that is a pressure vessel shall not be increased due to any material thickness that is in excess of that thickness required to meet the design pressure.

e) Jet loads

In consideration of sonic-type flares with an exit velocity greater than Mach 0,8, special considerations related to vibration and fatigue shall be considered in the mechanical design. Refer to A.2.6 for guidance. The requirement for vibration and fatigue analysis shall be mutually agreed between purchaser and supplier.

f) Flashback pressure

If the purchaser has specified that flashback pressure be taken into account, the pressure used in the calculations shall be specified by the purchaser.

g) Nozzle loads

These are imposed on the stack by the flare-header-to-stack connection and can have a major influence on the design and cost of the flare stack. This influence increases as the elevation of the flare-header increases. In general, the flare stack itself should not be used as a fixed anchor point for the flare-header piping. The purchaser shall specify the preliminary flare-header-imposed nozzle loads on the data sheets furnished to the vendor with the enquiry. The purchaser shall provide final flare-header-imposed nozzle loads during the design phase. The purchaser should minimize the nozzle loads imposed on the stack by

other service connections. If the purchaser does not furnish nozzle-load information, the flare supplier shall use the nozzle-allowable forces and moments specified in Table 2. The purchaser shall also define the loads and moments of the external piping nozzles (for steam, fuel-gas-to-pilot, etc.). If the purchaser does not impose them, then the designer shall select them.

h) Thermal loads

Some of the relief-gas cases described in the data sheets can have a gas temperature that is different from ambient. The flare-stack designer shall provide for thermal expansion and contraction that can be caused by a specified gas temperature or by temperature differences caused by wind or rain. Thermal loads are of greatest concern on guyed stacks and derricks. Special attention shall be given to the design of stacks where the stack wall temperature is expected to be 175 °C (350 °F) or higher. A hot stack wall, cooled on one side by wind or a combination of wind and rain, bends, inducing additional loads on the stack, guy wires or derrick and foundations. Counter-measures include shielding or insulating of the stack. The freedom of movement of a self-supported stack reduces the thermal load considerations, providing that the thermally induced deflection does not exceed 450 mm per 30 m (18 in per 100 ft). The designer shall also provide for thermally induced differential changes in length between the stack and the piping attached to the stack.

i) Erection and/or maintenance loads

The flare-stack designer shall be informed of the erection techniques that the purchaser will employ. If the stack is being erected in a single lift, the designer shall also be informed as to the degree of pre-erection attachment of piping, ladders and platforms, etc. Unless otherwise noted in the data sheets, lifting trunnions shall be designed for one-time use.

Some derrick-supported flares are designed to allow the flare riser to be lowered (either as a single section or in multiple sections) to allow grade-level access to the flare burner for maintenance. The designer shall provide for the loads imposed on the flare riser and derrick by the intended plan of demounting.

In some cases a davit, located near the top of the flare stack, is used to lower the flare burner to grade. The designer shall determine and provide for the davit-imposed loads based on the intended plan for this operation.

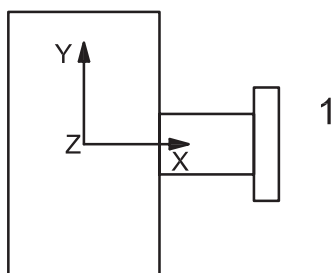
j) Special loads

The purchaser shall record on the data sheets any additional loads that will be imposed on the flare stack/support structure. Hydraulic shock load is not generally considered for design. Examples of special loads are

- 1) loads from ice build up,
- 2) hydrostatic testing of ancillary components,
- 3) loads imposed during transport,
- 4) hydraulic forces, which are possible with blow-dry liquid seals,
- 5) pressure waves, which are possible with staged flares.

Table 2 — Allowable forces and moments for flare nozzles ^a

Nozzle size DN (NPS)	F_x		F_y		F_z		M_x		M_y		M_z	
	N	(lbf)	N	(lbf)	N	(lbf)	N·m	(ft·lbf)	N·m	(ft·lbf)	N·m	(ft·lbf)
50 (2)	445	100	890	200	890	200	475	350	339	250	339	250
100 (4)	890	200	1 779	400	1 779	400	813	600	610	450	610	450
125 (5)	1 001	225	2 002	450	2 002	450	895	660	678	500	678	500
150 (6)	1 112	250	2 224	500	2 224	500	990	730	746	550	746	550
200 (8)	1 334	300	2 669	600	2 669	600	1 166	860	881	650	881	650
250 (10)	1 557	350	2 891	650	2 891	650	1 261	930	949	700	949	700
300 (12)	1 779	400	3 114	700	3 114	700	1 356	1 000	1 017	750	1 017	750
350 (14)	2 003	450	3 338	750	3 338	750	1 451	1 070	1 085	800	1 085	800
400 (16)	2 225	500	3 560	800	3 560	800	1 546	1 140	1 153	850	1 153	850
450 (18)	2 448	550	3 783	850	3 783	850	1 641	1 210	1 221	900	1 221	900
500 (20)	2 670	600	4 005	900	4 005	900	1 736	1 280	1 289	950	1 289	950
600 (24)	3 115	700	4 450	1 000	4 450	1 000	1 926	1 420	1 424	1 050	1 424	1 050
700 (28)	3 560	800	4 895	1 100	4 895	1 100	2 116	1 560	1 560	1 150	1 560	1 150
750 (30)	3 783	850	5 118	1 150	5 118	1 150	2 211	1 630	1 628	1 200	1 628	1 200
800 (32)	4 005	900	5 340	1 200	5 340	1 200	2 306	1 700	1 695	1 250	1 695	1 250
900 (36)	4 450	1 000	5 785	1 300	5 785	1 300	2 496	1 840	1 831	1 350	1 831	1 350
1 000 (40)	4 895	1 100	6 230	1 400	6 230	1 400	2 686	1 980	1 967	1 450	1 967	1 450
1 100 (44)	5 340	1 200	6 675	1 500	6 675	1 500	2 875	2 120	2 102	1 550	2 120	1 550
1 200 (48)	5 785	1 300	7 120	1 600	7 120	1 600	3 065	2 260	2 238	1 650	2 238	1 650
1 300 (52)	6 230	1 400	7 565	1 700	7 565	1 700	3 255	2 400	2 374	1 750	2 374	1 750
1 400 (56)	6 657	1 500	8 010	1 800	8 010	1 800	3 445	2 540	2 509	1 850	2 509	1 850
1 500 (60)	7 120	1 600	8 455	1 900	8 455	1 900	3 635	2 680	2 645	1 950	2 645	1 950



Key

1 Nozzle

^a Nozzle loads are applicable for the flare header to the gas riser but not applicable for auxiliary service piping, e.g. steam, pilot fuel, etc. The location of the relief-gas nozzle as a basis for design is 10 m (32,8 ft) above grade.

5.2 Design details

The following design details shall be incorporated into the support structure design.

- a) Stack deflection due to wind load or earthquake shall not exceed the following:
 - derrick supported structures: 150 mm per 30 m (6 in per 100 ft);
 - self-supported structures: 225 mm per 30 m (9 in per 100 ft);
 - guyed structures: 300 mm per 30 m (12 in per 100 ft);
- b) Stack sections in the form of a frustum of a cone shall be designed in accordance with API RP 2A WSD.
- c) Field assembly of the gas riser or stack sections shall be by welding unless otherwise specified on the flare data sheets. Flanged assembly may be used on multiple-section, demountable risers.
- d) A minimum corrosion allowance of 1,6 mm (1/16 in) for carbon steel components in contact with the relief gas stream shall be added to the minimum metal thickness necessary to meet the requirements of 5.1. No corrosion allowance is required on alloy steel portions of the stack unless specifically noted on the data sheets. Non-alloy steel internal parts of the liquid seal or knockout drums that are normally in contact with the seal fluid or relief gas stream shall have the corrosion allowance applied to each side. No corrosion allowance is required for derrick structures and other metal objects that do not normally come into contact with the relief gas stream.
- e) The following requirements shall be incorporated when the support structure design includes the use of guy wires:
 - 1) Guy-wire slope and initial tension shall take into account
 - the elevation of the guy connections to the riser (there may be more than one connection elevation),
 - available guy-wire anchor radius,
 - the range of riser temperatures, both ambient and process,
 - wind loads, and
 - mass distribution.
 - 2) There are two types of cables used for guy wires: wire rope and structural bridge strand, with the following acceptable supply specifications:
 - wire rope, in accordance with
 - ISO 2408:2004, Quality B for 10 mm to 50 mm (3/8 in to 2 in) diameter, class 6X36-IWRC with steel core,
 - ASTM A 475-03, Class A for 16 mm (5/8 in) diameter or less, with metallic core;
 - structural bridge strand, in accordance with
 - EN 12385-10 for 13 mm to 72 mm (1/2 in to 3 in) diameter, with zinc coating conforming to EN 10264-2:2002, Class A,
 - ASTM A 586-04, Class A, for diameters greater than or equal to 16 mm (5/8 in).

Refer to ASME STS-1 for cable selection criteria.

- 3) End fittings, turnbuckles, rods and pins shall have a load capacity suitable for the maximum guy wire tension expected. Guy wire hardware shall be strong enough to withstand a force at least equal to the minimum breaking force of the guy wire.
- 4) The initial guy wire tension shall not be less than 2 % or greater than 12,5 % of the maximum guy wire tension expected. Initial guy wire tension shall include a consideration of the ambient temperature variation and loads offset along the relief gas riser.
- 5) Turnbuckles or guy wire tension devices shall be located at the anchor end of the guy wire immediately above the anchorage. Locking devices shall be included with all turnbuckles and tension devices.
- 6) When guy wire deadmen (anchors) cannot be located symmetrically around the stack and at the same elevation, the analysis shall determine the load direction that provides the highest stress for all components, in addition to the design load analysis requirements in 5.1.

5.3 Materials of construction

Materials of construction shall be as specified in the flare data sheets. If a material is not specified, any portion of the flare stack that is normally exposed to the relief gases shall be of a material that is compatible with the gas composition as stated in the flare data sheets. In addition, the materials normally exposed to the relief gases shall be compatible with the most extreme maximum and minimum temperatures imposed by the relief gases, the ambient temperatures or the design temperature(s) specified in the flare data sheets. Portions of the flare stack or support structure that are not normally exposed to the relief gases may be of a material suitable for their purpose. Welded attachments to the portions of the stack that carry the relief gases shall be of a material that is compatible with the material of the respective gas-containing portion.

- The purchaser shall specify whether the service is sour (i.e. whether sulfide stress cracking is possible) in accordance with ISO 15156 (all parts) for oil and gas production facilities and natural gas sweetening plants, or in accordance with NACE MR0103 for other applications (e.g. oil refineries, LNG plant and chemical plant), in which case all materials in contact with the process fluid shall meet the requirements of that standard.

NOTE For the purpose of this provision ANSI/NACE MR0175 (all parts) is equivalent to ISO 15156.

Derrick structures may be designed for fabrication from members that are structural shapes, pipe or plate or any combination thereof.

Guy wires, as set forth in 5.2 (e), shall be all metallic, galvanized steel wire rope or structural bridge strand. Guy wire hardware shall be galvanized. Galvanizing shall be at least equivalent to the guy wires on which they are used.

Materials used for portions of the support structure that are designated as being designed according to the pressure design code shall be in accordance with material specification requirements of that code.

5.4 Welding

- a) Relief-gas-containing portions of the support structure shall be fabricated in accordance with the welding requirements of the structural design code or pressure design code.
- b) If the bottom portion of the stack is designed in accordance with the pressure design code, then the fabrication of that portion shall be governed by the welding qualification requirements of the pressure design code.
- c) Non-gas-containing portions of the support structure shall be fabricated in accordance with the welding requirements of either the structural design code or the pressure design code.

5.5 Inspection

Relief-gas-containing portions of the support structure shall be inspected in accordance with the following requirements.

- a) The structural design code or pressure design code shall be used for non-destructive testing and inspection procedures, techniques, standards for acceptance, inspector qualification and inspections.
- b) All welds shall be visually inspected during the welding operation and again after the work is completed to determine satisfactory penetration of weld metal fusion and satisfactory operator performance. After the welding is complete, welds shall be cleaned before the inspector performs the final weld inspection. The inspector shall pay particular attention to surface cracking, surface porosity, surface slag inclusion, undercut, overlap, gas pockets and size of weld. Defective welding shall be corrected according to the applicable code requirements.
- c) Radiographic weld inspection shall be performed on all full-penetration structural butt welds to the extent specified in the following requirements.

A minimum of one radiograph per each three shop circumferential seams on the relief-gas-containing structural shell shall be carried out at the vertical weld intersection. The developed radiographic film should show at least 150 mm (6 in) of weld seam.

- d) Other types of non-destructive testing may be utilized if specified on the flare data sheets.
- e) Hydrostatic testing is not required unless specified on the flare data sheets.
- f) If the bottom portion of the stack is to be designed and fabricated in accordance with the pressure design code, then the bottom portion shall be inspected in accordance with that code. In the case where the bottom portion is a code vessel, the upper (non-code) portion shall be inspected as set forth in (a) through (e) above. Hydrostatic testing is not required unless specified by the flare data sheets or a code stamp is specified.

Non-gas-containing portions of the support structure shall be inspected visually using the procedure set forth under item b).

5.6 Surface preparation and protection

Carbon steel external surfaces of stack and piping that can be directly exposed to weather shall be cleaned in accordance with ISO 8501-1:2007, grade Sa 2 ½, or SSPC SP-6/NACE No. 3. The cleaned surfaces shall then be primed with one coat of inorganic zinc primer to a minimum dry film thickness (DFT) of 75 µm (0,003 in). Surfaces shall be painted in conditions in accordance with manufacturer's recommendations on temperature and relative humidity.

Components of derricks, ladders, platforms and the like shall be prepared for, and galvanized in accordance with, ISO 1461 or the applicable sections of ASTM A 123, ASTM A 143, ASTM A 153, ASTM A 384 and ASTM A 385. Bolts joining galvanized sections shall be galvanized in accordance with ISO 10684 or ASTM A 153, or zinc-coated in accordance with ASTM B 633.

Alloy steel components do not require surface preparation or protection.

5.7 Attachments

5.7.1 Typical attachments to the support structure include piping for steam, pilot gas and assist gas, buoyancy seal drain, muffler drains, pilot ignition, electrical conduits and instrumentation conduits.

5.7.2 Attachments to the support structure shall not be supported by the flare burner.

5.7.3 The structural analysis shall include piping loads and wind and earthquake loads.

5.8 Aircraft warning lighting

- **5.8.1** Lighting on the support structure shall be in accordance with the code specified by the local aviation authority, which is typically the national incorporation of ICAO, Annex 14.

5.8.2 Warning lights on the structure shall be fixed or retractable, and shall be shielded from radiation as necessary.

5.9 Platforms and ladders

- **5.9.1** The purchaser shall specify whether platforms are required. A ladder is the preferred means of access to a platform but alternative access can be achieved via a crane basket or helicopter. The purchaser shall specify whether ladders are required.

5.9.2 An elevated flare can meet its design intent as stated in 4.1 without being equipped with platforms or ladders. However, at least for elevated flares more than 15 m (50 ft) high, a 360° platform should be provided near the top. This elevation may be increased depending on site-specific capabilities and maintenance practices. This platform should be located below the flare-burner mounting flange or connecting weld and be positioned so that it can be used during inspections, maintenance and flare-burner replacement.

5.9.3 If the flare is equipped with a buoyancy-type air seal, a platform should be provided for access to the inspection and clean-out nozzles. A 120° platform is commonly used.

5.9.4 Access platform(s) should be provided for inspection and maintenance of fixed, non-retractable aircraft warning lights.

5.9.5 Additional access platforms may be located at other locations as necessary. For example, the erection plan for the flare stack can make a full 360° or partial platform desirable at each stack assembly joint.

5.9.6 The maximum distance between platforms shall be 9 m (30 ft) or in accordance with local regulations if access between platforms is via ladders.

5.9.7 If the flare system is equipped with a knockout drum and/or a liquid seal, platforms can be required for access to man-ways, level instruments, etc.

5.9.8 If the flare is of multi-stage type, a platform shall be provided for inspection and maintenance of the staging valves.

5.1.9.9 In general, the flare-burner maintenance platform should have a minimum 0,9 m (3 ft) clearance width from the flare burner and its appurtenances. In some cases, placement of the platform and the flare burner/stack connection at a somewhat lower elevation can allow the use of a smaller-diameter platform.

5.9.10 Ladders shall not be attached to the flare burner.

5.9.11 Platform decking shall be open grating, designed for a uniformly distributed load of 500 kg/m² (100 lb/ft²) and a point load of 450 kg (1 000 lb).

5.9.12 Platforms and ladders shall be hot-dip galvanized carbon steel or shall be stainless steel.

5.9.13 Design of the ladders and platforms shall comply with local regulations.

6 Mechanical details — Enclosed-flame flare

6.1 Combustion chamber

Mechanically, the combustion chamber is a self-supported stack. The stack design should conform to an acceptable code, e.g. ASCE 7, using the site parameters for wind speed, rain, exposure factor, seismic factor, etc. The stack design and material shall accommodate the thermal requirements of the enclosed flame. Internally, the combustion chamber temperature is established by the flow of relief gases through the burners and how combustion and quench air are supplied to the flames. Most enclosed-flame flares are designed to operate with a maximum internal temperature of about 980 °C to 1 090 °C (1 800 °F to 2 000 °F). Flue-gas temperature in excess of 980 °C (1 800 °F) can produce visible emissions, not flames, due to ionization.

The combustion chamber requires an internal refractory lining. The refractory system selection and design shall consider

- peak operating temperature (with a safety factor),
- exterior shell temperature limits for materials and coating,
- thermal cycling with rapid increase and decrease of combustion chamber operating temperature with changes in relief-gas flows to the flare,
- velocity of the airflow into the combustion chamber and the flue-gas velocity out of the combustion chamber,
- environmental exposure to rain, wind, etc.,
- refractory weight, friability, expansion/contraction factors, durability, maintainability and service life,
- refractory curing schedules and start-up plans.

Refractory insulation for thermal heat loss is not a factor in the design; a large percentage of the heat of the enclosed flame flare is lost to the atmosphere.

The shape and size of the combustion chamber impacts the degree to which the flare can be pre-assembled to meet field-erection requirements. The external shell of the combustion chamber is typically fabricated of carbon steel. Internal surfaces can be lined or painted to mitigate dew-point corrosion as required by the enclosed-flame flare design and operating conditions. Any coating material shall be compatible with the design metal temperatures for the flare and its refractory lining. Special consideration shall be given to selection and application of protective coating systems since exterior metal temperatures can exceed 205 °C (400 °F).

Ladders and service platforms, for access to enclosed-flame flare instruments and for stack emissions sampling, can impact the structural design of the combustion chamber. Personnel protection is required adjacent to the combustion chamber when surface temperatures exceed 80 °C (175 °F) for areas for personnel access during operation. See 5.1 and 5.9.

6.2 Burners

There are distinct designs from several manufacturers that are available with many options. Mechanically, the burner design controls the fuel and air for combustion, its state of mixing and the ignition and completeness of combustion. Heat-affected areas are typically fabricated of heat-resistant stainless steel. Enclosed-flame flares can have the burners firing in a vertical upward direction or the burners can be horizontally fired into the combustion chamber. The choice of burner firing direction is a function of size and manufacturer's experience.

Flare burner assemblies are typically connected to burner piping by flanged or screwed fittings, or by welding. It is necessary that the selection of the connection type take into account the composition and temperature of the relief gas and possible exposure to high thermal loads from proximity to the flames or the combustion chamber. These temperature effects can loosen some screwed and flanged connections.

It is necessary that steam, air or other auxiliary connections to the burner, likewise, be engineered depending on their location relative to the flame and combustion chamber. These connections can be welded, flanged or screwed.

6.3 Burner piping

Burner piping should conform to the pressure design code as a minimum. The piping shall be engineered to have the flexibility to accommodate thermal expansion of the combustion chamber and the piping. It is necessary that the piping design take into consideration the requirements to maintain the engineered burner position with respect to the air inlet to the combustion chamber.

It is necessary that piping located inside the combustion chamber enclosure be engineered for high-temperature exposure since these can be subjected to flame impingement. Piping internal to the combustion chamber can be subjected to flame impingement resulting from poor air or gas distribution. Flame impingement can also result from liquid-pool fires that can form when condensation and liquid drainage into the combustion chamber occurs. It can be necessary to protect piping external to the combustion chamber, but within the wind fence, from radiant heat loads by radiation shields.

If liquid carryover and/or gas condensation can occur, the piping design should accommodate drainage. If liquid hydrocarbons are retained in the piping, they can form blockages.

Piping material selection shall be compatible with the relief-gas composition and temperature, and shall meet the requirements set by the enclosed-flame flare design.

6.4 Pilots

Each stage of an enclosed-flame flare shall be equipped with at least one pilot. The first stage can require more than one pilot; that decision should be made during the design phase. However, not every burner of every stage of an enclosed-flame flare requires a pilot. Depending on the burner design and the arrangement of the burners, a single pilot can light one main burner and cross-ignition to other burners can be achieved. The number of pilots depends on the number of burners, the design of the burners, the burner arrangement, and the operating status of the enclosed-flame flare. At higher gas-relief capacity, a substantial flame and a high temperature exist in the combustion chamber. This can ignite the relief-gas flow from the subsequent stages.

Pilot fuel and supply systems should be the cleanest, most reliable fuel source in the plant. The typical pilot is a single-firing-rate, pre-mix burner. The pilot gas orifice is generally quite small. Potential plugging of this orifice should be mitigated by good piping design and by the use of a strainer located immediately upstream of the pilot gas orifice.

Pilots for enclosed-flame flares can be engineered to facilitate inspection and maintenance while the flare remains in service. This is accomplished by locating key components external to the wind fence and/or by making the pilot assemblies easily removable from outside the wind fence.

Many of the pilot and pilot-ignition details covered in Clauses A.3 and A.4 are applicable to enclosed-flame flares. Enclosed-flame flares allow the use of flame scanners as the flames are enclosed in the combustion chamber. Pilots for burners in enclosed-flame flares are typically more protected from the weather than those of open-air elevated flares. With a properly designed enclosed-flame flare and with an effective wind fence design, the airflow across the pilot and burner is unidirectional whereas open-air elevated-flare pilots are affected by wind from varying directions.

6.5 Wind fence

Wind-fence designs follow the structural requirements as defined for the combustion chamber. The wind-fence design shall withstand heat, mitigate wind effects, limit access and provide acoustical dampening. Wind-fence enclosures of steel and concrete are typically utilized. Wind-fence designs can also control reflected light from the combustion chamber.

Wind-fence design shall limit access to the space inside the wind fence and to any hot metal surface. The wind-fence material selection shall provide for an external surface temperature acceptable for worker exposure. Doors or man-ways shall be provided to limit access to the inside of the wind fence. This access is for inspection, maintenance and repairs. Wind fences may also be equipped with viewing ports for observation while the flare is in service. The number of doors and view ports is selected based on inspection and access requirements, and on limitations to view and movement inside the wind fence.

6.6 Radiation shielding

All piping subject to thermal radiation, upstream of the individual burner risers, shall be adequately protected. Such piping is typically covered with loose gravel or metallic shielding. The covered piping shall be suitably protected from environmental effects and corrosion.

Annex A (informative)

Flare equipment overview

A.1 Types of flares and components

A.1.1 General

Flares can be grouped into the major categories described in A.1.2 to A.1.7.

A.1.2 Elevated

A.1.2.1 General

Elevated flares are generally oriented to fire vertically upward. The discharge point is at an elevated position relative to the surrounding grade and/or nearby equipment.

There are several types of support methods for elevated flares, as described in A.1.2.2 to A.1.2.4.

A.1.2.2 Self-supported

A free-standing riser supports the elevated flare burner without the use of guys or a derrick support. See Figure A.1 for a typical self-supported structure.

A.1.2.3 Guyed

An elevated riser supports the flare burner through the use of cables. Cables are attached to the flare riser at one or more elevations to limit the deflection of the structure. The cables (guy-wires) are typically positioned in a triangular plan to provide strong support. See Figure A.2 for a typical guy-supported structure.

A.1.2.4 Derrick supported

A steel trussed structure of one of the following types supports one or more flare risers.

a) Fixed derrick:

The riser is permanently supported by the structure. The flare burner can be maintained by lowering it with a davit or crane. The flare system shall be out of service when the burner is removed. See Figure A.3 for a typical fixed derrick support structure.

b) Demountable derrick (multiple-section riser):

A derrick with the riser(s) mounted to permit lowering the flare burner to grade for service. The riser is typically assembled in sections that can be raised and lowered using a track and guide system. This allows grade-level access to the flare burner. Many demountable derricks are designed to support multiple risers with their flare burners. Such a derrick can be designed so that all the flares, except the one being maintained, can be operational during the maintenance.

Figure A.4 illustrates a derrick with a multiple-section demountable riser: (a) in the normal operation position; (b) with upper sections slightly lifted at the start of the lowering operation; (c) during the process of lowering the bottom section; and (d) with the bottom section completely lowered.

c) Demountable derrick (with single-section riser):

A derrick with a single riser utilizing a track and guide system that allows the lowering of the flare riser and burner to grade in a single piece.

Figure A.5 illustrates a derrick with a single-section demountable riser: (1) in the normal operating position, (2) during the lowering process and (3) completely lowered to allow grade level access to the flare burner.

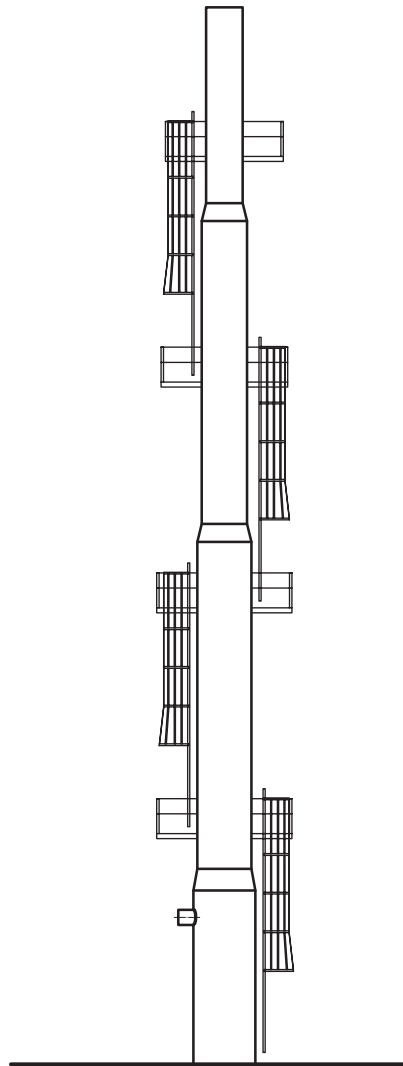


Figure A.1 — Self-supported structure

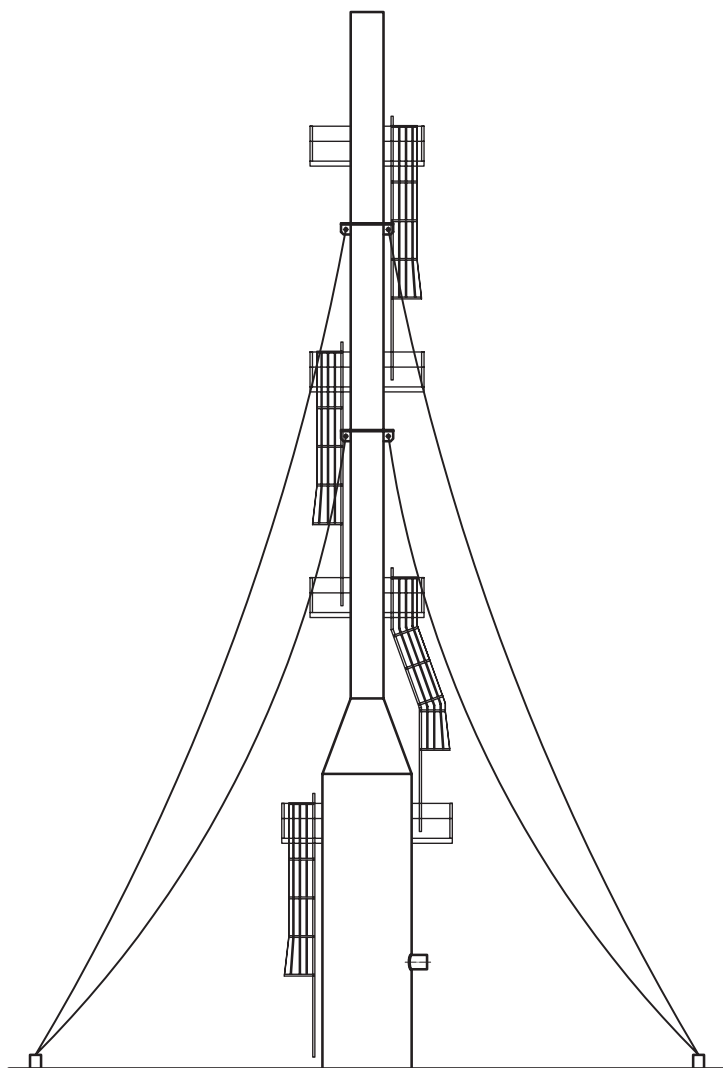


Figure A.2 — Guyed-support structure

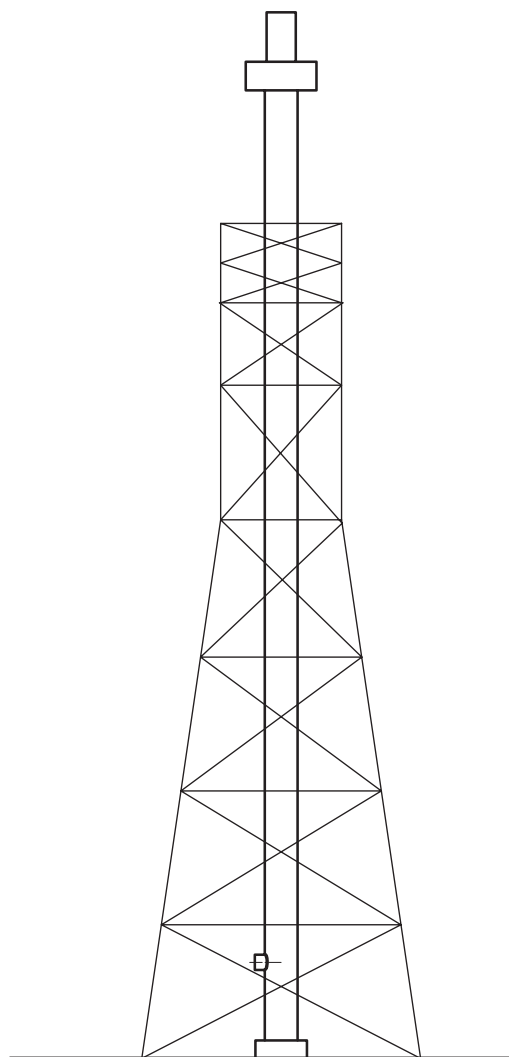
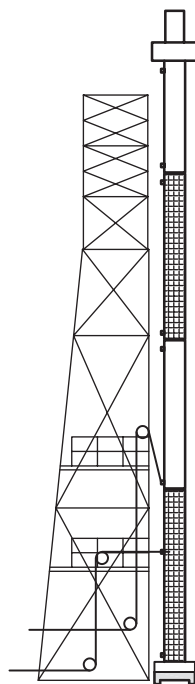
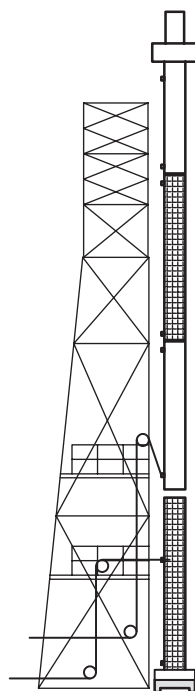


Figure A.3 — Typical fixed derrick support structure

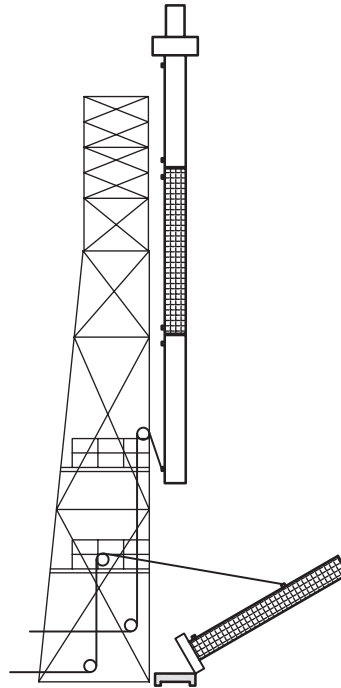


a) in the normal operating position

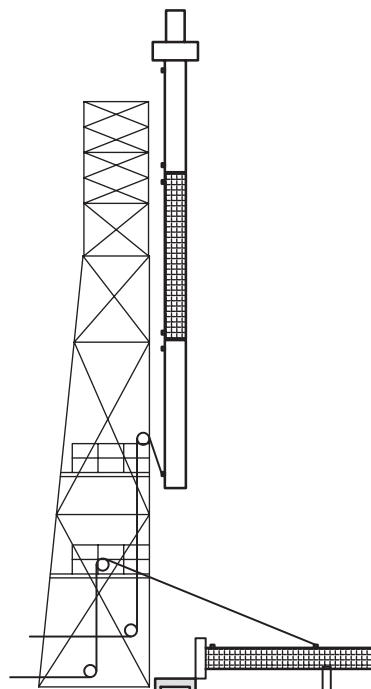


b) with upper sections slightly lifted at the start of the lowering operation

Figure A.4 — Demountable derrick with multiple-section riser (*continued*)



c) during the process of lowering the bottom section



d) with the bottom section completely lowered

Figure A.4 — Demountable derrick with multiple-section riser