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Guidance on Practice for API 537 Flare Details

GP 22-20

**BP GROUP
ENGINEERING TECHNICAL PRACTICES**

Foreword

This is the first issue of ETP BP GP 22-20. It is a comprehensive guide for flare details, based on documents of the three merged companies, BP, Amoco, and Arco. In addition, reference is made to other standards and reports that provide guidance in the use of heritage documents or similar documents. Normative references are mandatory to the extent that they are referenced and not superseded by this guide.

BP (pre 1999)

RP 44-3 Design Guidelines for Relief Disposal Systems, November 1993.

Amoco

A FE-FLR-00-E Fabricated Equipment—Flares—Engineering Specification.
A FE-FLR-00-G Fabricated Equipment—Flares—Guide.
A FE-STK-00-E Fabricated Equipment—Stacks—Engineering Specification.
A FE-STK-00-G Fabricated Equipment—Stacks—Guide.
PSS#6 Flare, Blowdown, Pressure Relief, Vent, and Drain Systems for Process Units.

PTA

PTA FE-FLR-00-P Fabricated Equipment Vertical Elevated Flares Procurement Specification.

Gulf of Mexico Deep Water Development Program (GOMDW)

1400-20-PR-RP-2002-13 Flare System Design Guideline.
1400-20-ME-SP-2510 Flare Stack, Tip, and Igniter.

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Introduction

- a. Guidance for flare details is based on API 537, 2003.
- b. Guidance statements of this GP are modifications to API 537.
- c. Modifications to API 537 are identified as Add, Modify to Read, or Delete.
- d. Paragraph numbers in this GP correspond to API 537.
- e. Paragraphs of API 537 that are not revised remain applicable.

By necessity, API 537 provides more flexibility than required by BP. API 537 does not include specific BP experience. This GP adds the requirements that BP has found are necessary for safe and cost effective operation.

From the experience of the industry as a whole, the API standards are a distillation of general experience. Individual companies have different cultures and operating procedures (again learned from experience). The BP requirements given in this GP fit with the operating and design philosophy used by BP.

This GP may refer to certain local, national, or international regulations, but the responsibility to ensure compliance with legislation and any other statutory requirements lies with the user. The user should adapt or supplement this GP to ensure compliance for the specific application.

In the application of this GP, BP may select options or waive requirements, depending on the nature of the project concerned. This may involve any requirement stated in this GP.

1 Scope

Add

- a. This GP provides guidance on BP practices associated with selection and design of flare system and equipment, materials selection, fabrication, testing, construction, maintenance, and operation.
- b. This GP complements GP 44-70 and GP 44-80.

While GP 44-70 and GP 44-80 cover the process aspects of relief systems, this GP covers issues associated with the flare as a disposal device, such as selection and design issues, and provides greater details for mechanical design requirements.

There may be some duplication on covered topics in these GPs. These duplications are considered as necessary and complementary, with the sole purpose to aid readers in better understanding of issues related to presented topics.

API 537 provides Equipment Data Sheets in Appendix A. Equipment data sheets are not included in this GP. The equipment data sheets and Instructions for Use of Data Sheets are included in DS 22-200 document. The equipment data sheets can be selected with SI units or U.S. customary units. The use of these equipment data sheets for new and existing flare systems is recommended. Completed equipment data sheets provide a uniform means of recording and communicating design information, such as general information, process design conditions, mechanical design data, and system performance data.



API 537 does not include issues associated with design of system for relieving gases by venting into atmosphere. These issues are primarily addressed in GP 44-80 and, as appropriate, in this GP.

Add

The following types of flares are within the scope of this GP:

- d. Pit flares.
- e. Marine or sea flares.
- f. Oil production platform boom flares.
- g. Portable/temporary flares.

Flares for the following facilities are within the scope of this GP:

- a. Refineries.
- b. Chemical plants.
- c. Terminals.
- d. Offshore installations (shallow and deepwater).
- e. Crude oil and natural gas gathering and processing centres.
- f. Pipelines: buried, aboveground, or subsea.
- g. Storage installations.
- h. Floating production systems.
- i. Well testing.
- j. Liquefied natural gas (LNG) facilities (plants and terminals).

2 Referenced publications

API

Add

API 673 Centrifugal Fans for Petroleum, Chemical and Gas Industry Services.

ASME

Add

ASME B16.47 Large Diameter Steel Flanges: NPS 26 through NPS 60.

ASTM

Add

ASTM C155 Standard Classification of Insulating Firebrick.

ASTM C401 Standard Classification of Alumina and Alumina-Silicate Castable Refractories.

Add

BP

GIS 22-101 Guidance on Industry Standard for ISO 13705 Fired Heaters (API 560).

GIS 22-201 Guidance on Industry Standard for Flare Systems.



GP 22-10	Guidance on Practice for Fired Heaters.
GP 44-70	Guidance on Practice for Overpressure Protection System.
GP 44-80	Guidance on Practice for Relief Disposal Systems.

BS

BS 6651	Code of practice for protection of structures against lightning.
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ISO

ISO 9001	Quality management systems-Requirements.
ISO 13705	Petroleum and natural gas industries - Fired heaters for general refinery service.

3 Definition of termsModify to Read

Terms used in API 537 as they relate to flares are defined in 3.1 through 3.86.

3.9 Coanda flareModify to Read

Flare tip that uses Coanda effect.

Coanda effect is aerodynamic skin adhesion effect in which gas follows the profile of a curved surface, entraining air up to 20 times its own volume.

Flares of this type generally use pressure of gas to achieve smokeless performance.

3.30 FlareAdd

System may take form of flare stack, flare boom, ground flare, and enclosed flare.

3.31 Flare burnerAdd

Flare burner includes all auxiliaries as attached to supporting stack or boom.

3.54 Pin actuated deviceAdd

- a. These types of devices can be reset in place without breaking a flange and may be considered as alternative for use of rupture disc device.
- b. Pin actuated valves are more costly and some offered valves might have questionable operating characteristics.

3.60 Smokeless capacityAdd

Requirements are defined by local requirements, such as UK Clean Air Act 1956, Section 34(2), and U.S. EPA CFR 60.18.



Add**3.69 Combustion support**

Addition of fuel gas to effluent to be flared for any of the following reasons:

- a. To increase fuel concentration to make effluent flammable and achieve required combustion destruction efficiency.
- b. To increase volume of effluent in order to increase flare tip velocity to avoid:
 1. Burn back in flare tip.
 2. Flame lick outside flare tip.
 3. Lazy flame situation that could damage adjacent flare tip.
- c. To maintain adequate slot velocity in flare tip using Coanda effect.
- d. To increase flame stability during high wind conditions (only as temporary solution until flare flame instability is resolved).

3.70 Flare boom

Horizontally displaced or inclined boom, together with other items listed for flare stack.

3.71 Flare stack

Elevated stack (either self supported, guyed, or structure supported), flare tip, pilot burners, igniters, smoke suppressing devices, flame heat radiation suppressing devices, service pipes, and miscellaneous auxiliaries.

3.72 Flare system

Whole closed disposal system for fluids discharged from pressure relief valves, other pressure relieving devices, control valves, or manually operated valves, terminating in one or more flares.

3.73 Flare vendor

Contractor who undertakes design, supply, and erection of flare.

3.74 Purge gas rate

Rate of flow of inert or combustible gas required to prevent oxygen ingress and oxygen concentration exceeding specified level in flare stack or supply ducting.

3.75 Maximum flaring rate

Maximum rate of flow to flare calculated in accordance with specified blowdown and relief philosophy for plant.

3.76 Maximum smokeless rate

Maximum rate of flow to flare, which is required to be burned smokelessly.

3.77 Operating range

Range of gas flows and conditions for which flare is required to operate.

3.78 Marine or sea flare

Flare remotely located from drilling/production platform. Typically used in shallow water platforms.



3.79 Low pressure tip

Flare tip that operates at low differential pressure across flare tip.

3.80 High pressure tip

Flare tip that is designed to operate at medium and high differential pressure across flare tip.

3.81 Variable orifice

Flare tip that continuously changes size of exit orifice to maintain higher exit velocities contributing better mixing between air and gas achieving higher non smoking rates.

3.82 Water injection

System that provides water injection into flare combustion zone to achieve flame temperature reduction and lower heat radiation rates emitted by flare flames.

3.83 Water curtain

System consisting of numerous spray nozzles that provide water curtain protection from intensive heat radiation emitted by flare flames.

3.84 Radiation shield

Structure, typically steel plate or other heat resistant materials, that provides personnel or critical equipment protection from intensive heat radiation emitted by flare flames.

3.85 Operational flaring load

Load results from process vent to normal safety valve leakage and main activities, etc.

3.86 Emergency flaring loads

Load results from emergency flare pressure relief devices (relief from upset and/or emergency blowdown system is activated).

4 Flare equipment overview**4.1 System purposes**

Add

Scope of this GP includes upstream production facilities, LNG, and other facilities within BP that are not mentioned in API 537.

4.2 Types of flares

Modify Title to Read

4.2.1 Vertical and inclined flare

Vertical flares generally fire flames in an upward direction. Sometimes, it is necessary, such as in platform boom flares or onshore well test flare, that the flame be directed away from the facility to reduce the flame radiation level and reduce effects of possible liquid carryover.

The elevated flares have the best dispersion characteristics. Visual and nose pollution can present public relations problems. Capital and operating costs are relatively high, and a significant plan area may be required to mitigate radiation heat concerns. Despite its disadvantages, the elevated flares are the most common installations in onshore facilities. The height of a flare is determined on the basis of



the ground level limitations of thermal radiation intensity, luminosity, noise, height of surrounding structures, and dispersion of exhaust gases.

Typically, the elevated flare supports a single flare service. Sometimes, due to space or other limitations, two or more services, with dedicated tips, are installed on a single stack. For such installation, numerous issues need to be addressed and considered, such as flame impingement from tip to tip, combined heat radiation rates and noise, and difficulty in scheduling maintenance work. In general, these installations are troublesome and need to be avoided.

The elevated flare can use a majority of types of flare tips that are currently being offered by flare manufacturers. Tips that can be used include those that use assisting media for smoke suppression, such as steam, air, and high pressure gas, as well as multi point tips.

Modify to Read

- a. Flare structures shall be designed to withstand loads imposed by known environmental conditions (wind, ice, temperature, etc.) that will be specified by BP.
- b. In addition to environmental loadings, structure shall be designed to withstand thrusts from liquid slugs (if there is risk that these can occur), gas discharging from flare tips, and imposed structural and equipment loads.
- c. Structure shall be designed for maintenance loads, such as supporting spare flare tip during tip replacement, additional scaffolding, lifting beams, tools, and personnel.
- d. Minimum flare height normally used is 7,6 m (25 ft). Shorter flare stacks can be considered, provided that flaring does not impose excessive thermal radiation or other safety hazards in vicinity.
- e. Due to lower overall installation cost, elevated flares should be guy supported or self supported, if practical, unless special requirements call for another type.
- f. There are several types of support methods for vertical flares.

4.2.1.1 Self supported (see figure 1)

Modify to Read

- a. In self supporting type, flare riser pipe is structural support for flare.
- b. This type of flare is used for short and medium height flares, typically between 9 and 30 m (30 and 100 ft) but can be designed for up to 76 m (250 ft) height, if minimum ground area is available.
- c. In some cases, base of stack incorporates water seal drum.
- d. This type of flare is well suited for air assisted type of flare.

Wind can set up forces that can make the structure oscillate rhythmically. This can be prevented by tapering the stack, using different diameters of pipe, or welding wind spoilers on the outside. The cost of this type is higher than the guyed stack, but its appearance is better, and it is easier to maintain.

4.2.1.2 Guyed (see figure 2)

Modify to Read

- a. Guyed stacks are typically used for heights up to 107 m (350 ft).
- b. Guyed stacks require guy wires that are attached to riser at one or more elevations to limit deflection of structure.



- c. Guy wires are typically positioned in triangular plan and shall be anchored by buried concrete block foundations.
- d. If there is no room for guy wires or concrete block foundations, stack shall be supported by derrick or stack may be self supporting.

4.2.1.3 Derrick supported (see figure 3)

Derrick supported stack is the most expensive to build and maintain. Usually, it is a four sided derrick, but a three sided derrick has also been used. This type of stack is normally selected for stacks above 61 m (200 ft) high and on locations where flare is exposed to strong winds.

Add

4.2.1.4 Boom and tower mounted flares

- a. BP will specify or flare Vendor may propose flare as tower or boom type, either on platform or remote.

Boom and tower mounted flares are found on marine drilling and production platforms. These flares use various standard flare tips designed for elevated flares. Booms are typically projected out over the water at an angle from the platform. The towers are located on the platform as far as possible from living quarters and critical equipment. Boom and tower mounted flares should, if possible, be situated downwind of the helideck, drilling deck, and operating area of the platform. If a single boom cannot be satisfactorily located, the use of two booms or one tower and one boom should be considered with the facility to switch over as wind conditions change.

- b. In general, there is high pressure (HP) flare, low pressure (LP) flare, and atmospheric vent on typical offshore production platform.
- c. HP flare should be low radiation sonic tip or other type and collects pressure safety valve (PSV) discharges from vessels designed for 700 kPag (100 psig) maximum allowable working pressure (MAWP) or greater.
- d. LP flare is typically standard pipe tip flare and collects PSV discharges from equipment less than 700 kPag (100 psig) but greater than 14 kPag (2 psig).
- e. Atmospheric vent
 - 1. Atmospheric vent is unlit open end pipe and services tanks or other equipment designed for operating pressure less than 14 kPag (2 psig).
 - 2. Atmospheric vent typically terminates midway up flare boom or at end of flare boom and is pointing away from boom structure.
 - 3. Atmospheric vents shall have flame snuffing system to prevent vents from burning (if vents are accidentally ignited) that may result in flare boom structural damage.

Except for structural details, sizing of this type of flare is similar to an elevated flare commonly used on onshore installations. The heat radiation limits imposed by platform design criteria have important influence on the flare boom length and on overall cost of platform. Use of heat radiation reduction options, such as inclined tip orientation, water injection and water curtains, and radiation shields, may be cost effective solutions, resulting in boom length reduction and significant savings in the overall platform cost.

- f. Design of flare structure shall take into consideration, in addition to radiation heat concerns, possibility and effect of liquid carryover and dispersion and location of hot gas plume.



- g. If several flare tips have to be sited in close proximity, i.e., high pressure and low pressure service, attention shall be given to possibility of interactive thermal damage to flare tips.
- h. Maintenance and inspection
 - 1. Access to flare tip(s) is usually required for maintenance and inspection.
 - 2. If used, maintenance platform shall be capable of withstanding heat produced by flare flame and anticipated loads.
 - 3. If platform is not needed, alternative method for access to flare tip(s) should be provided.
 - 4. Mechanical system may be provided to allow removal and replacement of flare tip.
 - 5. As an alternative to mechanical system, helicopter or barge based crane is effective but costly to provide mechanical system for tip installation and/or replacement.
- i. Flare structure, riser, and flare tip shall be constructed of materials suitable for both operating temperatures and marine environment.
- j. Materials for structure will be specified by BP or shall be subject to BP approval if specified by others.

4.2.1.5 Marine flares/remote flares

- a. Flare systems shall preferably be on platform.

This is due to the lower overall installation costs and ease of operation and maintenance.

- b. If amount of gas to be flared is so high that on platform flare is not practical or if local statutory regulations require, remote flare facilities shall be provided.

These types of flares are primarily used in shallow water drilling and production platforms.

There are numerous disadvantages associated with this type of installation, such as additional cost of connecting piping, difficulties with use of ignition system, and cost of constructing underwater foundations. These types of flares were used in the past primarily for venting purposes rather than for flaring service.

These facilities may be a bridge linked remote or a fully remote structure. Bridge linked structures can be floating, fixed, or articulated. Fully remote structures can be fixed or articulated.

- c. Specific attention shall be given in the design of the system to include:
 - 1. Subsea equipment (lines and risers, knockout drum, etc.).
 - 2. Condensate removal methods.
 - 3. Maintenance and repair (no hoists or cranes permanently available).
 - 4. Provision to avoid liquid accumulation from carryover or vapour condensation or sea spray into the flare line.
- d. Location of bridge linked flare shall be chosen to avoid wind carried hot gas stream or unburned gas affecting personnel and equipment on main platform.
- e. Fully remote flares typically are HP flare only.
- f. LP flare pressure may be sufficient to allow mounting on bridge linked structure. Otherwise, facilities for LP flaring should be provided on main platform.



Modify Title to Read**4.2.2 Horizontal or pit flares**Add

- a. Although this type of flare has been used in BP and other companies' facilities, due to potential for negative environmental impacts, such as flue gas dispersion and ground water contamination, their future use shall be limited or completely eliminated.

Horizontal low level open burn ground flare or pit flare is a simple construction, with low capital and operating costs and capable of burning gas and liquid hydrocarbon streams. Its use is primarily limited by local regulations, spacing requirements, smoke formation, and the dispersion of combustion produced gases. Depending on heat release, the minimum unobstructed distance surrounding a flare may vary from 76 to 152 m (250 to 500 ft). This type of flare is used primarily in remote locations, where there are no opacity restrictions and heat radiation concerns and local regulations allow the use of this kind of disposal system.

High maintenance cost, short tip life expectancy, and difficulties with pilot ignition system can be expected in this type of flare in windy areas if liquids are frequently being burned. Typically, a utility type of tip (an open pipe low pressure tip), with or without assisting media for smoke suppression, is used in pit flare installations.

- b. Flare lines leading to pit flare shall not be buried.

Flare header layout is an important design consideration. Radiation heat effect may cause overheating of the header piping, resulting in a rupture type failure.

Experience has shown that a flare line leading to pit flare presents no problem from flame radiation. The flow through lines provide sufficient cooling effect and lines remain cool. If the lines are buried for protection from radiation, the fill above the line may reach a high temperature during prolonged heavy flaring. If flow stops, it will heat the pipe, which will expand and may lift out of the ground. Better options for piping protection are use of heat shields or adequate height of berm. The typical height of berms is 1,2 to 1,8 m (4 to 6 ft). The berms are installed in all four sides of a squared shape burn basin. The basin is either excavated or a diked area.

- c. The following design enhancement options could be considered in existing and/or new pit flare design:

1. Tip location: Consider installation of tip on upwind side of prevailing wind direction. Wind will then carry flame away from flare tip. Because these flares are typically operated at low tip pressure, gas exit velocities are low, allowing wind, at lower release rates, to blow air inside of tip causing internal combustion and premature tip mechanical failure.
2. Tip heat protection: Consider use of some kind of additional tip protection from heat or burning flash fires caused by presence of liquids. Options may include selection of higher metallurgy for tip, refractory protection of tip, and use of heat shields.
3. Use of retractable pilot(s): Retractable pilot(s) can significantly increase flare operational safety, reliability and availability by allowing onstream pilot repairs/replacement.
4. The use of multiple tips, multiple stage designs to improve the distribution of combustion over a wider area to minimize smoke and radiant heat where possible.



4.2.3 Enclosed flame flares**Add**

- a. Plenum height shall be specified and provided to avoid wind causing downdrafts that force flames outside bottom of flare.

This kind of flare is the most versatile type. Since the flame is near ground level, dispersion of flare gases may result in severe air pollution or hazard if the combustion products are toxic or in an event of flameout.

- b. Auxiliary elevated flare for emergency flaring may be required to provide supplemental capacity to enclosed flame flare.

Enclosed flame flares generally have less capacity than open flares. Use of such combination system can reduce size and cost of enclosed flame flare.

The enclosed ground flare provides stable combustion due to its isolation from wind effects and ability to provide controlled conditions in the combustion zone. Complete combustion can be achieved with lower calorific value vent gases than possible with an open flare design. Therefore, higher thermal destruction efficiency can be achieved. This type of flare is desirable if high destruction efficiency is required and if local regulations require continuous monitoring of destruction efficiency performance.

This kind of flare system is disadvantageous because of capacity limitations, high capital cost, and high maintenance requirements.

The enclosed flame flare generally consists of a refractory lined structure of a cylindrical or rectangular shape enclosing single or multiple burners. A wall or a fence to cut off the direct route for light and noise to the surroundings screens the air inlet at the bottom of the structure.

- c. Division of burners into zones
1. To allow for greater turndown, burners may be divided into zones activating consecutively into operation.
 2. Some groups may be smokeless, others non smokeless.
 3. Control shall be automatic and may be by means of valves.
 4. If valves are used, liquid seals, rupture disks, or pin valves shall be installed in parallel to retain full flaring capacity in event of primary control system failure.
- d. If air and flare gas velocities are suitable, ceramic fibre blanket system should be used for enclosed flame flare structure lining.

Use of ceramic fibre materials will avoid refractory cracking due to sudden firing rate changes. Generally, gas velocities in excess of 10 m/s (33 ft/s) are a potential problem for ceramic fibre blanket, although there are ways to overcome the problem, such as covering with expanded metal lathe, covering with metal sheet, or wet felt soaked in rigidiser type materials. The selected lining will also depend on the combustion zone design temperature. The application of the ceramic fibre modules or blocks is more costly than use of ceramic fibre blanket system. However, this system increases lining resistance to temperature and erosion and should eliminate potential gas traps or areas where gas could gain entry. All edges should be downstream of the gas flow and fixed securely.

- e. Potential maintenance problems with enclosed flame flares should be identified at an early stage in a project.

Mobile enclosed flame flares are sometimes used while the main flare is being repaired or modified, allowing the operating facility uninterrupted service. Major

