NEW TECHNOLOGIES IN FLARE DESIGN

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Flaring has become more complicated than just lighting up waste gas.

Tighter regulations on both safety and emissions have aroused recently for environmental protection. These regulations have resulted in higher levels of concern and involvement in safety and emissions matters, not to mention smoke, noise, glare and odor.

As the flare is the most visible sign of wasted resources and pollution from oil, gas and petrochemical plants, flare system design has been greatly developed to respect environmental regulations and safety concerns.

A gas flare, (flare stack), is a gas combustion device used in industrial plants for burning off flammable gas. The role of the flare system is to provide a means of safe disposal of the vapor streams from its facilities, by burning them under controlled conditions so that adjacent equipment or personnel are not exposed to hazards, and at the same time obeying the environmental regulation of pollution control and public relations requirements.

Flare tip designs have developed significantly in recent decades and although many suppliers offer proprietary flare technologies, the basic design types available can be generally categorized as follows:

- Ground Flares
- Elevated flares
- Vent Tips

- **Ground Flares**

A ground flare is where the combustion takes place at ground level. Several types of ground flares exists; enclosed and open pit type.

Enclosed, concealed or ground flares are designed to hide the flare flame from view through the construction of a refractory (castable or ceramic fiber) lined enclosure which also serves to reduce radiation and noise. These types of flares are generally seen on onshore facilities due to their size.

Most enclosed flares of high capacity are rectangular, lower design capacities are usually cylindrical units.

This type of enclosed flare system was originally designed to eliminate the light and noise from the flaring of waste gases where it provides smokeless operation inside of a combustion chamber where no radiation exists outside the unit and no visible emissions.

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Multi-Point Ground Flares is another type of ground flares used when highly variable volumes of waste gas must be flared smokelessly but exceed the practical design limits of a single flare.


A burn pit flare is a single or multi point flare positioned horizontally over a dedicated pit or trench. The pit retains any condensates or liquids released with the gas.

In general, Burn-Pits are used in the disposal of gas and liquids, or just liquids. Burn-Pits are typically a non-smokeless system.


Compared to elevated flare, ground flare can achieve smokeless operation as well, but with essentially no noise.

However, it have poor dispersion of combustion product because its stack is near to ground, this may result in severe air pollution or hazard if the combustion products are toxic or in the event of flame-out.

- **Elevated Flare**

The most commonly used type in refineries and chemical plants

Simply; elevated flare system consists of flare header used to collect the waste gases and entrained condensate from all over the plant. Condensates are removed

using a condensate Knock out Drum (KOD). The gases to be burnt are then sent to a vertical flare stack.

The gases are burned in the elevated flare tip located at the top of the gas flare stack. Commonly the flame is open at the top of the gas flare stack and due to the open flame; this type of flare system can be a source of noise pollution. Also the radiation from open flame renders some area around the stack unsuitable for installation of any equipment and if adequately elevated, this type of flare has the best dispersion characteristics.

The main undesired effects caused by elevated flares are smoke, noise and high thermal flux to the surrounding areas.

As the primary environmental requirement is calling for smokeless burning to protect the environment from pollution; design optimization, and different types of flare tips were introduced.

Historically, the flare was just a vertical pipe which represents the most basic subsonic type of flares, sometimes called "utility flare". Such design will not smoke when burning low carbon content gases and are used when smokeless burning are not required or where smokeless combustion can be accomplished without external assist.

Utility flare tips are one of the lower capital cost options for safe disposal of waste gases.

When high smokeless capacities are required to be achieved especially with high carbon content gases, High pressure flare tips (to improve air/hydrocarbons mixture) are designed to deliver safe, economical, clean combustion to meet the stringent environmental regulations.

High pressure flaring can be achieved through steam /air assisted tips or sonic flare tips

The use of flare tips operating at high pressure has become very much normal practice in petrochemical operations. The use of high pressure systems enables the operator to minimize line, vessel and relief valve sizes in order to save on capital cost and weight.

The use of a high pressure flare does not only provide advantages in terms of capital cost but also in terms of improved flare tip performance.

A high pressure flare will deliver high capacity, improved efficiency, better dispersion and lower radiation. It will do this by utilizing the Kinetic energy in the high pressure gas as it exits the tip, to entrain more air and create turbulence to mix that air with the flare gas. Improved aeration and mixing results in a more efficient flame which burns with a shorter and cooler flame. The result is a reduction in unburned elements in the combustion products, an increase in the proportion of entrained air allowing for improved atmospheric dispersion, and a reduction in the temperature and surface area of the flame to improve radiation levels.

- **Steam Assist Flares**

They require large quantities of steam at a pressure of about 4 barg. The quantity of steam is proportional to the maximum day-to-day flow rate that needs to be (or can be) smokeless. Hence steam flares are more often specified with a certain percentage smokeless capacity. This figure commonly specified is 15% of the total flare capacity. Noise may also be an issue.

- **Air Assist**

When steam, the first choice medium of smoke suppression is not available or where the environmental conditions dictate, an air assist flare system using an air blower / fan provides a good solution. The air and flare gas should be introduced as two separate streams into the flare tip. The tip also gives lower radiation levels than a conventional pipe flare, although worst case radiation calculations are always based upon a ‘no fan’ scenario. To cover various smokeless requirements multiple blowers or blowers with variable speed motors can be used.

- **Sonic Flare Tips**

Single point sonic pipe flare is the simplest form of sonic high pressure flare tip. The tip operates by allowing flare gas to accelerate to sonic velocity at the tip exit. Single nozzle sonic flares have limitations. This type of tip is suitable for burning light hydrocarbons smokelessly, but as the hydrocarbons become heavier then more and more smoke will result at lower flows as the kinetic energy reduces and more air is required to burn heavier hydrocarbons. In addition there is a size limitation. As tip capacities increase then the exit diameter increases. As the flame envelop increases then it is more difficult for air to penetrate to the center of the envelope. This results in unburned hydrocarbons at the center of the flame ultimately producing smoke.

To overcome the limitations of single nozzle flare tips Designers of conventional flares have achieved this by passing the flare gas at high velocity through multiple nozzles rather than one large tip. This has the effect of increasing the surface area of gas exposed to the air and also reducing the effective diameter of the flare gas envelope allowing air to penetrate to its center. It is a single point flare tip with multiple sonic nozzles.

Due to the increase of the price of hydrocarbon gases, the problem of continuous flaring as too much gas was burned during a normal day, too much time were spent to detect leaking flare valves and doing maintenance on leaking valves, CO2 tax at about $ 8 million from flaring per year could be reduced and from an environmental

point of view, flaring was one of the emissions that could be reduced, hence the ZERO FLARING of FLARE GAS RECOVERY technique was emerged to recover valuable flare gases from normal operation and to use them again in either the process area or just as a fuel and hence reducing a considerable amount operating cost in an important step of process optimization due to enhancing the production.

Flare system maintenance is coincidentally very expensive. Unexpected flare failure is serious. The flare system cannot be maintained when in service and on most systems will require a complete production shutdown to change out flare components, thus costing a minimum of three or four days loss in production or during a planned shutdown the flare maintenance is often on the critical path. Thus it can be seen that if improvements in flare system maintenance can be achieved, the industry's desired aim of CO2 reduction through reduced flaring may be paid for by maintenance improvement. This is the target to be achieved.

- **Zero Flaring with Gas recovery System:**

Flare gas recovery system is one of the technologies developed to eliminate the need for continuous flaring where the gas is safely and cost effectively recovered and can be utilized for other purposes; can be exported, used as fuel gas, re-injected, and recovered back into the feedstock or any other system utilizing gas. The system also offers a substantial reduction in CO2 and NOx emissions.

In today's technology there are complete flare systems available that approach zero flare solutions. These systems cannot remove the basic need for an emergency flare as a final safety device, but can and do offer real cost and environmental benefits at extinguishing or managing the flare in daily use.

The concept comprises flare header isolation equipment, a gas recovery system and a reliable flare gas ignition system. The flare gas recovery system will be designed to meet the specific process conditions on the plant.

Flare Gas Recovery systems perform the following processes:

- Isolating the flare header with a proprietary-design liquid seal or staging valve
- Recovering the normally flared gases
- Removing liquids
- Compressing gases up to a defined pressure level
- Cooling recovered gases (if required)
- Delivering the recovered gases into the facility, so they can be processed and re-used as fuel gas.

Zero normal gas flaring arrangement consists of three major systems:

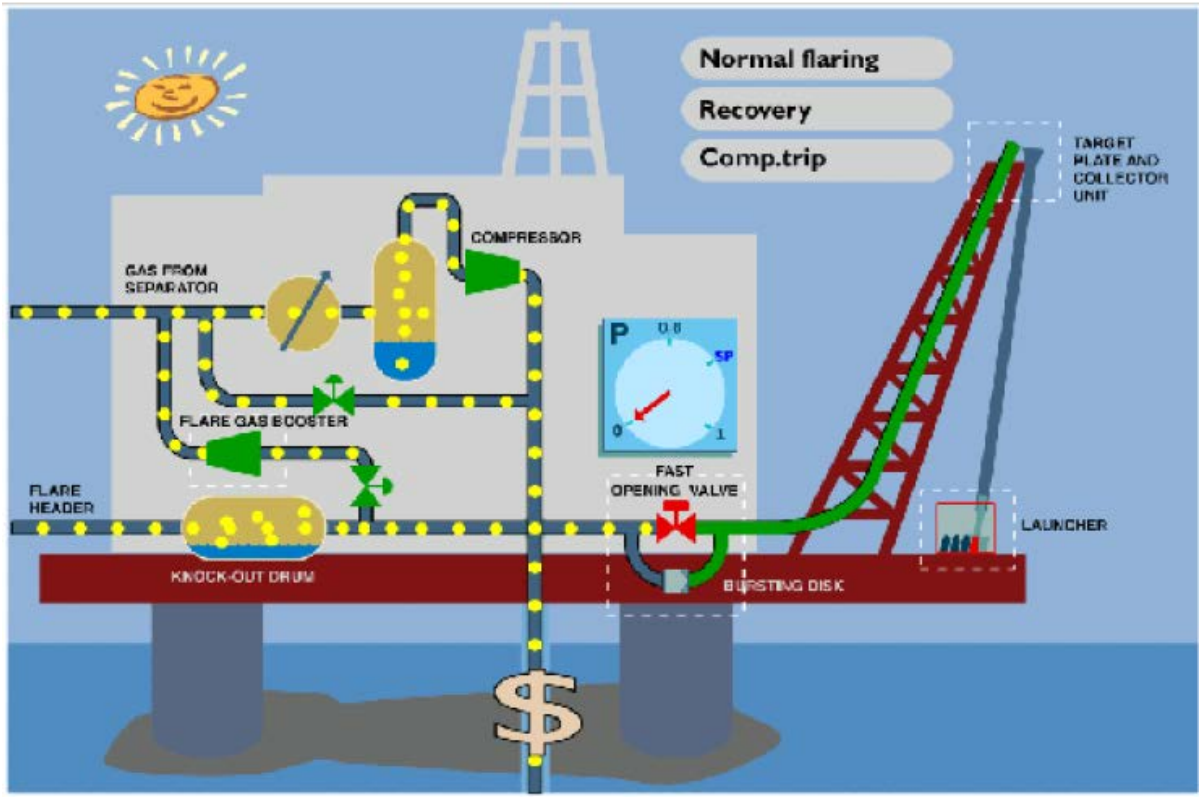
- Liquid seal or High integrity flare opening valve (FOV) (mechanism for closing the flare line (or vent)
- Flare Gas Recovery System
- Flare ignition system
- High Quality Safety System

If the pressure rises or any other unforeseen event happens, the fast opening valve or liquid seal will open the path to the flare, and the flare gas recovery will change into flaring mode, allowing emergency releases to be lead to the flare tip and burnt off safely.

When operating in recovery mode, a fast opening valve or liquid seal will close off the path to the flare stack, the recovered gas will then be lead back to the existing gas compression system and reintroduced, preferably where the process fluid is lowest. A pressure –boosting device (i.e compressor) may be necessary to meet the operating pressure at the tie in point to the gas compression system. Sometimes an ejector is installed as a pressure booster to meet the operating pressure at the tie in point to the gas compression system.

The zero flare system includes a nitrogen generator from which nitrogen is used to purge the flare stack during the zero flare modes.

In the zero flare systems, pilots in general are removed as the flare is only called upon to operate under high flow conditions.



Liquid Seals:

To make it possible to recover the flared gases, the liquid seals in the flare pipelines are necessary down-stream the flare knock out drum so that the restriction of gas in the flare line is maintained and the gas going to the flare is recovered by means of gas compressors or by means of ejectors. The liquid seal will regularize the pressure between upstream the liquid seal and Knock out drum. It breaks in case of any upset in the process plant and retrieve back automatically as and when system becomes normal.

Zero Flaring with Liquid Seal provide many advantages as it provides:

- Safe way to divert gas to recovery system.
- Can be designed for very low back pressure (1.4 PSIA to 14 PSIA)
- Liquid Seal will break within seconds from any process upsets
- Becomes auto effective as soon as normal operations are restored.
- Simple design for any flaring system with minimum delivery period
- Can be applied to divert different flared gases at different pressures to recovery system at single point.

Liquid seal usage have some limitations regarding to required pressure levels (maximum 1 barg) and resulted minimum temperatures and in such a case, fast opening valve is used instead.

Fast opening valve is a SIL 3 valve, available for flare line size ranging from 10” - 48 ", opens in less than 2 seconds and can operate up to 100 barg.

Liquid accumulation in the fast opening valve during flaring introduces the potential for liquid carry over, sometimes not seen in conventional flaring design where any condensate drains back into the flare knock out drum. To prevent liquid sitting in the fast opening valve, piping design requires a dead leg at low point in the flare drum discharge piping.

In case of using fast opening valve, a secondary pressure protection device- a burst disc was installed in parallel to the fast opening valve to provide a positive path to the flare in case the valve should fail to open.

A rupture pin valve is chosen over a rupture disc because it allows the valve to be reset without requiring the valve to be isolated from the process, significantly simplifying the design. Being external to the process, the pin is also not subject to corrosion from the process gas.

Recovery packages:

Depending upon the available process facilities and utilities at the plant, the flared gas recovery equipment is decided.

The compressor best suited for the flare gas recovery depends on many factors; such as process requirments, dependability, efficiency and maintenance requirments.

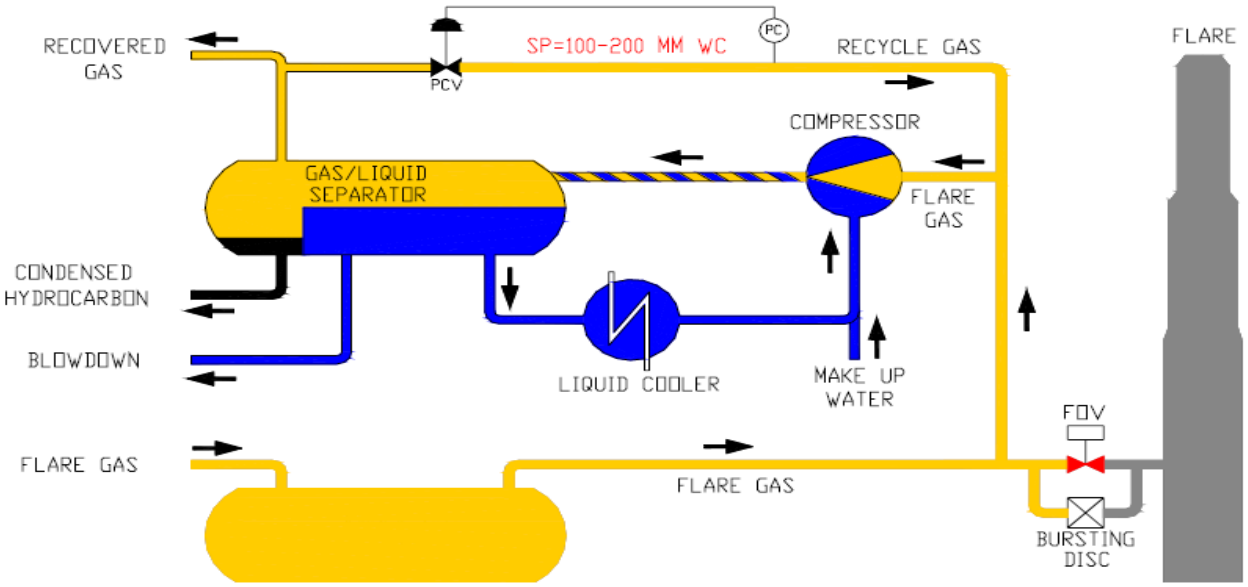
Liquid reing compressore use a liquid (often water) to form a seal in the shape of a ring between outer ends of the impeller and compressor housing. The centrifugal force from the rotating impeller forces liquid to the ouside wall formin a seal. This liqud also remove some heat of the compression from the recovered gas and wets the compressor internals for added safety.

Liquid Ring Compressors is a preferred mode of compression within the recovery systems. Liquid ring technology is proven in flare gas recovery applications and used

because of its durability and its ability to address the wide range of process compositions typical in flare applications, able to handle, toxic, corrosive and flammable gases and gases containing particulates. Main disadvantages are that maximum Pressure ~10 barg and has fixed speed.

Additional compressor types depending on the project application can be used.

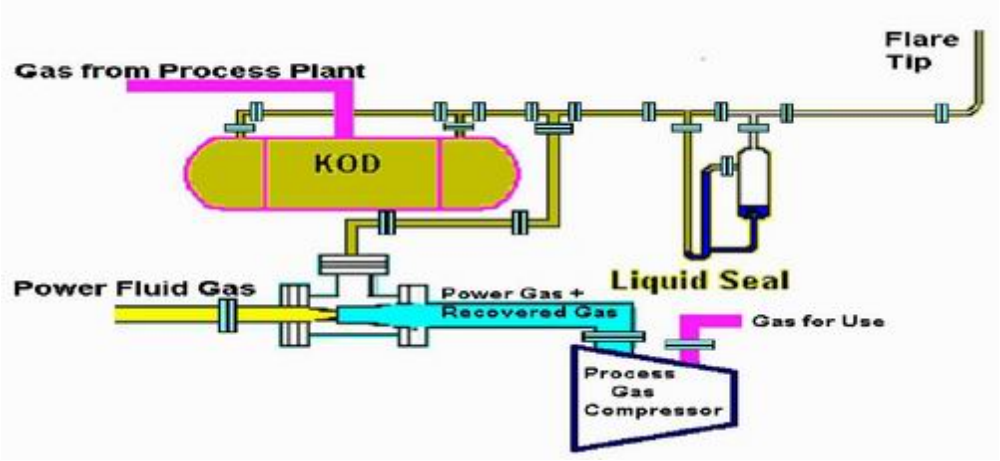
TYPICAL FLARE GAS RECOVERY SYSTEM



Typical recovery packages are:

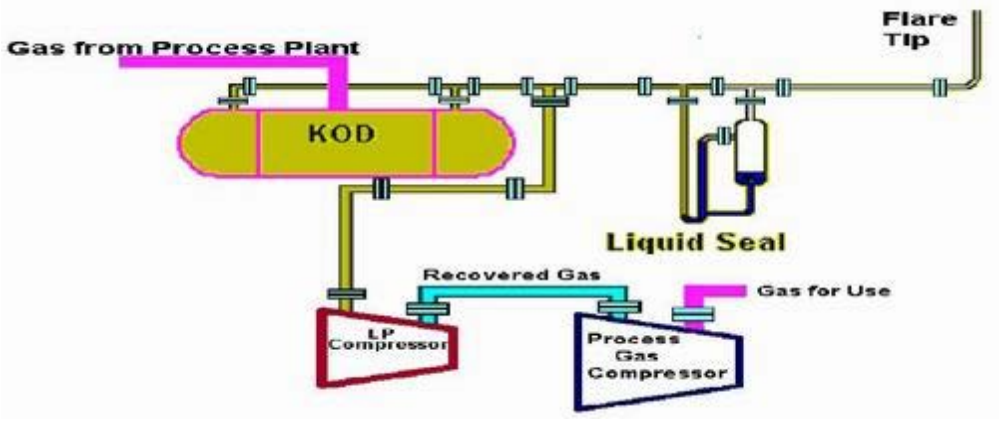
Ejector skid

- Blower skid
- Screw compressor skid
- Liquid ring compressor skid



The ejector application is totally dependent on the availability of motive fluid at the installation/ plant.

Depending upon the availability of motive fluid and availability of compressors capacities & their suction / discharge pressures, and also the available power & space, it can be decided whether introduction of Ejector or low pressure Gas Compressors are feasible to recover the total flared gas.



Pellet ignition:

Along with the flare gas recovery system was a new type of ignition system based on a pellet fired to hit a striker plate and shower the whole flare deck in sparks. This was required to improve the reliability of the flare ignition systems to match the new normally ‘not lit’ operational philosophy and allow the flare pilots to also be removed, further reducing CO2 emissions.

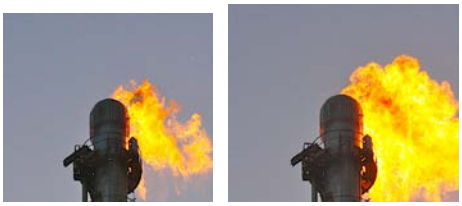
The ignition system guarantees ignition in all weather conditions. There is no electronic equipment or movable parts located in high heat radiation areas, making the system reliable and easy to maintain.

The ignition system will deliver a cascade of sparks over the flare tip to ignite the released gas where ignition is automatically initiated in the opening of either fast opening valve or rupture pin valve.

The ignition pellet is launched through a guide pipe to the flare tower. The pellet bursts and generates a shower of sparks when exiting the guide pipe. The resulting shower of sparks is directed towards the flare tip and instantly ignites the gas cloud.

The system is designed to operate for flare towers up to 2000 meters from the launching unit. The pellets are safe to handle and are stored in a magazine in the launching unit which is located at grade.

The spent cartridge is retained in a fragment collector that is mounted on the flare deck.



The pellet spark ignition system is very sensitive to the bends on the travel path and to guarantee ignition, two pellets are launched in every incident.

BASIC SPECIFICATION:

- Launching medium: Compressed air
- Launching pressure: 5-7 bar (110 psi)
- Launching range up to 2000m+
- Ignition pellet: -L x D 100mm x 20mm
- Weight 80 gram
- Min. bending radius: 3,6 m

The main disadvantage is the high capital cost and the reliance on a flare monitoring system if an auto re-ignition sequence is required.

It should also be noted that because the pellets are classified as dangerous goods (due the small incendiary charge) they are subject to specialist handling.

Damage to the guide tube can result in the pellets becoming stuck.

One challenge during construction is to insure that the pipe guide ran without any kinks to allow the pallet free travel to the flare tip and to minimize the possibility of a pellet sticking inside the guide pipe. The final ignition initiator is by spring loaded wings popping out of the pellet as it leaves the guide pipe insuring that the pellet does not ignite before leaves the tube.

The Flare Ignition Cabinet is installed at a safe distance from the flare stack and a guide pipe leads to the flare tip. The system is suitable for all flare tips and may ignite several flares on one flare deck. It combines high reliability and availability over the lifetime of the facility with low maintenance requirements, and is easily retrofitted into existing installations. It does not need any pilot burners, and has no equipment on the flare deck that is sensitive to heat, such as cables, instrumentation, or electrodes.

Finally as a conclusion, we have to say that Zero flaring Technology provides:

- Reduction of emissions dramatically i.e. NOx, SOx, CO2,..etc.
- Recovering of waste gases for fuel.
- Prolong life of the flare system where as the flare tip itself is no longer subject to continuous flaring, wear and tear is significantly reduced. Experience on other units has shown that continuously flaring may require several flare tip changes during the lifetime of the unit; this is now potentially reduced to none.
- Reduction in operating costs
- Eliminates visible flame and odors
- Rapid return on investment
- Requires minimal maintenance
- Meeting the stringent environmental regulations.
- CO2 tax saving

Open and ignited flare

The flare has always been a symbol for stable production

Closed flare system

Now a flameless flare may be a symbol for stable and clean production.