



INDAIR KMI Flare Tip

The Indair flare tip has been used for over 25 years in hundreds of applications requiring a low radiation, smokeless, high pressure flare design. In recent years the use of multiple Indair flares operated in parallel has been used very successfully in a wide range of applications and configurations.

In order to take advantage of the many operating benefits of the multiple Indair flare design, John Zink has developed a range of designs that provides a cost effective, low maintenance solution to a wide range of flare applications.

The KMI Multi-Point INDAIR flare tip design utilizes multiple small diameter Indair flare tips mounted on a common flare body. At the heart of the KMI Multi-Point INDAIR flare tip is the cast Indair flare tip. John Zink has developed a range of small Indair flare tips (4" to 12" tulip diameter) that fabricated as solid castings. The entire tulip assembly is a thick, solid stainless steel casting. This is in contrast to the large Indair tulip assembly that requires welding of a rolled plate tulip cone to the forged tulip bowl assembly.

The cast tulip assembly design provides many unique features in contrast to the large tulip assemblies including:

- The cast tulip assembly has no welded joints in the tulip assembly that are susceptible to failure.
- The entire tulip assembly is a solid, continuous, thick assembly with no changes in material thickness or type. There are therefore no differential thermal expansion forces due to dissimilar metals and/or changes in material thickness.
- The cast tulips are manufactured in bulk quantities and are significantly less expensive than the fabricated tulip assemblies.
- The flare tip and tulip assemblies are manufactured to exacting tolerances that are not susceptible to loss of tolerance due to heating and cooling after welding. This allows very tight tolerances in the slot width of the cast Indair flare tips.

The design of the KMI Multi-Point INDAIR flares uses an array of small cast Indair flare tips arranged in a pattern to assure adequate aeration of each individual Indair flare tip, while also ensuring cross-lighting between the individual tips.

The layout of the KMI Multi-Point INDAIR flare tip is very similar to that used by most conventional multi-point sonic flare tips. The main body of the flare tip has multiple small diameter arms that "Tee" off the main body in a symmetrical pattern. The major advantage with the KMI Multi-Point INDAIR flare tips is the use of unique Coanda



Principle of the Indair flares. These Indair multi-point “nozzles” are much more efficient at entraining and pre-mixing air into the flame than a conventional sonic flare tip nozzle.

The Indair design that is recommended for applications requiring high turndown is a “variable slot” design. The slot width (which determines the tip outlet area) remains at a small size during low gas flow rates and increases proportional with increase in gas flow. This design provides near infinite smokeless turndown design while maintaining high maximum flow capacities. This variable slot Indair design, therefore, produces 100% smokeless flaring from minimum (purge) to maximum design flow rates.

The high tolerance fabrication of the cast KMI Multi-Point INDAIR flare tips allows very small minimum slots, thereby providing infinite turndown. The flames produced by each of the individual, multipoint Indair flare tips remain thin and stiff under all flow conditions. This prevents any possibility of “flame lick” between the multi-point nozzles that causes severe damage to conventional multi-point sonic flares.

Conventional sonic flare tips have a fixed outlet area design. The smokeless turndown for these types of designs is roughly proportional to the maximum flow design operating pressure versus the pressure at which sonic velocity occurs.

Sonic pressure for most hydrocarbon gas streams will occur at about 10-12 psig backpressure. Therefore the smokeless turndown for conventional fixed outlet area flare tips is:

$$\text{Turndown} < \frac{\text{Max. Operating Pressure}}{\text{Sonic Pressure}}$$

For instance, if the maximum design pressure for a conventional sonic flare tip were 50 psig, the turndown would be less than 5:1. This would mean that at flow rates from 0-20% of maximum the flare could produce smoke. For most flare systems this 0-20% range is the typical normal operation. A conventional sonic flare tip would therefore smoke during most normal operations.

The only solution for providing reasonable smokeless turndown with a convention sonic flare tip is to provide an elaborate multi-flare tip design with many flare stages separated by control valves. This type of design is therefore very expensive to install and maintain.

The unique variable slot Indair flare tip provides infinite smokeless turndown without the need for these elaborate staged multi-flare designs. A single Indair flare tip provides 100% smokeless flaring and high flaring capacity with a very low radiation flame. The spring-loaded mechanism is extremely reliable, with a design similar to that used in safety relief valves.

The variable slot has been installed in over 200 installations worldwide for nearly 20 years. With smokeless flaring being a more important design feature in recent years the variable slot Indair has become the choice of most major oil and gas producers.



Indair Flare Tip Description

The Indair flare was developed to provide a safe and reliable high efficiency flare tip to produce smokeless, low radiation flare design without the need for outside assist media such as forced air or steam. The Indair flare is a pressure-assisted flare design which utilizes the internal energy within high-pressure gas streams to produce a highly aerated, turbulent flame.

The Indair flare utilizes the “Coanda Effect” to entrain and mix air into the hydrocarbon gas stream. High-pressure gas is ejected radially from the annular slot at the base of the Indair tulip. Instead of continuing horizontally, the gas adheres to the Coanda profile and is diverted through 90 degrees, entraining up to 20 times its own volume of air in the process.

The pre-mix air/gas mixture creates very efficient, 100% smokeless combustion of the flare gases. The flame produced by this efficient pre-mixed combustion is a very low radiation, low luminance flame. The flame length is less than half of that produced by a conventional flare tip. The flame is also a thin, stiff, pencil shape that is not easily distorted by crosswinds.

Flame initiation always takes place near the maximum diameter of the tulip, insuring reliable ignition of the gas by external pilots, even on sudden venting and under high wind conditions. Smokeless, low radiative combustion is achieved without the need for ancillaries such as steam, compressed air or fuel gas.

Unlike other flare tips, the flame propagates from the outside and there is always a protective film of hydrocarbon gas insulating the Coanda tip. This avoids overheating of the flare tip and allows it to be manufactured from conventional alloy steels, using normal welding procedures, without the need for sophisticated materials such as ceramics.

Advantages and Operating Characteristics of the Indair Flare

High Pressure Operation

Since the Indair flare operates at elevated pressure when burning HP gas (rather than near atmospheric pressure as with a conventional flare), significant savings in header size and knock-out vessel size may be made. The primary design consideration in sizing relief headers and liquid knockout vessels is the velocity of the gas. Maintaining a high backpressure at the flare tip keeps the gas compressed in the upstream flare header. This reduces the velocity of the gas for a given relief flow rate of gas.

Efficient Air Entrainment and Mixing

The efficiency of any combustion process is largely a function of the efficiency of the fuel/air mixing. Conventional low-pressure pipeflares emit a cylinder of hydrocarbon gases that rely totally on natural diffusion of air into the flame. This produces relatively



low combustion efficiency. Multi-point sonic pipeflare tip designs improve the efficiency by splitting the flow between smaller, separated cylinders of hydrocarbon gases and creating some air entrainment into the flame due to the sonic jet nozzles which are used. The unique Indair flare tip, based on the Coanda Effect, forms a thin film of hydrocarbon which entrains and pre-mixes air prior to combustion. The Indair flare, in most cases, produces combustion efficiencies in excess of 99.9%.

The Indair combustion efficiency is such that additional quantities of low-pressure gas may be fed to a central duct in the flare and burned efficiently and smokelessly with the main HP gas flare.

Smokeless Operation

Indair flares will provide smokeless combustion of high-pressure gas over their specified operating range. Conventional multi-point sonic flare tip designs can produce smoke when flaring heavy hydrocarbon gases, unsaturated hydrocarbon gases, or gas streams containing liquid droplets. The Indair flare tip, due to its unique pre-mixed turbulent flame, high air entrainment rate, and thin film combustion technique, will produce smokeless flaring of any hydrocarbon gas stream.

Low Radiation

The Indair flare produces a highly aerated turbulent diffusion flame that radiates far less heat than the equivalent flame produced by the conventional pipeflare. The reduction in radiation is achieved without the use of ancillaries such as steam, compressed air or fuel gas. The Fraction of Heat Radiated (F), which is also often termed flame Emissivity (e), is the portion of a flame's gross heat release that is emitted as radiation from the flame. The F-factor (or Emissivity) of Indair flares has been measured for a wide range of operating conditions. The value of F for Indair flares varies from 0.08 to 0.10. A value for F of 0.20 to 0.25 is used for an API-type pipe flare. A value for F of 0.12 to 0.15 is produced by conventional multi-point sonic flare tip designs.

Flame Length

The turbulent Indair diffusion flame with its increased combustion intensity is far shorter than that of an equivalent conventional flare. The flame length produced by an Indair flare is less than half that produced by a conventional API-type pipeflare. The short flame length produced by the Indair flare makes it an ideal choice of flare tip for ground level mounted flare designs.

Flame Stability

In contrast to the wind sensitive flame produced by a conventional flare, the Indair flare produces a flame with a high directional stability which is not easily distorted by cross-winds. The flame is extremely stable; in fact, Indair flares have been operating successfully in the North Sea in wind speeds in excess of 100 mph.



Liquid Carry-Over

Even with the best run production/separation installations, liquid carry-over to the flare line can take place, particularly under emergency relief conditions. With conventional pipeflares or multi-point sonic flare tips this can be a serious potential hazard giving rise to 'flaming rain' falling and pollution affecting a wide area.

The intense shear in the Indair slot region ensures efficient atomization of liquids, aiding vaporization and combustion. The Indair flare is capable of burning 25% by weight of liquid carry-over without any fall-out or smoke production whatsoever. The Indair flare tip can effectively atomize liquid particles with size in excess of 1200 microns. This feature means that, in many cases, the flare may be operated without a liquid knockout drum in the HP flare line.

Reliable Ignition

The Indair flame always initiates near the maximum tip diameter so that reliable ignition of the Indair flame is achieved, even on sudden venting and under high wind conditions.

Flare Capacities

In general, the volumetric gas flow rate (Q) through a sonic flare tip is a function of the absolute gas pressure (P) at the exit area (A) and the specific gravity and absolute temperature of the gas (Sg, T). The multiplier K is a function of flare design and to a lesser extent gas composition.

$$Q = KPA (T \times Sg)^{-0.5}$$

For conventional sonic flare tips, the outlet area A is fixed, and turndown is largely governed by the ratio of operating pressures:

$$\text{Turndown} = \frac{P_{\text{available}}}{P_{\text{minimum}}}$$

Where P minimum is normally around 10 psig.

With the unique variable slot (VS) Indair design, the area varies linearly with pressure. Much larger turndown ratios can be achieved since:

$$\text{Turndown} = \frac{P_{\text{available}} \times A_{\text{maximum}}}{P_{\text{minimum}} \times A_{\text{minimum}}}$$