



FLARING UP

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OUTLINES SPECIFIC DESIGN
CONSIDERATIONS FOR FLARING IN
AMMONIA AND UREA PRODUCTION.

As industry practices for safely and effectively disposing of waste products in ammonia or urea plants continue to evolve, operators require more comprehensive and complex flaring solutions. Designing combustion equipment to provide effective destruction efficiency (DE) for chemical, petrochemical and gas processing applications presents specific challenges that must be assessed on a per case basis. Typically, process reliefs with substantial heating value and the ability to easily ignite require less complexity while still ensuring proper DE.

However, for industries producing chemical compounds where the nature of the chemical itself makes ignition and high DE difficult to achieve – including ammonia – non-standard flare design practices must be employed to ensure clean and efficient combustion. In this article, an overview of the challenges of combusting compounds,

including ammonia, will be provided as well as the design philosophies used to ensure stable, efficient and clean combustion of such compounds.

Difficulties with ammonia combustion

Ammonia is a nitrogen-based compound, and nitrogen is a chemically inactive element. Other factors contributing to the difficulty of ammonia combustion include low flame propagation speed, low heating value and low flame temperatures. Meeting these challenges requires specific design criteria for ammonia flares (Figure 1).

To facilitate the combustion of ammonia, it is necessary to restrict the exit velocity of the waste gas to ensure the ammonia has adequate residence time for high DE combustion. Zecco has accumulated test data demonstrating a correlation between ammonia flame stability and exit velocity, which supports this design philosophy. If a flare system is not designed with this key metric, there is a higher potential for incomplete combustion and/or an unignited release of the waste gas.

Figure 2 illustrates this further: the maximum design exit velocity for waste gas containing ammonia is dependent



Figure 1. An example of a flare system designed to handle ammonia and urea facility waste gas.

upon the flare tip diameter. In general, as the flare tip diameter increases, there is a larger volume of gas and higher heat release from the flame. Thus, designing the flare tip diameter based on controlling the exit velocity assists in maintaining a flame temperature higher than the ignition temperature of ammonia, and improving the overall flame stability.

Design considerations for ammonia combustion

Extensive testing and validation performed at Zeeco's testing facility generated innovative advances in design considerations for the burning of ammonia process gas.

Tip waste gas distribution

Commonly, the portion of the flare referred to as the 'flare tip' is the upper 10 ft of the flare system. As ammonia waste gas enters the flare tip body, access to air and uniform mixing to promote combustion play a critical part in burning the compound. To achieve even distribution of the waste gas throughout the entire flare tip body, ammonia flare tips need to include flow distribution devices that properly disperse the waste gas, expose the waste stream to ignition sources as well as increase access to the combustion air.

High stability design and flame stabilisation

On typical utility flare tips, windshields are flushed with the flare tip exit and the pilots arranged on the outer perimeter of the windshield. In this case, a flame stabilisation system provides uniform flame stability for initial ignition as high heating value

gas can propagate combustion with ease after initial ignition is accomplished.

In contrast, for ammonia combustion, the windshield design should be modified to ensure wind effects are minimised and interaction between ignition point, air and fuel are concentrated in this area. Pilots are placed at strategic locations to increase stability and to be as close to the flare tip perimeter as possible for ignition. Zeeco designs and uses a specialty flame stabilisation system for low heating value gases, such as ammonia. With this system in place, the flare tip, pilots and flame stabilisation tabs are synchronised to promote the highest achievable flame stability. All of the components interact to provide a highly stable combustion zone so the ammonia burns freely and the flare system achieves high DE.

Exit velocity strategies

The physical behaviour of the gas can be modified when flaring ammonia. As mentioned, the effect of exit velocity regarding the combustion of ammonia waste gas is dramatic and design constraints can be put in place to promote stable combustion. Zeeco typically elects to increase the flare tip barrel diameter in conjunction with the use of diffusion apparatuses for ammonia applications. In doing so, ammonia can be slowed to an acceptable exit velocity and diffused throughout the flare tip, promoting proper mixing and stable combustion over a uniform area.

Design constraints for urea process flares

Urea processing plants represent another inherently challenging flaring application. The following offers proven design considerations for the proper combustion of urea process relief streams.

A significant volume of inert byproducts that are generated through the urea process make combustion of waste streams difficult to achieve. To meet this challenge, urea plants typically employ four different types of flares to handle the various relief streams from the plant: ammonia, discontinuous, continuous and main. Design considerations for an ammonia flare have been discussed. The discontinuous and main flares commonly handle streams with higher heating values and are, therefore, much easier to burn. As such, these flare designs are more standard and do not require the specific design constraints of an ammonia flare.

Another typical byproduct of the urea process is oxygen, a highly reactive compound. In the presence of other combustible compounds, oxygen makes a relief stream a combustible mixture even before reaching the flare tip exit. The continuous flare typically handles streams that contain oxygen. Specific requirements are necessary for waste streams containing oxygen because a combustible mixture is already present in the flare system before the introduction of ambient or combustion air. The continuous flare tip is designed to ensure the minimum exit velocity of the waste stream is higher than the flame velocity for the waste stream. Essentially, this model keeps the flame at the exit of the flare tip and prevents flame propagation into the flare stack and upstream equipment (flashback). In addition, the top portion of the flare tip must be applicable for severe environments to protect the flare tip barrel from the high temperatures of the flame. Adhering to the rigors of flaring high heating value waste streams helps

extend the life of the flare tip and increases production time between turnarounds.

Discussion

Aside from the combustion design for ammonia facilities, ancillary equipment should be assessed and evaluated.

For instance, liquid seal drums (LSDs) are commonly used as a safeguard to separate the flare system from the upstream header and equipment. As ammonia is soluble in water, when a relief stream containing ammonia flows through the LSD, the water will absorb some of the ammonia and form a corrosive ammonia solution. Often, the LSD is designed so that all of the water is removed with the waste gas during a flaring event and the LSD is refilled upon completion. In such instances, corrosion due to an ammonia water solution is not likely. However, if there are flowrates expected where the water will not be removed and replaced, further consideration may be needed. Requiring the LSD to be made of specialty materials, coating the inside of the LSD, and/or maintaining the quality of the water by continually skimming, and routine cyclical draining/refilling of the water are all possible methods to reduce the effect of ammonia streams through an LSD.

Ammonia flares are designed to have low exit velocities and low heat releases, so that noise caused by the flare itself is minimal. However, ammonia streams are typically high-pressure streams from the upstream equipment in the plant. A portion of this pressure drop will translate to noise that will travel through the plant's waste stream piping. As the flare tip is the only exit point for that waste stream and due to the necessary design characteristic for the flare tip, the tip can act as an amplifier for the noise produced in the upstream piping. Operators experiencing unexpected noise levels at the exit point of an

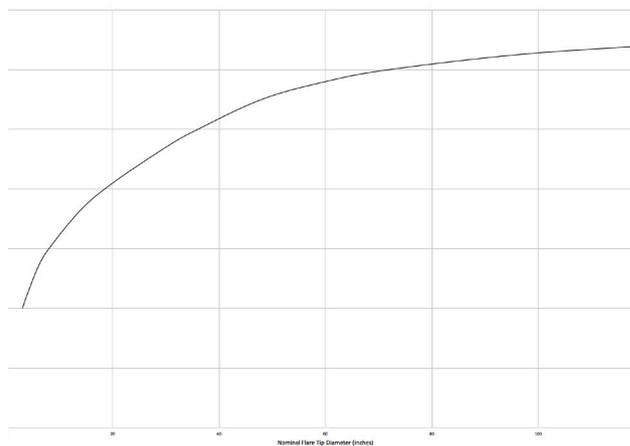


Figure 2. Typical maximum design exit velocity versus nominal flare tip diameter.

ammonia flare should take the high amount of pressure drop from the upstream piping or at the relief source into consideration.

Conclusion

There are many design aspects to consider when designing flare systems and ancillary equipment for ammonia waste processes. With the influence of more stringent emission regulations on the horizon, progress towards sound inherent design of flare systems to relieve waste will become more crucial. Through further testing and innovation, flare system providers, such as Zeeco, will have the opportunity to develop new solutions to provide clean, efficient and effective flaring solutions for ammonia and urea plants. **WF**