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Bulk Ammonia Supply Solutions for LED Manufacturers

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When large volumes of ultra high purity gas are needed for industry, bulk specialty gas supply offers a solution.

Abstract

Ultra-high purity (UHP) ammonia (NH_3) is an electronics specialty gas crucial in the manufacture of light emitting diodes (LED), which are used in applications such as automotive and traffic signage and are displacing conventional lighting alternatives based on their ability to operate at reduced power, lower temperatures and with extended lifetimes.

Large volumes of NH_3 are needed to provide the nitrogen source for the gallium nitride layers in the manufacture of LEDs. The traditional approach had been standard 1.5 ft^3 or 47 liter cylinders inside gas cabinets. However, as NH_3 volumes increased for the newer process tools, cylinders became impractical due to severely limited flow rates, which created thermodynamic issues such as cylinder cooling and reduced NH_3 quality. Bulk Specialty Gas Supply (BSGS) systems overcame many of the challenges.

BSGS systems, which contribute fewer impurities to the gas due to the larger volume to internal cylinder surface area ratio, use larger NH_3 source containers that feed high flow delivery systems that pipe NH_3 to the process tools. This is analogous to N_2 liquid bulk installations. Although many LED manufacturers have embraced BSGS systems, some LED manufacturers have taken a piecemeal approach and are experiencing problems in flow rates, purity, and minimizing costs. To remedy these problems, a total solutions approach is required.

This paper will address the elements of bulk NH_3 sup-

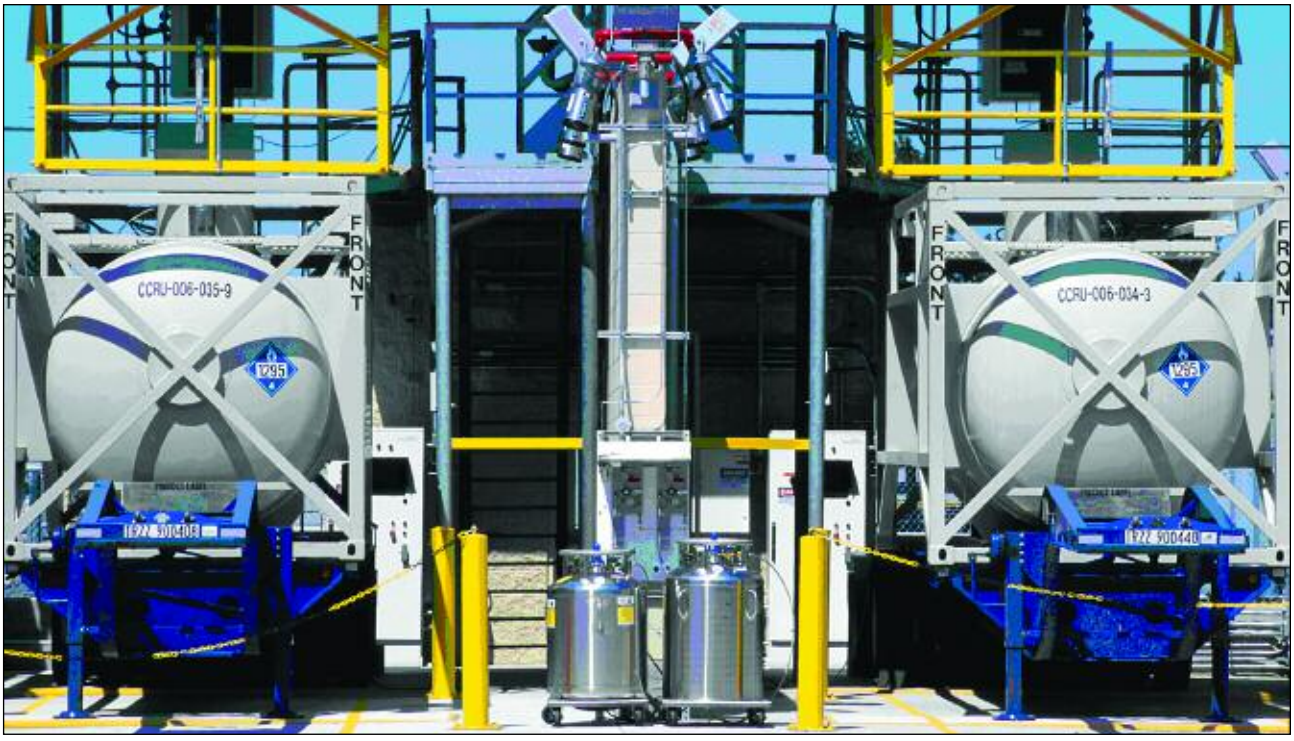

Figure 1: BSGS Installation of Bulk ISO Supply

ply, dispel popular myths, and profile the best overall solution for bulk NH_3 supply for LED manufactures.

The Elements of Bulk NH_3 supply

Large-scale distillation plants offer the most economical option for generating large volumes of NH_3 with the highest purity. This product is then transported to the customer's site via large heated containers. Next, the NH_3 source is meticulously connected to the BSGS system, which contains the necessary redundancy to minimize single points of failure and ensures that the NH_3 remains in its gaseous state. Single points of failure are best eliminated in the BSGS system design using Failure Mode and Effects Analysis (FMEA) for the entire system.

Keeping NH_3 in its gaseous state requires addressing the thermodynamic issues surrounding this formerly common refrigeration gas. Due to the larger gas volumes required, "heated" gas supply systems are needed to overcome the Joule-Thompson (JT) cooling effects, which will be exacerbated at higher flow rates. Both the JT cooling that occurs when pressure is reduced on a gas, as well as the energy required for heat of vaporization to convert the liquefied gas into a vapor, must be accounted for in the design.

As NH_3 volumes increase for the newer process tools, cylinders became impractical due to severely limited flow rates

A Total Solutions approach is best provided by gas manufacturers who address all elements of bulk NH_3 supply, including: large-scale NH_3 purification; a proven track record for integrated bulk delivery system design; reliability of NH_3 supply through on-site operation and maintenance of the bulk delivery system; and various financing arrangements.

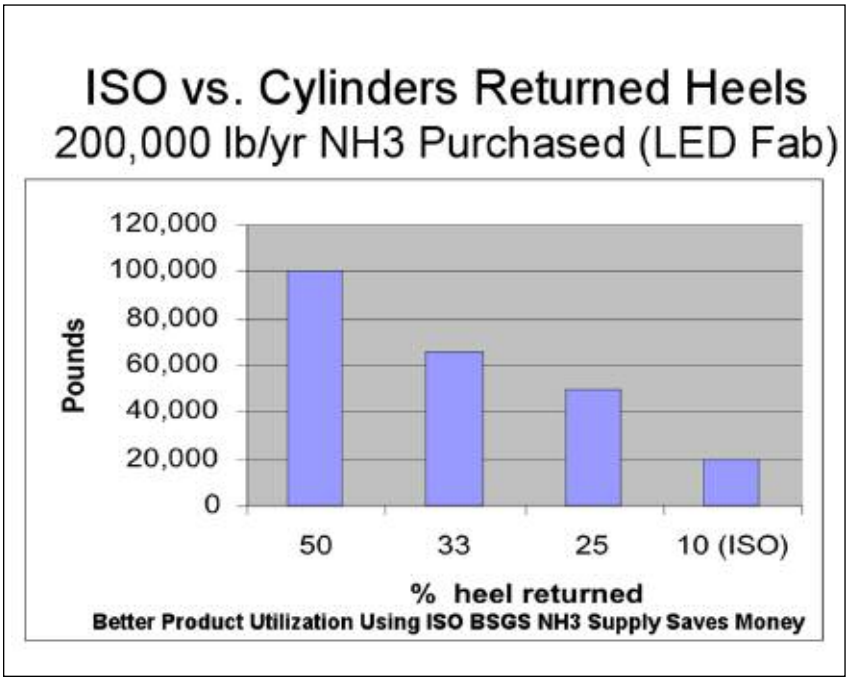

Figure 2. ISO Vs. Cylinder Heels

The "Total Solutions" Approach

Some LED manufacturers have been reluctant to adopt a BSGS system due to the fact that it will require a large, specialty gas source container on-site. However, it is important to remember that any BSGS system should be offered through a Total Solutions approach, not simply as a sale of equipment and gas.

Site Considerations and Installation:

Site considerations should be part of the offering to provide an optimum and safe installation. The BSGS system should be installed with the same containment, ventilation and monitoring protocols common in gas cabinet installations. BSGS systems should be able to be placed in an outdoor environment, allowing for the utilization of less expensive space versus traditional gas rooms. Outdoor conditions will require BSGS systems to be weather-proofed and housed in cabinets, and monitor-and-control electronic equipment to be conditioned for temperature and humidity. A roof is necessary to provide protection from snow, rain, and sun, all of which can influence system performance. Although the total length of the piping system is not expected to increase significantly, the diameter for specialty gases in BSGS service will typically require 1/2 inch or larger delivery lines rather than the 1/4 inch delivery lines used in cylinder gas cabinet supply. These lines also need to be heat traced.

Operating BSGS Systems:

Many LED manufacturers have little experience in operating and maintaining a BSGS system. BSGS system suppliers should provide written guidelines of relevant code requirements, product and project consulting, and be capable of installing an entire BSGS system for the LED manufacturer.

Emergency Response:

BSGS system suppliers should possess outstanding emergency response (ER) capabilities for LED manufacturer sites. These ER capabilities should run in conjunction with those of LED manufacturers and include the ability to train for, and respond to, incidents. United States Occupational Safety and Health Administration (OSHA) regulations under process safety management (PSM), as well as the United States Environmental Protection Agency's (EPA) risk management plan (RMP), need to be considered.

Keeping NH_3 in its gaseous state requires addressing the thermodynamic issues

Summary of Benefits

The benefits of BSGS systems to high-volume specialty gas users are significant. These include: reduced bulk NH_3 expenses of up to 50 percent versus cylinder gas expenditures; reduced total capital outlay versus that for multiple gas cabinets; minimized labor costs associated with gas cabinet maintenance, cylinder handling and change out; significant reductions in scrap costs due to greater product consistency; and easy expansion of the LED manufacturer's tool set through connection to a gas drop in the gas distribution piping (if the system is designed properly).

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