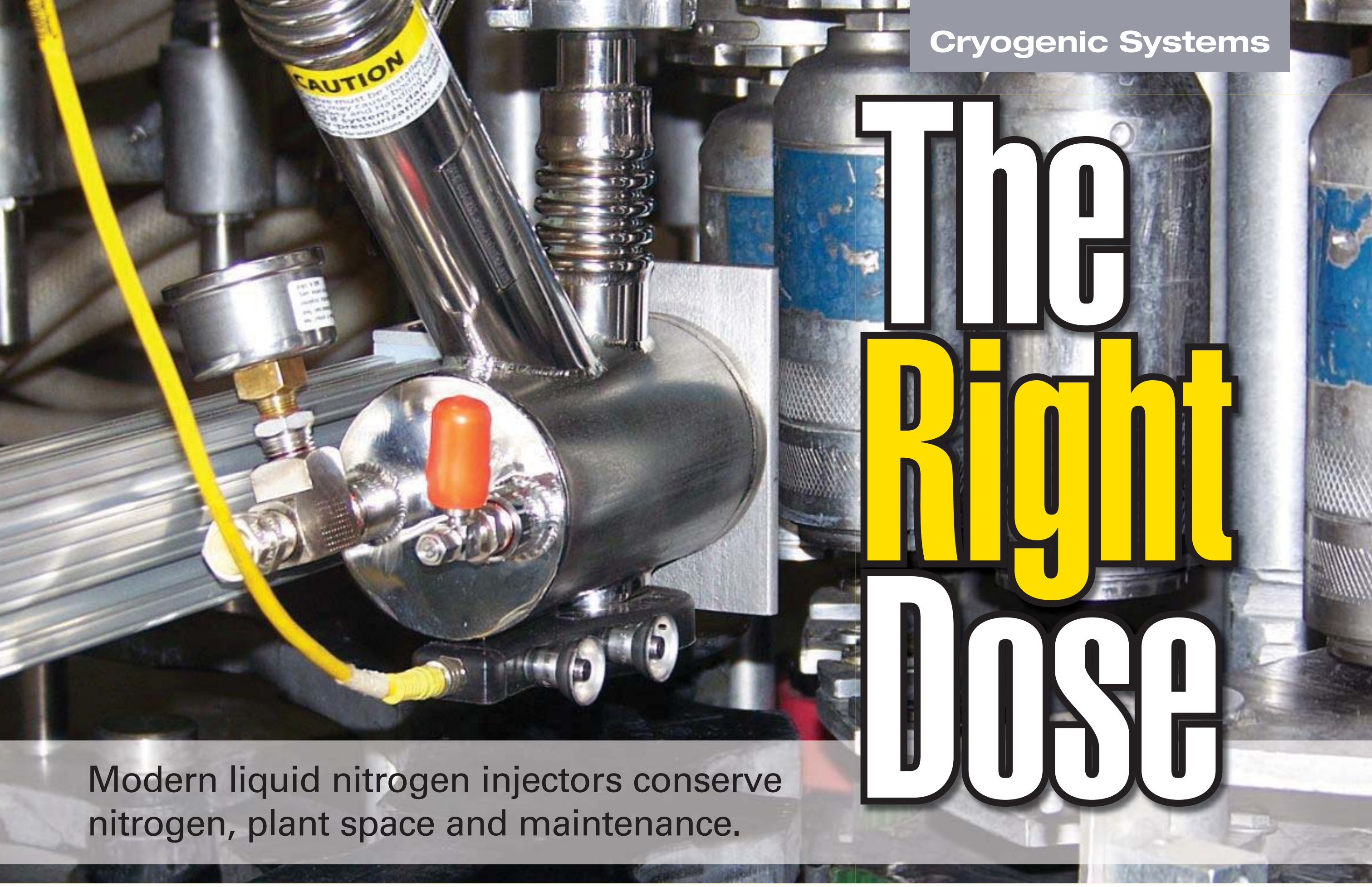

The Right Dose

Modern liquid nitrogen injectors conserve nitrogen, plant space and maintenance.

By Phil Redenbarger and Chris Hebb, Technifab Products Inc.

Liquid nitrogen (LN_2) injection is used throughout the food and beverage industry for inerting and pressurizing packages and containers. For example, bottlers of noncarbonated soft drinks, juices, water, wine and beer often use liquid nitrogen injection equipment to insert small, measured drops of liquid nitrogen into their containers to displace the oxygen-laden air. Soft food packages also are pressurized by liquid nitrogen injection to protect the package contents from crushing. In both cases, the dosed liquid rapidly evaporates into tasteless, colorless, odorless, inert gaseous nitrogen.

The liquid nitrogen typically is supplied from a storage dewar or bulk storage tank located inside or outside the facility. Because liquid nitrogen is a cryogenic liquid (-320°F [-196°C]), it usually is delivered to the process through a vacuum-jacketed pipe to minimize premature vaporization of the liquid. A liquid nitrogen phase separator often is used on the incoming line to make sure that the right pressure and only very cold liquid are delivered to the injection point just above the container (figure 1).

Injector Operation

When the liquid nitrogen is introduced into the container, the liquid vaporizes due to a temperature change. The liquid nitrogen injection drives out other unwanted gases (including oxygen) and covers the container contents with nitrogen gas. Because the vapor requires more volume than the liquid it replaces, the pressure within the container is increased. Pressure-influencing factors include the liquid level in the container, the temperature of the container contents and the dose droplet size.

Some liquid nitrogen injectors operate on continuous flow at all times. Others operate on discrete dosing when the container production line speed is low and then can be manually converted to continuous dosing at higher speeds. The benefit of discrete dosing is that the valve only opens and closes as each container passes below it, which conserves the amount of liquid nitrogen used in the process.

The type of sensing equipment used in the injector determines how efficiently the equipment will operate. Some injectors use only a basic sensor to turn the injector liquid stream on and off when containers are present. More sophisticated units use electronic controls to adjust discrete injector dosing to account for line-speed variations (figure 2).

Various orifice configurations also are available to control the type of injection pattern required for specific products. The best units allow simple and quick orifice change-outs only using hand tools.

Web Exclusive

Read more at www.process-cooling.com

Common LN2 Applications
Liquid nitrogen injection is used in bottled beverages, nuts and other perishable items, and hot filling operations, among others.

Production Line Considerations

Key factors to consider when putting together a liquid nitrogen injection system include the type of sensor, sensor location and available space on the production line.

The type of sensor selected primarily depends on the product being processed. For example, optical sensors typically can be used with clear bottles containing water or other transparent liquids; a process with metallic containers might operate better using proximity-switch technology (figure 3). Such systems can be either

A Brief History of LN_2 Injection

One of the earliest applications of liquid nitrogen dosing systems for pressurizing containers was developed by Reynolds Metal Company in 1982. A machine was developed that could inject predetermined amounts of cold liquefied gas into noncarbonated beverage cans just before they were sealed. This action pressurized the cans and added mechanical strength against collapse from stacking weight.

Shortly thereafter, Toyo Seikan Kaisha Ltd. developed a similar system. That system dropped liquefied gases into cans with the aid of a can-proximity sensor. The droplets of liquid nitrogen were released into the cans from a control valve and reservoir directly above. The reservoir atmosphere was allowed to pressurize, and the nitrogen vapors were directed coaxially with the liquid nitrogen droplets in a shield-gas flow to reduce nozzle freeze-up and clogging with ice from normal room humidity.

In 1989, Thornton Stearns, working for Vacuum Barrier Corp., added the subcooling of liquid nitrogen to the injection process. When controlled amounts of liquid nitrogen were added to uncapped containers moving on an assembly line, the immediate flashing to gas was prevented by making sure the liquid nitrogen was cold enough to stay a liquid at atmospheric pressure given its inherent vapor pressure.

Then, in 1998, Vacuum Barrier Corp. released for production an apparatus that located the vacuum-insulated liquid nitrogen reservoir up and away to one side of its dosing injector head. That advance permitted the dosing injector head to be mounted above a beverage canning assembly line. The reservoir was located behind the assembly line and was elevated enough to create a modest hydraulic pressure head at the control nozzle in the dosing injector head.*

Since 1998, other evolutionary changes have taken place principally with liquid nitrogen injection controls and nozzles. These improvements have resulted in better pressurization control and consistency of dosing.

**U.S. Patent No. 6,182,715*

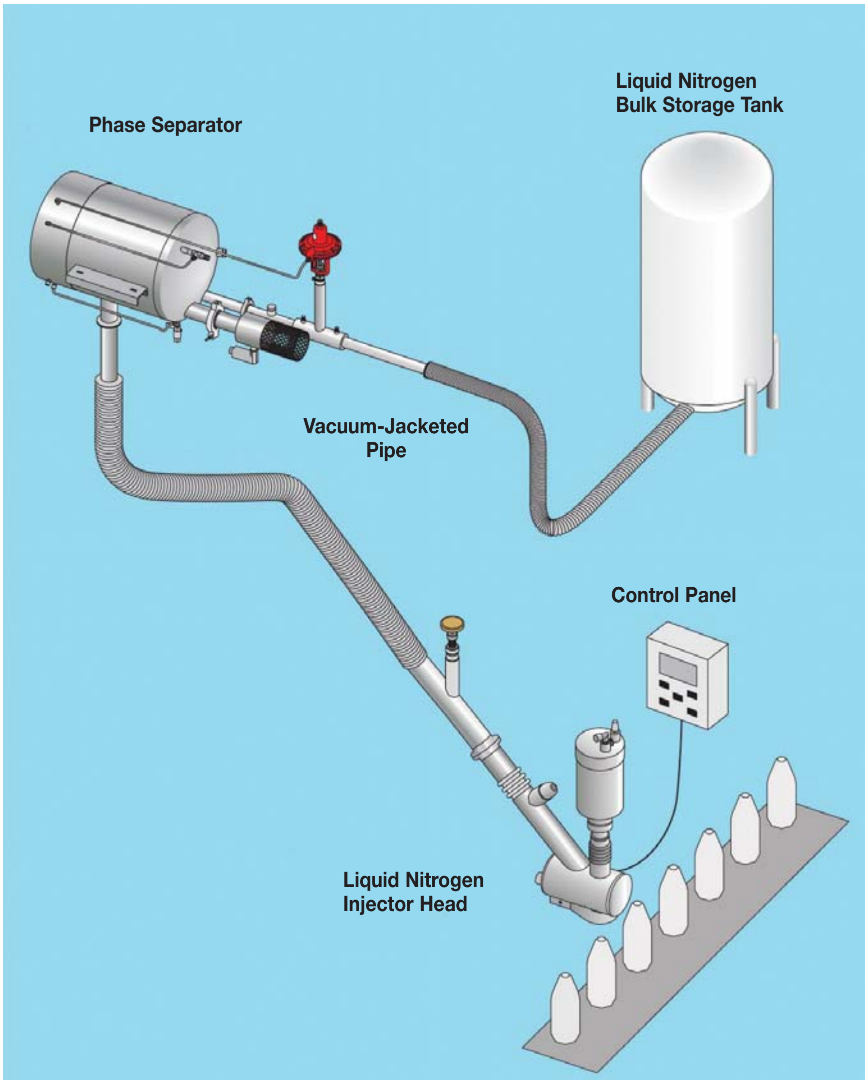

Figure 1. *Liquid nitrogen usually is delivered to the process through a vacuum-jacketed pipe to minimize premature vaporization of the liquid. A liquid nitrogen phase separator on the incoming line helps to ensures that the right pressure and only very cold liquid is delivered to the injection point just above the container.*

manually or electronically controlled. One advantage to electronic-controlled units is that multiple "recipes" or settings can be stored in the unit so that the equipment can adjust automatically to different containers or products without having to be recalibrated.

The container sensor location is another factor to consider. Some injectors require the sensor to be located at a precise location near the injector head. Other more-advanced systems allow the sensor to be located anywhere near the head, and the software can be told the location after the sensor is mounted. This feature accelerates setup and installation.

Typically, space is at a premium on packaging and bottling lines. Some of the most advanced nitrogen injectors are designed to minimize space requirements by using a remote overhead liquid reservoir connected to the injector by vacuum-insulated flexible plumbing. The remote reservoir acts as a phase separator, delivering vapor-free liquid at a consistently high density. The injector head is a small, simple device that can be mounted above the production line.

Also, because many production lines operate 24/7, maintenance is inevitable. Product serviceability therefore should be examined when considering a design. In some injectors, the valves and actuator modules can be replaced easily within minutes, thus minimizing downtime.

In conclusion, the state-of-the-art of liquid nitrogen injectors has advanced since the inception of the product more

Common LN_2 Applications

Bottlers of noncarbonated soft drinks, juices, water, wine and beer many times use LN_2 injection equipment to insert small measured drops of LN_2 into their containers. Processors of nuts and other perishable items also often use LN_2 to provide an inert atmosphere in containers. Soft food packages are also pressurized by liquid nitrogen injection to protect the package contents from crushing.

When used for inerting, the dosed liquid rapidly evaporates into tasteless, colorless, odorless, inert gaseous nitrogen that displaces the oxygen-laden air in the container. The container is then sealed, resulting in an inert environment. By reducing the oxygen content of the environment, the LN_2 dramatically extends the product shelf life.

When used for pressurizing, a small dose of liquid nitrogen typically is introduced into the container after it has been filled with product. The container is immediately capped or sealed, trapping the expanding gaseous nitrogen and creating positive pressure inside. Pressurizing enables processors to use thin packaging materials and yet be able to stack them for distribution.

Liquid nitrogen pressurization is often used in hot filling operations. The pressure introduced as a result of the nitrogen dose compensates for the vacuum conditions created when the hot product cools to ambient temperature. Without a dose of liquid nitrogen, some thin containers made from such materials as HDPE or PET would collapse when the hot contents cool to ambient temperature. Pressurized PET bottles are also less prone to "jamming" on high-speed lines and create a better surface on which to affix labels. The enhanced surface makes it possible to use less costly labeling materials and reduce overall packaging costs.

Figure 2. *Electronic controls adjust discrete injector dosing to account for line-speed variations.*

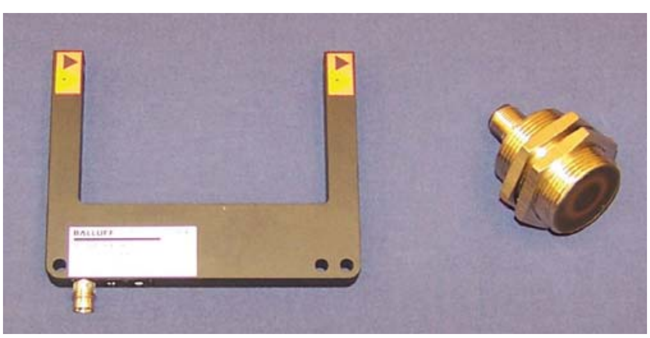

Figure 3. *Optical and proximity sensors are two types of sensors commonly used on a production line to sense containers.*

than 20 years ago. Technical advances continue to be made as all injector manufacturers strive to further improve the LN_2 dosing process. **PC**

Phil Redenbarger is vice president of strategic planning and Chris Hebb provides marketing for Technifab Products Inc., Brazil, Ind., a manufacturer of vacuum-insulated transfer systems for cryogenic fluids. For more information, call (812) 442-0520; e-mail sales@technifab.com or visit www.technifab.com.