REFRIGERATION REVIEW

Key Lessons for Preventing Hydraulic Shock in Industrial Ammonia Systems

Anhydrous Ammonia Release at Millard Refrigerated Services, Inc.
32 Hospital Admissions, 4 Placed in Intensive Care

While I applaud the efforts of improving safety, I would like to provide additional information that may shed new light on the probable causes of the Millard incident. I was asked by one of the insurance carriers to investigate the incident. As designers of many hundreds of ammonia systems, we are attuned to the nature of two phase flow characteristic of closed central ammonia systems. The flow of liquid and gas in suction lines necessitates care in the design of the piping system. Primary of the design is to be sure the suction line slopes adequately from the evaporators (air units) to the machinery room recirculator, liquid separator, and vessel. These lines are quite lengthy in some facilities, which can be a challenge to be sure it slopes continuously. If liquid is permitted to collect or lay in the line, it can pose a hazard for more than one reason. If too much liquid is in the suction line it can possibly cause a liquid flood back to the machinery room and, depending on the gas velocity and rate of startup, can be more liquid to return than the recirculator can separate. Also, if critical pressures are created in the suction line, reverse flow can occur. Critical flow occurs when pressure in one place of the piping system gets approximately one half of pressure in another part of the suction line piping. Critical pressure is a well-known phenomenon that can be calculated for a given gas, temperature, etc. It normally has a ½ relationship. What is important about this condition is once it occurs, gas from the area of higher pressure will move toward the area of lower pressure very rapidly and try to approach sonic speed. In refrigerants this is very critical because when it occurs, the pressure "head" will make any gas ahead of this gas condense instantly and change from gas to liquid. This is what I have called liquid cannon balls.

The Millard system had two, maybe three, things going against it. The first was the slope of the pipe line. While the industry says 1" in 40 ft is okay, we have always used 1" in 20' for the reasons outlined above. 1" in 40' is very hard to maintain. When asked to inspect the Millard system, the first thing we did was have the pipe line surveyed for elevation over its entire length. We found two areas that were trapped as much as 2+ inches. This, of course, leaves large pockets of liquid. The second was the use of what is known as CK-2 suction stop valves. These valves are a little cheaper than their counter part S9As but the CK-2 fails open, not closed. We have seen this type of failure occur on other systems using CK-2s. This is significant because if, for any reason, the CK-2s (which are used in each blast freezer defrost control group) drop open, have low pressure from hot gas supply (which keeps the valves closed), interrupted defrost, etc., the pressure in the evaporator coil is going to drop to the corresponding saturated temperature of the blast freezer coil. If that pressure is half the pressure that is in the pipeline near the machinery room, then reverse sonic flow will occur. Quite often when this occurs the liquid "cannon ball" will not only break open the end of the pipe line, it will enter the air unit coil with enough velocity to rupture the coil header, which I understand also occurred at the Millard facility.

So my recommendation would be to add the following:

- Slope suction lines 1"/20' and be sure they are sloped continuously, with no traps
- Use <u>fail close</u> suction stop valves (S9As), not the cheaper CK-2 valves.

CK-2 valve that failed open, causing a liquid cannonball.

Broken pipe due to critical sonic flow, caused by a CK-2 that failed open.