

# **MANUAL PURGING OF NONCONDENSABLE GASES**

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## **INTRODUCTION**

Noncondensable gases (NCG) in ammonia refrigeration systems are well-known operating liabilities in terms of excessive discharge pressure and water vapor ingress. They are usually managed at the maintenance level by use of mechanical purgers that draw mixed gases from various parts of the system, recover ammonia from the mixture and discharge the remaining NCG through a water bath and into a plant drain.

It is important to distinguish the preceding maintenance operation from what will be discussed here and what CFR 1910.119(f)(1)(i)(E) defines to be an Emergency Operation. This situation arises from levels of NCG that tend to severely limit refrigeration system operation or stop it altogether. These excessive NCG levels appear for two main reasons:

1. Rupture of sub-atmospheric pipe, heat exchangers and vessels from condensation-induced hydraulic shock.
2. Pressure test gases leaking through isolation valves into an operating system.

Typical plant response to such conditions is to run all condenser fans and pumps while manually bleeding the system from hand valves located at the high points of high- or single-stage discharge piping. This method is slow and wastes substantial amounts of ammonia due to the thorough mixing process in and downstream of the compressors. The method described below uses the same theory as the maintenance level purge operation, but adds mechanical and administrative controls to increase the NCG purge rate while minimizing the amount of ammonia released.

## **ANALYSIS**

Figure 1 shows a schematic drawing of an evaporative condenser and its inlet/outlet piping, including hand valves typically installed at or close to the inlet piping high points. Faced with an excessive NCG emergency, a customary response is to open these hand valves and bleed off high-pressure vapor to atmosphere in an attempt to keep system discharge pressure within acceptable limits. However, this vapor has just left the compressor and is flowing at 5,000-7,000 FPM, so the NCG and ammonia are thoroughly mixed. The mixture proportions depend on the amount of NCG in the system and cannot be calculated without further analysis. The net result is to bleed NCG and ammonia together until the entire refrigeration system charge is low enough to allow condenser operation. Unfortunately, this method wastes ammonia and does nothing to remove the NCG already in the condenser.

The bleed vapor can be discharged to the atmosphere if off-site consequences will allow it or into 50-gallon drums of water if not. Each method requires personnel to be in control of the bleed hand valves at all times. These valves can frequently only be accessed by ladder or from on top of the condenser eliminators, each of which restricts quick



personnel exit, so atmospheric discharge while remaining close to the discharge point can become quite a challenge. Discharge into water reduces ambient ammonia vapors, but can require many drums which must subsequently be moved without spillage and safely drained. Finally, any atmospheric discharge ammonia loss calculations are guesswork at best due to the unknown proportions mentioned above. It is possible to obtain the ammonia concentration of the weak aqua-ammonia mixture in the 50-gallon drums, but this will require test and measuring equipment.

In contrast, Figures 2 and 3 show a quite different way of handling this problem. Manual purge points have been added to the customary automatic purge point locations on top of the condenser piping outlets, where line velocity is ~150 FPM and most of the ammonia has been condensed into liquid running along the bottom of the pipe. The remaining vapor space above this liquid has a much higher percentage of NCG and thus requires a much lower volumetric flow rate to remove the same amount. The valves are easier to access and discharge piping termination is sufficiently removed from the operator to pose very little danger. Most importantly, NCG is removed directly from the condenser tube bundle and its normal operation is restored as quickly as possible.

NCG flow is calculated to be ~10 CFM of 125°F air at ~215 psig. Each condenser outlet valve group requires ¾” components in order to avoid use of ½” pipe, but this makes it tremendously oversized for the flow involved. The danger here is aspiration of the liquid ammonia in the bottom of the pipe with possibility of a highly visible white cloud leaving the discharge piping (see Figure 4). A minimally open ¾” hand expansion valve is still capable of far more flow than necessary and will remain at its last setting if personnel are absent. The solution is to add a spring-loaded valve such as is commonly found in oil drain piping and orifice flanges with an aperture sized for the 10 CFM flow. It is important to remember that this is an emergency operation and events can neither always be predicted nor controlled. These two components allow safe operation while preserving quick personnel exit and passive (automatic) purge operation shutdown.

Discharge piping can take a number of forms. The lowest cost method simply injects the NCG into the condenser discharge airstream above the condenser to take advantage of airstream entrainment. This method forces condenser fans to run at maximum capacity, requires personnel near the discharge point and provides only a partial basis for accurate release estimates. A better solution is to manifold each condenser outlet’s NCG discharge into a header and tie the header into the main safety relief valve (SRV) discharge header upstream of the header ammonia sensor. This insures maximum separation between personnel and ammonia discharge while providing ammonia concentration of the discharge flow for accurate and defensible release calculations. Large plants or those where the SRV discharge is far away might consider a compromise solution of local discharge headers



serving groups of condensers to save on piping costs and preserve the option for complete manifolding at a later date.

## **CONCLUSIONS**

- 1. Excessive NCG in a refrigeration system will limit or shut down system operation. These frequently result from sub-atmospheric piping rupture or leakage of pressure test gases into an operating system. This situation results in emergency operation of the system and emergency response is required. This includes updated SOPs, PHA, MOC and restriction of this procedure to fully qualified operators only.**
- 2. The customary solution of bleeding condenser inlet piping is better than nothing, but only that. It is wasteful, inefficient, does nothing for the NCGs already in the condensers and frequently poses unnecessary dangers to personnel in terms of valve access and ammonia exposure. Ammonia loss calculations using this method are little better than guesses and are frequently based more on how much is required to refill the system than how much was lost due to the release.**
- 3. A relatively small amount of piping and valves allows rapid and effective removal of NCG from multiple condensers simultaneously and can support accurate ammonia release calculations. Personnel operate a controlled flow with automatic shutoff from easily accessible locations and are remote from the discharge point.**



**Figure 1. Conventional location of manual purge valves.**

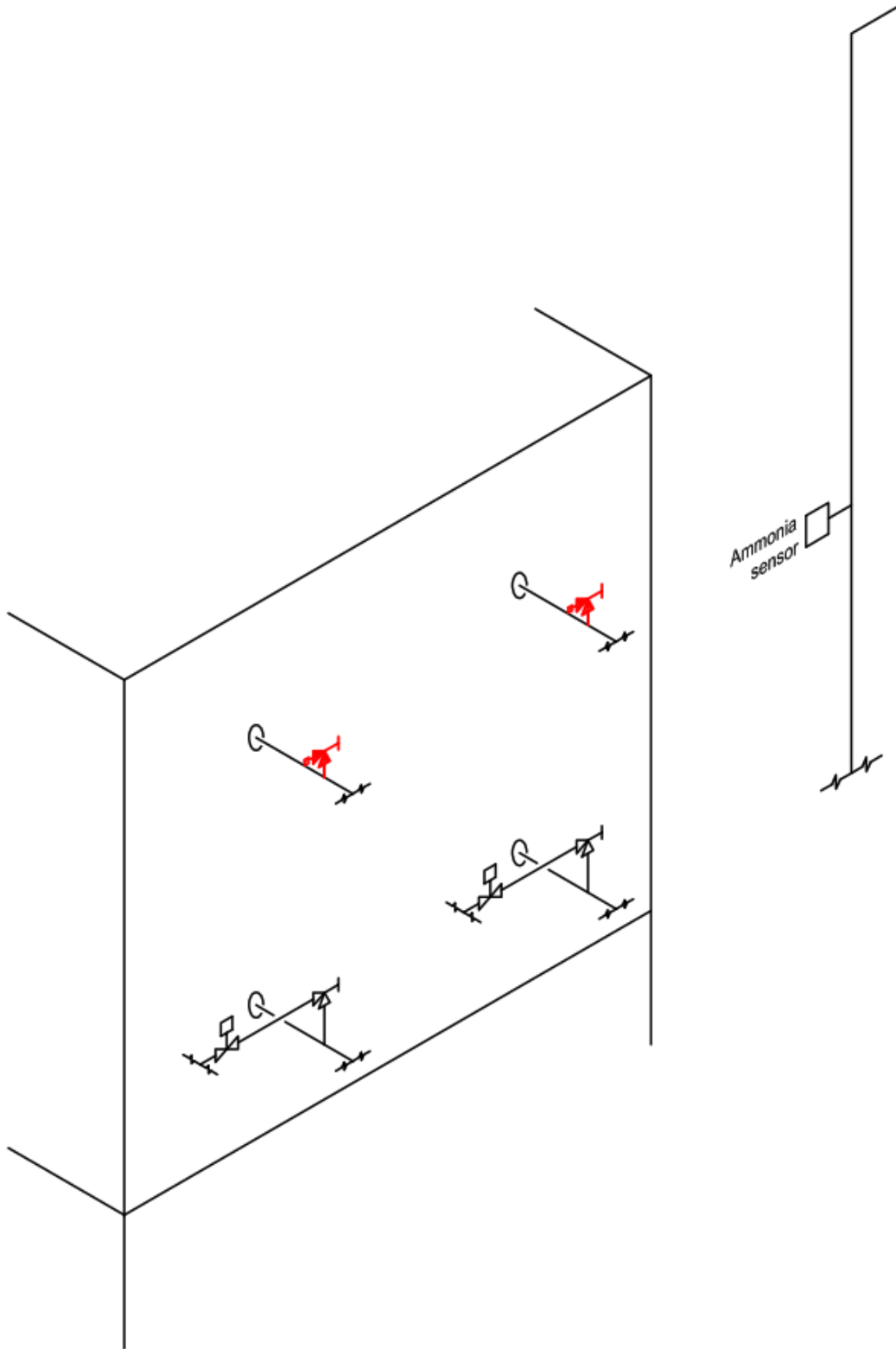
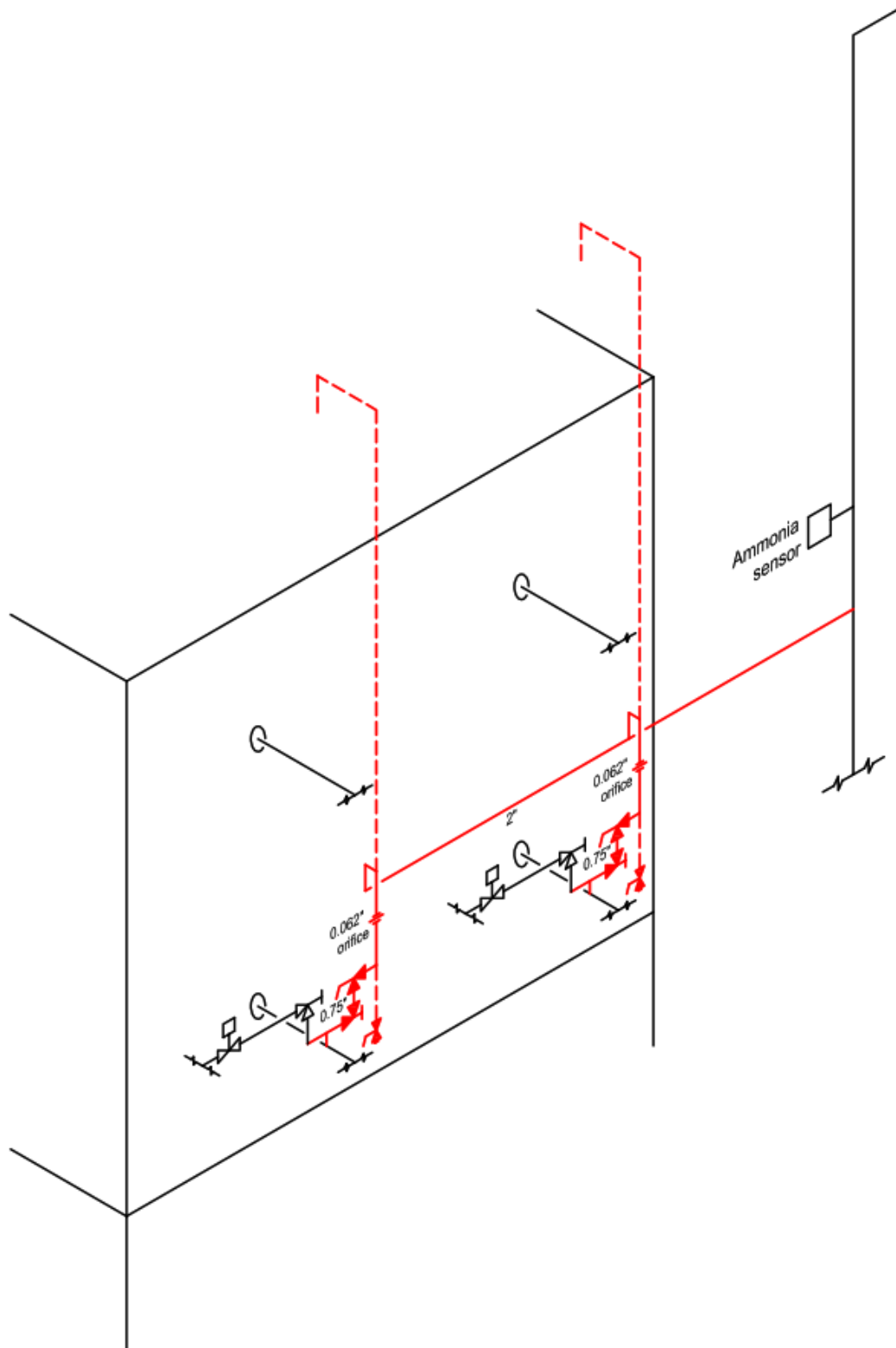
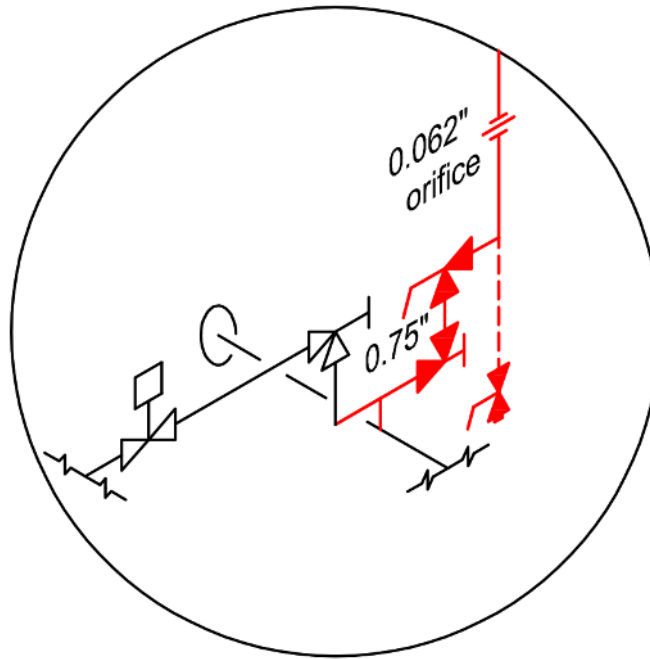


Figure 2. Functional location of manual purge valves.



**Figure 3. Functional manual purge valve details.**



**Figure 4. Radial cross section of horizontal condenser outlet piping.**

