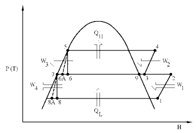
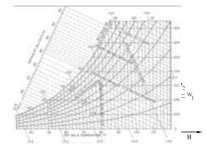
# REFRIGERATION REVIEW





Spring 2015 *A PRODUCT AND SYSTEM COMPONENT REVIEW PUBLICATION*

## The Noble Condenser

"Tech Talk" by Hank

You've heard me say many times about condenser water: **no treatment is the best treatment**. I know there can be exceptions to the rule, however I bear witness to a condenser that was installed 26 years ago that is currently being retired, not particularly because it's worn out, it just needs to be larger. The treatment of this condenser included natural passification using city-chlorinated water with daily pH checks that maintained its pH between 7.5 and 9.0 throughout its useful life. If the daily checks showed the pH getting out of bounds, the bleed-off was checked or increased, or the entire sump was drained, cleaned, and refilled. Some pipe had lost paint, but it shows no unusual corrosion. Had acid- or mineral-based water treatment been used, these pipes would be badly corroded.

I recall a condenser installed on a project in Honduras that inadvertently got treatment, unknown to me. It developed pin holes and the coil section had to be replaced. The treatment was stopped, but the interesting thing to note was that another project at the same plant provided a large galvanized condenser stand which provided for three new condensers and the relocation of the abused condenser. Even though no treatment was being used six months after the condensers and the abused condenser relocated, the spray-off from the abused condenser – residual minerals, etc. – created a well-defined six-foot circle around the abused condenser, which showed rusting of the galvanized condenser platform just adjacent to the abused condenser.

There have been a few articles put out over the last few years that say that a little deposit on the coils could provide a protective coating. Other than algae, natural zinc hot-dipped galvanization is a mold inhibitor for condensers. ***RR***

## IIAR 2 *__or__* ASHRAE 15

As a charter member of IIAR, I can witness that it has taken a long time to get model codes (IMC) to recognize ANSI-IIAR 2 as a code for ammonia refrigeration. I can remember when Hank Saye and I worked out the 1" valve bypass arrangement, and how skillfully Jeff Shapiro planned that that would set the stage for eliminating the hazardous valve boxes and the retention tanks. For all that effort, regardless of what Jeff was paid, I think he should be promoted to sainthood. If there was room in the Congressional Rotunda for another statue – Florida has two, one of whom is John Gorrie – we could put Jeff beside Gorrie.

Having covered all the positives, I would like to pass on my candid thoughts about our industry.

As a practicing engineer, I have seen the full gamut and would like to share my concerns going forward.

While the momentum of code recognition does wonders for one's ego, it took 30+ years to get IIAR 2 to the point of recognition. While all of us want the best for the industry, we are often blinded by our own little world of focus. I know the initiative of making bulletins into codes is well on its way. Hopefully everyone is starting to see and be concerned as to how this will be interpreted by government regulatory agencies, namely OSHA and EPA and state environmental agencies. While I maintain and assist many clients in engineering, I am also called in as expert witness, particularly where injury and death have occurred.

One of the primary concerns I have is not just the interpretation of ill-conceived bulletins, and now what could become codes, but also the misinterpretation of many of our "required" ("shall") and not required ("should") procedures. I was riding in a taxi to the annual

***(Cont'd on Pg 2)***

*(Cont'd. from Pg 1)*
IIAR meeting with one of the members who is in charge of eleven poultry plants. He had concerns regarding recent fines by EPA at one of his facilities for not testing the high pressure cutout valve for a compressor by closing the discharge valve. If he cannot get the fines rescinded, of course he faces the possibility of "double jeopardy" and willful violations. Whoever wrote this in our manuals obviously hasn't stood by an old compressor, possibly a horizontal one, and closed the discharge, not knowing whether the high pressure cutout would even work, let alone the compressor come apart in front of him. In some of the old plants, closing the suction valve was a fine art used to prevent floodbacks. I was called in on one where the individual didn't get it closed soon enough and was left blind the rest of his life. There are so many ambiguities in our well-meaning bulletins, and now-to-be codes, that if some specific clarification bulletins on these ill-conceived procedures are not created, EPA and OSHA won't have to worry about being funded, the refrigeration industry will do it for them!

**Ironically, a closed refrigeration system, by any standard, is not defined as a process; there are no chemical changes, and yet government agencies want to try and treat it like a process.** Somewhere and throughout out bulletins and codes we need to convey this to these agencies. Many of the inspectors came straight from chemical plants, and next thing you know they want to use API, etc.; even some of our "technical members" want to throw API calculations into relief valve vent lines. We need to make it very clear that closed systems are not chemical processes. These agencies have to have materials sufficient to teach them the difference. They will always have new people, and our bulletins and codes are the only textbooks they have for reference.

So, having said all that, **I am now questioning the wisdom of trying to make bulletins into codes in a three-year period, whereas it took 30 years to get IIAR 2 into a form that would be considered presentable** (which, of course, there are some portions I still do not agree with). As I see it, we should have workshops where all the dreamers who think these bulletins should be codes can be the end users, and others can be OSHA and EPA agents levying fines for discrepancies between "perceived industry standards" or verbatim per some of our bulletins and now-to-be codes. In a very simplistic way, as a charter member, we saved ourselves from National Electric, and now we have decided to shoot ourselves in the foot. We need to spend more time developing what we would expect to be used for passing judgment on an ammonia refrigeration system. ***RR***

---

## Machinery Room Ventilation

**Machinery Room ventilation is the first and most important design of an ammonia machinery room.** Sadly, its geometry is often determined by an architect or general contractor that only thinks cost.

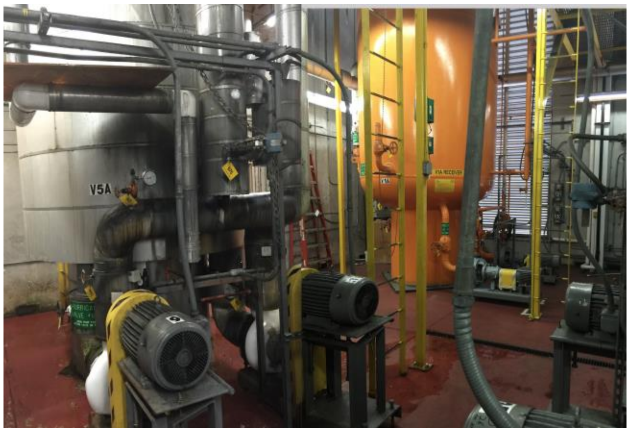
Machinery Room location is paramount in terms of accomplishing good ventilation. In years past some of the dairies put Machinery Rooms in basements. It was almost a tradition in that the Machinery Room would be below the processes for which it served. Of course, the fallacy of that is having poor ventilation in many basements. Machinery Room explosions have proven this point. Ammonia explosions can occur not only in basement Machinery Rooms, but also in any poorly ventilated Machinery Rooms, and particularly those with low ceilings. Ammonia gas wants to rise, so the Machinery Room, as a minimum, should be 25 feet high with very controlled air movement. Typically we would place multiple exhaust fans along one Machinery Room wall in the ceiling and locate all vessels and recirculator pumps below them. This would permit air pattern in one direction from one side of the Machinery Room to the other. The air inlets would be on the opposite end on the lower areas of the wall. Both the exhaust fans and the inlets need to be spread across the width of the Machinery Room.

Of course, in Northern climates, the fans need to be activated with thermostats and/or ammonia detectors to prevent freezing of the pipes and making the temperatures too low in the Machinery Room area. In some cases, heat may be required, but this should be electric as opposed to open flame gas.

With Machinery Rooms of reasonable height, our calculations indicate that even in the event of a liquid spill in the Machinery Room environment, the concentration ratios would be low enough for the ventilation fans to remove the ammonia gas before it reached explosive levels. Although there are many Machinery Rooms that have additions and multiple walls, generally the effort should be made to keep the Machinery Room as one rectangle. Machinery Rooms in the order of 60' x 60' can handle refrigeration capacities well into the 3,000 to 5,000 TR range. Judicial use of space, like using vertical recirculators, facilitate in good space utilization. More times than not condensers are located above the roof, which helps ventilation for these components and places most of the high side (pressure) refrigerant above the roofline.

Now with IIAR switching to volume basis (30 air changes per hour), green engineers are thinking low ceilings. So now we can start to blow them up and use high-risk horizontal recirculating vessels. I would hope we can get some latitude so design engineers can specify safe systems in all regions of the country and world.

Oh, one last thing we need to consider: the 30 air changes per hour doesn't recognize the quantity of ammonia in the room as it has in the past. As shown in the following picture, you could possibly have a 30' x 30' machinery room with 60,000 pounds of ammonia.
The compressors for this portion of the system were (4) 800 HP diesel compressors which we do not want to
*(Cont'd. on Pg 3)*




place in the same room as the ammonia vessels. So, the point being, changing to cubic feet has caused many aberrations to safety. In this case, 30 air changes may not be enough. Hopefully, in the future we can refine the requirements for machinery room ventilation to recognize them. ***RR***

---

# Comments to CSB Regarding the Safety Bulletin about the Anhydrous Ammonia Release at Millard Refrigerated Services

The CSB issued a report on the Millard Refrigeration incident. In my opinion, it was incomplete, so I wrote comments to them, which I have listed below.

I reviewed your recent article about the Millard ammonia incident. 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 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 evaporator (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 <u>critical</u> 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 1/2 relationship. What is important about this condition is once it occurs, gas from the higher pressure area will move toward the lower pressure area 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 OK we have always used 1" in 20' for the reasons outlined. 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-2. Why this is significant is that if, for any reason the CK-2s (which are used in each blast freezer defrost control group) drop open, 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 pipe line 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. 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.**

Hope this will add clarity. ***RR***

---

# Questions for EPA

I was recently asked by a news journalist what questions I would ask EPA if I had the opportunity. Not to steal their thunder, but this is what I would ask.

Why are closed cycle refrigeration systems regulated under OSHA? **Just because ammonia is a refrigerant does not make the refrigeration cycle a process by any chemical definition.** The refrigerant does not change chemically in any way as it circulates inside the system. The type of concerns for safety in the PSM program are intended for a chemical process, i.e. Upset conditions, energy balance, etc. Ammonia has a very good safety record compared to other chemicals. The incident rate from refrigeration systems is way below incidents from other chemicals such as natural gases, which, if anything, should be a process because when it is

***(Cont’d. on Pg. 4)***

*(Cont'd. from Pg. 3)*
burned and used for heating it is a process where the chemical is changed.

The next question is why is there so much concern about ammonia in our environment? Tons of ammonia is produced by lightening each year, and all forms of life contain it. It is a root chemical in our plant and animal structure. Farmers inject it directly in the ground as the "cleanest" fertilizer possible. It has no run-off side-effects, etc**. It is truly green.** ***RR***

---

# Critical Flow

Borrowing from a previous publication with equations for the pressure drop of two phase flow, a method of calculating critical flow was included in the article. All designers should become familiar with this because this is what causes reverse flow, such as happened at Millard Refrigerated and several other plants that experienced low temperature evaporators being exposed to the piping system, that inadvertently reduced pressure because of cold evaporators and causes critical reverse flow. This is from the article referenced below:

DESIGN AND SAFE OPERATION
OF
AMMONIA REFRIGERATION SYSTEMS

(With Emphasis on Recirculation Pipelines)

By: Henry B. Bonar, II
For
Second Edition 02/15/1997

Originally Given At:
1996 RETA NATIONAL CONVENTION
VALLEY FORGE, PENNSYLVANIA
OCTOBER 24, 1996

The calculation for critical flow from the article is as follows.

**Critical Pressure**

$NH_3$ at -40°F. Cp=.52; Cv ~.399; k= Cp/Cv=1.31 (Gas constant)

Ratio$_C$ [5] $= \dfrac{P_2}{P_1} = \left[\dfrac{2}{k+1}\right]^{\frac{k}{k-1}}$ [3] (10)

Ratio$_C$ = .544 Critical Pressure Ratio

Example:

If system operated at 10 psia and shut down for an extended time and the suction pressure increased to 25 psig; what would the pressure be (if reached instantly) that could cause sonic flow?

Solution:

Pc = .544 (25+14.7)

Pc = 21.5 psia (*Answer*)

Note: This pressure is easily achieved with compressors on this system since it was capable of operating at 10 psia. So care should be taken to not get below .544 times any residual pressure which may be in portions of the system by gradually lowering pressures back to normal.

$P_2$ – Downstream (lower) pressure
$P_1$ – Upstream (higher) pressure

[5] Chaddock, Werner, Papachristou, "Pressure Drop in the Suction Lines of Refrigerant Recirculation Systems," Paper presented at ASHRAE Annual Meeting, Nassau, Bahamas, June 25-29, 1972. ***RR***

***REFRIGERATION REVIEW***
A Publication of Bonar Engineering
and Construction Co.
Editor: Amy S. Pilgrim
Mail Inquiries to:
PO Box 60009
Jacksonville, FL 32236