"THE MONEY LEAKING FROM THE MECHANICAL ROOM"

A PRACTICAL GUIDE TO ADDRESSING CHILLER LEAKS

By: James R. Parsnow
Carrier Corporation
Syracuse, NY
4/16/98

“THE MONEY LEAKING FROM THE MECHANICAL ROOM”

A Practical Guide To Addressing Chiller Leaks

The U.S. Environmental Protection Agency published a proposed rule in Fall, 1997 to reduce the emission limits for chillers and industrial process refrigerant equipment. This rule may become law under the U.S. Clean Air Act (CAA) in 1998. The ruling will reduce allowable emission rates to 5% on new equipment and reduce existing equipment, allowable leak rates per Table # 1.

There will be discussion on how to define new vs. existing chiller leak rates, and how to distinguish between leaks during system operation and repair.

This ruling refocuses the industry’s efforts on containment practices and improving refrigeration chiller designs for the future. As demonstrated by Table # 2 leak rate in the industry has dramatically improved in new designs. In the past, leaking chillers were tolerated due to readily available supply and cost. Today, (Table # 3) if a refrigerant charge is lost, the cost can be substantial.

EPA To Tighten Leak Rates For Chillers

Type Of Equipment	*Current Allowable Leak Rate % of Charge / Yr*	*Proposed Allowable Leak Rate % of Charge / Yr*
Commercial Refrigeration Built Before Or During 1992	**35**	**15**
Commercial Refrigeration Built After 1992	**35**	**10**
Industrial Process Refrigeration (see note 1)	**35**	**35**
All Other Industrial Process Refrigeration	**35**	**20**
All Other Appliances built Before Or during 1992 (see note 2)	**15**	**10**
All Other Appliances Built After Or During 1992 (see note 2)	**15**	**5**

Notes: 1. Built before or during 1992, custom built, possessing an open drive compressor, and containing a single, primary refrigerant loop (direct expansion)
2. Containing more than 50 LB. of refrigerant (e.g.. comfort cooling chillers)

Table #1

Leak Rates For Rotary Chillers

Type Of Equipment	*Old Installed Chillers - Hermetic Motor Driven*	*Old Installed Chillers Open Drive Motors*	*New chillers Hermetic Motor Driven (Best In Industry)*	*New Chillers Open Drive Motors*
Negative Pressure (Operating below atmospheric pressure in cooler)	**15%**	**17%**	**0.5%**	**1 - 2%**
Positive Pressure (operating above atmospheric pressure in cooler)	**8%**	**10%**	**0.1%**	**1 -2%**

Table # 2 Source: Input discussion with ARI

For example, a typical 500 Ton CFC chiller that becomes over pressurized due to a system malfunction could result in a $29,000 (CFC 12) refrigerant replacement expense. Unlike the past, that incident could also cost building owners and managers downtime on a process or the building itself - a cost that certainly would exceed the refrigerant cost. **This is the money leaking from the mechanical room.**

Also, under the Clean Air Act, if a leak occurs, building owners and managers have thirty days to correct the leak or develop a dated retrofit/retirement plan, and complete all actions detailed in the plan within one year from the plan date. Beyond that, if detected, they can be fined $25,000 per day per incident under the Clean Air Act Regulations. Not only is this costly, but embarrassing as EPA has released examples of violations to the press.

What actions should a facility owner take?
Referring back to Table # 2, leak rates can be reduced to 0.5% - 2% on new equipment. On older installed equipment, reducing the leak rates to 2% - 5% is possible with close attention to proper “containment.”

If the chiller is a negative pressure chiller (old CFC-11 or newer HCFC-123 chillers) as noted in Table # 2, the leak rates historically have been high. Although these chillers operate below atmospheric pressure on the cooler side of the chiller, they are operating well above atmospheric pressure in the condenser and compressor.

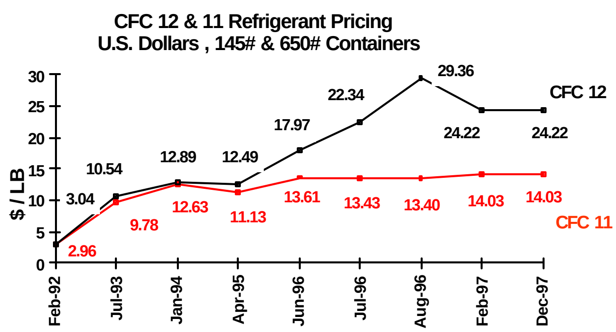
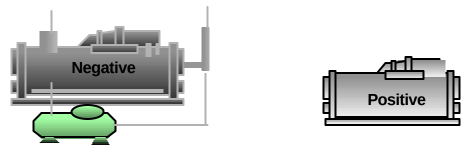


Table # 3 Source: Retail Market Price 12/97

This results in a critical leak path of sucking air and moisture into the cooler which adds to corrosion and loss of refrigerant from the condenser and compressor. Why do manufacturers of these chillers allow a design of this type? Simply stated, the customer did not want to pay for upgraded containment in the past. For example, these negative pressure chillers were supplied to the market with standard purge units to purge out the air and moisture that leaked into the cooler. However, on these standard units, for every pound of non-condensables (air/moisture) that was purged - between three to twenty pounds of refrigerant was exhausted.

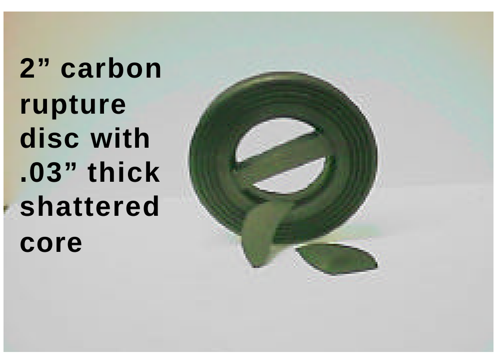
Today, very high efficient purge systems are available that significantly lower this emission. This product along with improved containment equipment is available (table #4). Remote refrigerant storage tanks are available for serving negative pressure chillers, as the construction of negative pressure chillers does not allow for internal storage during service. A special notation should be made that external storage and transfer pump units are required by the U.S. Clean Air Act during service. These storage and transfer units must meet the requirements of the U.S. Clean Air Act for evacuation levels in removing refrigerant and also comply with standard ARI-740 as a recyle/reclaim device. Does this law require that an owner of equipment must purchase a storage/transfer unit? "No," however the agency servicing the chiller must supply certified equipment during the service. It is highly recommended that if the chiller is larger than 300 tons of refrigeration that the owner purchase a storage tank. Forcing a service agency to bring smaller, multiple tanks on site to store the refrigerant results in increased risk of refrigerant emissions during transfer and increases the potential for a refrigerant spill. Also at that nominal level and above the refrigerant charge, (approximately 720 pounds) removal result in a long transfer period and an increase in potential leaks.

Installed Costs Negative Pressure Vs Positive Pressure Designs



	Negative	Positive
• Refrigerant Storage Tank	$ 6,500	Built In
• High Efficiency Purge	$ 4,400	Not Required
• Back Up Relief Valve	$ 3,800	Built In
• Pressurizing System	$ 6,000	Built In
• Oil Filter Isolation	$ 1,000	Built In
• Add For Installation	$ 3,000	Not required
Total	$ 24,700	$ 0

Table # 4

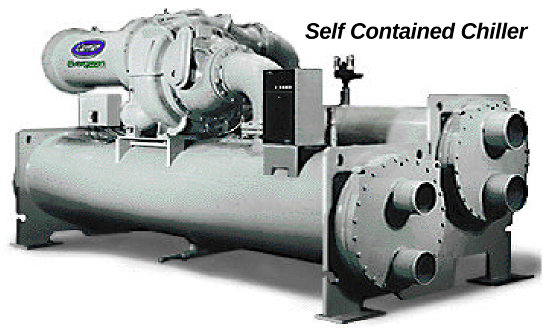


Back-up relief valves are an excellent device to prevent the loss of refrigerant in a chiller. The standard pressure relief device on a negative pressure CFC-11 or HCFC-123 chiller is a carbon disk with a .03 inch membrane, which   shatters at 15 psig. Any over-pressurization results in total loss of the refrigerant. Back-up relief valves have been created to lower this loss during over-pressurization. These back-up devices contain non-fragmenting disks with a reseating plunger that will relieve the pressure and then reseat. This saves a good portion of the refrigerant that was lost. These devices typically cost $3,800 which may vary with installation costs.

When you consider that a total loss of CFC-11 or HCFC-123 on a 500 ton chiller could result in a refrigerant bill of $ 5,028 (HCFC-123) to $16,836 (CFC-11), the $3,800 back-up valve is a good investment, especially when you also consider the opportunity cost of chiller downtime. Two other good containment products on the market are pressurizing systems and oil filter isolation valves.   Pressurizing systems facilitate leak detection on negative pressure chiller to ensure the chiller remains below the leak rate requirements of the CAA. Isolation valves allow oil filters to be changed while isolating the main oil circuit, which typically has a considerable amount of entrapped refrigerant. Piping all of the mentioned containment devices typically will cost an additional $3,000 for a total of $24,700.

This add-on containment is a recommended practice when upgrading or purchasing new negative pressure chillers. This added cost and installation was considered during the design of the new chillers using HCFC-22 or HFC-134a and as can be noted in table # 4 was eliminated or built in to these chillers.

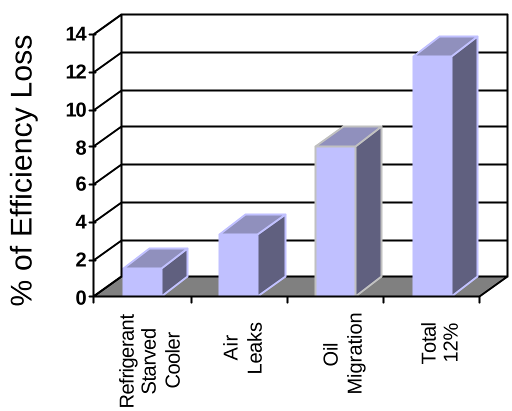
A key feature of these positive pressure/certified vessel chillers is the ability to charge the refrigerant into the equipment at the factory, and ship them to the construction site. This greatly reduces the emissions, start-up time and incidents of accidents that could result when charging a chiller on site. Also, with the use of isolation valves built into the chiller, refrigerant can be stored in the chiller during service. With best in class, 0.1% annual leak rates and the ability to store refrigerant in the chiller, the equipment results in an emission preventable design.


Self Contained Chiller

The compressor motor type should be considered in lowering emissions of refrigerants.
The industry offers semi-hermetic sealed motors up through 2,000 tons of refrigeration. Above that level the horsepower requirements dictate that open drive or separate coupled motors are used. Where the semi-hermetic (hermetically sealed, but serviceable) prevent the loss of refrigerant, open drive motors will lose approximately 2% of the chiller full charge annually. As refrigerant and oil mix during the chiller operation, any loss of oil results in the loss of refrigerant entrapped in the oil. On existing open drive equipment, the placement of a refrigerant detection monitor close to the open drive seal is an excellent method to indicate both the excessive loss of refrigerant but also as a warning that the seal between the motor and the compressor may have excessive wear and in need of replacement. This loss of refrigerant is addressed in a reference standard ASHRAE Guideline 3-1996, “Shaft seals are required on open style compressors and can be a source of refrigerant leakage”. (Start of paragraph 4.1.1.1 ASHRAE Guideline 3). This standard is an excellent reference guide in reducing emissions in air conditioning equipment. Written by a committee of industry experts, the practices addressed in this guideline are the standard to reduce refrigerant emissions.

The money leaking from the mechanical room is not only the loss of the expensive refrigerant but also the loss of efficiency of the chiller. In the use of negative pressure chillers (CFC-11, HCFC-123 designs) this loss of efficiency is a result of the refrigerant leaks both internally and externally. Negative pressure chillers have a potential leak path that draws non-condensable air and moisture into the cooler section of the chiller. For every 1 psi of air that leaks into a negative chiller, a 3% loss of efficiency occurs. As air is a non-condensable product in the chiller, the air will collect in the upper portion of the chiller’s condenser and reduce the effect of the heat exchanger. All the more reason to have a high efficiency purge to remove these non-condensables.

Loss of refrigerant through condensers and compressors which operate above atmospheric pressure for all chiller equipment (CFC-11, HCFC-123, CFC-12, HFC-134a) can result in a shortage of refrigerant to provide the proper heat transfer in both the cooler and condenser as the optimum refrigerant charge is lowered.



Negative Pressure Efficiency Losses

Also in negative pressure chillers, the air and moisture leaking into the chiller can combine to produce oil forming in the cooler, due to both the leaks and the migration of oil from the compressor during part load capacity. This foaming of oil can result in a 8% loss in cooler efficiency as the foaming blankets the upper heat transfer portion of the cooler.

When you consider that a negative pressure chiller is purchased at a specific efficiency level and then can degrade by as much as 12% due to system leaks, prevention of these leaks will lower your power bill. A review of your refrigeration chiller equipment should be addressed.

The importance of leak prevention and specification of advanced designs is critical to ensuring that money is not leaking from the mechanical room.

To assist in this effort the references listed below will provide valuable assistance.

Jim Parsnow is Director of Environmental Systems Marketing for Carrier Corporation and can be contacted at 315-433-4376 or Fax 315-432-7836
E-Mail jim.parsnow@carrier.utc.com

References:

ASHRAE Guideline-3 - Reducing Emission of Halogenated Refrigerants in Refrigeration and Air-Conditioning Equipment and Systems

American Society of Heating, Refrigerating, and Air conditioning Engineers, Inc.
1791 Tullie Circle, NE, Atlanta, GA 30329
Phone: (404) 636-8400 Fax: (404) 321-5478

ARI 740-93 - Refrigerant Recovery/Recycling Equipment

Air Conditioning and Refrigeration Institute
4301 North Fairfax Drive, Suite 425
Arlington, VA 22203
Phone: (703) 524-8800 Fax: (703) 528-3816

U.S. EPA Guidelines and Law
U.S. Environmental Protection Agency
401 M. Street, S.W.
Washington, DC 20460
EPA Hotline: 1-800-296-1996