Refrigeration systems play a very important role in the food processing chain. They are used in the steps prior to food processing, such as in the post-harvest handling and storage of fruits and vegetables. In food processing, refrigeration systems are part of manufacturing processes, such as cooling and drying of processed and semi-processed products. They are also needed before and after packaging, during transportation, storage, exhibition and sale of the finished product to the consumer. Therefore, the issue of refrigerant replacement needs to be taken seriously by food processing establishments. Knowledge of all the details of this issue is a “must” to implement the measures required.

This publication outlines the major elements of the refrigerant replacement issue. For further information, readers should contact the authors or a refrigeration equipment representative.

What is the refrigerant replacement issue?
Several compounds used in the refrigeration industry have been found to be environmentally harmful. The Montreal Protocol identified several refrigerants that need to be phased out to prevent more damage to the environment. Among these refrigerants are the chlorofluorocarbons, more commonly known as CFCs. These CFCs are widely used in mobile air conditioning (automobiles), stationary systems (retail food storage, processes refrigeration, cold storage and chillers) and large air-conditioning units.

What is the Montreal Protocol?
The original 1987 Montreal Protocol, signed by 24 countries, suggested a CFC production level in the year 2000 that would be 50 percent of the 1986 level. However, in June, 1990, signatory nations to the original protocol met in London to revise the document. To date, approximately 60 nations, representing 90 percent of the world’s use of CFCs, have signed the revised protocol, which calls for a complete phaseout of the production of CFCs by the year 2000.

Why are the CFCs environmentally harmful?
The CFC is a very stable compound that, when released into the atmosphere, finds its way to the ozone layer. At the ozone layer, the chlorine atom of the CFC molecule, activated by solar energy, breaks down the ozone molecule, causing a depletion of the ozone layer. The depletion of the ozone layer increases the penetration of harmful levels of ultraviolet radiation into the atmosphere.

Do all CFCs have the same impact on the environment?
No. The refrigerants used in small air conditioners such as those in homes and small commercial applications, are not fully halogenated as are CFCs. Referred to as HCFC 22, this refrigerant is less stable than the CFCs, and decomposes before it reaches the stratosphere. Although less damaging to the ozone layer, HCFCs do contain chlorine and will have some impact on the ozone, thus the requirement to phase them out at a later date. CFC 11 and 12 have an ozone depletion potential that is 20 times that of HCFC 22.

What are the national provisions regarding the phasing out of refrigerants?
The House and Senate reached a compromise agreement that was included in the 1990 Clean Air Act Amendments. The amendments include phasing out ozone-depleting chemicals by the end of the decade and put restrictions on hydrochlorofluorocarbons (HCFCs) that will begin to take effect a quarter of a century from now. The 1990 Clean Air Act Amendment indicates that production of the CFCs R-11, R-12, R-113, R-114 and R-115 will be phased out by the year 2000. Production of HCFCs will be frozen in the year 2015 and banned by 2030. Also, the amendments include provisions prohibiting the venting or
disposing of refrigerants, and recapture, recycling and safe disposal regulations will be instituted by the Environmental Protection Agency (EPA) beginning in 1992. A ban on venting CFCs or HCFCs during plant repair, service and disposal will begin after July 1, 1992. Mandatory recovery and recycling regulations will be instituted by the EPA and will become effective for CFCs on July 1, 1992, and for HCFCs by the end of 1995 at the latest.

**How will these provisions affect my operation?**

For example, if you have refrigeration equipment that uses R-12 or R-11, the provisions in the 1990 Clean Air Act Amendments mean that you will not have available, by the year 2000, equipment that uses these types of refrigerants, nor will the refrigerants be available from manufacturers. Also, venting R-11 or R-12 during equipment servicing will be prohibited after July 1, 1992.

**What alternatives do I have?**

First, you should not vent the refrigerant to the air; instead, recycle it. Second, you might be able to substitute new refrigerants for the banned CFCs, but you need to consult the equipment manufacturer before doing this. New refrigerants are in the developmental stage now, but some will reduce the efficiency of the equipment, are incompatible with equipment currently in operation, or both.

**Can I substitute the R-11 refrigerant in my equipment with an HCFC?**

If your equipment uses R-11, perhaps you could substitute an HCFC such as R-123. However, this alternative will depend on your equipment, because R-123 is an aggressive solvent that attacks seals and gaskets and dissolves protective coatings around motor windings in hermetically sealed R-11 units. Also, R-123 is somewhat less efficient (2 to 5 percent less efficient) as a refrigerant than R-11. In any case, you should consult the equipment manufacturer before taking these steps. A successful switchover with long-term operating performance efficiency requires an engineered conversion.

**How about substituting CFC-12 with HCFC 22?**

A short-term solution used by some supermarkets is to substitute HCFC 22 for CFC 12. Experiences vary, but apparently the substitute or “drop-in” works satisfactorily. There probably will be a reduction in refrigeration capacity and possibly some compatibility problems with the materials used in the refrigeration equipment. A grocer should contact the equipment manufacturer before making such a substitute.

**Will the operating costs of refrigeration units that use banned CFCs change?**

Yes. The decrease in availability of the banned CFCs is going to drive prices up. For example, in mid-1989, the price of one pound of CFC R-11 was $3.00; by mid-1990 it was $5.50. As the total ban goes into effect, supply and demand may drive the price up even faster. Also, federal taxes on the CFCs, now $1.37 per pound, will increase to $4.90 per pound by 1999. However, if existing equipment does not leak or the refrigerant is recycled, there will not necessarily be an increase in operating cost. Only when the equipment is serviced with virgin CFCs will there be a cost increase.

**Should I be more attentive to the maintenance of my refrigeration equipment?**

Certainly. There is no question that preventing any kind of leakage in your refrigeration equipment is becoming more important. When refrigerants were inexpensive and available, leakage was not considered significant. Now, as we are seeing, the refrigerants are not going to be available and venting will soon be prohibited. Therefore, more attention should be given to places where leaks in the refrigeration system can occur. Preventing leaks will also benefit the environment by reducing the amount of CFCs or HCFCs in the atmosphere.

**What are the major sources of leaks in a refrigeration system?**

Leaks occur most frequently from vibrations transmitted to the piping by the movement of the compressor, and by pressure pulsations as the refrigerant is pushed through the piping. Leaks are found most often in tubing, flanges, o-rings, and connections where components meet. To prevent leaks, maintenance checks should include tightening fittings, checking welded joints, replacing worn gaskets and seals, and attention to the anti-leak integrity of a chiller’s outer shell.

Special attention needs to be given to narrow tubing close to the source of vibration. The closer small-diameter tubing is to the source of the vibration, the greater the refrigerant line breakage. Another important factor in refrigerant leakage is the expansion and contraction of the piping and components.

**How often does a refrigeration system lose its complete refrigerant charge?**

Statistically, the average refrigerant system loses its complete refrigerant charge three times in ten years.

**Is the efficiency of the equipment affected by the refrigerant loss?**

Refrigerant leakage reduces the efficiency of the refrigerant system and the compressor life, no matter how well the system was designed.

**How does a leak develop?**

For example, suppose a small refrigerant leak begins in a liquid line flare nut somewhere in the system. As the liquid refrigerant leaks into atmospheric pressure, it boils by absorbing heat from the surrounding metal surfaces. The flare nut and flare nut face temperatures begin to drop, the metal contracts and the leak grows. This process rapidly accelerates the...
leak size in just a few hours. As the periods of liquid line flash gas increase, the line pressure drops due to the friction caused by the movement of the liquid in the partially filled piping. The long periods of flash gas continue, causing extensive wear on the expansion devices. Although the refrigerant leaks could be in the high pressure line, capillary action will permit moisture to enter into the sealed system, reducing compressor lubrication. The refrigerant leak then causes the pressure to drop on the low pressure side of the system, thus decreasing refrigerant mass flow which returns oil to the compressor. The pressure drop preventing the oil from returning to the compressor also will raise the reciprocating pump compression ratio.

**How does the leak affect operating costs?**

The most costly leak, from an energy consumption standpoint, is a slow leak. Compressor capacity is gradually reduced, requiring longer run times to achieve the temperature required. Each 1 pound of pressure drop beyond the design temperature could decrease efficiency by 3 percent and system capacity by 8 percent. The refrigeration cost is then compounded by the extended compressor run time. If enough refrigerant has leaked out to permit the compressor to reach its low pressure switch cut-out point, it will begin short cycling. The compressor will use seven times its running load amps with each start for a split second. The high frequency of starts at this point will overheat the compressor motor windings, perhaps even causing motor burnout. Therefore, the operation and maintenance costs of the equipment increase considerably.

**How can I prevent a refrigerant leak?**

A preventive maintenance program is necessary for any refrigeration system. It should include scheduled inspections and cleaning of all parts of the system. Unfortunately, preventive maintenance is only part of the answer to keeping the system operating. Failures, such as leaks, need to be discovered immediately before major damage can occur.

**What are some signs of a refrigerant leak?**

If your system is equipped with sight glasses, a quick check may indicate if you have a problem. Bubbles in the sight glass usually indicate that the system is low on charge. Other indicators include lower than usual suction side pressure. Keep a log of the suction side pressure. If you notice a trend toward lower pressures, have the system checked. Oils are carried with the refrigerant. Often, oil will be visible at the point of a leak. Oil will be easier to see on clean equipment, so house-keeping becomes important. Monitor run times of your equipment. If your system starts to run more often than in the past, it may be an indicator of problems.

**Are there refrigerant loss alarms?**

There are several types of refrigerant loss alarms in use today. A receiver float alarm warns when the liquid level in the receiver tank has fallen to a set point. An electronic leak detector senses surrounding air in the facility and responds to the presence of halogen gas. Another type is the low pressure switch; this alarm is activated by a pressure drop below the normal assigned temperature requirement in the suction line, indicating a refrigerant leak. In the microprocessor liquid line monitor a constant refrigeration recirculation system displays and records maximum time of normal flash-gas, and an alarm sounds when normal flash-gas times are exceeded substantially.

**What type of facility would use these alarms?**

Refrigeration alarms are mainly used in large systems where much equipment and the cost of the facility make the installation of these alarms feasible. However, a small facility usually does not have these alarms and has to rely on the periodic inspection of all of the components, paying attention to operation efficiency and the system’s pressure.

**References**


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