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Could lack of a good refrigerant management plan be putting your firm at risk?

It's been a dozen years since the federal government began enforcing Section 608 of the Clean Air Act (CAA) Amendments of 1990. Still, however, many organizations are either unaware of or choose to ignore their responsibilities under these regulations, which govern the release of ozone-depleting refrigerants into the atmosphere. Unfortunately, as several companies across the U.S. have discovered, the results of failing to comply with Section 608—whether due to ignorance or willfulness—can be extremely costly.

The rules prohibit "individuals from knowingly venting ozone-depleting compounds (generally CFCs and HCFCs) used as refrigerants into the atmosphere while maintaining, servicing, repairing, or disposing of air-conditioning or refrigeration equipment."[1] In addition, the owners/operators of equipment requiring refrigerant charges of more than 50 pounds are held strictly accountable for refrigerant emissions that exceed specific guidelines, as well as for the manner and timeliness with which leaks are monitored, documented, reported and repaired. Violators are subject to civil and/or criminal penalties that include fines of up to $27,500 per day and up to 5 years in prison.

The United States Environmental Protection Agency takes its job of enforcing these rules very seriously. Not only does the agency investigate leaks properly reported by owners/operators or other responsible parties, it routinely conducts surprise facility inspections and offers rewards of up to $10,000 for information about unreported violations that leads to successful prosecution or settlement. Building owners/operators who are unable to provide required equipment service and maintenance records, who have used uncertified technicians or refrigerant recovery and recycling equipment, or have in any other way failed

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Choosing and using exit signs requires careful consideration

Over the past twenty years, exit signs have undergone many technological advances. Most of these advances have focused on reducing energy consumption. As a result of the array of options now available, the task of choosing the best sign for occupant safety can sometimes be a daunting one for building owners/managers.

In the early 1980s, it was virtually impossible to find an exit sign illuminated by anything other than incandescent bulbs. A typical internally illuminated sign, equipped with two 20-watt incandescent bulbs, operating 24 hours a day every day of the year, consumed over 350 kilowatt-hours of electricity each year. Multiply that by the tens or hundreds of signs found in many commercial properties and you see that the contribution of incandescent exit signs to facility energy costs could be substantial. Another disadvantage of incandescent exit signs is the relatively high level of maintenance they require to prevent bulb burnouts that could render the signs ineffective during an emergency.

By the mid-1980s, exit sign makers had begun creating signs that relied on other, more efficient light sources. The first widely accepted of these were dedicated compact fluorescent lamp (CFL) signs, which use

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to follow prescribed Section 608 regulations can be subject to stiff penalties (see sidebar on this page).

Even if you have implemented a detailed refrigerant management and regulations compliance program at your facility, you should periodically review the program to ensure it is being both properly followed by all affected personnel (including outside contractors) and adequately funded. If you haven't developed such a program, you should do so immediately. The following questions in no way cover all the points you need to be aware of when establishing a new or auditing an existing refrigerant management and regulations compliance program. They can, however, serve as a good point for getting started.

Have you designated one person to serve as your facility's refrigerant manager?

This person should: be knowledgeable of all pertinent regulations; be the key developer and overseer of a refrigerant leak management plan; have the authority and budget to enforce all aspects of the plan; be responsible for maintaining all required records and coordinating the purchase, usage and storage of all refrigerants; and ensure proper training and certification for all personnel involved in the servicing and maintenance of refrigerant-containing equipment or the purchase or storage of refrigerants.

Have you conducted an inventory of your facility's equipment and refrigerants?

This inventory should list the type of refrigerant-using equipment you have, manufacturers, model and serial numbers, age, location, capacity, refrigerant charge, and service history—including records relating to refrigerant recharging. You can group small equipment (those requiring refrigerant charges of less than 50 pounds each) together, if you wish. Likewise, you need to inventory existing refrigerant supplies (those in storage as well as those already installed). Also, analyze past refrigerant purchases, uses, reclamations and disposals for thoroughness and accuracy. This information can be used to uncover potential problems that need monitoring or correction.

Have you developed a leak management mission statement and plan?

This plan should clearly outline all responsible and acceptable refrigerant handling practices and should be available and understood by all affected personnel (including outside contractors).

Do you keep detailed refrigerant records?

These should include much of the information gathered during the equipment and refrigerant inventory—including equipment type, size, identification numbers, refrigerant charge and service/maintenance records—as well as logs of all refrigerant leaks; what type of equipment was used to detect each leak; when and how it was repaired; and the quantity of any refrigerant released, added, recovered or disposed of. If you should be inspected, the EPA will expect complete documentation from the date your business opened or July 1992 (whichever came first) through the present.

Do you report and repair leaks according to EPA requirements?

Under Section 608, owners/operators of equipment having a refrigerant charge of over 50 pounds are required to follow a strict repair or replacement timetable if the 12-month leak rate is 35% or higher for

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Paying the price for non-compliance

Since the Clean Air Act Amendments went into effect in 1992, a number of companies have paid the price for failing to comply with the refrigerant management and recycling regulations outlined in Section 608. Below are case histories of just a few.

- In July 1998, USEPA cited the owners of a Dover, Delaware, mall for allowing a non-certified technician to service CFC-containing air conditioners, for buying CFC-containing refrigerants on multiple occasions when they did not have a certified technician, for failing to use certified CFC recovery and recycling equipment, and for not maintaining proper service records. The company was fined $47,400.

- In November 1999, the USEPA took action against a Southern California restaurant-management firm for failing to use certified technicians and refrigerant recovery and recycling equipment for work performed on CFC-containing appliances. A fine of $97,900 was imposed.

- In September 2000, a USEPA press release reported that Meyer's Bakery, of Little Rock, Arkansas, agreed to pay a $3.5 million fine for allowing "thousands of pounds of HCFCs to leak from appliances [in facilities in five states] without performing required repairs. Meyer's service logs revealed that Meyer's continued to add refrigerant and operate equipment without making repairs even where the leak rates were greater than 58 percent and as high as 22,531 percent."

- In August 2004, the EPA reached an agreement with Abbott Laboratories that called for Abbott to pay $17,903 in fines and to spend an additional hundreds of thousands of dollars to retrofit seven refrigeration units to use non-ozone depleting refrigerants. Abbott was cited for failing to repair chillers that leaked excessive amounts of CFC.

Report casts doubt on benefit of polarized refrigerant oil additives

For the past several years, products known as polarized refrigerant oil additives have been manufactured, sold and installed in cooling and refrigeration equipment across the country for the intended purpose of improving system efficiency. E Source, an energy research organization owned by Platts, recently looked into the existing data regarding the benefits provided by these products and issued its findings in a January 2004 report (ER-04-2 Tech), written by Jay Stein, titled "The Polarized Debate over Polarized Refrigerant Oil Additives" (www.esource.com). The following article is excerpted from that report.

Polarized refrigerant oil additives are liquids designed to be introduced into all sorts of refrigeration systems, including air conditioners, chillers, heat pumps, walk-in coolers, and freezers. According to vendors, these additives mix with refrigerant oil, enabling it to lubricate more effectively and to reduce resistance to heat transfer. Furthermore, vendors say that polarized additives are capable of achieving energy savings that range from 5 to 30 percent of overall refrigeration system consumption. These additives have been on the market for many years now.

Although each polarized additive manufacturer uses a different chemical formulation, the marketers tend to make relatively similar claims about how their products work. Most assert that their product adheres to metal better than the oil that coats the interior of most refrigerant systems. As a result, they say, their product will displace the oil film, as well as dirt and other impurities suspended in the film. The net effect of this displacement, according to marketers, is that the insulating value of the oil and its accompanying impurities is reduced, dramatically improving the flow of energy across heat transfer surfaces. Furthermore, these marketers claim that this thin layer of additive improves lubrication, reducing friction losses in the compressor.

The chief benefit vendors claim is that their additives will reduce refrigeration energy consumption, with estimates ranging from about 5 to 30 percent of overall refrigeration energy use. The other key benefits that marketers tout include extended equipment life and quieter operation.

Of all the claims made by the manufacturers of polarized refrigerant oil additives, we have only found that two have been corroborated by empirical evidence:

- *Improved lubricity:* The test results we have seen demonstrate that pure oil was able to withstand pressures of only 300 pounds per square inch (psi), but the oil containing 5 percent of a polarized additive was able to withstand up to 4,500 psi. Assuming that these tests are accurate, it's clear that oil mixtures containing the additives do exhibit increased lubricity [the capacity of a lubricant to reduce friction]—at least initially. [The tests did] not measure the material's response to long-term exposure.
- *Quieter operation:* Several observers noted that after adding a polarized additive to a refrigerant system, the system ran noticeably quieter. Again, we don't have in our possession any empirical evidence that this effect continues over the long term.

We've yet to see any empirical data that these

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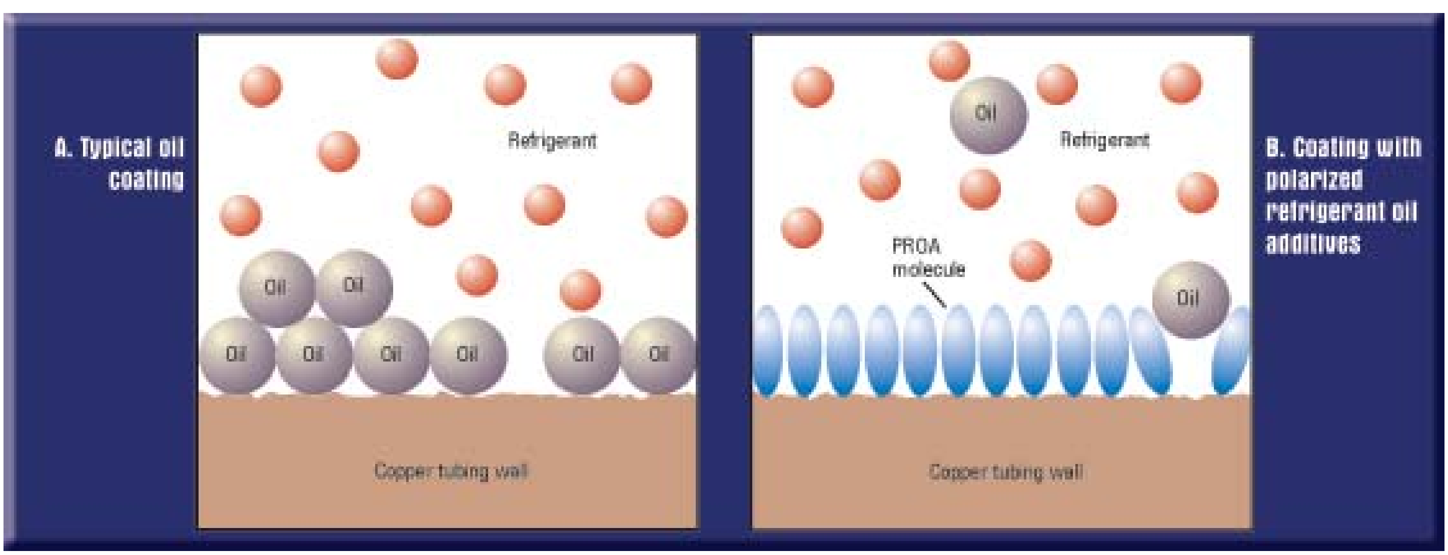

The internal surfaces of refrigerant systems are typically coated with a thin layer of oil, as shown in diagram A. The companies that market polarized refrigerant oil additives (PROA) say the additives more strongly adhere to metal than oil does, so that PROA molecules displace oil molecules, leaving a coating of additive molecules, as shown in diagram B. Source: Platts

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additives actually

- displace refrigerant oil, or
- by any mechanism, reduce heat transfer resistance on the internal surfaces of refrigerant heat exchangers.

Even if we did have such evidence, it's still not clear that it would be sufficient to establish the effectiveness of these products. We have in our possession several simulation studies that indicate that the mechanisms for savings touted by additive vendors is probably incapable of delivering the savings they claim. The first set of simulations we have seen was prepared for Intertek Testing Services, the international testing, inspection, and certification company. What they found was that for every 10 percent improvement in internal heat transfer, the overall efficiency of the simulated heat pump improved by only about 1 percent. The second set of simulations was done by Trane Co. In the Trane simulations, it took about a 25 percent improvement in the internal heat transfer coefficient to produce a 1 percent improvement in overall efficiency.

In addition, we have uncovered evidence that improving lubricity within the compressor is also unlikely to produce more than just a few percentage points of savings. According to Copeland Corp., one of the world's leading manufacturers of air-conditioning compressors, only about 4 percent of power input to a compressor is lost in the form of friction that could be affected by a lubricant additive. Copeland reports that it has tested several oil additives and was unable to detect any "meaningful change in compressor power consumption."[1]

So, based on the empirical record to date, it is unlikely that the savings mechanism promulgated by most refrigerant additive vendors is capable of delivering the 5 percent minimum savings being claimed by some vendors. We have pointed out this discrepancy to all of the additive vendors that have contacted us directly in recent years, but we have yet to receive an explanation of how their proposed savings mechanism could achieve the savings they promise.

The vendors that have responded have offered to send us field tests of their products. However, many of the tests we reviewed simply ignored unintended variations. Others were clearly administered by parties with an interest in the results [and] the history of science has shown repeatedly that the judgment of biased researchers may be clouded in ways they are not even conscious of. Last, some test reports were so sketchy that we couldn't tell what procedure the researchers had followed.

Three tests [that did follow acceptable test procedures] in qualified laboratories, showed that little or even negative savings were achieved by adding a polarized refrigerant oil additive to a packaged rooftop unit. In some of these tests, some of the units did achieve savings of about 2 percent.

The economics of small savings

What if one were to use an additive despite such modest prospects for savings? Might that choice prove to be cost-effective? To answer these questions, we assumed a 10-ton rooftop unit operating in a climate similar to Dallas, Texas. In addition, we assumed that the owner of the unit was paying 8 cents per kilowatt-hour. Therefore, improving the unit's efficiency by 2 percent would save about $36 a year.

How much would it cost to get those savings? [Based on reported costs of $50 to $100 per ton to purchase the additive and up to $75 in labor costs] the cost of installing a polarized refrigerant oil additive in our hypothetical 10-ton unit would range from about $650 to $1,150. Assuming a savings of around $36 per year, that would yield a simple payback period ranging from about 18 to 32 years—longer than the expected lifetime of many air-conditioning units.

The last word

Curently, the mechnism by which vendors of polarized refrigerant oil additives theorize that their products improve the efficiency of refrigeration systems is unsubstantiated. Furthermore, it's clear from the large body of product tests available that, for any given system, little or no savings can result from applying these products. It is inconclusive whether or not greater savings would be possible under other, unspecified conditions.

Given the confusion about mechanisms and test results, we are not persuaded that polarized refrigerant oil additives represent a reliable, effective means of improving the energy efficiency of refrigeration systems.

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[1]Copeland Corp., "Application Engineering Bulletin, AE-1282, Oil Additives," unpublished report (March 1989), Sidney, Ohio, web www.copeland-corp.com

Exit, *continued from page 1*

about 75% less energy than comparable incandescent models. CFL bulbs also last 10 to 13 times longer than incandescents, thereby improving the sign's reliability while reducing maintenance requirements.

Two other technologies introduced in the 1980s and early 1990s were light-emitting diode (LED) exit signs, which use two to five watts of electricity, and electroluminescent signs, which use as little as one-half watt. Both LED and electroluminescent exit signs have long lives and require far less maintenance than incandescent or, even, CFL models. Today, LED models account for the majority of new exit sign sales.

All of these technologies have a common pitfall: They need electricity. Installation of a power-illuminated sign can be costly, requiring an electrician to run and connect electrical wiring. Adding to the purchase and installation cost is the need for a backup power source—either a battery pack or separate emergency circuit—that will allow the sign to remain functional in the event of a power outage. And even these backup power sources aren't necessarily fail-safe.

In an effort to address these shortcomings, the tritium exit sign—which consumes no electricity—was developed. This self-luminous sign contains tertiary hydrogen, a radioactive material whose decay causes phosphors in the sign to glow. Although hundreds of thousands of tritium signs have been installed in the U.S., their radioactive content has raised concerns among some consumers and consumer safety advocates.

Today, another, safer type of self-luminescent sign is gaining in popularity. Photoluminescent exit signs employ glow-in-the-dark pigments made of strontium oxide aluminate crystals to absorb and store ambient light. When the ambient light is removed, as in a power outage, the photoluminescent sign will glow as it releases its stored energy. Because they can be charged by existing light sources, when installed in appropriate locations, photoluminescent exit signs require the use of zero extra energy. They are also easy to install (no electrical wiring required) and maintain (just dust). When properly charged, photoluminescent signs bearing the Underwriters Laboratories (UL) label will retain sufficient brightness to satisfy current national and local building safety codes for at least 90 minutes.

However, photoluminescent exit signs are not appropriate for all situations. Code requires them to be installed in a location where they will constantly receive a minimum of five foot-candles of external illumination (a fluorescent light source is best) whenever the building is occupied. This makes them unsuitable for theaters, hotel rooms, and other spaces that are frequently darkened during occupancy; or in areas where lighting is controlled by occupancy sensors or where the signs' lighting circuits are controlled by occupant-accessible on-off switches.

In addition, photoluminescent signs require 60 minutes to fully charge after being discharged. So if they are used in buildings where the lights are turned off at night, there will be a lag between the time the occupants return and the point at which the signs will be fully charged and functional the next morning. This lag can be eliminated by turning on the charging lights an hour before they are needed for occupancy, but this will negate some or all of the photoluminescent sign's efficiency advantage over LED signs.

Another potential problem posed by photoluminescent exit signs, as well as by most of the other energy-efficient alternatives to incandescent signs, is their relatively low luminance (light output) level, especially when compared to internally illuminated incandescent exit signs. Photoluminescent, LED, electroluminescent, and tritium exit signs that bear the UL label are considered to have sufficient luminances to meet National Fire Protection Association (NFPA) guidelines, upon which many communities, including the City of Springfield, base their fire safety codes. The problem, according to some parties, is that these guidelines are based on the amount of luminance required to make exit signs visible in clear conditions.

If smoke is present, dimly illuminated exit signs can quickly become obscured. A study conducted by the National Research Council Canada's Institute for Research in Construction, indicated that brighter signs are more easily located and identified in hazy or smoky conditions. In that study, occupants benefited from sign luminances of 1200 or more candela/meter^2 (cd/m^2)—about 25,000 to 30,000 times brighter than the average photoluminescent exit sign. (***Note:*** The 1200 cd/m^2 levels tested in this study also far exceed the 8.6 cd/m^2 minimum luminance required until recently by the NFPA and UL for internally illuminated exit signs.

Photoluminescent exit signs are, perhaps, best suited for use in conjunction with electrically operated signs, where the brighter, power-illuminated signs are used overhead and the photoluminescent signs are placed further down the wall where they might be easier to see in smoky conditions. If photoluminescents are used in this way, care will need to be taken to ensure furniture and other items do not block the signs from their light source during non-emergency periods or from occupant view during an emergency.

The availability of energy-efficient options to standard incandescent exit signs has led to dramatic energy savings by U.S. companies over the past two decades. At the same time, it has complicated the decision-making process for building owners/operators. There is no cookie cutter answer to which type of sign will be best for your facility. The solution requires careful consideration of the specific needs of your building and its occupants, as well as the safety features of and regulations applicable to each alternative.

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commercial refrigerant and industrial process refrigeration equipment or 15% or above for all other appliances, including comfort cooling systems. You must report leaks that meet these criteria to the EPA immediately upon discovery and, in most cases, must either repair the leak within 30 days of the discovery or submit a retrofit-retirement plan for the equipment within 39 days and follow through on that plan within one year of the plan's date. (The timetable may be extended for industrial process chillers.)

Refrigerant leaks can affect your bottom line in more ways than one

The potential for hefty penalties and, in worst cases, prison, are not the only damages you can suffer as a result of unchecked refrigerant leaks.

By federal mandate, the manufacture, sale and use of chlorine-based refrigerants (CFCs and HCFCs) are being phased out. As a result, supplies of these products, which have been the most common types of refrigerants used in commercial and residential refrigeration equipment for decades, have become scarcer and their costs have dramatically increased.

Before these phase-outs began, when supplies were plentiful, companies generally found it much less expensive and more convenient to simply top off or recharge leaking equipment than to make repairs. Today, however, you could spend tens of thousands of dollars to replace the refrigerant in one large chiller.

Refrigerant replacement costs aren't the only expense that can result from leaks. When operating with a suboptimal refrigerant charge, a chiller will use more energy to produce the same level of cooling that it produces when it is properly charged. As a result, leaking systems can increase your energy costs.

Regardless of the size or type of business you have, if you own or operate any type of refrigerant equipment you most likely are subject to Section 608 of the Clean Air Act Amendments of 1990. You owe it to yourself to take immediate steps either to develop a program to ensure full-scale CAA compliance or to audit your existing program to ensure it will afford you maximum protection against punitive action by the EPA.

[1] "Complying With The Section 608 Refrigerant Recycling Rule," www.epa.gov/ozone/title6/608/608fact.html

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