

# **ADVANCED ENGINEERING LTD**

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## **Refrigerant Recovery and Leak Detection**

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### **ABSTRACT**

This paper briefly summarises the very latest developments in refrigerant recovery units which, because of the Montreal Protocol, are required to cope with both recovery, installation and retrofit situations involving CFC, HCFC and HFC refrigerants.

The paper also considers the causes and the environmental and economic implications of leaks in air conditioning and refrigeration systems. Looking in depth at a popular, simple and economic solution suited to all systems, which is both approved and qualifies for BREEAM credits and points under both BREEAM 1/93 and BREEAM 98 for offices.

## **REFRIGERANT RECOVERY & LEAK DETECTION**

Few people remain unaware of the crucial role played by the ozone layer. It helps shield the earth from the most damaging part of the sun's radiation.

To protect the ozone layer, the United Kingdom along with many other nations, signed international agreements designed to control the production and consumption of CFC and Halon compounds. The European Commission on the 1st July 1998 adopted proposals to prohibit the use of HCFC's in new equipment (except for reverse cycle heat pumps) effective from 2001 and to ban the use of HCFC's for the servicing of plant and equipment from 2008. Building owners, consultants, engineers and specifiers will therefore find that they are increasingly involved in refurbishing, retrofitting and decommissioning refrigeration and air conditioning equipment.

### **REFRIGERANT RECOVERY**

#### **Why we need to recover refrigerants**

Section (33) ic of the Environmental Protection Act which came into force on 1st April 1992, makes it an offence for any person to "treat, keep or dispose of controlled waste in a manner likely to cause pollution of the environment or harm to human health".

The penalties are severe, namely

- A. On summary conviction (i.e. in a magistrates court) a term of imprisonment not exceeding 6 months or a fine not exceeding £20,000 or both!
  
- B. On conviction on indictment (i.e. by a jury) a term of imprisonment not exceeding 5 years or a fine (unlimited) or both!

### **Recovery Units - Choices**

A recovery unit is an essential tool in ensuring that you not only stay within the law but conserve refrigerant, protect the environment and maybe save a £20,000 fine ..... or worse.

With the increasing variety of refrigerants and blends in use it is essential that a recovery unit should be capable of recovering CFC, HCFC and HFC refrigerants.

Early recovery units were built around hermetic compressors which, though not ideal, were readily available. These proved very popular until refrigerant blends began to appear (there are now over 50 available).

A major breakthrough occurred in 1991 when a revolutionary oil-less compressor was developed specifically for refrigerant recovery, eliminating virtually all of the problems inherent in traditional hermetic technology.

Capable of accommodating every commonly used refrigerant without risk of cross contamination, the oil-less compressor offered numerous advantages. Unaffected by moisture, acid and temperature and with a separate motor, the oil-less compressor can be used without difficulty on mineral, ester, PAG and alkyl-benzene oils.

A further breakthrough came in 1998 with the launch of the PROMAX RG5410 high pressure recovery unit, incorporating all the benefits of the oil-less compressor, able to recover all common refrigerants and importantly with the added ability to recover R410A and the new range of high pressure refrigerants destined to replace the HCFC R22.

### **REFRIGERANT LEAK DETECTION**

A few years ago, leak detection in refrigeration and air conditioning systems was considered to be a last minute inconvenience. Searching for leaks consisted of a time consuming and monotonous inch by inch search over every potential leak site area. When this job was undertaken the first priorities were the obvious high risk areas - flared joints, mechanical joints, shaft seals, expansion valves, fusible plugs etc.

If, as was often the case, insufficient evidence was found of any major leak, the engineer was then faced with a choice of continuing a possibly fruitless and labour intensive search or withdrawing from site and hoping the leak would not show again.

**Most systems leak.** Indeed experts agree that as much as 70% of all refrigerant consumed (estimated at £40 million in 1998) has been for “topping up” refrigeration and air conditioning systems.

In the last few years the state of leak detection has changed dramatically as a result of four factors

- Concern about our environment
- Legislation to phase out and ban CFC's
- The escalating cost of refrigerants
- The introduction of time and labour saving leak detection technology

### **What causes leaks?**

Refrigerant leaks are a physical path or hole usually of irregular dimensions most frequently caused by vibration and mechanical stress - flare failures, fractured tubing, shaft seals, etc.

The combination of temperature, pressure and vibration often produces intermittent small leaks which will eventually grow to become larger ones.

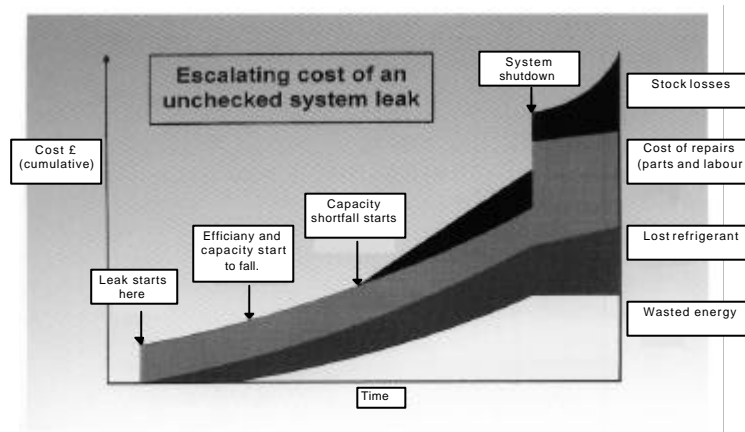
R134a and many of the fluids put forward as alternatives to CFCs are expensive and, in some cases, leak more readily than the traditional refrigerants they replace.

HFC refrigerants require synthetic polyolester (POE) based lubricants, in addition to being more expensive than the original mineral oil they replace, these products can act as aggressive solvents flushing and cleansing the inside of a system exposing the weaker areas where leaks may, and often do, occur. Too often a previously 'leak free' system retrofitted to an HFC system, has become in a short while, a 'refrigerant free' system having lost a significant proportion of the charge!

Most leaks, even those where a pipe eventually fractures will, in the early stages, be small leaks. Many leaks will also be intermittent, refrigerant loss, therefore, may not be noticed for some while or until the plant performance has degraded to the extent that the cooling cycle is affected. This type of leak, along with what may be a myriad of small leaks, are difficult to locate and it is not uncommon to find that many systems habitually operate short of refrigerant. A recent survey (Tait J. 1997) of 38 commercial "condensing unit type" installations showed that **55%** were short of refrigerant.

Energy costs rise considerably when refrigeration plant operates inefficiently. The Good Practice Guide 178, gives an indication of the cost born by owners of refrigeration plant who typically suffer annual leakage rates of up to 15%. Energy costs alone are given for a cold store spending £22,000 per year on electricity 90% of this (£19,800) on refrigeration. With a typical annual leakage rate of refrigerant put forward as being 15%, energy wastage amounts to around £4,000 per year. Added to this, of course, is the cost of refrigerant, labour, downtime, and, if it occurs, product spoilage. See fig. 1

Efficient leak detection is, therefore, a vital and ongoing factor in reducing cost and system breakdown



**Figure 1 Escalating cost of an unchecked leak**  
**Courtesy of ETSU - Good Practice Guide 178**

A major disadvantage of virtually all traditional refrigerant leak detection methods is that to achieve success in finding a leak, refrigerant has to be leaking at the time the operator happens to be looking. Industry experience, confirmed by research, indicates that most leaks start off as small leaks and at this stage are very difficult to find. Intermittent leaks, the bane of every engineers life, are very

difficult if not impossible to track down and resolve. These leaks, together with persistent small leaks, often lead to inordinate amounts of costly time and labour in trying to resolve the problem, in addition the owner also has had to pay the increased energy costs involved in running an inefficient plant.

### **Refrigerant leak detection made simple with UV fluorescence**

Of all the methods of refrigerant leak detection, one has a unique set of user benefits that bears noting. The method is Ultraviolet (UV)fluorescent leak detection.

It is the only method that allows inspection of an entire AC&R system quickly and easily and can simultaneously pinpoint the exact location of every leak under virtually all conditions.

### **How it works**

The air conditioning or refrigeration technician introduces a liquid fluorescent additive into the AC&R system. The additive mixes and circulates with the lubricant. Whenever there is a leak, the additive/lubricant mixture escapes with the refrigerant. The refrigerant evaporates, the additive/lubricant mixture remains at the leak site. The additive residue gives off an unmistakable, bright yellow/green fluorescent glow when illuminated by a UV lamp.

The small leaks, so hard to find with most other methods, are inevitably exposed, the dye does not degrade at all when

**Figure 2 Capsules and detection lamp. Courtesy of Spectronics.**

exposed to refrigerants and the fluorescence remains visible for a long period of time. This is ideal as it produces a cumulative system where even minute leaks will be easily detected as the fluorescent material collects around a leak site over time. The intermittent leak, the one that occurs at 4 am on Sunday mornings and which cannot be located on Monday (because it is not leaking on Monday) can be pinpointed with an ultraviolet fluorescent system. Although the method is simple, it is important to carefully select additives and ultraviolet lamps to ensure optimum results.

The most critical factors for any fluorescent leak detection system designed for use within refrigeration equipment are the properties of the dye which will be introduced into the system. The dye must be oil and refrigerant soluble in order to be effective in both the liquid and vapour phases of the refrigeration cycle. The fluorescent response of the dye must be strong enough to allow the final concentration of the dye within the oil to be minimal, assuring that any potential effects on the heat transfer properties of the system will be negligible. The dye must also be suitable enough to withstand the varying pressure and temperature

fluctuations it will encounter without losing its fluorescent properties or reacting with the many other materials it will encounter.

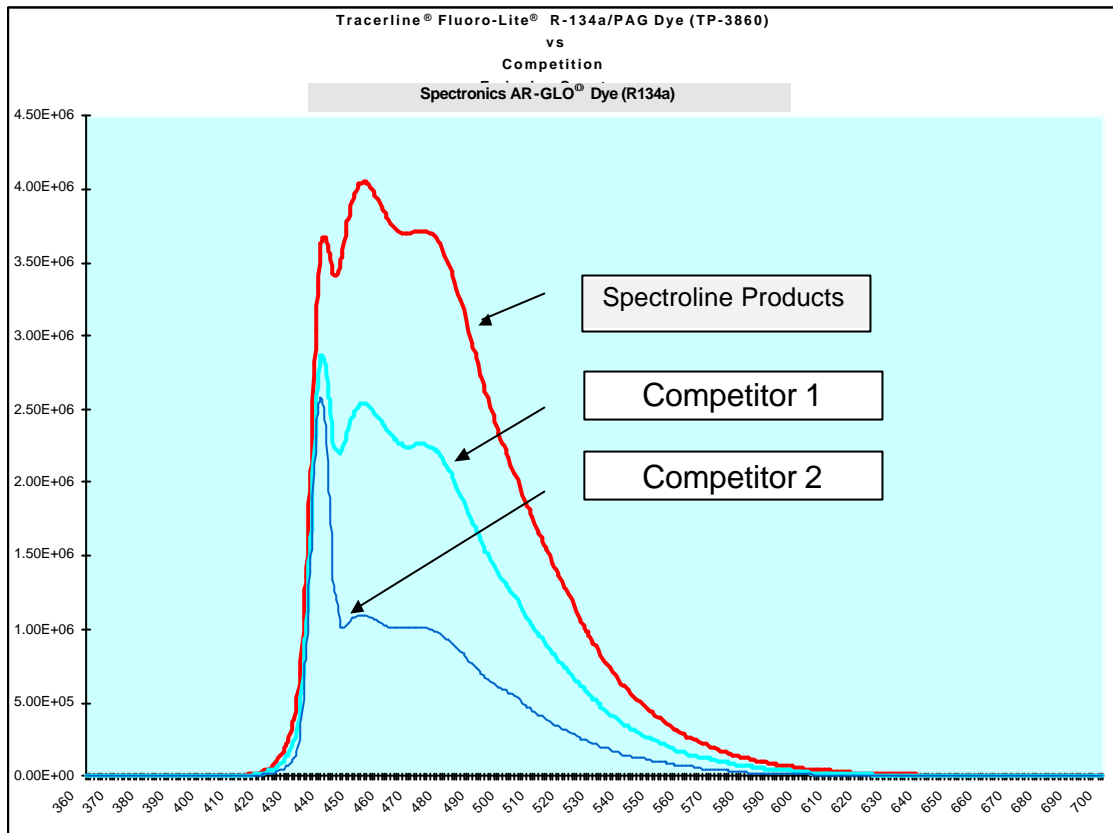


Figure 3 Not all dyes are the same.....

### Choosing the correct fluorescent dye

Compressor manufacturers spend enormous amounts of time and money on researching lubricants of the correct viscosity and quality. They must be satisfied that lubricants are compatible with the chosen refrigerant, stable at high temperatures and perform well in all circumstances. Technicians should therefore ensure that only dyes subject to these same rigorous performance trials and carrying manufacturer and OEM approvals are considered for use.

Universal all-purpose dyes sold for use with both R22 and R134a systems, for example, are based on polyolester oils and unlikely to ever gain approval from compressor manufacturers. A similar situation exists with dyes containing aromatic solvents. These substances reduce the viscosity of oil and therefore affect the lubricity and, more likely, the sealing function of the lubricant. They are also immiscible in R134a.

These concerns have been resolved with the introduction of proprietary lubricant - specific and solvent free Glo-Stick<sup>®</sup> capsules together with the new EZ-Ject<sup>™</sup> multi dose dye injection system. Both of these comply with the best practice manufacturing requirements of the minimum amount of dye and a simple method of infusion that preserves the integrity of a system by denying moisture, air, dirt and contaminates sometimes associated with the use of bottled dyes.

Lubricant specific and solvent free Spectroline<sup>®</sup> additives have been approved by compressor manufacturers and other major refrigeration and refrigerant OEM's and refrigerant reclaimers they also qualify for BREEAM. The reason for these approvals is that the additives are a solution of colourant (which is a super stable ultraviolet fluorescent molecule) and high quality refrigeration oil that is the same as the system lubricant (it may be mineral, polyolester, PAG or alkyl benzene). Once the additive is in the system, the final concentration is 1 part colourant to 350-500 parts (c 0.2%) lubricant.

The stability of the lubricant specific additive's colorant molecule plus its exceedingly low concentration in the host lubricant ensure that there will be no deleterious effects to the lubricant's physical or chemical properties or system components. Over 25 million refrigeration and air conditioning systems have been successfully infused with solvent free lubricant specific additives from Spectronics.

### **New Lamp Technology**



**Figure 4** Titan™ UV/Blue™ 12v Lamps. TP-8000 and TP-8200.

*Courtesy of Spectronics Corporation*

Stunning advances have recently been made with the introduction of TITAN™ broad-spectrum lamps. A technique has been developed and patented by Spectronics which optimises fluorescent responses of materials by employing lamp filters equipped with optical thin film coatings commonly known as interference filters.

These filters operate by having multiple thin films or coatings applied to a surface of the filter, thus a filter can be designed which will transmit specific wave lengths and reflect those which are undesirable. The transmission curve of this filter effectively incorporates the peak excitation wave lengths of both the perylene dye and the naphthalimide dye typically used in the industries employing fluorescent inspection. Outperforming all other lamps on the market, **Titan** lamps can be used effectively with any fluorescent dye used for leak detection.

## **CONCLUSION**

Ideally suited for air conditioning and refrigeration systems, fixed and mobile and requiring no particular expertise, Fluorescent leak detection can offer one of the best available techniques at a modest cost.

Requiring no maintenance adjustment or calibration, unaffected by droughts or heavy concentrations of refrigerant. The Spectroline UV Fluorescent Leak

Detection System works on any size of system is approved and qualifies for BREEAM credits and points under both BREEM 1/93 and the latest version BREEAM '98 for offices

Reference sites include: ships of the US and British Navy, Petrochem sites, refrigeration transport fleets, British Railways, British Telecom, supermarket chains, air conditioning and refrigeration unit manufacturers.

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