

Lesson Learnt from a Recent Incident in Ma On Shan : Any Explosion Risk for Environmentally Friendly Refrigerants ?

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Introduction

Total elimination of ozone-depleting substances is considered the best way to protect the environment. Refrigerants used in air-conditioning systems and as chemical agents for flame inhibition in firefighting are required to have low or even zero ozone depletion potential (ODP) after the enforcement of the Montreal Protocol [1]. However, health and safety should be a priority concern in any approach to environmental protection.

On 9 January 2013, an explosion [2] occurred in a restaurant. As reported in the news, the explosion might be triggered by a leak of environmentally friendly refrigerant. In fact, the author had pointed out the risk of fire and explosion of environmentally friendly refrigerants years ago [3]. Potential health effects of clean agents were highlighted in the study [3]. It was also pointed out that ODP is not the only issue. The problems of global warming, toxicity and risk of explosion should all be seriously considered.

As the recent explosion [2] might be fuelled by environmentally friendly refrigerants, it is the right time to carry out systematic research to better understand the potential explosion hazards of environmentally friendly refrigerants. Appropriate fire safety management, including safety precautions and remedial work to upgrade the system, can then be proposed. Scientific evidence in the literature should be used as references, and other possible non-zero ODP options must be studied thoroughly.

Refrigerants

The first generation of refrigerants was introduced [4] in the 1830s through the invention of the vapor-compression machine. Most of these refrigerants were toxic and flammable. Some refrigerants, such as sulfuric (ethyl) ether, ammonia and hydrocarbons, were highly reactive.

Many accidents occurred, and durability later became an added requirement for refrigerants [5]. Fluorinated refrigerants including chlorofluorocarbons (CFCs) were used in positive displacement centrifugal compression machines in early 1930s. “Freon” is probably the most well-known refrigerants in the refrigeration and air-conditioning industry. Fluorocarbons have been used as refrigerants for decades because of their stability, low toxicity and flammability. Propane is also used as the odorless safe refrigerant.

Environmental Protection

The first global environmental problem of ozone destruction was identified by Molina and Rowland [6]. Later on, the Montreal Protocol [1] was formulated to protect the upper atmospheric ozone layer. Chlorinated and brominated refrigerants, foam blowing agents, aerosol propellants, fire suppressants and other chemicals were scheduled to be phased out in many countries. When the protocol was signed, ozone depletion was the only environmental concern.

The Heating, Ventilation, Air-Conditioning and Refrigeration (HVACR) market moved very quickly from CFCs to hydrochlorofluorocarbons (HCFCs) and then hydrofluorocarbons (HFCs) with almost zero ODP. Later, it was realized that ozone depletion is not the only environmental issue to be handled. The effect of global warming received more attention as people believed that it would lead to climate change. In fact, implementing the zero ODP policy is very expensive to provide energy efficiency for solving the problems of global warming or climate change [1].

An environmental assessment on the selection of refrigerant recommended by the Technical and Scientific Committee (TSAC) [7] has been adopted since January 2005. The life-cycle ozone depletion index LCODI and the life-cycle direct global warming index LCGWI_d of the refrigerant used by the HVACR system for a building, normalized per refrigeration ton of cooling capacity and per year of design equipment life, are calculated and compared.

Two important factors affecting LCODI and LCGWI_d are the leakage rate and the refrigerant charge. These variables impact the formula significantly and become key areas that arouse disagreements among manufacturers.

Past Safety Research

Lunde and Lorentzen [8] found that a toxic, flammable-in-air refrigerant with an odour can have a lower accident frequency and risk than a nontoxic, non-flammable, odourless

refrigerant. The usage and risk of hydrocarbon refrigerants in motor cars in Australia and the US were studied by Maclaine-cross years ago [9]. As reported, the actual accident frequency and the risk of using hydrocarbon refrigerant in motor cars were much lower than predicted when commercial use commenced.

Many hydrocarbons have good thermodynamic and heat transfer properties which make them favourable to be used as refrigerants. They have no ODP and negligible Global Warming Potential (GWP). The major problem for their general use as refrigerants is their flammability as raised by Granryd [10]. Further, the values of ignition energy required for propane and isobutane are very low. Storing hydrocarbon refrigerants in small spaces will impose hazard. Places installed with air-conditioning and refrigerating systems using clean refrigerants should have fire safety provisions specified by the local authority. The use of hydrocarbon refrigerants was gradually gaining more psychological acceptance, at least in several European and South East Asian countries, using statistical data by that time.

Note that the low predicted values on risk [9] might be prompted by the low accident frequency recorded in 1994 and 2004. The extensive use of hydrocarbon refrigerants in the past years might change the situation in the very near future. The recent explosion incident [2] might only be the starting point.

Way Forward

Global warming and climate change depend on many factors and not just carbon emission. For example, a slight perturbation of the earth orbit or any sudden changes at the solar surface might result in very different climates. These factors are entirely out of human control [11].

Air-conditioning and refrigerating systems used in everyday life must be safe. There is an explosion possibility for air-conditioning systems which use clean refrigerants, particularly hydrocarbons. The incident can be fatal and kill immediately. Experienced old air-conditioning craftsmen might not have handled flammable refrigerants before, and they might still have the perception that refrigerants are not explosive. Further, there are many fake goods in the market. Such air-conditioning systems might pose a greater problem as they start to age. As raised by Granryd [10], people can easily accept an “old well-known risk”, but fear the unknowns. A higher frequency of accidents with clean refrigerants will definitely give more uncertainties on the safety of air-conditioning and refrigerating systems with clean refrigerants.

It might be too early to abandon these air-conditioning and refrigerating systems with flammable refrigerants or specifying too much fire service installations in places housing these systems after only one incident. Asking all air-conditioning craftsmen to wear appropriate personal protective equipment now is also difficult. However, the government has to take appropriate action if more incidents of clean refrigerant explosion are reported. At least, they have to work out a contingency plan, such as better control and tighter inspection on the use of clean refrigerants and system maintenance. No systematic research [3] has been conducted to explore the possible hazards of environmentally friendly refrigerants under local conditions of having so many air-conditioning systems in a dense concrete jungle packed with tall buildings. Such studies have to commence as soon as possible.

References

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