

Executive Summary

Direct Investigation into the Safety Regulation of Eco-friendly Refrigerants

Background

In January 2013, an explosion occurred and a fire broke out in the air-conditioning plant room in a restaurant in Ma On Shan when a technician was repairing the air-conditioning systems. More than 20 persons were injured and the restaurant was seriously damaged.

2. According to media reports, the incident was probably caused by improper use of flammable refrigerants and the refrigerants in question were not under Government regulation or subject to any legislation. It was further reported that traditionally used refrigerants were of low flammability, but in recent years, some traders were promoting flammable refrigerants as being eco-friendly and energy-saving. Yet, their high flammability meant that improper use of such refrigerants could be very dangerous.

3. In view of the importance of safe use of refrigerants to our daily lives, The Ombudsman initiated this direct investigation.

International Development of Refrigerants

4. The more traditional refrigerants, namely chlorofluorocarbons (“CFCs”) and hydrochlorofluorocarbons (“HCFCs”), are of low flammability but not eco-friendly. Under the Montreal Protocol on Substances That Deplete the Ozone Layer (“the Montreal Protocol”)¹, CFCs have been phased out while HCFCs are being replaced gradually.

5. Currently, the more widely used refrigerants, i.e. hydrofluorocarbons (high global warming potential) (“HFCs (high GWP)”), are of low flammability but only semi-eco-friendly. The parties to the Montreal Protocol are discussing ways to replace or control HFCs (high GWP).

6. New-generation refrigerants, including hydrocarbons (“HCs”) and hydrofluorocarbons (low to moderate global warming potential) (“HFCs (low to moderate GWP)”), are more eco-friendly but more flammable. Some flammable refrigerants are banned in certain places but are being introduced for use under restriction in other places. Details are tabulated below.

¹ The Montreal Protocol is an international treaty which aimed at protecting the ozone layer by gradually phasing out ozone depleting substances. The Protocol came into force in January 1989. To date, it has been ratified by 197 parties, including all members of the United Nations.

Types of Refrigerants	Eco-friendliness	Flammability	Use and Regulation in Different Countries
Traditional Refrigerants			
1. CFCs	Not eco-friendly	Low	Already phased out under the Montreal Protocol
2. HCFCs	Not eco-friendly	Low	Scheduled for phase-out under the Montreal Protocol
3. HFCs (high GWP)	Semi-eco-friendly	Low	Parties to the Montreal Protocol are discussing ways to replace and control them
New-Generation Refrigerants			
4. HCs	More eco-friendly	High	<p>USA and Singapore:</p> <ul style="list-style-type: none"> ● R290 banned on large air-conditioning systems ● R290 allowed on domestic air-conditioners but under strict safety restrictions (allowed for use in USA since 11 May 2015) <p>Mainland China:</p> <ul style="list-style-type: none"> ● After risk assessment and setting of standards, Government and businesses jointly promote the production and marketing of room air-conditioners that use R290. Some models are already being exported. ● Out of safety concern, Government does not approve of the use of R290 as a direct substitute for R22 (a non-flammable refrigerant) in equipment originally designed for R22
5. HFCs (low to moderate GWP)	More eco-friendly, but inferior to HCs	Low to moderate flammability, but not as flammable as HCs	Japan: Produces air-conditioners using R32.

Safety Requirements for Using Flammable Refrigerants

7. According to guidelines issued by the United Nations Environment Programme (“UNEP”) and information from other countries, safety requirements for using flammable refrigerants include the following:

- flammable refrigerants should only be used on suitably designed systems.
- extra training is required for workers engaged in the installation, repairs and demolition of refrigeration systems using flammable refrigerants.
- for indoor refrigeration systems, the amount of refrigerants used should be restricted.
- all related facilities and materials must be free from any potential source of ignition.

Regulation of Refrigerants in Hong Kong

8. In Hong Kong, there is no specific legislation to regulate refrigerants. Nor is there any Government department responsible for coordination. Currently, the regulation of refrigerants involves at least four Government departments and four Ordinances. The situation is set out below:

- Environmental Protection Department (“EPD”, under Environment Bureau): to control or phase out the manufacture and use of ozone depleting substances under the Ozone Layer Protection Ordinance.
- Electrical and Mechanical Services Department (“E & MSD”, under Development Bureau): if a refrigerant falls within the definition of liquefied petroleum gas (“LPG”) under the Gas Safety Ordinance, it comes under E & MSD regulation.
- Fire Services Department (“FSD”, under Security Bureau): if a refrigerant is a non-LPG dangerous good under the Dangerous Goods Ordinance, it comes under FSD regulation.
- Labour Department (“LD”, under Labour and Welfare Bureau): to regulate the responsibilities of employers and employees in respect of safety in the working environment based on the Occupational Safety and Health Ordinance.

The Use of Flammable Refrigerants in Hong Kong

9. In order to understand the use of refrigerants in Hong Kong, this Office studied the information provided by Government departments, the import statistics, the developments of refrigerants in countries manufacturing air-conditioners/refrigeration systems, and other relevant information available in the market.

10. The departments concerned provided the following information:

- EPD: did not hold information unrelated to environmental protection (such as flammability).
- FSD: learned from the industry that the use of flammable refrigerants had become more common because of the active promotion of environmental protection worldwide in recent years.
- E & MSD: considered the use of flammable refrigerants highly risky under the present circumstances in Hong Kong (i.e. lack of suitable facilities and properly-trained workers) but nonetheless repeatedly stressed to this Office that flammable refrigerants were not widely used in Hong Kong, nor was there any information to suggest that they would be increasingly used, because it had learned from the trade associations that Hong Kong had not imported any equipment designed for the use of flammable refrigerants. The Department also considered the industry not to have any incentive to replace non-flammable refrigerants with flammable ones in the original equipment. Nevertheless, the initial findings (passed to us in March 2015) of E & MSD's inspections in late 2014 and early 2015 showed that apart from the Ma On Shan case, other places in Hong Kong already saw flammable refrigerants being used to replace non-flammable refrigerants on unsuitable air-conditioning systems.

11. Statistics on Hong Kong's retained imports showed that flammable refrigerant substances accounted for about 8% of all refrigerant substances.

12. Information on producer areas of air-conditioners/refrigeration systems indicated that at least mainland China and Japan are already manufacturing air-conditioners that use flammable refrigerants. As there is no control in Hong Kong, such air-conditioners can be imported any time.

13. Meanwhile, some companies in the environmental protection business are conducting door-to-door visits to prospective clients to market "eco-friendly and energy-saving" HC refrigerants (which are highly flammable). They claim that in addition to being energy-efficient, these refrigerants can be used on the original equipment to replace non-flammable refrigerants without modifying the equipment. Similar advertisements can be found on the Internet. Some of these companies have

approached the Vocational Training Council (“VTC”) and suggested that the Council provide training courses to workers on how to handle flammable refrigerants.

14. The above information suggests that while flammable refrigerants are not being widely used in Hong Kong, their increasing use is possible. A point to note is that with no control in Hong Kong, flammable refrigerants and air-conditioning systems using them can be imported any time.

The Ma On Shan Incident

15. This direct investigation examined the following three aspects of the Ma On Shan incident.

I. Cause of the Fire

16. The cause of the explosion and fire was that a technician, while doing repairs, extracted flammable refrigerant from the air-conditioning system into a non-reusable cylinder not designed for refilling, resulting in a leakage. The mixture of flammable refrigerant and air came into contact with a source of ignition (which FSD believed to be the electricity extension unit), thus triggering off an explosion and a huge fire.

17. The incident highlighted the importance of worker training and the danger of mishandling flammable refrigerants.

II. Enforcement actions by Departments

18. After the incident, FSD successfully prosecuted the air-conditioning contractor. A total fine of \$22,000 was imposed for the offences of:

- storing dangerous goods (other than LPG) without a licence; and
- using unauthorised gas cylinders (referring to the other cylinders found on the premises, which were of a different model from the one involved in the explosion).

19. LD also successfully prosecuted the air-conditioning contractor for failing to provide a safe working environment for his employees, and a total fine of \$35,000 was imposed.

20. It should be noted that the charges brought by FSD did not actually deal with the cause of the fire. In fact, the Dangerous Goods Ordinance stipulates that:

“a licence to store any dangerous goods shall be deemed to include a licence to use such goods.”

In other words, once a set of premises is licensed to store dangerous goods, use of such dangerous goods on the premises is allowed. FSD explained that in general, when a set of premises is licensed to store dangerous goods, that means it is in compliance with FSD's fire safety requirements, and thus provides a safe environment for using the dangerous goods specified on the licence. Such arrangements are a practical means of addressing the need for ensuring that the public will use dangerous goods under safe conditions. Our follow-up investigation revealed that under the Dangerous Goods Ordinance, FSD's regulation of the use of dangerous goods is directed only at whether there are proper storage measures before and after the use of such goods, but not at how the dangerous goods are used (such as the use of refrigerants in air-conditioning systems).

III. Follow-up Action

21. The restaurant in Ma On Shan had installed three air-conditioning systems. LD was informed by the proprietor of the restaurant that all the systems used flammable refrigerants. However, E & MSD noticed that those systems were not suitable for flammable refrigerants, and one of the recommendations in LD's investigation report was that "consideration should be given to recharging the air-conditioning systems with non-flammable refrigerants in order to eliminate fire hazards".

22. After the explosion, LD issued a suspension notice to stop maintenance work on the three air-conditioning systems, pending submission by the proprietor of a project proposal conforming to safety standards. After the issuance of suspension notice, LD conducted regular inspections at the restaurant to monitor that no maintenance work was carried out, but the restaurant could continue to use the two systems not involved in the explosion. As "continued use" of the air-conditioning systems was not in breach of the suspension notice, therefore no action was taken by LD.

23. The use of flammable refrigerants on unsuitable air-conditioning systems involved a degree of risks, but no action was taken by any Government department in this incident. The reason was that under existing legislation and mechanisms, the three departments concerned invariably considered such operation to be outside their respective jurisdictions, with following views:

- E & MSD: the refrigerants used were not LPG refrigerants, and the Gas Safety Ordinance does not regulate non-LPG refrigerants.
- LD: the Occupational Safety and Health Ordinance does not regulate matters other than safety at work.
- FSD: the Dangerous Goods Ordinance does not regulate the use of refrigerants on air-conditioning systems.

Our Findings

Overall Observations

24. New-generation refrigerants, including HCs and HFCs (low to moderate GWP), are more eco-friendly but more flammable, and suitable safety facilities are required in using these refrigerants. Globally, while some flammable refrigerants are banned in some places, they are introduced for use under restriction in a regulated manner in others. In some places, regulation of refrigerants may fall under the jurisdictions of different departments but usually there will be a leading or coordinating department.

25. In Hong Kong, the regulation of refrigerants involves at least four Government departments and four Ordinances. However, there is no specific legislation enacted to regulate refrigerants, nor is there any department responsible for coordination.

26. Prior to the introduction of flammable refrigerants, there might not be major problems with such regulatory arrangements. Nevertheless, the Ma On Shan incident showed that the problem of insufficient regulation would emerge if flammable refrigerants were increasingly being used. Our investigation found the following six areas of concern.

I. Inadequate Regulatory Mechanisms

27. Depending on their composition, flammable refrigerants may be classified as LPG or non-LPG. The two types of refrigerants are regulated under different legislation, as explained below:

- If the composition of a refrigerant falls within the definition of LPG under the Gas Safety Ordinance, E & MSD has the power to regulate its manufacture, storage, transport, use, import and supply, including its use in air-conditioning systems.
- For refrigerants classified as dangerous goods (other than LPG), FSD can invoke the Dangerous Goods Ordinance and regulate their manufacture, storage, transport and general use (see para. 20) but not their import or supply, nor their use in air-conditioning systems.

28. To put LPG and non-LPG refrigerants with similar flammability under different legislation might lead to problems, as can be seen from the following examples:

- In 2011, the air-conditioning contractor involved in the Ma On Shan incident had, at certain premises in Hong Kong, replaced a non-flammable refrigerant with a flammable LPG refrigerant (HR427) on an air-conditioning system of a design not suitable for flammable refrigerants. In accordance with the law and out of safety concern, E & MSD ordered that operation of the system be stopped immediately.

- In the Ma On Shan incident, the same contractor again used a flammable refrigerant on three air-conditioning systems which were not designed for flammable refrigerants. Nonetheless, E & MSD classified the refrigerant (HR429) used on this occasion as non-LPG. As a result, after one of the systems exploded, the remaining two were allowed to continue operation without any regulatory control. This was because under the existing mechanisms, the three departments concerned considered such operation to be outside their jurisdictions.

29. Are such regulatory arrangements sufficient or appropriate? We consider that Government should carefully review the issue.

II. Disagreement on Jurisdictions

30. There was disagreement between E & MSD and FSD on who should be responsible for regulating certain types of flammable refrigerants (including R290, a highly flammable refrigerant the safe use of which was causing concern internationally). This disagreement emerged in 2010 and remained unresolved to date.

31. The major causes of disagreement include the following:

- Before 2010, E & MSD considered R290 and R600a, two flammable refrigerants, to be under its purview. However, E & MSD changed its position in 2010 after obtaining legal advice on the definition of LPG.
- After this change in its jurisdiction, E & MSD notified FSD in writing at least four times between 2010 and November 2014, but the message expressed in some of those notifications was not entirely clear.
- Regarding the four notifications issued by E & MSD, FSD claimed that it found no record of receiving two of them. FSD did receive the third notification, but took it as E & MSD's comments on an isolated case. E & MSD's message of changing jurisdiction only came across to FSD in November 2014. After receiving that message, FSD expressed its disagreement and intended to clarify the demarcation of jurisdictions with E & MSD after seeking legal advice.

32. As the matter concerns public safety, the protracted disagreement could lead to serious problems. For instance:

- Those intending to import or use the refrigerants concerned in accordance with the law would be at a loss as to what to do. For example, an air-conditioning supplier made an enquiry with E & MSD in November 2014 as to the regulatory requirements for flammable refrigerant HR427A, but till March 2015 was not given a full answer.

This was because E & MSD and FSD could not agree on which department should be responsible for regulating HR427A.

- Some people might take advantage of this grey area and evade regulatory controls, thereby jeopardising public safety. For example, the initial findings of the inspections carried out by E & MSD between late 2014 and early 2015 showed that apart from the Ma On Shan case, other places in Hong Kong also saw flammable refrigerants being used to replace non-flammable refrigerants on unsuitable air-conditioning systems. The flammable refrigerant used was HR429, which both E & MSD and FSD claimed to be outside their jurisdictions.

33. We consider that E & MSD and FSD should work together to resolve the disagreement on their jurisdictions as quickly as possible.

III. Inadequate Monitoring

34. Our investigation found that none of the departments concerned were fully in the picture as regards the development of refrigerants and their use in Hong Kong, as detailed in paragraph 10 above. In particular, we found E & MSD's understanding of the use of flammable refrigerants in Hong Kong inadequate because –

- Air-conditioning equipment using flammable refrigerants are already being manufactured in mainland China and Japan. Even if such equipment has not been imported by members of the major trade associations, they may have been imported by other air-conditioning suppliers.
- Hong Kong has no control on the import of flammable refrigerants or air-conditioning equipment using such refrigerants. Even if no such equipment has so far been imported, there can be no guarantee that they will not be imported in future.
- Even if Hong Kong has not imported any equipment suitable for flammable refrigerants so far, the initial findings of E & MSD's recent investigations already revealed that, apart from the Ma On Shan case, flammable refrigerants were being used to replace non-flammable refrigerants on existing air-conditioning systems with unsuitable design in various places in Hong Kong.

35. In the circumstances, there is a need for the departments concerned to establish a comprehensive and forward-looking monitoring mechanism in order to effectively regulate the use of refrigerants and ensure public safety.

IV. Lack of Communication and Coordination

36. In Hong Kong, the regulation of refrigerants involves at least four Ordinances under the respective purview of four Government departments. None of the departments is responsible for assuming a coordinating or leading role.

37. This lack of coordination had resulted in, *inter alia*, the following problems:

- The disagreement between E & MSD and FSD on their jurisdictions since 2010 remained unresolved while public safety was at stake.
- None of the departments concerned is fully in the picture regarding the development of refrigerants, nor is any one responsible for the comprehensive monitoring of the matter.

38. We consider effective coordination among the departments essential. In view of the complicated situation involving different legislation and jurisdictions, Government should appoint one department to act as coordinator.

V. Inadequate Liaison and Publicity

39. The departments liaised mainly with the major trade associations in the industry. This was inadequate, as the major trade associations could not represent those operators who were not their members (such as the air-conditioning contractor in the Ma On Shan incident), nor could they represent the small operators in the industry.

40. We consider it necessary for the departments concerned to expand their liaison networks, and make greater use of publicity and education to reach out to small air-conditioning operators and servicing workers. Public education is also important. The departments should work to raise public awareness about the new-generation flammable refrigerants, so as to protect the public from being misled and their personal safety compromised.

VI. Inadequate Training for Workers

41. The direct cause of the Ma On Shan incident was improper work procedures in recovering the flammable refrigerants. The accident highlighted the importance of worker training. Moreover, the guidelines issued by the UNEP and information from other jurisdictions all stressed that extra safety training was essential in the use of flammable refrigerants.

42. The current situation regarding training in Hong Kong is:

- Air-conditioning workers in Hong Kong are not required to undergo training on air-conditioning.

- While VTC (the major provider of vocational training in Hong Kong) offers non-compulsory courses on air-conditioning, these do not cover training on the use of flammable refrigerants in air-conditioning systems.
- A local air-conditioning workers association expressed concern to E & MSD that Hong Kong workers have insufficient knowledge of and are poorly equipped to handle flammable refrigerants. The association also pointed out that flammable refrigerants are increasingly being used on the Mainland and there is no control over their import into Hong Kong.

43. The Ma On Shan incident has raised an alarm for the Government departments. We consider that the Government should review the situation and consider enhancing regulation on the training for air-conditioning workers.

Recommendations

44. The Ombudsman recommends that Government should:

- (1) enhance inter-departmental coordination and appoint one department to take up the coordinating and leading role in the regulation of refrigerants;
- (2) resolve the differences between E & MSD and FSD regarding their jurisdictions as quickly as possible;
- (3) establish a comprehensive and forward-looking mechanism to monitor the development of refrigerants and their use in Hong Kong; and
- (4) review the regulatory arrangements for refrigerants, in particular –
 - (a) review whether it was proper to put LPG and non-LPG refrigerants that were equally flammable under different regulatory mechanisms;
 - (b) consider enhancing regulation on training for air-conditioning workers;
 - (c) consider strengthening liaison with the air-conditioning industry; and
 - (d) consider making greater use of publicity and education to increase public awareness of the safe use of refrigerants.