

Challenges on the Control of Cooking Fume Emissions from Restaurants (BAQ 2002)

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ABSTRACT

Over the past decade, there have been more concerns from the public over the release of oily cooking fumes from restaurants in a highly compact city like Hong Kong, particularly for those restaurants located in densely populated areas. The problems become much intense and prominent in the urbanized regions where restaurants are sited remarkably close to dwellings.

To tackle the worsening situation, a multi-pronged pragmatic approach has to be adopted to effectively control the dispersion of cooking fumes through regulatory framework, in-situ control, technological development for control equipment, publicity, etc.

This paper summarizes the extent of cooking fume problems, findings of surveys, concentration and composition of cooking fumes. The technical solutions, administrative measures, existing and possible mechanism, as well as the programmes for controlling cooking fume from restaurants are also discussed.

Keywords: cooking fume, particulate, odour, control equipment, electrostatic precipitators

1.0 INTRODUCTION

Hong Kong is a vibrant city famed for its great variety of food that represents the essence of local culture. Getting along with the thriving food business, the emissions of cooking fumes and odour from restaurants would be inevitable. Quite a lot of the exhaust outlets of ventilation ducting system in commercial kitchens are always not located at favourable locations, in particular in densely populated urban regions. With the increasing environmental awareness of people, the excessive emissions of cooking fume / odour have become the target of complaints. Residents living in close proximity to the exhaust outlets of restaurants tend to lodge complaints with EPD or the press media against nuisances caused by emission of cooking fumes and odour.

In response to the complaints, extensive efforts have been dedicated to ameliorate the problem, such as imposing requirements on the suitable positioning of the exhaust outlets, installation of control equipment and formulating guidelines for separation distances. With implementation of such measures, notable progresses have been made but there still have room for further improvements. EPD has been working in collaboration with the restaurant trade through undertaking a partnership programme as well as academy to explore viable options for abating the cooking fume emissions.

2.0 THE COOKING FUME PROBLEMS

There are about 9,000 restaurants of varying sizes serving a wide range of cuisines in Hong Kong. Given the compact living environment, residents nearest to restaurants are prone to nuisances attributed from cooking fume emissions. Moreover, with the increasing expectation for a quality standard of living, nuisances caused by cooking fumes have become a growing concern in recent years. General speaking, cooking fume emissions may not necessarily constitute a nuisance unless it becomes annoying to the receptors. However, once this occurs, the issue would become a target of repeated complaints from people resided in close proximity to the exhaust outlets.

According to the statistics of the Environmental Protection Department (EPD), the number of complaints against cooking fume/odour emissions from restaurants increased from 378 cases in 1995 to 678 cases in 1998. In 1999, the corresponding figure surged to 1,305 and peaked in 2000 at 1,501 before turning down. Please refer to Table 1 below for details.

Table 1. Complaint cases against cooking fume/odour received by EPD

	1998	1999	2000	2001	2002 (up to Oct)
Number of Complaints	678	1305	1501	1223	856

Apart from nuisance, cooking fumes may also contribute to the emission of fine particulates and volatile organic substances. A few studies suggested the possibility of increasing the lung cancer risk due to cooking fume emissions. This possibility, however, has not been established nor confirmed yet as there are many other potential confounding factors such as diet, exposure to environmental tobacco smoke and occupation. Despite this, it is considered necessary to take appropriate actions to control the emissions to a level that it would not cause nuisance from an environmental perspective.

A survey was conducted in 1999 in an attempt to find out the causes for the abrupt rise in complaints. The results indicated that frying, charbroiling, deep-frying and roasting were the main cooking processes that caused most emissions from restaurants. Of the various types of restaurants, the Chinese restaurants were most vulnerable to complaints (approx. 22%) followed by bistros (approx. 20%). Although most restaurants under justified complaints (91.5%) had installed certain control equipment, the majority of which (84.1%) were of low efficiency devices, such as grease filters, air washers, hydrovents. Inadequate installed capacity, improper operation / maintenance of control equipment were attributable to the ineffective control of emissions. After remedial action taken, 55% cases were satisfactorily resolved by improvements for operation and maintenance of control equipment, while 16% by redirecting of exhaust outlets.

Moreover, the number of complaints decreased with increasing buffer distances as evident by about 10% of the complaints in which buffer distances equaling or exceeding 20 meters. Under this context, sufficient separation distance between exhaust outlets and receptors is imperative in easing environmental impacts, thereby averting complaints.

The majority of local restaurants are engaged with cookery of Chinese cuisines. The common methods of Chinese cooking include stir-frying, flash-frying, deep-frying, stewing, steaming, and so forth. The Chinese cooking is characterized by the stir-frying which is a classic and most often used Chinese cooking method; it involves quick cooking over high heat in wok. The chef tosses and turns the food as it cooks, ensuring that the food is constantly in motion which allows meats to stay juicy and flavorful and vegetables to come out tender-crisp. By doing so, lots

of oily fumes are generated while part of it catches fire giving out soots.

In 2002, a real-life cooking testing has been conducted to evaluate the concentration and composition of cooking fumes from stir-frying and deep-frying process. Two representative cooking processes have been chosen, i.e. frying of rice vermicelli with beef and deep-frying of shrimps. The results are summarized in the following tables.

Table 2. Average Concentration of Cooking Fumes Obtained from Cooking Test

	Concentrations of Cooking Fumes Total, mg/m³	Concentrations of Cooking Fumes PM 10, mg/m³	Concentration of Cooking Fumes PM 2.5, mg/m³
Stir-frying of Rice Vermicelli with Beef	85	27	24
Deep Frying of Mantis Shrimps	30	12	5

A rough estimation by projecting the above emission rate derived from frying of rice vermicelli with beef was presented in Table 3. The cooking fumes emission could be significant and of the same order of magnitude as the other combustion emissions.

Table 3. Rough Estimation of Emissions of Cooking Fumes from Restaurants

	Total, tonnes per annum	PM 10, tonnes per annum	PM 2.5, tonnes per annum
Total emission of cooking fumes at exhaust outlets	1,500	1,170	850

3.0 THE NEED FOR CONTROL

Apart from the substantial quantity of particulate emissions, cooking fumes may comprise a wide range of components, such as oil, fats, aliphatic hydrocarbons, poly-aromatic hydrocarbons, aromatic amines, aldehydes and elemental carbon. The nature and quantities of pollutants emitted would highly depend on the cooking stuff, styles of cooking and even on cooking fuel. These components may be harmful to human health pending further studies to confirm. Restaurants should be required to fit advanced control equipment with kitchen exhaust systems, especially where char-broilers, roasting or other smoke generating cooking equipment is operated. The most commonly used pollution control equipment are hydrovents and electrostatic precipitators to abate cooking fume emissions. Both are installed within the exhaust system and play integral roles in reducing overt air pollution.

The air pollution control equipment should be properly designed, installed and serviced to ensure optimal performance. The design should always be based on the anticipated peak load conditions. The large amount of oily fumes and odour generated from frying, charbroiling or roasting need to be removed from the extracted air, by efficient air pollution control equipment, before it is discharged into the atmosphere.

4.0 CONTROL OF COOKING FUMES

Restaurants may cause nuisance such as cooking fumes to the surrounding sensitive receivers if not properly controlled. In general, the nuisances caused by cooking fumes from restaurants are a result of cooking fumes

discharged at improper locations, i.e. too close to other receptors. The problem is stemmed from inadequate provision or maintenance of the control equipment and improper discharge of cooking fume emissions. The installation of properly operated and site-specific control equipment can help reduce the extent of the nuisance but complete elimination of cooking fumes is usually technically not feasible. A more effective means is to require the extension of the exhaust ducts to roof level or to maintain a sufficient separation distances from the nearby buildings.

The solution to resolve the cooking fume and odour problems can be two folds: first, by adopting planning mechanism to maintain adequate buffer distance between dwellings and restaurants; and second, achieving better design of exhaust systems equipped with appropriate emission control devices.

4.1 Precautionary Measures through Planning Control

As a precautionary measure to enhance efficient dispersion for restaurant emissions, a good land use planning practice is of paramount importance to provide adequate buffer between residential blocks and commercial restaurants. The possibility of creating nuisance problem should be avoided in the earliest planning stage as far as practicable and feasible.

4.1.1 Land Use Planning

It has been reckoned that restaurants, cooked food center, fast food shop and canteen are not to be allowed in “Residential (B)” and “Residential (C)” zones; while permission on individual merit should be required in “Residential (A)”, “Commercial/Residential”, “Commercial”, “Government/Institution/Community” and “Open Storage” zones. Certain rendering activities, such as meat-roasting activities, should not be permitted for operation in non-industrial areas and to licence these factories in accordance with relevant regulations.

4.1.2 Provision of Separation Distances

Imposing a planning setback condition for land use is indeed a precautionary measure to deter possible problems from occurring. As long as this can be attainable, it is indubitably that provision of sufficient buffer (say 20 m) will ease most of the potential problems but is not always technically feasible and practicable under the local context where land use and population are competing fiercely with each other.

The desirable separation distances identified in the 1999 comprehensive survey has been tabulated below for implementation as far as practicable:

Table 4. Recommended Separation Distances from Exhaust Outlets

Type of Restaurants		Minimum Separation Distance of Exhaust Outlet from Sensitive Receptors (m)
(a)	Restaurants without deep frying, charbroiling, roasting or similar operations, or restaurants with fewer than 2 cooking stoves for stir frying	5
(b)	Restaurants with deep frying, charbroiling, roasting or similar operations, or restaurants with 2 or more cooking stoves for stir frying	
(i)	Restaurants with fewer than 5 frying stoves or total heat input for these operations less than 4,600 MJ/h	10
(ii)	Restaurants with 5 or more frying stoves or total heat input for these operations equal to or more than 4,600 MJ/h	20

4.1.3 Exhaust Installation Approval through Licence Application under APCO

The exhaust ducts serving the cooking stoves should be extended to a level of at least 3 meters above the highest point of its own building, or the neighbouring building as appropriate, or alternatively, to install relevant air pollution abatement equipment with proper siting of exhaust as required.

4.2 Control of Cooking Fumes

There is a variety of cooking fume control equipment available in the marketplace to reduce cooking fume emissions, such as hydrovents, air washers, packed tower scrubbers, electrostatic precipitators, etc.

In comparison with other pollution control equipment, such as water spray hoods or air washers, electrostatic precipitators (EP) can collect and remove oil mists more effectively. The EP incorporates negatively charged plates which give the oily particle a negative charge. The particles are then routed past positively charged collector plates, or grounded plates, which attract the negatively-charged oily particles. The particles stick to the positive plates until they are collected. The gaseous stream passing through the EP should be invisible provided that the capacity of EP is adequate and that the EP is constantly maintained to good working conditions, since grease accumulated on the collector plates would significantly reduce the removal efficiency. In this regard, EP should be regularly cleaned and serviced by competent technicians. In addition, to optimize the overall performance in capturing cooking fume particulates, it is recommended to use EP coupled with water spray hoods or hydrovent in the exhaust system. Table 5 shows the average concentrations of two typical cooking processes after passing through the EPs.

Table 5. Average concentration of cooking fumes after Electrostatic Precipitators

	Concentrations of Cooking Fumes Total, mg/m ³	Concentrations of Cooking Fumes PM 10, mg/m ³	Concentration of Cooking Fumes PM 2.5, mg/m ³
Stir-frying of Rice Vermicelli with Beef	21	16	12
Deep Frying of Mantis Shrimps	5	2	2

Although these control equipment intended primarily to capture oil mists can reduce odour level to a certain extent, their effectiveness for reducing either cooking fumes or odour varies considerably, depending on a number of variables such as principle of operations, cooking process and weather conditions.

In order to gauge the effectiveness of EP in abating cooking fume emission, a review of the relevant complaints was conducted for cases handled between 2000 and mid 2002. The exercise can help explore any correlation between the drop in complaint figures over the past few years with the use of EP in the restaurants.

A total of 231 survey sheets were returned for analysis, of which 44 restaurants under justified complaint had their kitchen installed with EP in response to EPD's advice. After installing EP, there were no further complaints against 33 out of the 44 restaurants. Only three cases were justified complaints in which the performance of EP was deteriorated by inadequate maintenance work such as lack of collector cell cleaning. Hence, it is evident that 41 out of the 44 cases (i.e. 93%) had their emissions reduced subsequent to installing EP.

There were 13 justified cases where EP was found installed at time of complaint investigation. Inspection revealed that 7 complaints were due to inadequate EP maintenance, 5 cases were caused by insufficient buffer distance / improper positioning of exhaust outlets and 1 case involved cooking odour emission. It indicates that the effectiveness of EP in abating cooking fume would very much hinge on whether proper maintenance is adequately provided while buffer distance also plays a crucial role in easing the potential nuisance.

5.0 ADMINISTRATIVE MEASURES

In addition to the technical measures, appropriate actions have been taken to ensure effective abatement of air pollution nuisance. The government has been implementing relevant control plans and exploring the use of best available control technology aiming for reducing and treating oily fumes prior to discharge.

5.1 Existing Control Requirements

The various government departments have implemented certain control measures over the abatement of cooking fumes:

- The EPD requires restaurant operators to control their emissions without causing an air pollution nuisance to the nearby receivers. A cleaner mode of gas-fired combustion is highly recommended for kitchen furnaces or stoves. For gaseous fuel consumption exceeds 1,150 MJ / hour, the submission of plans and specifications for approval under the Air Pollution Control (Furnaces, Ovens and Chimneys)(Installation and Alteration Regulations) is required prior to installation.
- The Food and Environmental Hygiene Department (FEHD) requires that the exhaust be treated with hydrovent / water scrubber and electrostatic precipitators before discharge, details for implementation of the latter is underway;
- The Building (Planning) Regulation requires exhaust to be at least 2.5 m above street.

5.2 Partnership Programme between EPD Local Control Offices and Restaurant Trade

The growing complaints about cooking fumes and odours from restaurants in the late 1990s has prompted EPD to initiate a partnership programme with the trade to address the problems. The "Helping the Restaurant Trade Environmental Programme" was launched to improve restaurants' environmental performance and working conditions, reduce operating costs and enhance the trade's image on promoting the "green" concept.

The programme involves technical support and development, environmental education, collaboration with stakeholders, waste reduction and resources conservation. A free one-stop "Help Desk Service" was established, which includes a Green Restaurant Web Site (<http://www.greenrestaurant-hk.org>), a dedicated hotline (tel: 2784 6638), a Meet-the-Advisor service and an updated List of Environmental and Pollution Control Equipment Suppliers/Contractors. Two Chinese-version environmental guidebooks were published for distribution, one for restaurant managers and another for chefs together with some promotional leaflets and posters.

The EPD also holds regular liaison meetings with the food and restaurant trade to improve communication and enhance partnership. The meetings have been well received by stakeholders as the Hong Kong Federation of Restaurants and Related Trades, the Association of Restaurant Managers, the Association of Hong Kong Catering Services Management, the Hong Kong Food Council, the Business Environment Council and the Hong Kong Productivity Council. A two-day trade exhibition and seminar has been launched for the restaurant trade on 3rd & 4th July 2002 at the Convention and Exhibition Centre to exchange experiences among the trade and equipment users.

5.3 Licencing Requirements imposed by FEHD

The Food & Environmental Hygiene Department (FEHD), in issuing a restaurant licence, would require the exhaust be treated with hydrovent coupled with an electrostatic precipitator before discharging cooking fumes into the open air and the exhaust outlet is to be located at least 2.5 m above ground level to prevent causing nuisance.

The FEHD is working with EPD to finalize relevant licensing procedures in order to ensure effective control equipment be installed to EPD's requirements.

5.4 Benchmarking of Electrostatic Precipitators (EP)

There is a wide range of EP control equipment supplied in the local marketplace, a number of which are manufactured from the mainland while some imported from overseas. However, their operating performance is not quite certain despite suppliers claim that the removal efficiency exceeds 95%. For benchmarking the operating performance of this type of equipment, the development of a Standard Operating Procedure is underway to evaluate the individual model for licencing application to be executed by FEHD.

Oil fumes generated from heating of commercially used cooking oils would be employed for testing. In order to ensure the concentration of fumes generated in a laboratory environment can satisfactorily represent those emitted from the real-life kitchen operation, a real-life cooking testing was also conducted to establish correlation between the two oil generation methods. A cooking unit was set up to generate cooking fumes comparable to that from a real-life smoky cooking process, such as frying rice vermicelli with beef (炒粉麵) and deep frying seafood. While continuous cooking was being conducted, measurements were carried out to evaluate the levels of cooking fume emissions from the two separate cooking processes and sampling was taken at both the inlet and outlet of EP in full compliance with the relevant USEPA requirements. Total oil mist, PM₁₀ and PM_{2.5} levels of cooking fume were separately evaluated. The filters were then taken for analysis by infrared and gravimetric method.

6.0 CONCLUSIONS AND OUTLOOK

Being exacerbated by the highly congested environment, the emission of cooking fumes from restaurants has been a lingering and challenging air pollution issue in Hong Kong for years. The EPD has been committed to meet this challenge by joint cooperation with the trade, environmental professionals and other interested parties. With the continual efforts, certain success as reflected by the recent decline in complaint figures have been achieved.

To tackle the problem, the best option would be providing sufficient separation distance to alleviate the potential nuisance. However, it may not be always achievable at unfavourable locality, and under such circumstances, effective control equipment should be installed with particular reference to the site specific requirements.

Proper maintenance is very crucial in ensuring optimal performance and prolonging service life of the control equipment. For electrostatic precipitators, steps would be taken to urge the equipment suppliers to equip auto-wash features in their products and meanwhile coaching the trade operators on appropriate operation / maintenance of equipment. Here are some highlights of action to be taken:

- *Better maintenance of control equipment* – encouraging equipment suppliers to provide after-sale service to undertake re-conditioning of EP on a regular basis;
- *Development of standard testing for type approval of equipment* – an acceptance method to be developed as a yardstick to evaluate performance;
- *Exploring on innovative control technologies* - further explore any new control equipment with proven performance for abating cooking fumes;
- *Foster links with restaurant trade* – to enhance better understanding of demands from respective parties through launching regular seminars, training programmes, demonstration visits, etc.

Installing EP has proved to be an effective method to tackle a portion of the problem only with efficient operation and proper maintenance. It is imperative that pragmatic approach and practice should be aptly implemented, taking into account the site-specific factors, through regulatory framework, in-situ control, innovative treatment techniques, publicity and education in a bid to either prevent or alleviate the impacts.