Letterhead of Environment and Food Bureau Government Secretariat

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1 February 2001

BY HAND

Clerk to the LegCo Panel on Environmental Affairs,
LegCo Secretariat,
3/F., Citibank Tower,
3, Garden Road,
Central,
Hong Kong.
(Attn: Miss Odelia Leung)

Dear Miss Leung,

LegCo Panel on Environmental Affairs
Follow-up to meeting on 2 January 2001

As requested by Members at the meeting on 2 January 2001, I enclose the report entitled "Modification, Compliance Checking & Surveys of Existing Dry-Cleaning Machines" prepared by the Hong Kong Productivity Council in March 1998 for Members' reference. I wish to point out that Sections 4 and 5 of the report are no longer relevant since they are based on an earlier control proposal which has been superseded by the present one drawn up after consultation with the trades. Nevertheless, Section 6 on the Survey of Trades Information should still be valid.

Members may wish to note form the report that in 1997, 91% of the vented dry-cleaning machines (DDV) surveyed were aged 4 years or above. These machines will reach their normal retirement age of 10 to 12 years by 2005, i.e., at the end of the 5-year grace period for this type of machines if the new legislation is enacted this year, and will have to be replaced anyway even if no control scheme is to be introduced. Similarly, 86% of the sub-standard non-vented machines would be over 3 years old and would reach their normal retirement age by 2007, i.e., at the end of the 7-year grace period for this type of machines.

A copy of our past research work on overseas studies on the health effects of PCE is also enclosed for your reference. I hope that the information could facilitate your research work.

Yours sincerely,

(Albert W H Leung)
for Secretary for the
Environment and Food

Encl.

c.c. DEP (Attn: Mr. C W Tse)

MODIFICATION, COMPLIANCE CHECKING & SURVEYS OF EXISTING DRY-CLEANING MACHINES

[Final Report]

Prepared By

Environmental Management Division
Hong Kong Productivity Council

31st March 1998

This report is printed on recycled paper

EXECUTIVE SUMMARY

Background to this Project

1. Perchloroethylene (PERC) has been widely used in the dry-cleaning industry in Hong Kong. PERC is a probable human cancer-causing agent. To protect the health of the general public, Environmental Protection Department (EPD) intended to reduce the emission of PERC to the atmosphere from the dry-cleaning industry.

2. There are two types of dry-cleaning machines commonly found in Hong Kong, namely dry-to-dry vented type (simply called vented type or DDV) and dry-to-dry non-vented type (simply called non-vented type or DDNV). The former emits much more PERC to the atmosphere than the latter and can be converted to the latter by simple modification work. This project is to provide EPD hands-on experience of the modification work in local context and information of the trades.

Modification of Vented Type Dry-cleaning Machines

3. Two dry-cleaning machines of DDV type were selected according to EPD's requirements. One of them was relatively new and the other was relatively old. Both machines were branded "Suprema", the most popular brand in Hong Kong. The two machines were converted to DDNV type with the following steps:

   - Replace the original water cooling coil with a refrigerated condenser
   - Install door interlock system
   - Disconnect the original air discharge vent pipe
   - Test the performance of the modified non-vented type dry-cleaning machine

4. Upon completion of the modification work, the two dry-cleaning machines were tested against EPD's requirements. The machines could generally achieve the requirements. In the course of converting the dry-cleaning machines, a number of technical constraints were encountered and some precautions were made. These technical constraints and precautions were documented in this report.

5. For the two dry-cleaning machines selected in this project, the costs for modification work ranged from about HK$60,000 to HK$90,000, depending on the capacities and conditions of the concerned machines. After the modification, the dry-cleaning machines consume more electricity and water but consume less PERC. When balancing the costs and savings incurred by the modification work, the net annual savings for the two machines are from about HK$11,000 to HK$20,000. The payback period for the modification work is about 4 to 6 years for these two machines.

Compliance Checking of Non-vented Type Dry-cleaning Machines

6. Two DDNV type dry-cleaning machines were selected according to EPD's requirements. One of them was relatively old and the other was relatively new. A door interlocking system was installed at both machines so that the doors cannot be opened during a normal drying cycle until the condenser outlet temperature reaches to the designated temperature.

   The PERC concentrations of the drums and air temperature of the condenser outlets of the dry-cleaning machines were measured. The PERC concentrations of both machines were found well below 8,600 ppmv. However, the vapour temperatures at the condenser outlets of both machines were found higher than 7°C, i.e. not complied with the EPD's requirement on condenser outlet temperature.

7. For the two dry-cleaning machines selected in this project, the costs for installing door interlocking system for each machine were HK$6,000.

Survey of Trades Information

8. The survey was conducted with three approaches, namely phone survey, postal survey, and field survey. About 1,000 questionnaires were sent out and more than 300 telephone calls were made. Besides, all laundries located in Sham Shui Po District were visited to collect and verify information.

9. Totally 115 laundries with on-site dry-cleaning operation returned their questionnaires. The 115 dry-cleaners accounted for 165 dry-cleaning machines. It was projected that there are totally 277 dry-cleaners and 396 dry-cleaning machines in Hong Kong.

10. The dry-cleaners were classified into three categories, namely hotels, shops, and factories. The following table summarises the numbers of different types of dry-cleaning machines for the three categories of dry-cleaners.

	DDV	**DDNV**	**Total**
Hotel	6	23	29
Shop	51	23	74
Factory	29	33	62
Total	86	79	165

11. The following summarize the attributes of the hotel dry-cleaners and their dry-cleaning machines:

- Mainly DDNV machines
- More relatively new machines
- "Multimatic" is the most popular brand
- Machine capacities are of medium duty
- Relatively high mileage
- Most PERC recovery systems are using refrigerated condensers
- Most invested less than HK$500,000 in the dry-cleaning operation
- Annual business turnovers in dry-cleaning operations are usually between 1 million to 2 million dollars
- Profit margins are usually between 31-60%

12. The attributes of the shop dry-cleaners are:

- DDV to DDNV is about 2 to 1
- Their DDV machines were quite old while their DDNV machines were quite new
- "Suprema" is the most popular brand
- Machine capacities are of medium duty
- Relatively low mileage
- Most PERC recovery systems are using water-cooled condensers
- Most invested less than HK$500,000 in the dry-cleaning operation
- Annual business turnovers are usually over HK$300,000
- Profit margins are usually less than 30%

13. The attributes of the factory dry-cleaners are:

- DDV to DDNV is about 1 to 1
- Their DDV machines were quite old while their DDNV machines were quite new
- "Bowe" and "Suprema" are the most popular brands
- Machine capacities are of medium to heavy duty
- Relatively low mileage
- Most PERC recovery systems are using refrigerated condensers
- About half invested more than HK$500,000 in the dry-cleaning operation
- Annual business turnovers are usually less than 2 million dollars
- Profit margins are usually less than 30%

CONTENT

LIST OF APPENDICES

1. INTRODUCTION

Perchloroethylene (PERC) has been widely used in the dry-cleaning industry over half century, and is the most popular dry-cleaning agent in Hong Kong. It replaced carbon tetrachloride and most petroleum solvents because of its comparatively low toxicity compared with carbon tetrachloride and non-flammability compared with petroleum solvents. However, PERC is one of the 189 substances listed as hazardous air pollutants of Clean Air Act Amendment of the United States and is a probable human carcinogen, i.e. a probable cancer-causing agent. To protect the health of the general public, it is the intention of Environmental Protection Department of Hong Kong to reduce the emission of PERC to the atmosphere from the dry-cleaning industry.

There are two types of dry-cleaning machines commonly found in Hong Kong, namely dry-to-dry vented type (simply called vented type or DDV) and dry-to-dry non-vented type (simply called non-vented type or DDNV). The former emits much more PERC to the atmosphere than the latter and can be converted to the latter by simple modification work. This project is to provide EPD hands-on experience of the modification work in local context and information of the trades. This report summarizes the major findings of this project.

2. OBJECTIVES

The objectives of this project are to:

(i) Convert two existing vented type dry-cleaning machines to non-vented type ones.

(ii) Check compliance of two existing non-vented type dry-cleaning machines in terms of cooling down temperature and PERC concentration.

(iii) Conduct survey on the dry-cleaners in Hong Kong to provide information regarding the attributes of their existing dry-cleaning machines and the business information of the dry-cleaning process.

3. METHODOLOGY

According to the objectives of the project, the methodology to conduct this project is also divided into three parts as follows:

- Modification of vented type dry-cleaning machines
- Compliance checking of non-vented type dry-cleaning machines
- Survey of trades information

3.1 Modification of Vented Type Dry-cleaning Machines

This task was completed through the following:

(a) Identify two vented dry-cleaning machines

Based on EPD's requirements on the attributes of the dry-cleaning machines, HKPC sourced the machines from laundry shops, laundry factories, and hotels. HKPC assessed over fifteen machines and finally selected two most suitable machines with the consent of EPD.

(b) Modify the dry-cleaning machines

HKPC sourced the suitable contractor for the modification work from the dry-cleaning machine suppliers and experienced trade practitioners. Several invitations of quotation were sent but only one contractor showed positive response. HKPC assessed the competence of the contractor through reviewing its track record and visiting its existing customers. With the agreement of EPD, HKPC appointed the contractor, Spechem Company, to carry out this modification work.

With the supervision of HKPC, the contractor modified the two selected dry-cleaning machines by installing refrigerated condenser and door interlocking system.

(c) Collect information of the modification work

By collecting the necessary information from the contractor together with the observation made during the modification work, HKPC obtained the cost information, steps, and technical difficulties of the work.

(d) Estimate the running cost of the modified dry-cleaning machines

Based on the information provided by the contractor and the operation figures obtained from the dry-cleaners, HKPC worked out the recurrent costs of the modified dry-cleaning machines.

3.2 Compliance Checking of Non-vented Type Dry-cleaning Machines

This task was completed through the following:

(a) Identify two non-vented dry-cleaning machines

Based on EPD's requirements on the attributes of the dry-cleaning machines, HKPC sourced the machines from laundry shops, laundry factories, and hotels. HKPC assessed over fifteen machines and finally selected two most suitable machines with the consent of EPD.

(b) Check compliance of the two dry-cleaning machines

During the cool down cycle, HKPC measured the temperature at the downstream of the refrigerated condenser of the selected non-vented dry-cleaning machines.

At the same time, PERC concentration was measured at the downstream of the refrigerated condenser during the cool down. The method of determining PERC concentration is given in Appendix I.

In the tender specifications, it proposed that PERC concentration should be measured from the drum. However, due to technical constraint, EPD agreed that the PERC concentration was measured near the condenser.

(c) Install door interlocking system to the two dry-cleaning machines

HKPC appointed the same contractor to install the door interlocking system to the two dry-cleaning machines. HKPC also supervised the installation work and checked the function of the door interlocking system upon completion.

(d) Provide information on the installation work

By collecting the necessary information from the contractor together with the observation made during the modification work, HKPC obtained the cost information, steps, and technical difficulties of the work.

3.3 Survey of Trades Information

HKPC conducted a survey to provide information of existing dry-cleaning machines in Hong Kong including the following:

- age distribution of each type of existing machine
- brands of existing machines

Moreover, the survey was also focused on the business information of existing dry-cleaners of small, medium and large scale including the following:

- initial investment costs
- operating costs
- business turnover
- profits

Three types of methods were used to gather information from the dry-cleaners:

(a) Phone Survey

Those laundries having their records in telephone directory were contacted via phone. Those with on-site dry-cleaning operation were identified and letters with questionnaire were mailed to the identified laundries. If the laundry operators were reluctant to complete the questionnaire, required information was inquired via phone in order to obtain as much information as possible.

(b) Postal Survey

Basic information (company name and address) was obtained from the Census and Statistics (C&S) Department. The concerned HSIC code is 9520, i.e. Laundry, dry-cleaning and garment services. Letters with questionnaire were mailed to the laundries related companies. A sample of the questionnaire is given in Appendix II.

Besides, some hotels also perform on-site dry-cleaning operation. The Federation of Hong Kong Hotel Owners Limited was therefore approached to obtain contact information of hotels (hotel name, address and phone & fax number). Letters with the same questionnaire were mailed to those who have on-site dry-cleaning operation.

(c) Field Survey

Field survey was conducted by on-site visit on the laundries. One district was selected to conduct the field survey. Based on the information from the C&S Department, all laundries in the district were visited and relevant information regarding dry-cleaning operation if any was obtained through on-site interview by HKPC staff. Moreover, on-site verification of information on the already received questionnaire was also conducted.

4. MODIFICATION OF VENTED TYPE DRY-CLEANING MACHINES

Regarding the modification of vented type dry-cleaning machines, EPD requires that the two selected machines for conversion should meet the following criteria:

- 1 of them shall be a new machine of 1 to 3 years old;
- another one shall be an old machine of 7 to 10 years old; and
- 1 of them shall be of "Suprema" make.

During the selection process, various types of dry-cleaning service providers including hotel, hospital laundries, dry-cleaning retail shops and factories were contacted. Some machines were found to be too old to convert or required extensive repair. HKPC had successfully identified two vented type dry-cleaning machines that fulfilled the above-mentioned requirements for modification. The details of each selected machine are shown in the following table:

Table 4.1: Specification of the Selected Vent-Type Dry-cleaning Machines for Modification

Facility Type	Model of Dry-cleaning Machine	Year of Service	Total Machine Drum Capacity (kg)
Retail Shop	Suprema 850 S2	10	15
Dry-cleaning Factory	Suprema 1020 S3	3	25

4.1 Steps of the Modification Work

Switching from the vented type to the non-vented type dry-cleaning machines, the downtime of each machine for modification is approximately three days. The major steps of the modification work are detailed below:

(a) Replace the original water cooling coil with a refrigerated condenser

The water cooling coil originally used in the vented type dry-cleaning machine should be taken out and replaced by a refrigerated cooling coil, or called refrigerated condenser. A separate refrigeration unit (chiller), including refrigeration compressor, water-cooled condenser, expansion and solenoid valve with connecting pipe, are installed to provide evaporation effect for the refrigerated condenser in dry-cleaning machine so as to condense PERC vapour during drying and cool-down cycle. As a rule of thumb, the size of the compressor (in horsepower, hp) is approximately one tenth of the capacity of the machine (in pound, lb). Therefore, with such estimation, the size of the refrigeration compressor used in both modified non-vented type dry-cleaning machines are listed below:

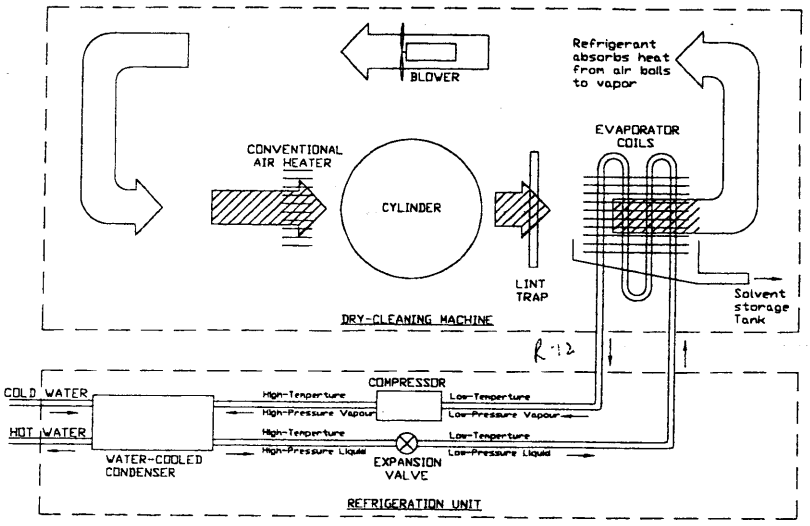
Table 4.2: Size of Refrigerant Compressor Used in the Dry-cleaning Machine for Modification

Facility Type	Model of Dry-cleaning Machine	Total Machine Drum Capacity (kg[lb])	Size of Refrigeration Compressor Used (hp)
Retail Shop	Suprema 850 S2	15 [33]	3.5
Dry-cleaning Factory	Suprema 1020 S3	25 [55]	6

Moreover, all refrigerated piping should be properly fixed and insulated. Cooling tower is idealistic to cool the circulating water from water cooled condenser in the refrigerant unit for heat rejection. The continuous supply of municipal water is, however, employed at both premises due to lack of floor space to accommodate a cooling tower system.

Besides that, proper safety devices, such as compressor motor overload cutoff and low/high pressure fault alarm should also be installed in the refrigeration unit to protect the compressor. Figure 4.1 illustrates an example of modified non-vented type dry-cleaning machine with refrigeration unit.

Figure 4.1: Refrigeration Unit for Modified Non-Vented Type Dry-cleaning Machine



(b) Install door interlock system

As required by the EPD, a door interlock system needs to be installed at each converted machines so that the door cannot be opened during a normal drying cycle until the downstream vapour temperature of the refrigerated condenser reaches to the designated temperature for continuous 3 minutes. The designated temperature is 7℃ for dry-cleaning machines with steam coil and 5℃ without steam coil (See also 4.3(a)).

The design of the door interlocking system is based on the fact that the machine door cannot be opened during the automatic dry-cleaning cycle. When the cool-down starts for a few minutes, the interlocking system will be activated. The program of the dry-cleaning machine will be suspended and the system starts sampling the signal from the temperature sensor located at the condenser outlet. The timer of the interlocking system will be triggered once when the temperature of the condenser outlet reaches the designated temperature. When the timer counts to three minutes, the program of the dry-cleaning machine will resume and the door can be opened at the end of the program. However, the timer will be reset whenever the temperature sensor gives a signal higher than the designated temperature. This logic makes sure that the door can only be opened when the above mentioned EPD's requirement is met.

(c) Disconnect the original air discharge vent pipe

For the vented type dry-cleaning machine there is a vent pipe which allows vapour/air mixture from the dryer to the atmosphere during the cool-down in drying cycle. After modification, the machine is a fully enclosed system which the recovery of PERC and cool-down of heat air for drying are done by refrigerated condenser. This vent pipe is, therefore, no longer required and should be blocked by a damper or simply disconnected it.

(d) Test the performance of the modified non-vented type dry-cleaning machine

After all the aforesaid are completed, the modified machines are to be tested to verify the above standard under the condition that they are being operated at least 75% of their capacity load filled with dry-cleanable materials. Reconditioning the modified machine should be done by replacing seals, gaskets and valve or fine tuning the time of drying and cool-down cycle in order to improve its efficiency.

4.2 Functional Test Results of the Modified Dry-cleaning Machines

Upon completion of the modification work, the two dry-cleaning machines were tested against the requirements set by EPD by washing dry-cleanable materials of over 75% load. The modified machines showed capability of cooling down the vapour to the designated temperatures for continuous three minutes within 15 minutes from the start of the cool-down. In addition, the door interlocking systems were demonstrated functioning as required. Besides, it was found that the time for drying and cool-down cycle after modification did not differ noticeably before and after the modification work. Furthermore, it was found that the odorous smell from dry-cleanable materials after washed was reduced in the modified machines, and also the washed dry-cleanable materials are much easier to iron as reported from the machine users.

4.3 Technical Constraints and Precautions

To convert a vented type dry-cleaning machine to non-vented dry-cleaning machine, the major technical constraints or difficulties encountered are summarized as follows:

(a) Steam Heating Coil for Drying

When converting those machines using steam heat for drying, HKPC has to consider that the temperature of vapour below 5℃ may possibly causes damage to the steam heating coil. During the cool-down in the drying cycle, the condensed water in the steam heating coil may freeze due to the low temperature of vapour (below 5℃), since the steam heating coil is turned off in the cool down period. As a consequence, the steam heating coil will crack because of the volume expansion due to the phase change (from liquid to solid phase). Once the steam heating coil cracks, hot steam will come out and cause washing material shrunk. However, this problem can be solved by means of installing an anti-freeze device at the steam heating coil and setting the vapour temperature at downstream refrigerated condenser to 7℃ in lieu of 5℃. By the experience of the contractor, setting the vapour temperature to 7℃ can provide a sufficient safety margin for the steam heating coil from being damaged. Anti-freezing device can be in form of temperature sensor with electrical interlock, which stops the dry-cleaning machine operation by disconnecting the power supply when the vapour temperature at the steam coil drops to a pre-set temperature. Alternatively, it can be done by installing a pressure differential control installed in the chiller, which limits the coil temperature (refrigerated condenser) by stopping the operation of refrigerant compressor.

(b) Electric Oil Heater for Drying

Instead of steam heating coil, some machines employ the electric oil heater for drying. That is the case of the modified machine in the retail shop. heat retention in the oil heater will cause the temperature of vapour remained high even though the electric heater is switched off during the cool down cycle. To reach the standard of 5℃ vapour temperature, the refrigerant compressor has to be run longer or using a more powerful chiller to provide extra-cooling, compared with the steam heating coil dry-cleaning machine. From economic point of view, it is not practical to install such a powerful refrigeration chiller to achieve 5℃ vapour temperature. From technical point of view, it is not feasible to retrofit a more powerful refrigerated coil to the existing machines because of its larger size. Extend drying time is, therefore, a more practical approach to serve the purpose. In the retail shop, the cycle (drying + cool-down) is extended from initially 22 minutes to 30 minutes, resulting a level of 8,600 ppmv or below of PERC concentration at the downstream of refrigerated condenser at the end of the whole washing cycle. However, the vapour temperature still remains around 11℃. To achieve the requirements of both temperature (5℃) and PERC concentration (8,600 ppmv), the electric oil heater in the machine should be replaced by a steam heating one.

The time required for the washing cycle of the machine in the retail shop and the dry-cleaning factory before and after modification is presented in Table 4.3.

Table 4.3: Time for the Washing Cycle Before and After Machine Modification

Machine Model		Washing	Drying	Aeration/Cool-down
Suprema 850 S2	Before	10	18	8
	After	10	21	9
Suprema 1020 S3	Before	14	23	8
	After	14	23	10

As seen in Table 4.3, it is found that the washing time for both machines before and after modification is the same. There is only a slight difference in drying or aeration/cool-down period, which accounts for not more than 3 minutes. As a consequence, it can be concluded that the disparity in time for the whole washing cycle could be regarded as minimal under the modification from vented to non-vented dry-cleaning machine.

(c) Heat Rejection System for Refrigeration Unit

In the refrigeration unit, heat absorbed from the PERC vapour in the refrigerated condenser during the cool-down cycle needs to be rejected by the condensing medium, which is water in typical systems. A cooling tower should be used because it conserves water and maintains the temperature of water entering to the condenser in the refrigerant unit. In this system, the water is cooled as it passes through the cooling tower, and is then returned to the condenser in the refrigeration unit to absorb more heat. Nevertheless, most of the dry-cleaning retail shops or factories in Hong Kong are lack of adequate space or resources to build up a cooling tower system in their premises. Taking these two modified non-vented type dry-cleaning machines as an example, only the continuous municipal water supply from the main is adopted to absorb heat from the refrigerant since the machine owners expressed that they could not afford to install a cooling tower at this moment.

(d) Blockage in PERC Recovery Pipe

PERC recovery pipes of the modified machines are possibly blocked by lint. This could usually happen to the machines during the period of first few weeks just after conversion. This is because the recovery rate of PERC with the new refrigerant cooled cool is much higher than the previous water-cooled coil, which results in the blockage of recovery pipe when the lint is trapped into it. However, it could be resolved by disconnecting the recovery pipe for cleaning once per week to make sure that no lint is remained in the recovery pipe. Also a practice of frequent cleaning the lint filter could also maintain its removal efficiency, which results in improving the cleanliness of PERC recovery piping in the modified machines.

(e) Restricted Air Flow in Cool-Down Cycle

As mentioned in 4.4 (b), the modification of dry-cleaning machines with electric oil heaters for drying may encounter the difficulties in achieving the required vapour temperature of 5℃. Besides replacing the heating coil or extending the cool down cycle, air flow restriction by means of closing air damper, bypass the air flow or even switching off the air circulating fan during the cool-down cycle could also achieve the requirement of vapour temperature. However, with such modification (localized cooling), the concentration of PERC in the drum is not actually reduced even though the required temperature at the downstream of the refrigerated condenser is fulfilled. Therefore, it is not recommended for the dry-cleaners and machine conversion engineers or technicians to comply with the vapour temperature requirement by restricting the air flow in the machines during the cool-down cycle.

4.4 Costs Involved in the Modification Work

Total capital investment for the above modification work comprises the following items:

- Direct Cost:
  - (i) Equipment cost
    - refrigeration unit
    - refrigerated condenser
    - door interlock system
    - refrigerant piping and electrical wiring
  - (ii) Installation cost
    - handing and erection
    - electrical, water and refrigerant piping connection
    - insulation
- Indirect Cost
  - engineering and supervision
  - functional test
  - machine downtime

Table 4.4 summarizes the estimated capital costs involved in the modification of the two selected machines from vented type into non-vented type with the door interlock system.

Table 4.4: Estimated Costs for Dry-cleaning Machine Modification
(Conversion from vented type to non-vented type machine with door interlock system)

Modification item	**Machine Model**	
	Suprema 850 (15 kg drum capacity)	Suprema 1020 (25 kg drum capacity)
	Direct Cost (Equipment)	
1. Refrigeration unit and condenser	HK$38,000	HK$63,000
2. Door interlock system	HK$4,500	HK$4,500
3. Refrigerant piping and electrical wiring	HK$1,500	HK$1,500
4. Refrigerant piping insulation	HK$150	HK$150
	Direct Cost (Installation)	
5. Handing and erection	HK$1,500	HK$1,500
6. Installation	HK$15,300	HK$15,300
	Indirect Cost	
7. Functional Test	HK$1,500	HK$1,500
Total	**HK$62,450**	**HK$87,450**

Remark: 1. The pre-installation work takes approximately 2 weeks.
2. The installation work and functional test take about 3 days to complete.
3. The costs shown in the above are obtained from the contractor of modifying dry-cleaning machines.
4. The cost for machine downtime is negligible because the installation work can be arranged at the time the machine is normally not used.

As shown in the above table, the estimated capital costs for converting dry-cleaning machine with capacity of 15 kg and 25 kg are HK$62,450 and HK$87,450 respectively. These costs include all equipment and required accessories, handling and installation, and a functional test after modification.

4.5 Recurrent Costs and Savings of the Modified Dry-cleaning Machines

To account for financial impacts for the proposed regulation for PERC dry-cleaning operation by the EPD, HKPC needs to consider the potential savings from PERC usage after modification. It is no doubt that the amount of PERC usage after modification will be much reduced because the recovery of PERC vapour by refrigerated condenser is far more efficient than the water cooling coil. Moreover, less PERC vapour is being expelled to the atmosphere since the modified machine is a totally enclosed system. To what extent the amount of PERC savings to compensate for the modification cost and additional running cost such as electricity and water supply for refrigeration unit, it all depends on the condition of modified machine in facility and the frequency of its operation.

The recurrent costs or savings of the modified machines are primarily from three aspects, namely electricity, water, and PERC. In order to estimate the change of electricity charge, HKPC measured the electricity consumption rate of the add on components and calculated the additional annual electricity charge by considering the annual operation time of the components.

Regarding water cost, HKPC calculated the additional water consumption by taking consideration of the size of the compressors and the operation time of the refrigerated condensers.

HKPC requested the concerning dry-cleaners to record the change of usage in PERC induced by this modification work. The dry-cleaners accumulated data of about three months and provided to HKPC to calculate the savings from using less PERC. The recurrent costs and savings due to the modification work are summarized in Table 4.5 while the detailed calculation of the above costs is given in Appendix III.

Table 4.5: Recurrent Costs and Savings Due to the Modification Work

Facility type		**Retail Shop**	**Dry-cleaning Factory**
Make of dry-cleaning machine		Suprema 850 S2	Suprema 1020 S3
Add on annual costs	Electricity charge	HK$2,541	HK$3,080
	Water charge	HK$1,110	HK$1,327
Induced annual saving	PERC saving	HK$14,700	HK$25,200
Net annual saving		HK$11,049	HK$20,793
Cost of the modification work		HK$62,540	HK$87,450
Payback period		5.7 years	4.2 years

Remark: The retail shop and the dry-cleaning factory have their own water tanks to keep the condenser water from the refrigerated condenser for further use in wet washing. For other laundries that have no receiving water tanks, the add on water charge can be significantly higher than the above figures.

For the above two cases, the additional costs incurred by the modification work were merely a few thousand dollars per year but the savings induced were ranged from fifteen thousand to twenty five thousand dollars. Therefore, both cases showed positive net annual saving due to the modification work. By considering the costs of the modification work and the net savings, the payback periods for the laundries are about 4 to 6 years.

Apart from the above-mentioned tangible savings, some intangible savings due to the modification were also experienced and reported by the dry-cleaning operators. For instance, with the modified dry-cleaning machines, the washed materials are less wrinkly and the workers can take less time to iron them. The productivity of the laundries is indirectly improved because the workers can make use of the saved time to perform other duties in the laundries.

5. COMPLIANCE CHECKING OF NON-VENTED TYPE DRY-CLEANING MACHINES

Based on EPD's requirements, the following non-vented type dry-cleaning machines, listed in table 5.1, were chosen for installing a door interlock system.

Table 5.1: Dry-cleaning Machine for the Door Interlock System Installation

Facility Type	Model of Dry-cleaning Machine	Year of Service	Total Machine Drum Capacity (kg)
Hotel Laundry	Donini D40	6	18
Hotel Laundry	Economatic C45	2	20

Again, the selected machines had been undergone a thorough inspection by our professional judgment to verify their working performance in accordance with the scope of work mentioned in section 4.1.

5.1 Steps of the Modification Work

Basically, the non-vented type dry-cleaning machine has already used the refrigeration technology to recover PERC vapour in the process of drying and cool-down cycle. The basic concept of the door interlock system is same as the one installed in the modified non-vented type dry-cleaning machine, as described in step (b) in section 4.1, except that it is installed within the machine instead of the refrigeration unit. Therefore, details of the door interlock system installation in the non-vented type dry-cleaning machine are typically followed the step (b) mentioned in section 4.1. As the work for the modification is much simpler, the downtime of each machine is only approximately one day.

Machines should be tested to verify the door interlocking system whether it works in compliance with the standard. As the two selected machines are using steam heat for drying, the door interlock system is set to trigger at vapour temperature of 7℃ so as to protect the steam coil from being damaged.

5.2 Measurement of PERC Concentration and Condenser Outlet Temperature

PERC concentration measurements were taken at the two modified dry-cleaning machines. Below are the result summary of the measurement undertaken on 11.11.97 and 21.11.97.

Table 5.2: Result Summary of the PERC Concentration Measurement

Result	Machine Model	
	Donini D40 (drum capacity 18 kg)	Economatic C45 (drum capacity 20 kg)
1. PERC Concentration (ppm)	1,997	2,815
2. Vapour Temperature at the Condenser Outlet (℃)	9.4	10.8

The measured PERC concentrations of both machines were found well below 8,600 ppmv. However, the vapour temperatures at the condenser outlets of both machines were found higher than 7℃, i.e. not complied with the EPD's requirement on condenser outlet temperature.

5.3 Technical Constraints and Precautions

Compared with the modification from vented to non-vented type dry-cleaning machine, the installation of door interlock system on existing non-vented type dry-cleaning machine seems to be a minor conversion which is unlikely to encounter specific technical problems. The common scenario of the two modified non-vented type dry-cleaning machines is that their refrigerated condensers are incapable of cooling down the vapour temperature to 7℃ in the required period of time, and hence the machine door can never be opened if the interlock system is activated. Consequently, the interlocking system was deactivated after its installation.

5.4 Costs Involved in the Modification Work

Obviously, the major capital cost for such modification is the cost for purchasing the door interlocking system and its installation. A breakdown of cost involved is listed below:

- Direct Cost:
  1. <u>Equipment cost</u>
     - door interlock system
     - electrical wiring
  2. <u>Installation cost</u>
     - electrical connection
- Indirect Cost
  - functional test
  - machine downtime

Table 5.3: Estimated Costs for Installation of Door Interlock System on Non-Vented Type Dry-cleaning Machine

Modification item	**Machine Model**	
	Donini D40 (drum capacity 18 kg)	Economatic C45 (drum capacity 20 kg)
	Direct Cost (Equipment)	
1. Door interlock system	HK$4,000	HK$4,000
2. Electrical wiring	HK$500	HK$500
	Direct Cost (Installation)	
3. Installation	HK$1,000	HK$1,000
	Indirect Cost	
4. Functional Test	HK$500	HK$500
Total	**HK$6,000**	**HK$6,000**

Remark: 1. The pre-installation work takes 1 day.
2. The installation work and functional test take 1 day.
3. The costs shown in the above are obtained from dry-cleaning machines contractors.
4. The cost for machine downtime is negligible because the installation work can be arranged at the time the machine is normally not used.

As noted, the total capital cost for installing a door interlock system is about HK$6,000, which is independent on the type and capacity of machine. These costs include the supply and installation of door interlock system, and a functional test after installation.

6. SURVEY OF TRADES INFORMATION

The survey was conducted in December 1997 and lasted for about two and half months. 955 questionnaires were sent out and more than three hundred phone calls were made to identify laundries and hotels of interest and to boost up the response rate. Whenever necessary, the laundries were contacted via telephone to clarify the information in the returned questionnaires.

6.1 Response of the Survey

(a) Response from hotels

The response rate of hotel is encouraging, 76 hotels (100%) can be contacted and 22 of them have on-site dry-cleaning operation. Among these 22 hotels, 19 hotels completed and returned the questionnaires.

(b) Response from laundries (excluding hotels)

i) Phone and Postal Survey

From the information from the C&S Department, 879 laundries were identified. Some of them could be contacted through telephone and completed and returned the questionnaire. The following table shows the breakdown of the survey response of the laundries.

Table 6.1: Response Breakdown of the Laundries (excluding Hotels) from the C & S Department

<table>
<tr><th colspan="7">No. of Laundry and Description</th></tr>
<tr><td rowspan="3">No. of Laundry from the C&S department</td><td rowspan="3"></td><td rowspan="2">Responded</td><td rowspan="2">262</td><td>On-site Dry-cleaning</td><td>138 (53%)</td><td>Replied / Not Replied</td><td>96 / 42</td></tr>
<tr><td>No on-site Dry-cleaning</td><td>124 (47%)</td><td colspan="2"></td></tr>
<tr><td>Not Responded</td><td>617</td><td colspan="4"></td></tr>
<tr><td>Total</td><td>879</td><td colspan="6"></td></tr>
</table>

Remark: "Responded" / "Not Responded" refers to the laundries that answered / not answered enquires regarding the adoption of on-site dry-cleaning operations while "Replied" / "Not Replied" refers to laundries that completed the questionnaires / not willing to participate in the survey or did not completed the questionnaire. Those "Responded" with on-site dry-cleaning operations but "Not Replied" means that they only answered with on-site dry-cleaning operations but not answered any other questions in the questionnaire even over the phone.

ii) Field Survey

One district from the territory was selected for the field survey and the selected district was Sham Shui Po.

The field survey boundary started from the East of Yau Yat Tsuen to the West of Mei Foo Sun Chuen. It covers the entire Sham Shui Po district according to the boundary set by the District Board. Inside the boundary, Yau Yat Tsuen, Shek Kip Mei, Tai Wo Ping, Sham Shui Po, Cheung Sha Wan, Lai Chi Kok and Mei Foo Sun Chuen are all within the field survey boundary. Seventy-Six laundries were identified based on the information from the C&S Department and they contribute about one-tenth of the total number of laundries in the territory. Moreover, varieties of residential and commercial developments were identified. Several public housing estates (e.g., Skek Kip Mei Estate, Pak Tin Estate, So Uk Estate and Cheung Sha Wan Estate etc.) are located in this district and numerous private residential buildings are located around Sham Shui Po and Cheung Sha Wan. There is also an industrial area situated in Lai Chi Kok. Different kinds of premises (e.g., residential, commercial and industrial etc.) can be found within the boundary. Under the resources of this study, it is believed that the selected district is appropriate to represent the general pattern of dry-cleaning operation in the territory. A map showing the field survey area is attached in Appendix VI for reference.

Regarding the field survey in Sham Shui Po District, some of the laundries were found to be closed or not exist and only part of them had on-site dry-cleaning operation. The breakdown of the result is tabulated in Table 6.2.

Table 6.2: Breakdown of Field Survey Results

Status	No. of Premises	Percentage (%)
Not exist or closed	34	45
Laundry but no on-site dry-cleaning	32	42
Laundry with on-site dry-cleaning	10	13
Total	76	100

(c) Overall response

According to the result from field survey, 45% of the laundries are already closed or not exist. Assuming that such ratio is applied into the total number of laundry from the C&S Department, 396 (879 x 45%) laundries are estimated to be already closed or not exist. Subtracting this amount from the "Not Responded" laundries, there should be 221 (617-396) laundries which are still operating. Assuming the percentage of laundries having on-site dry-cleaning operation is the same as the "Responded" group, number of laundries having dry-cleaning operation in the "Not Responded" group is estimated to be 117 (221 x 53%).

Overall speaking, total number of laundries in the territory is estimated to be 277 [22 (Hotels) + 138 (Responded) + 117 (estimated from "Not Responded")]. This figure is on conservative side as the laundries having on-site dry-cleaning operation in the "Not Responded" group are believed to be fewer. Normally speaking, laundries without on-site dry-cleaning operation tended to not respond because they thought the survey was irrelevant to them.

The response of the survey is tabulated in the Table 6.3.

Table 6.3: Breakdown of Replied Dry-cleaning Related Laundries

Nature	Number of Company	Number of Machine
Hotel	19	29
Shop	71	74
Factory	25	62
Total	***115***	***165***

According to the above table, the ratio of the number of companies to the number of machines is about 1:1.43. By applying this ratio, total number of dry-cleaning machines in Hong Kong is estimated to be 396 (277 x 1.43).

Presentation and analysis of trade information was based on the above 115 replies in this study. In order to have better understanding about the trade information, the 115 companies were divided in three categories, namely, hotel, shop and factory. Shop is defined as small dry-cleaning facilities usually located on the ground floor of residential or commercial buildings while factory is defined as dry-cleaning facilities usually located in the industrial buildings and the scale is usually larger than the shop.

6.2 Results of the Survey

Graphical and numerical summary of the trade information for the three categories were presented in Appendix IV. Moreover, comparison of dry-cleaning machine properties among the three categories (hotel, shop and factory) was also shown in Appendix V.

The results of survey on the three categories are individually summarized and discussed in the following subsections. In addition, the last subsection summarizes and discusses the overall results of the survey.

(a) Survey results on hotels

i) Age Distribution of Each Type of Existing Machines

Table 6.4: Age Distribution of Machines

Type		Age (Years)	
DDV	21%	0 -3	0%
		4 - 7	0%
		> 8	100%
DDNV	79%	0 -3	17%
		4 - 7	43%
		> 8	39%

As shown in Table 6.4, it is observed that most of the machines are DDNV and the remaining are DDV. Totally, over one-third of the DDNV type machines are aged over 8 years and only small portion are under 3 years. All DDV machines are older than 8 years.

Regardless of type of the machine (DDNV or DDV), half of them are aged over 8 years and one-third are aged between 4 to 7 years and the remaining are under 3 years (Appendix IV).

ii) Brands and Capacities of Existing Machines

Table 6.5: Brands of Machines

Brand	Percentage (%)
Multimatic	34
Spencer	17
Economatic	14
Donini	14
Others	21

As shown in Table 6.5, it is found that "Multimatic" is most commonly used in hotels, about one-third of the machines are of this brand. "Spencer", "Economatic" and "Donini" are also commonly used in hotels.

Table 6.6: Capacity of Machine

Capacity (kg)	Percentage (%)
< 15	17
16 - 25	69
26 - 40	14

Regarding the capacity of the machine, it is observed in Table 6.6 that more than two-third of the machines are in the capacity range between 16 and 25 kg and only small portion are less than 15 kg and over 26 kg. It is expected that hotel laundries handled considerable amount of clothes everyday, e.g. bed sheets, staff uniforms, and guest merchandise. Some of the services are even so called "same-day delivery service". It is

therefore expected that hotels tend to employ machines of intermediate capacity in order to be able to handle such large quantity of clothes.

iii) Mileage, PERC Recovery System, and Drying Device of the Machines

Table 6.7: Machine Mileage

Mileage (kg/litre of PERC)	Percentage (%)
< 10	5
11 – 30	47
31 – 60	32
> 60	11
N/A	5

Mileage is defined as amount of cloth cleaned (in kg) per amount of PERC used (in litre) and can be used as an indicator to illustrate the machine efficiency in terms of PERC consumption.

It is observed that machine mileage ranges from 7.3 to 72 kg/litre and the average is 32.4 kg/litre (Appendix IV). As shown in Table 6.7, about half of the hotels performed mileage in the range of 11 to 30 kg/litre while the other two-fifth performed even better than 31 kg/litre and only very minor portion performed less than 10 kg/litre.

Table 6.8: PERC Recovery System

Recovery System	Percentage (%)
Refrigerated Condenser	86
Water-Cooled Condenser	14

Regarding the PERC recovery system in the machines, it is found that most of the machines are using refrigerated condenser operated by either refrigerant or chilled water. Regarding the machine drying device, most of the machines are steam heated and only small portion are electricity heated (Appendix IV).

Overall speaking, the mileage performance in hotels is best among the three categories. It is probably due to larger portion of machines using refrigerated condensers, which have better efficiency in recovery of PERC in the cooling stage. Moreover, machine maintenance in hotels is probably comparatively better as designated staff (e.g., technician or engineer) is usually responsible for the machine maintenance.

iv) Business Information

Table 6.9: Business Information

Initial Investment (HK$)	
< 500,000	42%
500,001 - 1,000,000	16%
> 1,000,001	16%
N/A	26%

Business Turnover (HK$/yr)	
< 500,000	5%
500,001 - 1,000,000	5%
1,000,001 - 5,000,000	42%
5,000,001 - 10,000,000	5%
> 10,000,001	5%
N/A	37%

Operating Cost (% of Business Turnover)	
< 30	16%
31 - 50	21%
51 - 70	26%
> 71	5%
N/A	32%

Profit (% of Business Turnover)	
< 30	16%
31 - 60	37%
> 61	16%
N/A	32%

As shown in Table 6.9, it is found that almost half of the hotels invested less than HK$500,000 in dry-cleaning operation. However, about one-fourth are either unable to report or unwilling to disclose such information.

About two-fifth of the hotels have business turnover in dry-cleaning operation in the range of HK$1,000,001 to HK$5,000,000 per year. Similarly, more than one-third are either unable to report or unwilling to disclose such information.

About half of the hotels claimed the operating costs are in the range of 31 to 70 %. However, about one-third of the hotels are either unable to report or unwilling to disclose such information.

About one-third of the hotels claimed that their profits are in the range of 31 to 60% of the business turnover. Similarly, nearly one-third of the hotels are either unable to report or unwilling to disclose such information. According to these findings, considerable amount of profit can be generated from dry-cleaning operation in hotels. It is reasonable to believe that hotels are willing to invest in dry-cleaning operation which are considered to be one of the profitable operations in hotel activities. This further explains that most of the hotels are using DDNV type machines which are more expensive than traditional DDV type. The high installation cost of DDNV type machine can be off-set by better recovery efficiency of PERC as PERC is one of the major expenses in dry-cleaning operation as claimed by the operators.

(b) Survey results on shops

i) Age Distribution of Each Type of Existing Machines

Table 6.10: Age Distribution of Machines

Type		Age (Years)	
DDV	69%	0 - 3	8%
		4 - 7	51%
		> 8	41%
DDNV	31%	0 - 3	57%
		4 - 7	30%
		> 8	13%

As shown in Table 6.10, it is found that more than two-third of the machines in shops are DDV type. Among the DDV type machines, half of the machines are aged between 4 to 7 years and more than one-third are over 8 years. For the DDNV type machines, more than half are aged under 3 years. In short, most of the DDNV machines in shop are "new" (age under 3 years) while about two-fifth of the DDV machines in shops are over 8 years. It is believed that most shops are just "small to medium" scale laundries and they did not invest very much on dry-cleaning operation. In fact, some dry-cleaners started their business by purchasing second-hand machines. DDV type machines are therefore popular in shops. On the other hand, for some shops that intended to invest more in the dry-cleaning operation, they normally shifted the machine type from DDV to DDNV because of more advanced technology and better recovery efficiency of PERC. Most of the newly bought machines are therefore of DDNV type.

Regardless of type of the machine (DDNV or DDV), nearly half are in the range of 4 to 7 years and about one-fourth are aged under 3 years (Appendix IV).

ii) *Brands and Capacities of Existing Machines*

Table 6.11: Brands of Machines

Brand	Percentage (%)
Suprema	54
Bowe	16
Spencer	11
Donini	4
Economatic	3
Others	12

"Suprema" is the most common type of machine used in shops and it contributes about more than half of the machines in shops. "Bowe" and "Spencer" are the second and third common types respectively.

Table 6.12: Capacity of Machine

Capacity (kg)	Percentage (%)
> 10	26
11 -20	62
21 -30	9
N/A	3

Regarding the capacity of the machine, nearly two-third of the machines are in the capacity range of 11 to 20 kg. As mentioned before, most shops are just "small-medium sized" scale and thus "small-medium" sized machines are commonly used.

iii) Mileage, PERC Recovery System, and Drying Device of the Machines

Table 6.13: Machine Mileage

Mileage (kg/litre of PERC)	Percentage (%)	
	DDV	DDNV
< 5	8	5
6 -10	26	10
11 - 15	16	24
16 - 20	12	5
> 21	2	0
N/A	36	57

It is observed that machine mileage ranges from 2 to 66 kg/litre and the average is 12 kg/litre. As shown in Table 6.13, two-fifth of the shops performed mileage in the range of 11 to 20 kg/litre. Nevertheless, about one-fourth could not provide information about the machine mileage because of no proper recording practice to log down the required data.

Table 6.14: PERC Recovery System

Recovery System	Percentage (%)
Refrigerated Condenser	31
Water-Cooled Condenser	69

Regarding the PERC recovery system in the machines, it is found that most of the machine are using water-cooled condenser operated by tap water at normal temperature. Regarding the machine drying device, about half of the machines are electricity heated and the other half are steam heated (Appendix IV).

The comparatively poor performance of machine mileage found in shops is not unexpected as most machines in shops are of DDV type, which are using water-cooled condensers to recover PERC. As discussed earlier, water-cooled condenser is found to be less effective in PERC recovery when compared with refrigerated condenser. This leaded to the increase in PERC consumption in DDV type machines when compared with DDNV type. Moreover, as mentioned before, most machines in shop are "old" one. Generally speaking, the overall performance for older machines is poorer.

iv) Business Information

Table 6.15: Business Information

Initial Investment (HK$)	
< 100,000	4%
100,001 – 300,000	24%
3000,001 – 500,000	30%
500,001 – 1,000,000	15%
> 1,000,001	4%
N/A	23%

Business Turnover (HK$/yr)	
< 300,000	6%
300,001 – 600,000	11%
600,001 – 1,000,000	17%
> 1,000,001	20%
N/A	46%

Operating Cost (% of Business Turnover)	
< 40	1%
41 – 60	6%
61 – 80	23%
81 – 90	17%
> 91	6%
N/A	48%

Profit (% of Business Turnover)	
< 10	13%
11 – 20	17%
21 – 30	11%
31 – 50	8%
> 51	1%
N/A	49%

As shown in Table 6.15, it is found that more than half of the shops invested in the range of HK$100,000 to HK$500,000 in dry-cleaning operation. However, nearly one-fourth are either unable to report or unwilling to disclose such information. Such findings in initial investment concur our findings discussed above, i.e. most of the shop are "small to medium" scale.

In the view of dry-cleaning operation, nearly half of the shops are either unable to report or unwilling to disclose the business turnover information. Most shops provided both drying cleaning and washing service and they normally do not break down the business turnover into dry-cleaning and washing individually. Nevertheless, among the remaining, one-fifth of the shops have business turnover more than HK$1,000,001 per year and about one-third are below HK$1,000,000 per year.

Similarly, nearly half of the shops are either unable to report or unwilling to disclose the operating cost information. Nearly half of the shops claimed that the operating costs are more than 61% of their business turnover.

Again, nearly half of the shops are either unable to report or unwilling to disclose any information on profits. About one-third of the shops claimed that the profits are below 20%. According to the present business findings, it reflects that dry-cleaning operation in shops is comparatively not so profitable as claimed by the shop operators.

(c) Survey results on factories

i) Age Distribution of Each Type of Existing Machine

Table 6.16: Age Distribution of Machines

Type		**Age (Years)**	
DDV	47%	0 - 3	14%
		4 - 7	34%
		> 8	52%
DDNV	53%	0 - 3	39%
		4 - 7	42%
		> 8	18%

Both DDV and DDNV type machines are commonly used in factory, each type shares about half of the machines in factories. About half of the DDV machines are aged over 8 years. For the DDNV type machine, it is contrary that considerable amount (about two-fifth) of the DDNV type machines are aged under 3 years and the other two-fifth are aged between 3 to 7 years. It is observed that most DDV type machines are old one when compared with DDNV type machine in the factories. It is also found that there are still some old-aged (> 8 years) DDNV machines existing and are still being used in the trade.

Regardless of the machine type (DDV or DDNV), about two-fifth of the machines are aged in the range of 4 to 7 years (Appendix IV).

ii) Brands and Capacities of Existing Machines

Table 6.17: Brands of Existing Machines

Brand	Percentage (%)
Bowe	29
Suprema	26
Spencer	10
Mulitmatic	6
Union	5
Economatic	3
Others	21

Both "Bowe" and "Suprema" are the most common types of machine used in factories. These two brands share more than half of the machines in factories.

Table 6.18: Capacity of Machines

Capacity (kg)	Percentage (%)
< 10	11
11 - 20	48
21 - 30	34
31 - 50	6

Regarding the capacity of the machines, it is observed that nearly half of the machines are in the capacity range of 11 to 20 kg. Generally, it is found that factories are using medium to large scale machines. It is probably due to the fact that many outlet shops collect clothes and pass to factories for dry-cleaning and it is common that several shop outlets are served by one factory. Consequently, medium to large scale machines are necessary to handle such large quantity of clothes.

iii) Mileage, PERC Recovery System, and Drying Device of the Machines

Table 6.19: Machine Mileage

Mileage (kg/litre of PERC)	Percentage (%)
< 10	56
11 - 20	24
21 - 40	16
> 41	4

It is observed that machine mileage range from 1 to 48 kg/litre and the average is 14 kg/litre. As shown in Table 6.19, it is found that more than half of the factories performed mileage below 10 kg/litre.

Table 6.20: PERC Recovery System

Recovery System	Percentage (%)
Refrigerated Condenser	58
Water-Cooled Condenser	39
Refrigerated Condenser and Carbon Adsorber	3

Regarding the PERC recovery system in the machines, it is observed that more than half of the machines are using refrigerated condenser operated by either refrigerant or chilled water. It is also found two machines in a factory are employing both refrigerated condenser and carbon adsorber. Regarding the machine drying device, about three quarters of the machines are steam heated (Appendix IV).

Even though more than half of the machines in factories are using refrigerated condenser system for PERC recovery, the overall performance of mileage is not high as expected. This is probably due to comparatively low loading of their relatively large machines. In order to shorten the process time of the clothes, many factories may operate the machine under its normal loading since it takes time to accumulate the required quantity of clothes of similar colours. The machine mileage in the factories are therefore comparatively low.

iv) Business Information

Table 6.21: Business Information

Initial Investment (HK$)	
< 300,000	28%
300,001 – 500,000	12%
500,001 – 1,000,000	16%
1,000,001 -3,000,000	28%
> 3,000,001	4%
N/A	12%

Business Turnover (HK$/yr)	
< 500,000	8%
500,001 – 1,000,000	20%
1,000,001 – 2,000,000	12%
2,000,001 – 4,000,000	8%
> 4,000,001	16%
N/A	36%

Operating Cost (% of Business Turnover)	
< 50	4%
51 – 70	12%
71 – 90	32%
> 91	12%
N/A	40%

Profit (% of Business Turnover)	
< 10	28%
11 - 20	16%
21 - 30	12%
> 31	4%
N/A	40%

About one-fourth of the factories invested below HK$300,000 in dry-cleaning operation and also about one-fourth invested between HK$1,000,001 to 3,000,000. However, small portion of the factories are either unable to report or unwilling to disclose such information.

More than one-third of the factories are either unable to report or unwilling to disclose any information on business turnover. One-fourth of the factories have business turnover over HK$2,000,000 and can be considered to be large scale laundries having dry-cleaning operation.

Two-fifth of the factories are either unable to report or unwilling to disclose any information on operating costs. Nearly half of the factories claimed that the operating costs are over 70% of their business turnover.

Similarly, two-fifth of the factories are either unable to report or unwilling to disclose the profit figure. Most of the factories revealed that the profit are below 30% of their business turnover. One-fourth are even lower than 10% of their business turnover. According to the figures of operating costs and profits provided by the operators, dry-cleaning operation

in factories is not so profitable as most of the factories have only less than 30% profit of their business turnover. Large portion of the income is spent in operating costs including labor, raw materials (e.g., PERC and detergent etc.), rental, electricity and machine maintenance etc. Except for some large scale factories (having a couple of machines and large business turnover), almost none of them are going to invest further resources in dry-cleaning operation, e.g., purchasing of new machine or upgrading the machines.

(d) Overall Results on the Survey

Regardless of the commercial operation type (hotel, shop and factory), the following features are discussed:

i) Machine Age

Table 6.22: Overall Machine Age

Age (Years)	Percentage (%)
0 – 3	23
4 – 7	41
> 8	36

Over two-fifth of the machines are aged between 4 to 7 years and about one-third are aged over 8 years. Only nearly one-fourth are aged under 3 years. It is found that most of the machine using in the laundries are not new one, some of them are even using for more than 10 years.

ii) Machine Type

Table 6.23: Overall Machine Type

Type		Years	
DDV	52%	0 - 3	9
		4 - 7	42
		> 8	49
DDNV	48%	0 - 3	38
		4 - 7	39
		> 8	23

Both DDV and DDNV type machines share about half of the machines in the laundries. Among the DDV type machines, nearly half of the machines are aged over 8 years while two-fifth are aged between 4 to 7 years. Only small portion are under 3 years. For the DDNV type machines, about two-fifth of them are aged under 3 years and the other two-fifth are between 4 to 7 years. Overall speaking, DDV type machines found in the laundries are normally "old" one while considerable portion of DDNV type are new one.

iii) Machine Brands

Table 6.24: Overall machine Brands

Brand	Percentage (%)
Suprema	34
Bowe	20
Spencer	12
Multimatic	8
Donini	6
Others	20

"Suprema" is the most popular machine in laundries while "Bowe" is the second one. These two brands contribute to over half of the machines. It is believed that they are the common brands of machine used in the trade.

iv) PERC Recovery System and Drying Device of the Machines

Table 6.25: Overall PERC Recovery System

Recovery System	Percentage (%)
Refrigerated Condenser	51
Water-Cooled Condenser	48
Refrigerated Condenser and Carbon Adsorber	1

Half of the machines are using refrigerated condenser while the other half are using water-cooled condenser. Very few machines are using both refrigerated condenser and carbon adsorber.

Table 6.26: Overall Heating System

Heating Type	Percentage (%)
Steam Coil	66
Electric Oil Heater	34

Most of the machines are heated by steam heated coil while the remaining are heated by electric oil heater. Most of the machines in hotels and factories are heated by steam. It is probably that they have their own steam boilers providing the required steam. However, as space is limited in shops and their scale is not large enough to operate boiler in a cost-effective way, most of the machines in shops are heated by electric oil heater.

v) Machine Mileage and Consumption of PERC

Overall speaking, the average machine mileage is found to be 13.7 kg/litre and ranged from 1 to 72 kg/litre. The total consumption of PERC in the laundries is found to be 374 tonnes per year.

6.3 Limitations of the Survey

During the survey, the following difficulties were encountered:

(a) Some shop and factory laundries were reluctant to complete the questionnaire even though on-site visit was paid.

(b) Regarding the business information (e.g., initial investment costs, operating costs, business turnover and profits etc.), this information was unavailable for some laundries because of their poor recording and management system. Hotel laundries comparatively performed better in this aspect as they have better management system to record the required data.

(c) In this survey, the amount of clothes cleaned in shops and factories were estimated by multiplying the machine capacity (kg) with number of operating times. Loading factor of 75% is applied as dry-cleaning machines are not normally fully loaded and 75% loading was assumed in this study. As the laundry operators of shops and factories neither exactly weighed nor recorded the weight of clothes in their operating procedure, the annual clothes cleaned data should be therefore regarded as rough estimate. However, the amount of clothes cleaned in hotels was obtained from the hotel operators and was not estimated by HKPC according to the mentioned method.

Environmental Management Division
Hong Kong Productivity Council

31st March 1998

APPENDIX I

Measurement Method of Perchloroethylene

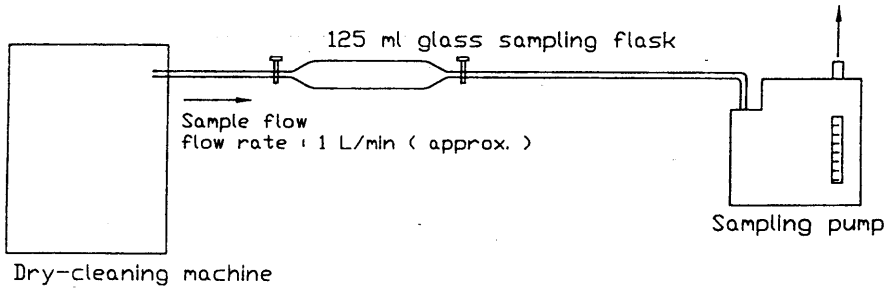
Measurement Method of Perchloroethylene

1. Summary

The objective of the test is to measure the level of perchloroethylene in the test dry-cleaning machines. Air sample is collected by glass sampling flask for subsequent analysis. A unit of gas chromatography with flame ionization detector (GC-FID) is employed for sample analysis.

2. Sample Collection

A clean glass sampling flask and a portable sampling pump are employed for collection of air sample. A flexible sampling tubing, a sampling flask and a sampling pump are connected in series. The sample flow rate is set to about 1 L/min. During sampling, the valves of the sampling flask are kept open for about 3 minutes for pre-purging. Then the valves will be closed and then the sample will be delivered to laboratory for analysis.



3. Sample Analysis

A unit of Hewlett Packard GC-FID is employed for sample analysis. The instrument is multi-point calibrated with perchloroethylene in hexane. The linear regression coefficient of the calibration curve should be 0.999 or above. Air sample is directly injected for analysis. The result of analysis will be reported as ppmV and percentage volume where appropriate.

APPENDIX II

Survey Questionnaire (Sample)

Letterhead of Hong Kong Productivity Council Environmental Management Division

DRY CLEANERS SURVEY

1. Name of Company_____
2. Name of Owner_____
3. Postal Address_____
4. Factory Address_____
5. Contact Person at Site_____
6. Telephone Number of Contact Person_____

7. Do you dry clean onsite? ☐ YES ☐ NO

8. Amount of clothes dry-cleaned_____kg/year

9. Operation time:
   From_____:_____to_____:_____
   Days_____per week

10. Type of Solvent used, and how much used in 1996?
    - Perchloroethylene _____litres/year
    - Stoddard (140F) _____litres/year
    - Other _____litres/year

11. Operation details of the dry-cleaning machines. (Please refer to the attached table)

12. Approx. initial investment cost HK$_____

13. No. of workers,_____

14. Approximate business turnover (1996) HK$_____

15. What is % of operating cost compared with annual business turnover?_____%

16. Profit Margin (Approx.)_____%

Additional Comments:_____
_____
_____

Question 11.

Operational Details of the Dry Cleaning Machine

Type of Dry Cleaning Machine[(1)]	Brand Name	Model No.	Year of Service	Quantity	Capacity (kg)	Steam/Electrical Heated	Type of Solvent Recovery or Air Pollution Control Device Adopted[(2)]	Remarks

Remarks: (1) *T - Transfer*
DDV - Dry to Dry Vent
DDNV - Dry to Dry Non-Vent
Others, please specify

(2) *RC - Refrigerated Condenser*
AD - Azeotropic Device (Solvation)
CA - Carbon Adsorber
CT - Cooling Tower
Others, pleasespecify

乾洗設施調查報告（第一頁）

（根據 1996 年資料）

1. 公司名稱：_____
2. 所有人名稱：_____
3. 郵寄地址：_____
4. 工場地址：_____
5. 工場聯絡人：_____
6. 聯絡人電話：_____

7. 是否在現場乾洗：　□ 是　□ 否

8. 如有現場乾洗，請指出乾洗衣服之數量：_____公斤／年

9. 工作時間：由_____：_____至_____：_____
   每星期_____天

10. 所使用之溶劑類型以及在 1996 年購買之數量？

    ～ 高氯乙烯_____公升／年
    ～ STODDARD (140F)溶劑_____公升／年
    ～ 其它_____公升／年

11. 乾洗機之運作詳情（請參考附表）

12. 最初成立廠房之成本（大約）HK$_____

13. 員工數目：_____人

14. 商業銷售（大約）HK$_____／年

15. 廠房之運作費用佔全年商業銷售量之百分比：_____%

16. 週邊利潤（大約）HK$_____／年

附加意見：_____
_____
_____

乾洗機之運作詳情

種類[1]	牌子	型號	服務年期	數量	容積（公斤）	蒸氣發熱／電力發熱	溶劑回收設備或附設乾洗機的空氣污染控制裝置之類型[2]	附註

附註：

(1) T ～ 轉移型
DDV ～ 乾出乾入型
DDNV ～ 密封式乾出乾入型
其他，請註明

(2) RC ～ 冷凝器
AD ～ 共沸裝置（溶劑化作用）
CA ～ 碳吸附劑
CT ～ 冷卻器
其他，請註明

APPENDIX III

Detailed Calculation of
Recurrent Costs and Savings of the Modification Work

Recurrent Costs of the Converted Suprema 850 S2

1. Electricity cost

Electricity consumption rate for the add on components
= 3 A x 380 V x $\sqrt{3}$
= 1.98 kW

Operation time of the add on components per washing cycle
= time for drying + time for cooling
= 30 min/batch

Number of washing per day
= 12 batches

Number of working day per year
= 329 day

Annual electricity consumption of the add on components
= 329 days x 12 batches x 30 min/batch / (60 min/hr) x 1.98 kW
= 3909 kWH

Annual electricity cost
= 3909 kWH x HK$0.65/kWH
= HK$2541

2. Water cost

Assumed energy efficiency ratio of the chiller
= 10 (cooling in btu/hr)/(power input in W)

Size of compressor
= 3.5 hp

Cooling capacity
= 10 x 3.5 hp x 746.27 W/hp
= 26120 btu/hr
= 2.18 tons

Heat generated
= 2.18 tons x 3.516 kW/ton + 3.5 hp x 0.74627 kW/hp
= 10.3 kW

Assuming in/out condenser water temperature difference = 5℃, water consumption rate
= 10.3 kW / (4.2 kJ/kg/℃ x 5℃)
= 0.49 kg/s
= 0.49 l/s

However, from the experience of the dry-cleaner, usually 95% of the water can be reused for other laundry processes in the same premises. Thus, actual water consumption rate due to the chiller
= 0.49 l/s x 0.05 x 3600 s/hr / (1000 l/m^3)
= 0.0882 m^3/hr

Annual water consumption
= 329 days x 12 batches x 30 min/batch / (60 min/hr) x 0.0882 m^3/hr
= 174 m^3

Annual water cost
= 174 m^3 x HK$(4.58[water charge] + 1.2[sewage charge] + 0.6[trade effluent surcharge])/m^3
= HK$1110

3. PERC saving

The dry-cleaner estimated that 7 barrels of PERC can be saved every year when using the new system.

Cost for each barrel of PERC
= HK$2100

PERC saving per annum
= 7 x HK$2100
= HK$14700

Recurrent Costs of the Converted Suprema 1020 S3

1. Electricity cost

Electricity consumption rate for the add on components
= 5.2 A x 380 V x $\sqrt{3}$
= 3.4 kW

Operation time of the add on components per washing cycle
= time for drying + time for cooling
= 33 min/batch

Number of washing per day
= 7 batches

Number of working day per year
= 362 days

Annual electricity consumption of the add on components
= 362 days x 7 batches x 33 min/batch / (60 min/hr) x 3.4kW
= 4739 kWH

Annual electricity cost
= 4739 kWH x HK$0.65/kWH
= HK$3080

2. Water cost

Assumed energy efficiency ratio of the chiller
= 10 (cooling in btu/hr)/(power input in W)

Size of compressor
= 6 hp

Cooling capacity
= 10 x 6 hp x 746.27 W/hp
= 44776 btu/hr
= 3.73 tons

Heat generated
= 3.73 tons x 3.516 kW/ton + 6 hp x 0.74627 kW/hp
= 17.6 kW

Assuming in/out condenser water temperature difference = 5℃, water consumption rate
= 17.6 kW / (4.2 kJ/kg/℃ x 5℃)
= 0.83 kg/s
= 0.83 l/s

However, from the experience of the dry-cleaner, usually 95% of the water can be reused for other laundry processes in the same premises. Thus, actual water consumption rate due to the chiller
= 0.83 l/s x 0.05 x 3600 s/hr / (1000 l/m^3)
= 0.1494 m^3/hr

Annual water consumption
= 362 days x 7 batches x 33 min/batch / (60 min/hr) x 0.1494 m^3/hr
= 208 m^3

Annual water cost
= 208 m^3 x HK$(4.58[water charge] + 1.2[sewage charge] + 0.6[trade effluent surcharge])/m^3
= HK$1327

3. PERC saving

The dry-cleaner estimated that 12 barrels of PERC can be saved every year when using the new system.

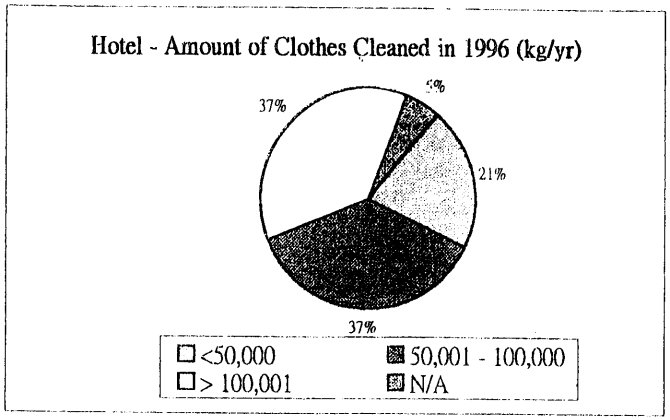
Cost for each barrel of PERC
= HK$2100

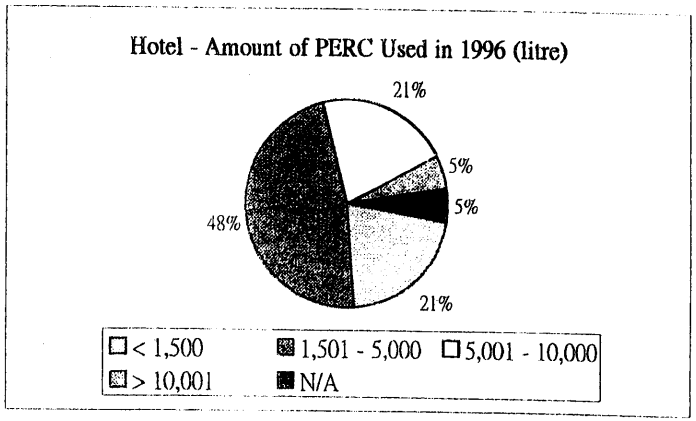
PERC saving per annum
= 12 x HK$2100
= HK$25200

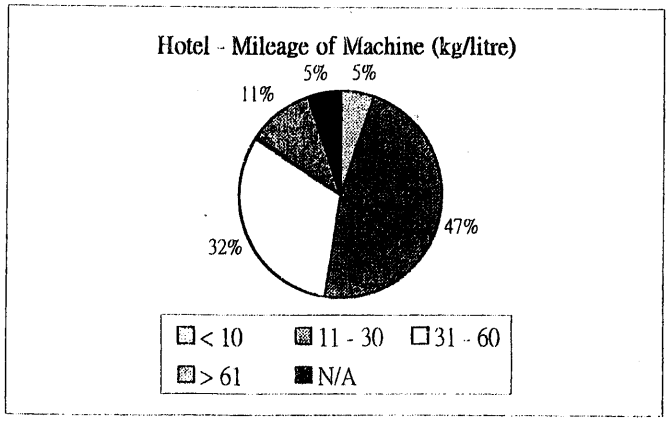
APPENDIX IV

Graphical & Numerical Presentation of Survey Data on Dry-cleaning Machine (Hotel, Shop & Factory)

Figure A4.1: Summary of Survey Data on Dry Cleaning Machine (Hotel)







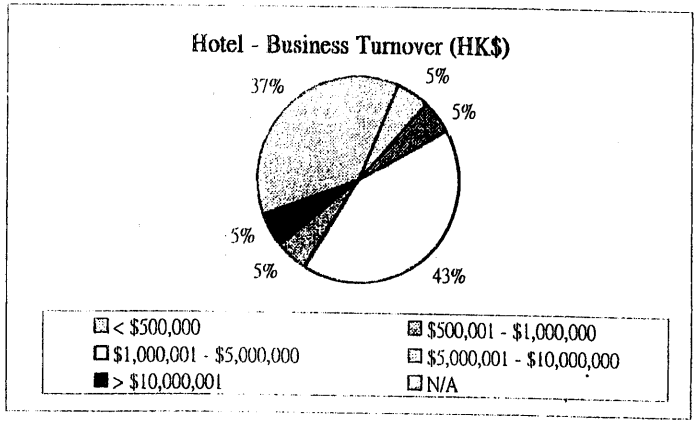


Figure A4.2: Summary of Survey Data on Dry Cleaning Machine (Hotel)

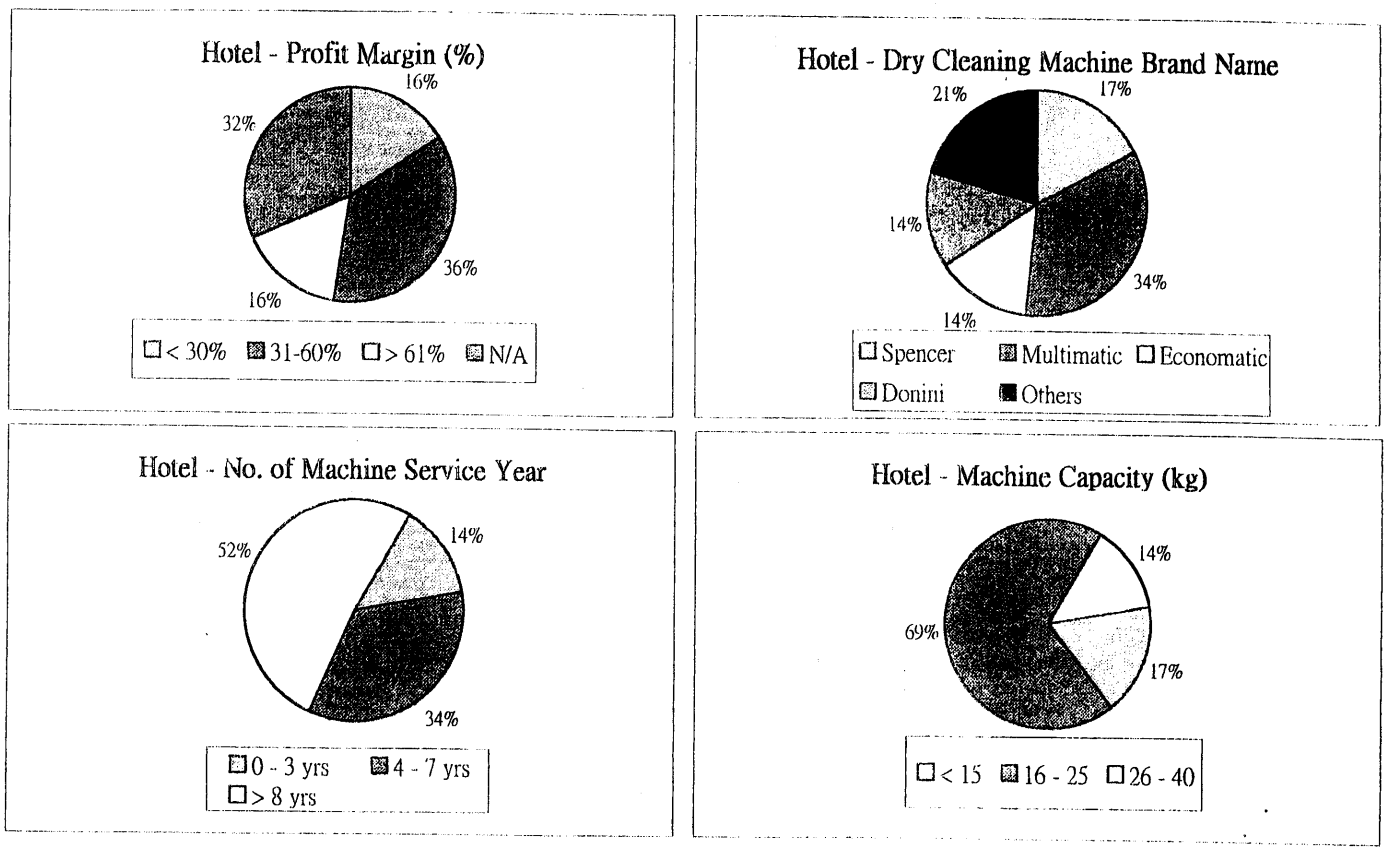
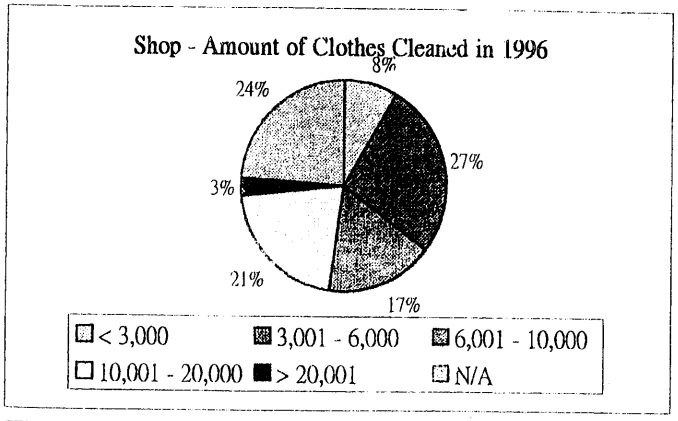
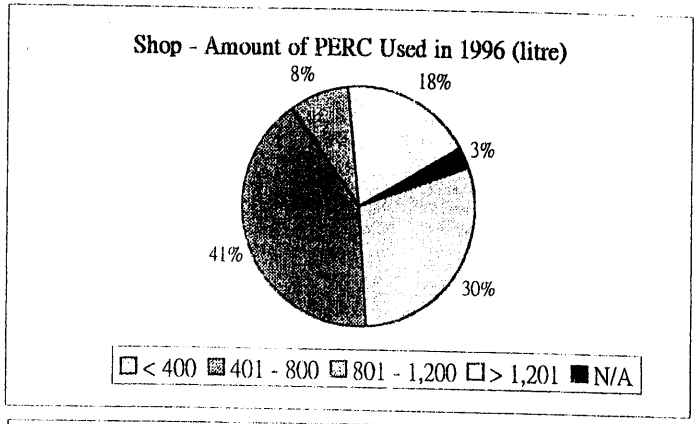
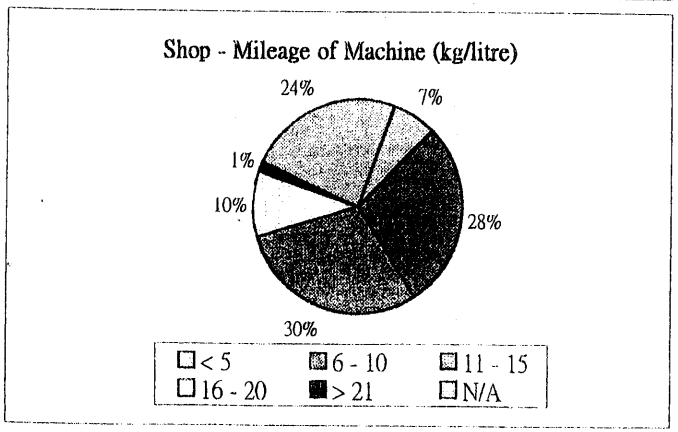


Figure A4.3: Summary of Survey Data on Dry Cleaning Machine (Shop)







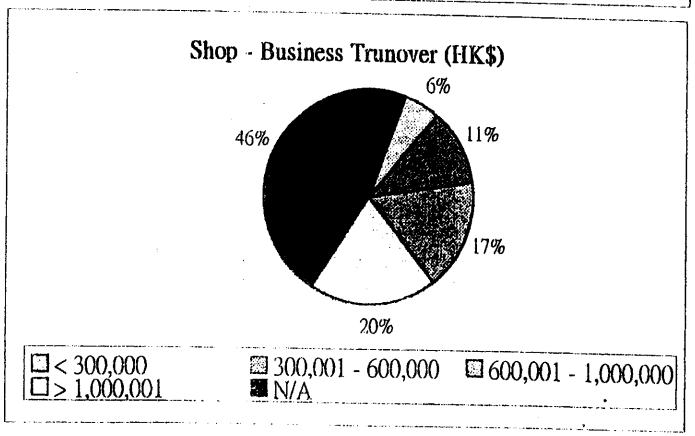
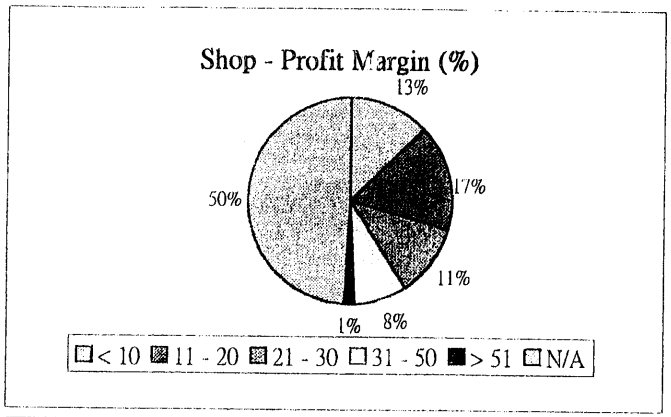
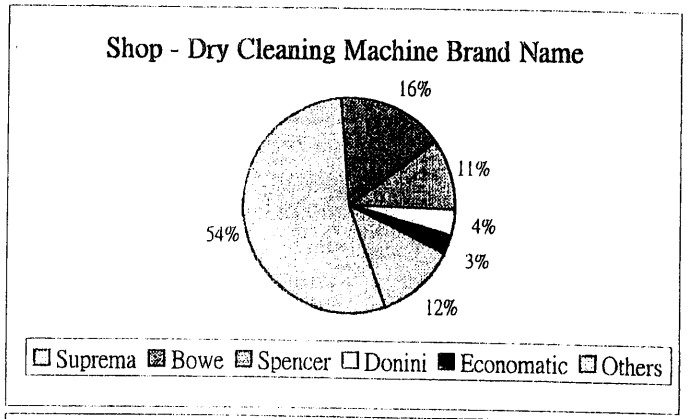
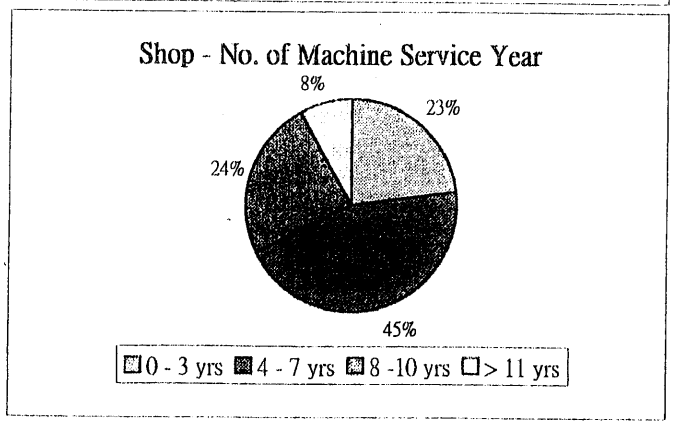


Figure A4.4: Summary of Survey Data on Dry Cleaning Machine (Shop)







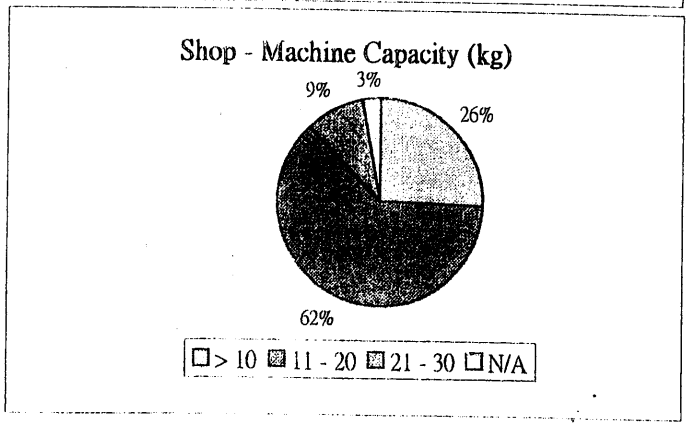
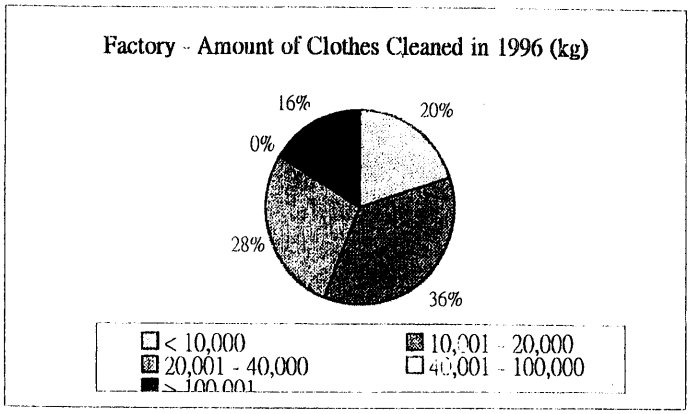
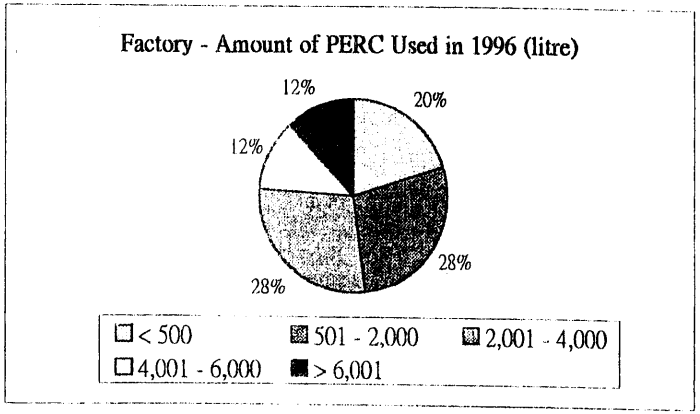
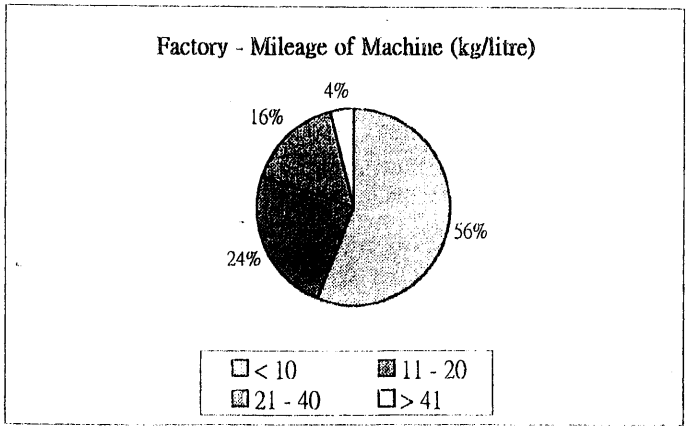


Figure A4.5: Summary of Survey Data on Dry Cleaning Machine (Factory)







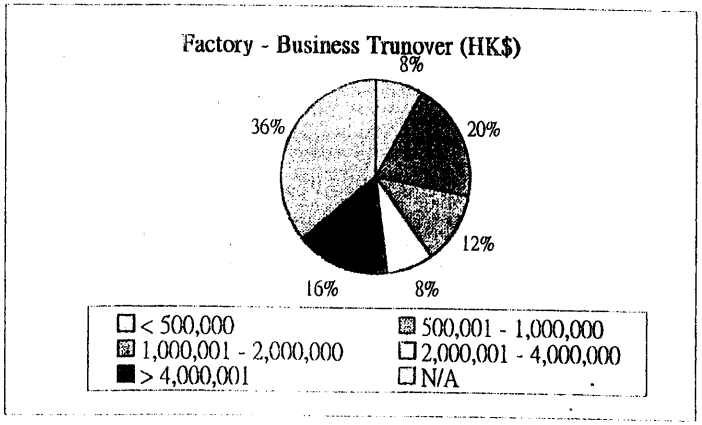


Figure A4.6: Summary of Survey Data on Dry Cleaning Machine (Factory)