



USED OIL FILTER STUDY (FOR DISTRIBUTION)

**M&R ENVIRONMENTAL, BURNABY
NEWALTA, DELTA
HETHERINGTON INDUSTRIES, PORT ALBERNI**

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EXECUTIVE SUMMARY

Conestoga-Rovers & Associates (CRA) was commissioned by BCUOMA to undertake a study of drums of used oil filters in British Columbia (BC). The study involved the survey of 500 45 gallon drums of used oil filters at three different processing facilities: M&R Environmental (Burnaby), Newalta (Delta) and Hetherington Industries (Port Alberni).

The key objectives of the study included the following:

- to determine the typical composition of a drum of used oil filters;
- to evaluate the ratios and typical weights of different filter types in drums of used oil filters; and
- to determine the typical amount of free product, general waste and non-eligible filters in a drum of used oil filters.

As part of the field survey the contents of each of the 500 drums were sorted, counted and weighed according to a prescribed BCUOMA sort criteria, which included five major categories and five sub-categories.

Interpretation of the trends and averages of the drum data collected was determined by evaluation of the raw arithmetic means for the various data categories. The results were then sub-categorised by the drum generator sub-region. Within the 500 drums studied, four different generator sub-regions of BC were surveyed: Lower Mainland, Kelowna, Vancouver Island and Prince George.

Only minor variations between the generator sub-regions were identified during the study. The findings derived from the used oil filter study include:

(i) *Typical composition of a 45 gallon drum of used oil filters*

- Weight of drum of used oil filters: 116.4 kg
- Drum weight: 21.4 kg
- Eligible steel oil filters: 75.0 kg
- Eligible paper oil filters: 3.2 kg
- Non-eligible oil filters: 1.17 kg
- General waste: 1.0 kg
- Free product: 14.6 kg

(ii) *Ratio of different filter types received*

Three main filter categories and five sub-categories were counted and weighed during the filter study. On average 161 filters were recorded per 45 gallon drum of used oil filters. The composition of these filters can be broken down as follows:

- 131 steel filters (< 8 inches in length)
- 12.1 steel filters (8 to 24 inches in length)
- 0.04 steel filters (> 24 inches in length)
- 11.7 paper filters (< 8 inches in length)
- 0.4 paper filters (8 to 24 inches in length)
- 5.7 non-eligible filters

(iii) *Average weights of different sizes and types of filters*

- Steel filter (< 8 inches in length): 0.436 kg
- Steel filter (8 to 24 inches in length): 1.468 kg
- Steel filter (> 24 inches in length): 2.929 kg
- Paper filter (< 8 inches in length): 0.247 kg
- Paper filter (8 to 24 inches in length): 0.775 kg
- Non-eligible filter: 0.206 kg

1.0 INTRODUCTION

Conestoga-Rovers & Associates (CRA) was retained by the British Columbia Used Oil Management Association (BCUOMA) to undertake the Used Oil Filter Study during the summer of 2007. The purpose of the filter study was to obtain more reliable and relevant information on the contents of 45 gallon drums of used oil filters in British Columbia (BC). This data would enable BCUOMA to have a better understanding of the true composition and filter count being recycled and processed, and consequently enable better support and more accurate financial compensation for the various processors located in BC.

1.1 OBJECTIVES OF THE BCUOMA FILTER STUDY

CRA undertook the study according to the key objectives outlined in the BCUOMA Request for Proposal, dated March 20, 2007. The key objectives included:

- to determine the overall composition of a 45 gallon drum of used oil filters;
- to determine the ratio of the different filter types received in the drums;
- to determine the average volume of free product received in a drum;
- to determine the average weight of different sized steel and paper filters;
- to determine the average weight of waste received in a drum; and
- to determine the average weight of non-eligible filters received in a drum.

1.2 HISTORIC USED OIL FILTER STUDIES

Since BCUOMA's inception in July 2003, the association has relied upon statistical data from the Alberta Used Oil Management Association (AUOMA) to estimate the number, type and weights of filters being recycled and crushed in BC.

However based on filters sale records and Return Incentive claims from the used oil filter processors within BC, it appeared that there were notable differences between drums of used oil filters in BC compared to in Alberta. Processing records indicated that BC drums are approximately 10 kg heavier than in Alberta, while the ratios of filter sizes remain comparable.

As part of this drum study, the number of paper filters being recycled is also evaluated. The use of paper oil filters is increasing, which is having a direct impact on the

processing operations and associated costs when recycling, sorting and crushing the drums of used oil filters. Obtaining numerical values for the mass and number of paper filters being recycled and understanding the effect of paper filters on the overall typical 45 gallon drum composition will enable BCUOMA to develop and fine-tune the existing oil filter Return Incentive Program to more accurately represent the recycling and processing trends occurring in 2007 and beyond.

2.0 FIELD SURVEY

2.1 LOCATIONS

The field survey was conducted between June and August 2007 at the following three facilities in British Columbia:

- i. M&R Environmental, Burnaby (Lower Mainland);
- ii. Newalta, Delta (Lower Mainland), and
- iii. Hetherington Industries, Port Alberni (Vancouver Island).

2.2 SAMPLE SIZE

A total of 500 randomly selected 45 gallon drums of used oil filters were surveyed for this study. 200 drums were surveyed at each of the Lower Mainland facilities (M&R Environmental and Newalta) and 100 drums were surveyed at Hetherington Industries.

In order to get an accurate and fair representation of the different drum compositions and different filter types processed at each of the facilities, no preferential generator selection or pre-evaluation of the drums to be surveyed was undertaken at either M&R Environmental or Newalta.

At Hetherington Industries preferential selection to those drums originating from island sources was given to ensure a broader range of regional influences and variations could be captured in the survey. However, as above, no other form of pre-evaluation or preferential generator selection was undertaken.

2.3 SAMPLING PROCEDURE

2.3.1 FIELD SURVEY TEAM

The field survey team consisted of two CRA personnel. These personnel were responsible for the categorisation, counting and weighing of all filters and materials contained within each of the study drums.

At each of the facilities the survey team was also assisted by the Site oil crusher operator. The operator was responsible for operating the oil filter crusher and loading/unloading the drums into the crushing machine.

To ensure correct categorisation of the different filter classifications, CRA met with BCUOMA representatives on the first day of the field study, who explained in the detail the different oil filter classifications and categories. During this briefing session, the differences between paper, steel and non-eligible filters were explained.

2.3.2 HEALTH AND SAFETY

Health and Safety of the personnel conducting the field survey was vital. Continuous air monitoring at all three facilities was conducted using a photo-ionisation meter. Colorimetric tubes were also used as required for evaluation and measurement of benzene gas presence and concentration.

Air quality conditions at each facility fluctuated significantly depending on the air temperature, the operation of other machinery and processing equipment in the vicinity of the oil crusher/sorting area and the general ventilation and air circulation at the facility.

At two of the facilities (M&R Environmental and Hetherington Industries) personnel were required to wear air purifying respirators due to the elevated levels of volatile organic compounds (VOCs) detected in the breathing space while working.

2.3.3 CHARACTERISATION OF DRUM CONTENTS

Classification and categorisation of the used oil filters and other materials received in the used oil filter drums was performed according to the sort-criteria prescribed by BCUOMA in the RFP.

The five major categories and five sub-categories are as follows:

- **Steel filters**
 - Less than 8 inches;
 - 8 to 24 inches; and
 - Greater than 24 inches.
- **Paper filters**
 - less than 8 inches; and
 - 8 to 24 inches.
- **Non-eligible filters**
- **Waste**
- **Free Product**

During the field study, it was observed that the three facilities categorised and crushed and/or disposed of certain filter types and waste material differently. The differentiations between filter categories included:

- treatment and disposal of paper filters in general;
- treatment and disposal of paper filters with steel inner tubes versus plastic inner tubes;
- treatment and disposal of the different transmission filters, (i.e. filters with two steel sides, two plastic sides, two paper sides or one side steel/one side plastic), and
- treatment of generic waste received, i.e. fabric waste (absorbent booms and spill pads), miscellaneous steel parts and aerosol cans.

Further description of the site-specific sorting and disposal processes at each of the three facilities is presented in the following Section.

2.4 FIELD OBSERVATIONS

General observations of the used filter crushing process at each of the facilities were recorded and noted during the field survey. The main difference between the processing facilities was the classification of 'crushable' and 'non-crushable' filter

materials, and consequently the amount of waste generated from the pre-crushing sorting.

All three facilities sorted the contents of the used filter drums prior to crushing, separating out all paper filters, certain transmission filters, oversized and/or non-eligible filters, aerosol cans, absorbent pads and general waste.

Typically, the amount of generic waste in each drum was negligible. During the field survey, it was noted that those drums that contained a significant amount of waste material appeared to have been pre-determined as such by the generator and that the non-filter materials were placed together in a particular drum unit. Generic waste included items such as old rags, oil spill absorbent pads and booms, oil filter packaging, plastic oil bottles, small miscellaneous vehicles parts, aerosol cans and, to a limited degree, 'generic' rubbish.

2.4.1 SITE-SPECIFIC SORTING AND CRUSHING SPECIFICATIONS

As detailed in Section 2.3.3, the crushing and disposal methods for the different filter types varied between the three processing facilities. The limitations and restrictions of the oil filter crusher were typically the deciding factor in the different crushing and disposal methods adopted by each of the facilities. At all three Sites, the crushing machines required careful and controlled filter loading and all three units experienced major blocks and stoppages during the survey period.

The following sections detail the site-specific filter categorisation criteria and 'crushability versus waste' assessment for each of the three facilities.

2.4.1.1 M & R ENVIRONMENTAL

Steel Filters: All regular steel oil filters from 0 to 24 inches in length are crushed.

Transmission Filters: Transmission filters with either one or two steel sides are crushed with the steel filters. Filters with two paper sides are crushed with the paper filters. Filters which were plastic on both sides are classified as general waste.

Paper Filters: All paper filters are sorted into separate bins and crushed separately from the steel filters to extract any free product. The crushed filters are then disposed. If the

paper filters have a wire mesh over top of the paper, these are classified as steel filters and are crushed with the steel filters.

Non-eligible Filters: All steel non-eligible filters are crushed with the steel filters and air filters are crushed with paper filters. Certain oversized filters (>18 inches) are classified as general waste and are not crushed due to their construction and/or material composition.

Waste: All fabric waste, i.e. absorbent booms, spill pads and any fabric rags are kept and 'spun' to recover any oil product. Plastic waste (i.e., old oil containers) is sorted for plastics recycling. Miscellaneous steel parts are sorted into the crushed filter bin.

2.4.1.2 NEWALTA

Steel Filters: All regular steel oil filters from 0 to 24 inches in length are crushed.

Transmission Filters: All transmission filters regardless of composition are classified as waste.

Paper Filters: Paper filters with either steel inner tubes or covered in wire mesh are crushed with the steel filters. Paper filters with plastic inner tubes are classified as waste.

Non-eligible Filters: All steel non-eligible filters are crushed with the steel filters. All other non-eligible filters (plastic) are classified as waste.

Waste: All rags, spill pads, absorbent booms, miscellaneous steel and plastic parts are classified as waste.

2.4.1.3 HETHERINGTON INDUSTRIES

Steel Filters: All regular steel oil filters from 0 to 24 inches in length are crushed.

Transmission Filters: Transmission filters with either one or two steel sides are crushed with the steel filters. Filters with both sides either paper or plastic are classified as general waste.

Paper Filters: Paper filters with steel inner tubes and/or are covered in wire mesh are crushed with the steel filters. Paper filters with plastic inner tubes are classified as waste.

Non-eligible Filters: All steel non-eligible filters are crushed with the steel filters. All other non-eligible filters (plastic) are classified as waste.

Waste: All fabric waste (i.e., absorbent booms) spill pads and any fabric rags are kept and 'spun' to recover any oil product. All other materials are classified as waste.

3.0 DATA INTERPRETATION AND STATISTICAL ANALYSIS

Primary categorisation and interpretation of the data was based on the regional location of the generator (source) of the drum of used oil filters. Oil filter drums from four BC regions were surveyed during the study (Lower Mainland, Kelowna, Prince George and Vancouver Island).

Interpretation of the trends and averages of the drum data collected was determined by evaluation of the raw arithmetic means for the various data categories. This method of evaluation determines the mean or average value by summing the data together and dividing by the sample size. This method does not take into account the normality of the data distribution curve.

4.0 RESULTS

Primary categorisation and interpretation of the data was based on the regional location of the generator (source) of the drum of used oil filters. Oil filter drums from four BC sub-regions were surveyed during the study (Lower Mainland, Kelowna, Prince George and Vancouver Island). Table 4.1 outlines the numbers and regional split of the survey sample set across these four sub-region locations.

4.1 GENERAL DRUM CHARACTERISTICS

Evaluation and analysis of the 45 gallon general drum characteristics are summarised in Table 4.1. These include: the total full drum weight, fullness of the drum, the weight of waste and the weight of free product in the drum.

The full drum weight of any given drum fluctuated significantly. The maximum drum weight recorded during the survey was 192 kg while the lightest was 39 kg.

The 'fullness' of the drums surveyed was relatively consistent. The majority of drums were between 90 to 100 percent full. Drums which were less full were typically those that contained larger filter sizes and therefore were more difficult to fill efficiently.

The volume of free product in the bottom of the drums had a considerable effect on the overall drum weight, individual filter weights and weight distribution of the drum contents. Both oil and paper filters which had been submerged in product (either diesel fuel or oil) weighed significantly more (up to 50 percent more) than non-saturated filters.

4.2 FILTER QUANTITIES AND CHARACTERISTICS

Tables 4.2 and 4.3 summarise the composition of the filter component of the drums of used oil filters. The filters are categorised and evaluated according to the prescribed BCUOMA filter classification system, as outlined in Section 2.3.3.

4.3 SECONDARY CATEGORISATION

During the field survey it was noted that the composition of the drums processed varied significantly. As a result of this varied drum composition, the data was also categorised

according to the predominant filter type identified in each drum. Table 4.4 outlines the drum numbers and split of the survey sample set across the different filter type classifications.

4.4 CATEGORISATION OF WASTE

Table 4.4 presents a summary of the waste received in the drums of used oil filters.

In order to more accurately depict the true mass of waste received, drums with waste were categorized into waste mass exceedance groupings (i.e., drums with over one, two and five kilograms of waste).

Evaluation of the average waste in a drum considering the facility-specific waste classification system (as described in Section 2.4.1) is summarised in Table 4.5. This evaluation considered that eligible BCUOMA filters that were being treated as waste were to be factored into the overall waste evaluation.

4.5 TYPICAL DRUM COMPOSITION

Table 4.6 summarises the typical drum composition as identified by the study. The drum composition is assessed in the three following formats:

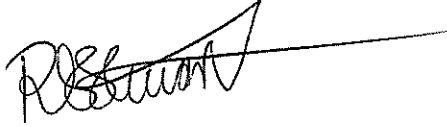
- the number of filter units in a typical drum;
- the weight distribution of the different categories; and
- percentage evaluation of the different categories.

A graphical representation of the drum composition (by mass) is presented on Figure 4.1.

4.6 RECOVERED PRODUCT: OIL AND STEEL

Table 4.7 presents an evaluation of the used oil and scrap steel recovery from each of the processing facilities. This assessment used a combination of survey sourced data and facility supplied data.

All of Which is Respectfully Submitted,
CONESTOGA-ROVERS & ASSOCIATES

A handwritten signature in black ink, appearing to read 'Roanna Stewart', with a long horizontal flourish extending to the right.

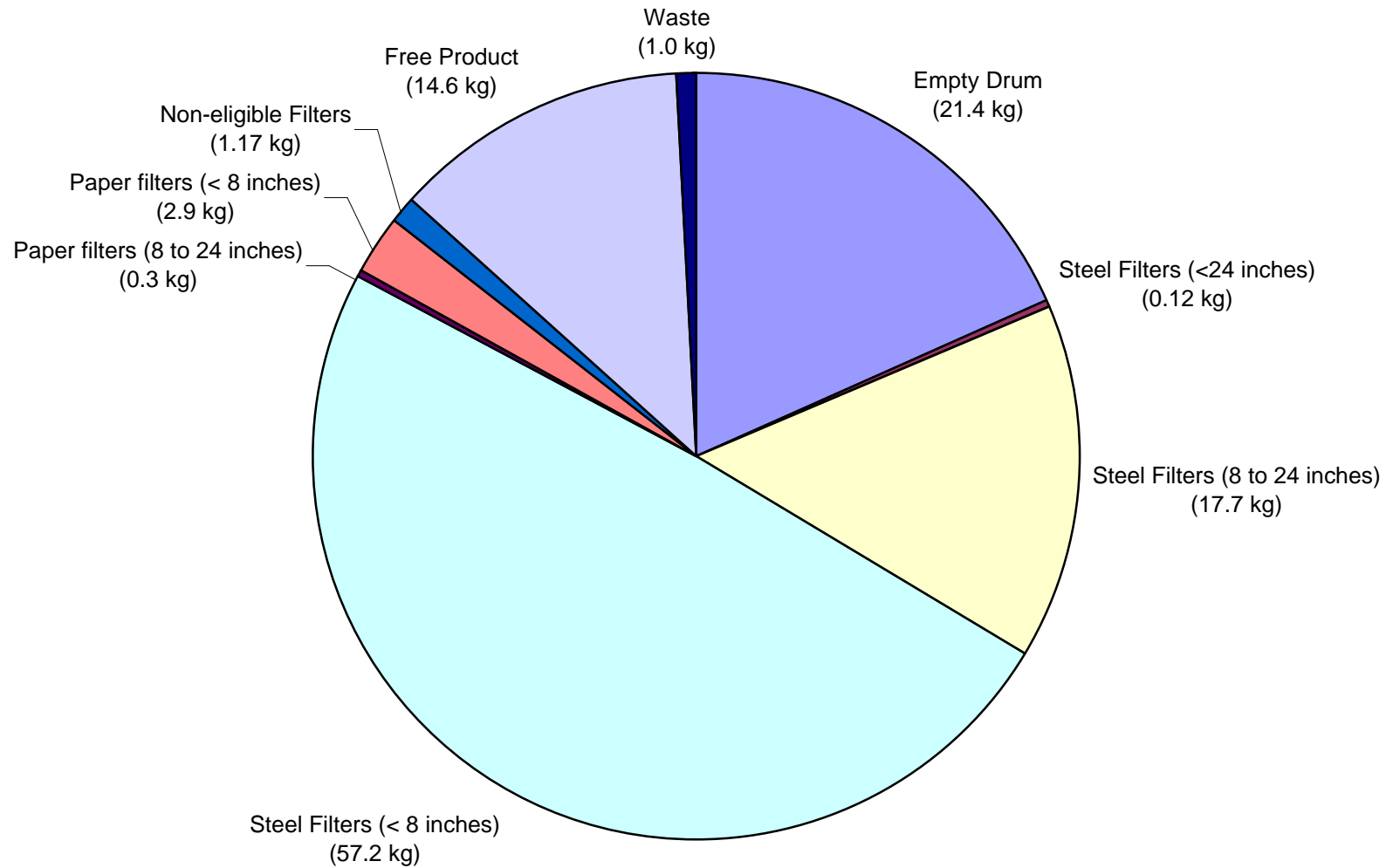
Roanna Stewart, B.E.

A handwritten signature in black ink, appearing to read 'Dave Marrow', with a long horizontal flourish extending to the right.

Dave Marrow, B.A. Sc.

FIGURES

FIGURE 1
TYPICAL DRUM COMPOSITION
USED OIL FILTER STUDY
BRITISH COLUMBIA USED OIL MANAGEMENT ASSOCIATION
BRITISH COLUMBIA, CANADA



TABLES

TABLE 4.1
GENERAL DRUM CHARACTERISTICS
USED OIL FILTER STUDY
BRITISH COLUMBIA USED OIL MANAGEMENT ASSOCIATION
BRITISH COLUMBIA, CANADA

	<i>ALL DRUMS</i>	<i>Lower Mainland</i>	<i>Kelowna</i>	<i>Prince George</i>	<i>Vancouver Island</i>
Number of drums surveyed	500	362	70	38	30
Mean full drum weight (kg) ⁽¹⁾	116	117	114	113	112
Mean fullness of drum (%) ⁽¹⁾	96	96	98	96	97
Mean weight of waste (kg) ⁽¹⁾	1.04	0.89	1.08	2.32	1.11
Mean weight of free product (kg) ⁽¹⁾	15	16	10	16	11

Notes:

⁽¹⁾ Calculated as the raw arithmetic mean (i.e. the sum of all the drums divided by the sample size).

TABLE 4.2
FILTER QUANTITIES
USED OIL FILTER STUDY
BRITISH COLUMBIA USED OIL MANAGEMENT ASSOCIATION
BRITISH COLUMBIA, CANADA

	TOTAL NUMBER OF FILTERS	MEAN NUMBER OF FILTERS PER DRUM ⁽¹⁾				
		<i>ALL DRUMS</i>	<i>Lower Mainland</i>	<i>Kelowna</i>	<i>Prince George</i>	<i>Vancouver Island</i>
All Filters	80,544	161.1	171	143	126	129
Steel Filters (Total)	71,655	143.3	153	124	112	116
Steel Filters (< 8 inches)	65,571	131.1	140	115	97	107
Steel Filters (8 to 24 inches)	6,063	12.1	13	9	15	9
Steel Filters (> 24 inches)	21	0.04	0.06	0.0	0.0	0.0
Paper Filters (Total)	6,033	12.1	13	7	11	9
Paper Filters (< 8 inches)	5,840	11.7	13	7	10	8
Paper Filters (8 to 24 inches)	193	0.4	0.4	0.2	0.4	1
Non-Eligible Filters	2,851	5.7	5	12	3	4

Notes:

⁽¹⁾ Calculated as the raw arithmetic mean (i.e. the sum of all the drums divided by the sample size).

TABLE 4.3

FILTER UNIT WEIGHT ⁽¹⁾
USED OIL FILTER STUDY
BRITISH COLUMBIA USED OIL MANAGEMENT ASSOCIATION
BRITISH COLUMBIA, CANADA

	<i>ALL DRUMS</i>	<i>Lower Mainland</i>	<i>Kelowna</i>	<i>Prince George</i>	<i>Vancouver Island</i>
Steel Filters (< 8 inches)	0.436	0.412	0.533	0.472	0.529
Steel Filters (8 to 24 inches)	1.468	1.376	1.749	1.726	1.839
Steel Filters (> 24 inches)	2.929	2.929	N/A	N/A	N/A
Paper Filters (< 8 inches)	0.247	0.225	0.381	0.227	0.411
Paper Filters (8 to 24 inches)	0.775	0.705	0.643	1.531	0.750
Non-Eligible Filters	0.206	0.249	0.117	0.229	0.142

Notes:

- ⁽¹⁾ Calculated as the raw arithmetic mean (i.e. the sum of all the drums divided by the sample size).
N/A The mean could not be determined as no filters of this type were recorded in this sub-region.

TABLE 4.4

**DRUM CLASSIFICATION: PREDOMINANT FILTER TYPE ⁽¹⁾
USED OIL FILTER STUDY
BRITISH COLUMBIA USED OIL MANAGEMENT ASSOCIATION
BRITISH COLUMBIA, CANADA**

<i>Drum Classification</i>	<i>Number</i>	<i>Mean Full Drum Weight (kg)</i>	<i>Mean Number of Filters Per Drum</i>	<i>Mean Weight of Waste (kg)</i>	<i>Mean Weight of Free Product (kg)</i>
All Drums	500	116	161	1.0	15
Drums of steel filters <8 inch ⁽²⁾⁽³⁾	287	130	229	1.0	16
Drums of steel filters >8 inch ⁽²⁾⁽⁴⁾	123	96	52	1.0	13
Drum of steel filters - mixed sizes ⁽²⁾⁽⁵⁾	72	101	71	1.4	13
Drums of Paper Filters ⁽⁶⁾	3	76	211	0.3	9
Drums of Non-Eligible Filters ⁽⁷⁾	2	53	7	53	1
Drums of Steel/Paper Filter Mix ⁽⁸⁾	12	110	216	0.2	9
Drums of Steel/Non-Eligible Filter Mix ⁽⁹⁾	1	73	52	0.0	13

NOTES:

- (1) 'Mean' calculated as the raw arithmetic mean (i.e. the sum of all the drums divided by the sample size).
- (2) At least 60% of the filters are steel (by number).
- (3) Steel Filter Drum: At least 70% of the filters are <8 inch (by weight).
- (4) Steel Filter Drum: At least 70% of the filters are >8 inch (by weight).
- (5) Steel Filter Drum: Approximate equal mix of filter sizes (by weight).
- (6) At least 60% of the filters are paper (by number).
- (7) At least 60% of the filters are non-eligible (by number).
- (8) Approximately equal mix of paper and steel filters (by number).
- (9) Approximately equal mix of steel and non-eligible filters (by number).

TABLE 4.5

**CATEGORIZATION OF WASTE
USED OIL FILTER STUDY
BRITISH COLUMBIA USED OIL MANAGEMENT ASSOCIATION
BRITISH COLUMBIA, CANADA**

GENERAL WASTE

Average weight of waste per drum (kg)	1.04
Maximum weight of waste (kg)	28
Drums with over 1 kg of waste (%)	17.2
Drums with over 2 kg of waste (%)	13.6
Drums with over 5 kg of waste (%)	4.8

CALCULATED WASTE PER DRUM	<i>M&R</i>	<i>NEWALTA</i>	<i>HETHERINGTON</i>
Average weight of general waste per drum (kg)	1.0 ⁽¹⁾	1.1	1.1
Average weight of paper filters (kg)	- ⁽²⁾	2.3	3.2
Average weight of transmission filters (kg)	- ⁽³⁾	0.29	- ⁽³⁾
Total average weight of waste per drum (kg)	1.0	3.7	4.3

Notes:

- (1) Does not take into account the weight of the oil recovered in the spill cloths that are 'spun' for oil recovery.
 (2) Does not take into account the weight of the paper filters disposed post-crushing.
 (3) Transmission filters are processed with the regular steel filters at this facility.

TABLE 4.6

**TYPICAL DRUM COMPOSITION
USED OIL FILTER STUDY
BRITISH COLUMBIA USED OIL MANAGEMENT ASSOCIATION
BRITISH COLUMBIA, CANADA**

	NUMBER ⁽¹⁾	WEIGHT (KG) ⁽²⁾	WEIGHT (%) ⁽³⁾
Total Weight		116.4	
Empty Drum	-	21.4	18
Steel Filters (total)	143.3	75.0	64
- Steel Filters (< 8 inches)	131.1	57.2	49
- Steel Filters (8 to 24 inches)	12.1	17.7	15.2
- Steel Filters (<24 inches)	0.04	0.12	0.11
Paper Filters (total)	12.1	3.2	2.7
- Paper filters (< 8 inches)	11.7	2.9	2.5
- Paper filters (8 to 24 inches)	0.39	0.30	0.26
Non-eligible Filters	5.7	1.17	1.0
General waste	-	1.0	0.9
Free Product	-	14.6	13
Total eligible BCUOMA filters (steel and paper)	155	78.2	1
Total eligible BCUOMA paper filters	12	3.2	0

Notes:

- ⁽¹⁾ Number of filters in an 'average' drum.
- ⁽²⁾ Weight of each type of filter in an 'average' drum.
- ⁽³⁾ Weight of each type of filter in an 'average' drum, evaluated as a percentage of the total drum weight.

TABLE 4.7

**RECOVERED PRODUCT: OIL AND STEEL
USED OIL FILTER STUDY
BRITISH COLUMBIA USED OIL MANAGEMENT ASSOCIATION
BRITISH COLUMBIA, CANADA**

	<i>M&R</i>	<i>NEWALTA</i>	<i>HETHERINGTON</i>
<i>Oil Recovery:</i>			
Average volume of free product recovered per drum (litres) ⁽¹⁾⁽²⁾	16.5	14.4	9.5
Average volume of product recovered during crushing (litres) ⁽³⁾	25.5	19.0	9.8
<i>Steel Recovery:</i>			
Average weight of 'crushable' filters 'pre-crushing' (kg) ⁽¹⁾⁽⁴⁾	76	77	77
Average weight of crushed steel generated per drum (kg)	50.2	57.6	67.4

Notes:

(1) Data collected during the study

(2) Assumes 1 kg of product = 1 litre of product

(3) Calculated from data obtained from the Processing Facility Records

(4) 'Crushable' filters included all steel filters and non-eligible filters