Requirements for the Collection, Transportation, Storage, Handling and Treatment of Household Cooling and Freezing Appliances containing CFC, HCFC or HFC

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1. Objective

The objective of these requirements is to ensure:

- the non-polluting separation of household cooling and freezing appliances in fractions, for material recycling or energy recovery;
- the environmentally sound disposal of CFC, HCFC and HFC ("controlled substances") [1].This means the destruction of ozone depleting substances in accordance with Regulation (EC) No 2037/2000 on substances that deplete the ozone layer, such as CFC and HCFC, and the destruction of climate endangering compounds such as HFC and also CFC and HCFC.
- safe treatment of HC [3]. Precise requirements for treatment of HC is described in the document "Requirements for the Collection, Transportation, Storage and Treatment of Cooling and Freezing Appliances containing Hydrocarbons (HC)" [11].

This document follows the legal requirements concerning monitoring, recycling and recovery targets according to the Directive 2002/96/EC or corresponding national regulations, monitoring of "controlled substances" as recovered for destruction and implement a regular performance verification test procedure carried out by an independent auditor (see chapter 6, Annex 1).

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[1] In this paper CFC, HFC, HCFC are summarized as "controlled substances":
CFC - Chlorofluorocarbon (e.g. R12, R11), HCFC Hydrochlorofluorocarbon (e.g. R22, R141b) and HFC - Hydrofluorocarbon (e.g. R134a)). CFC and HCFC are ozone depleting substances and have a high global warming potential (GWP) while HFC do not deplete the ozone layer but have a significant global warming potential.

Clarification: CFC, HCFC, HFC and HC are all VOC´s – Volatile Organic Compounds, however in some documents and specifications the term “VOC” is incorrectly used to refer only to HC.

2. General Requirements

The requirements apply to the separation of “controlled substances” from household cooling and freezing appliances for destruction. Dismantling and treatment is performed in two steps. Step 1 for taking “controlled substances” and oil out of the cooling circuits and step 2 for the extraction of “controlled substances” from the insulation foam for destruction and the separation of recyclable and recoverable material (metals, glass, plastics, cables, etc.).

Overall the document consists of a set of minimum requirements concerning:

- Collection, storage, transport and handling;
- Recovery and destruction of controlled substances;
- Use of output fractions (recovery and recycling targets of 80% and 75% respectively, these targets as according to Directive 2002/96/EC or future amended versions);
- Safety measures for equipment or parts of equipment [2] containing unidentified gases to secure that all equipment or parts of equipment containing any kind of HC [3]are treated adequately;
- Quality assurance (monitoring and reporting);
- Inspection and control.

Other legal requirements like dismantling of Hg-switches [4], PCB [5] containing capacitors, NH_3-water-chromate [6] mixtures or requirements derived from the explosion potential of HC [7], [8] are herewith mentioned only, but not described in-depth.

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[2] Equipment or parts of equipment, for example loose parts such as doors, of which the presence of a gas or the gas-content cannot unambiguously be ascertained.

[3] HC - Hydrocarbons (e.g. Propane, Butane, Cyclopentane, Iso-Butane and Iso-Pentane).

[4] Hg - Mercury

[5] PCB - Polychlorinated Biphenyls

[6] NH_3 - Ammonia

[7] Directive 94/9/EC on the approximation of the laws of the Member States concerning equipment and protective systems intended for use in potentially explosive atmospheres

3. Collection, storage, transportation and handling

1) Sorting of types of cooling and freezing appliances [9] shall take place at the treatment plant.
2) Sorting of types of cooling and freezing appliances for end of life treatment in advance of the treatment process shall be performed by, and supervised by, trained personnel and in accordance with the treatment requirements of cooling and freezing appliances.
3) The signatories of this document commit to not allowing in their contracts with collection points, or with any party collecting appliances, to pre-sort types of cooling and freezing appliances for end of life treatment purposes.
4) Collection, storage, transport and handling of cooling and freezing appliances shall be done carefully to avoid damage of the appliances and leakage of controlled substances. If oil leakage is recognized, appropriate measures shall be taken to minimize environmental impacts.
5) All sites for storage and treatment shall at least be in line with the technical requirements of Annex III of Directive 2002/96/EC.
6) As for storage, transport and handling also the treatment of cooling and freezing appliances require precautionary protective measures due to the flammability of hydrocarbons. Places where hazardous explosive atmospheres may occur shall be especially designated. Furthermore, the ban on ignition sources and the ban on entering by unauthorized persons shall be indicated (Annex III of Directive 2002/96/EC). Nonobservance should be punished.
7) Transports optimisation is allowed as long as the initial size of the cooling and freezing appliances, including cabinets, is not reduced and good condition of the appliances is ensured.
8) All sites shall demonstrate that they are secured against unauthorised access.
9) The “controlled substances” separated shall be carefully stored, handled and transported to avoid any emissions before destruction.

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[8] Directive 1999/92/EC on minimum requirements for improving the safety and health protection of workers potentially at risk from explosive atmospheres (15th individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC)

[9] “Types” of appliances are distinguished in CFC, HCFC, HFC, HC or NH_3 containing appliances.

4. Requirements concerning treatment and output quality

All cooling and freezing appliances and parts thereof which are not clearly identified as HC-type, either concerning refrigerant or foaming agent, must be treated as CFC, HCFC and HFC-type ones [10] [11]. Therefore treatment facilities for all types of appliances shall comply with explosion protection measures as stated in the Directive 1999/92/EC.

Separated “controlled substances” [1] shall be destroyed by a suitable thermal or chemical process. The destruction shall be proven by corresponding documents (e.g. bill, delivery sheet).

The treatment process of end of life cooling and freezing appliances is usually performed in two steps:

4.1. Step 1: CFC, HCFC, HFC and unidentified gases [2], Oil and compressor

1) All liquids that contribute to a contamination of separated fractions during, or after, the treatment process, shall be removed.
2) All refrigerants shall be separated from oil.
3) The amount of CFC, HCFC and HFC separated from cooling circuits shall be equal to, or higher than 90% of the expected amount (see Annex 1) of these substances.
4) The compressor oil with less than 0.2% total halogen content [12] may be used for material recycling or in normal incinerators, provided national regulation permit this procedure.
5) The compressor oil with more than 0.2% total halogen content shall be treated only in thermal processes for the safe destruction of “controlled substances” [1].
6) Compressors shall not be re-used.

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[10] For clearly identified HC cooling and freezing appliances please follow the “Requirements for the Collection, Transportation, Storage and Treatment of Cooling and Freezing Appliances containing Hydrocarbons (HC)” published in October 2006 by WEEE-Forum, CECED and EERA.
[11] Including also loose parts, delivered to the treatment plants (e.g. doors).
[12] With a refrigerant of CFC, HCFC, HFC there will be a halogen (e. g. fluor and chlor) content in the compressor oil. For example 0.2 % total halogen content in the compressor oil corresponds to 0.18 % R12.

4.2. Step 2: CFC, HCFC, HFC, and unidentified gases, PU [13]

1) The treatment of appliances in step 2 shall be carried out with step 1 treated appliances only (called “cabinets”).
2) The amount of CFC, HCFC, and HFC separated from the PU-foam shall be equal or higher than 90% of the expected amount (see Annex 1) of these substances.
3) After treatment PU-fractions shall contain not more than 0.2 % CFC, HCFC, and HFC.
4) It has to be guaranteed that the PU-residues (contained in the metal and plastic fractions separated for use as secondary raw material) are minimised to avoid losses of “controlled substances” [1]. Therefore, residues of PU contained in the ferrous and the nonferrous-metal fraction are to be kept below 0.3%; residues of PU contained in the plastic fraction are to be kept below 0.5 %.

4.3. Recycling and Recovery aspects

Cooling and freezing appliances and components, materials and substances that are processed as described above, are expected to fulfil the requirements of the Directive 2002/96/EC, in order to achieve a rate of recovery of at least 80% and a recycling rate of at least 75% by weight per appliance [14].

5. Requirements concerning Quality Assurance

1) Treatment companies for cooling and freezing appliances shall use state-of-the-art technology [15] to reach the required targets and follow accepted environmental practises for the separation of controlled substances.
2) Treatment companies for cooling and freezing appliances shall have a certified ISO 9001:2000 and ISO 14001, or equivalent audited quality management system in place, which also includes treatment processes and in-house monitoring.

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[13] PU: abbreviation for polyurethane, used as isolation material in cooling and freezing appliances, expanded with either CFC, HFC, HCFC or HC

[14] Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment (WEEE) or corresponding national regulations

[15] “State-of-the-art technology” means, that the installation allows the recovery of “controlled substances” as well as the removal of Cyclopentane and fulfils the requirements according to chapter 4.

3) In addition to the usual controlling and documentation performed by the quality system, treatment companies are requested to keep operation journals which register all incoming cooling and freezing appliances according to types and categories [16] and all the outgoing materials and the controlled substances (see chapter 6).

6. Requirements for the annual data reporting (monitoring and records)

Annual reports with the following compiled information have to be prepared. These reports should include:

- Number, type and category of appliances as input to step 1 (separation of oil and refrigerants);
- A distinction between intact [17] and damaged/empty [18] appliances;
- Number, type and category of step 1 treated cabinets;
- Evidence (invoice, delivery sheet) on the amount of “controlled substances” [1] delivered for destruction out of step 1 and 2 separately considering the amounts on stock at the beginning and at the end of the year;
- Residual concentration of ”controlled substances” in PU fraction;
- Residual concentration of “controlled substances” in oil;
- Residual concentration of PU at metal and plastic fractions;
- Point of delivery and technologies used for ‘final fractions’ delivered to final treatment technologies;

7. Inspection and Control

The quantity of separated liquids and fractions and their forwarding destination shall be documented in compliance with monitoring requirements of the national

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[16] “categories” of cooling and freezing appliances describe different sizes:
- category 1: domestic refrigerators (up to 180 l - usually one door)
- category 2: domestic combined fridge-freezers (up to 350 l - usually two doors),
- category 3: domestic freezers (chest or cabinet, less than 500 l).

[17] Intact could mean a cooling circuit still under pressure

[18] A damaged cooling circuit still contains some oil.

implementations of Directive 2002/96/EC on waste electrical and electronic equipment (WEEE).

1) Compliance with the quality requirements (see chapter 5) will be decided by responsible take-back parties [19] that take back WEEE and with which treatment facilities have established contracts
2) It is recommended that an independent organisation with adequate knowledge of the treatment processes of cooling and freezing appliances will make annual inspections to control the following points:

   - Publication of annual report and all the records of treated cooling and freezing appliances and removed controlled substances and/or cabinets (see chapter 6);
   - The capability of the treatment company to comply with requirements put forward in this document;
   - Compliance with environmental legal and other requirements (permits, storage area etc.).

3) A regular performance verification test, for installations step 1 and step 2 treatment steps as described in the Annex 1 of this document should be carried out regularly by independent auditors with proven knowledge about the testing of cooling and freezing appliances treatment installations.

   3.1) A performance verification test shall be implemented not later than three months of operating under the contract with the take back party. A performance verification test shall be also done after installation and starting up of any new equipment or after relevant changes to treat step 1 and/or step 2 or the move and re-installation of old equipment at an other site.

   3.2) To secure that the requirements are met continuously, performance verification tests shall be made within appropriate time frames. The frequency of verification tests shall be determined by risk assessment and specified in the contract between the take back party and the treatment facility.

   3.3) If a performance verification test demonstrates that the treatment installation does not fulfil the requirements, the take back parties shall be informed. In this case the treatment facility shall stop its operations and shall take appropriate corrective measures and a new performance test shall be performed in accordance to 7.3.1.

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[19] Responsible take back parties usually are take back systems (WEEE Compliance Schemes), but could also be producers (e.g. Germany) or B2B take back.

8. Revision of the requirements

The requirements presented in this paper are based on practices and best available technologies of today. It may be that new and better practices and technologies will emerge in the next 5 to 10 years. The signatories commit to reviewing the requirements document after a period of 5 years or when new developments make a revision necessary.

Annex 1

Performance Test Recycling Step 1

The determination of the degree of recovery as a percentage of the expected amount controlled substances for destruction in recycling step 1 can be achieved in two alternatives. Tests should be carried out with appliances containing CFC only.

Following input data:
In a 100 unit test of appliances with intact cooling circuits and identification plates every single appliance is weighed before and after the treatment and the separated CFC and oil is compared with the total amounts filled in according to the identification plates. Those appliances which are recognized as defective should be sorted out. Likewise during the entire test observations with visible CFC and oil losses, water and material losses which affect the mass balance must be noted.

The following recordings are available after the test:

- total weight CFC (**A**) and oil (**B**) in kg
- total weight of the CFC amount in accordance with indications on the identification plate (**C**)
- total weight reduction (**D**) of all sucked off appliances in kg
- amount of defective appliances or appliances with losses, which affect the mass balance. Comparison of the weight reduction of each appliance with the expected amount of weight reduction (CFC and oil) can indicate defective cooling circuits. Decisions on defective circuits have to be taken in order to get plausible figures for the mass balance

The following results with consideration of the number of defective appliances or other observations are determined:

Mass balance: The relationship between (**A + B**) to (**D**) is a measure for the entire plant achievement concerning mass recovery. Results more largely than 0.97 are considered as tolerable values.

CFC recovery: 1) The relationship between (**A**) to (**C**) is a measure for the installation performance concerning CFC recovery. The result may not fall below 0.9 (=90 %). 2) The relationship between (**A**) to (**D - B**) is a measure for the installation performance concerning CFC recovery. The result may not fall below 0.9 (=90 %).

CFC per appliance: The relationship (**A**) to the number of intact appliances supplies the amount of CFC per appliance. A typical result is more largely 115 g per appliance.

Oil per appliance: The relationship (**B**) to the number of oil containing appliances supplies the amount of oil per appliance. A typical result is more largely 240 g per appliance.
Portion of defective appliances: The number of defective appliances according to experience lies between 10 and 20 %.

Following output data:
At least 1'000 appliances with intact cooling circuits [1] containing CFC are treated according to the used procedure and technology. Oil and CFC are separated. The cylinder for taking the CFC is weighed before operation begins and again when the operation is complete. The weighed amount in kilograms is divided by the number of compressors. The CFC recovered in grams per compressor is determined. The result shall not be lower than the 90% level of expected CFC [2].

Performance Test Recycling Step 2

The determination of degree of recovery as a percentage of the expected amount of controlled substances for destruction in recycling step 2 can be achieved in two alternatives. Tests should be carried out with at least 1000 appliances containing CFC only in their insulation foams.
The PU output fraction and the CFC fraction of 1’000 appliances are weighed.

The containers made available to take the CFC are weighed empty before beginning of work and with filling after ending the work. The weighing result in kg CFC (without water!!!) is divided by the number of appliances. As a result the CFC amount in gram per appliance is determined (value = **A**).

During the treatment of the appliances several samples of the PU output fraction to a total weight of approximately 1 kg have to be sampled and manually divided into its PU and non-PU part (styropor, wood etc).

The PU plastic part corresponds to 91.5% (=100%-8.5% for the amount of CFC) of the corresponding PU foam input. Part of the CFC is still remaining in the PU plastic part what is called the matrix content and part of it is recovered as condensed fluid. So the expected total amount of CFC considering also the amount analysed in the

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[1] 1'000 compressors
[2] Each country has to determine the expected amount according to their experience of the mix of size of compressors. In most of the European countries this value is 115 g R12 per compressor. HFC containing appliances should not be part of this performance test.

matrix can be calculated. The PU part of the fraction is sent to a laboratory to analyse the content of CFC in the matrix.
The total amount of CFC recovered (condensed and matrix part) for destruction shall be 90% of the expected and calculated amount [3].

Following input data:
The procedure when determining the CFC quantities in grams per appliance is according to the category of appliance:

category 1: domestic cooling appliances (up to 180 l),
category 2: domestic combined cooling& freezing appliances (180 l to 350 l),
category 3: domestic freezing appliances (chest or cabinet, less than 500 l).

The following benchmark values, depending on the category of appliance, are to be met when separating CFC:

Appliance category 1: 240 g CFC per appliance
Appliance category 2: 320 g CFC per appliance
Appliance category 3: 400 g CFC per appliance

The minimum amount of recovery for CFC for destruction has to be calculated according to the mix. In case of the 60/25/15% mix it should be not below 283 g/unit [4]. On the basis of the actually available mix of appliances, the expected rate of CFC recovery (**M**) according to the following formula is calculated:

M g/appliance = (X % appliances cat1 x 240 g/appliance) + (Y % appliances cat2 x 320 g/appliance) + (Z % appliances cat3 x 400 g/appliance)

Following output data:

The amount of PU fraction (**P**) in kg is determined as follows:

With a suitable method of analysis the portion of foreign material in the recovered PU fraction in kg is determined (**a**).
The by an external laboratory determined remaining amount of CFC (in kg) in the matrix of the PU structure is assigned with **b**

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[3] Each country has to determine the expected amount according to their experience of the mix of size of appliances. In most of the European countries this value is 314.5 g CFC per appliance.
[4] Based on the following assumption: 3.7 kg PU per appliance, 8.5% CFC => 314.5 g → 90% = 283 g per appliance.

The amount of the pure PU fraction (PU fraction minus amount foreign material minus matrix content CFC in kg still in the foam is determined (**P-a-b**) = result = **c** kg of PU.

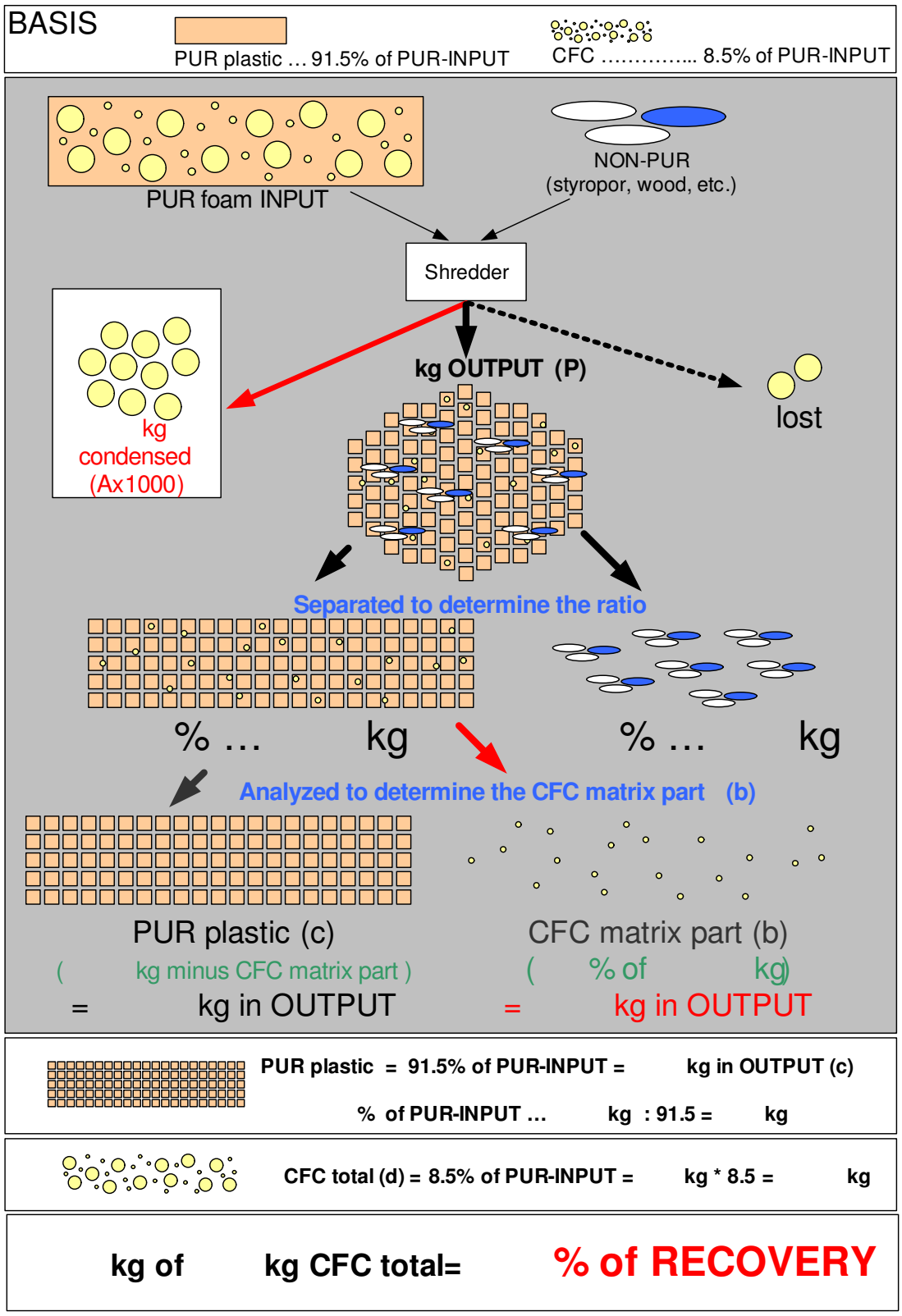
The amount of PU calculated by **c** corresponds to 91.5 % of the origin material (91.5 % PU/8.5 % CFC). Thus with the formula ((**c** x 100/91.5) - **c**)) the amount of the original loading of CFC in the PU as an output fraction can be calculated. Result = **d** kg CFC

All possible losses of PU are determined and evaluated (remaining PU adhering at Fe-metals, at NE-metals, at plastics and at other output materials). Result = **e** kg CFC

The efficiency on the basis of the yielded PU-fractions is calculated with the following formula: Recovery rate = sum(**A**x1000)/sum(**d + e**)

The efficiency on the basis of the brought in input-mix can be calculated with the following formula: Recovery rate = sum(**A**x1000)/sum(**M**x1000)

The following drawing is visualising the conditions with PU and CFC.


BASIS
PUR plastic … 91.5% of PUR-INPUT
CFC …….. 8.5% of PUR-INPUT
PUR foam INPUT
NON-PUR
(styropor, wood, etc.)
Shredder
kg OUTPUT (P)
lost
kg
condensed
(Ax1000)
Separated to determine the ratio
% … kg
% … kg
Analyzed to determine the CFC matrix part (b)
PUR plastic (c)
(kg minus CFC matrix part)
= kg in OUTPUT
CFC matrix part (b)
(% of kg)
= kg in OUTPUT
PUR plastic = 91.5% of PUR-INPUT = kg in OUTPUT (c)
% of PUR-INPUT … kg : 91.5 = kg
CFC total (d) = 8.5% of PUR-INPUT = kg * 8.5 = kg
kg of kg CFC total= % of RECOVERY