AMBOSO
Air Depuration & Combustion Plants

CFC DEPURATION PLANT
APPLIED AT
DISPOSAL REFRIGERATORS PROCESS

TECHNICAL PRESENTATION

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1 - CFC (chlorofluorocarbon)

A **chlorofluorocarbon** (**CFC**) is an organic compound that contains only carbon, chlorine, and fluorine, produced as a volatile derivative of methane, ethane, and propane. They are also commonly known by the DuPont brand name **Freon**. The most common representative is dichlorodifluoromethane (R-12 or Freon-12). Many CFCs have been widely used as refrigerants, propellants (in aerosol applications), and solvents. Because CFCs contribute to ozone depletion in the upper atmosphere, the manufacture of such compounds has been phased out under the Montreal Protocol, and they are being replaced with other products such as HFCs (e.g., R-410A), hydrocarbons, and CO2. However, these replacements are sometimes considered pollutants in their own right.

2 - DISPOSAL REFRIGERATORS PROCESS

Disposal of abandoned refrigerators is an important aspect in the field of disposal of durable goods.

Disposal of refrigerators consists of their disassembly (mainly the blower / motor from the shell), after this operation the process is mainly divided in three steps.

Step 1 treatment
1) All refrigerants and all oil shall be removed from the refrigerating system;
2) All refrigerants shall be separated from oil;
3) All oil shall be contained within a closed system until the concentration of refrigerant is below 0,2 % w/w VFC;
NOTE The VFC content should be measured and expressed as concentration of R12 in the oil.
4) No residual VFC within the oil shall be allowed to be released to the atmosphere;
5) The total mass of refrigerants removed from the refrigerating system (sum of VHCs and
VFCs) shall be monitored and documented continuously.

Step 2 treatment
The cabinet is made with polyurethane foam, sheet metal and plastics, while shredding everything is chopped and you have the release of gases that were used to expand the polyuretan.
The current construction methods use cyclopentane as expanding gas, but in the past CFC's (chlorofluorocarbons) have been widely used.
Up till this day 70% of refrigerators to be disposed contains polyurethane foams expanded with CFC's.

1) The treatment of appliances in step 2 is normally carried out with step 1 treated appliances (called “cabinets”);

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2) Insulating foam shall not be manually removed;
3) The crushing of cabinets and the separation of crushed fractions shall be performed in a way so that emissions of VFCs and VHCs to the atmosphere are minimised according to national legislation;
4) The residual content of VFCs contained in the separated metal and plastics fractions shall be minimised;
5) The residual VFCs within the crushed insulating foam shall not be released to the atmosphere. They shall be converted into compounds that do not deplete the ozone layer;
6) The total mass of blowing agent (sum of VHCs and VFCs) removed from the insulating foam shall be monitored and documented continuously.

Step 3 treatment
Where the VFCs are being converted on site into compounds that do not deplete the ozone
layer, continuous recorded input data for raw gas and output data for clean gas shall be monitored and documented continuosly.

3 - CFC DEPURATION PLANT

AMBOSO has developed a system in order to purify gas emissions containing CFC.

3.1 - Process description

Basically, technology applied in this system is “combustion technology”.
This system is mainly applied at STEP 2 (cabinet shredding) but it can also applied to disposal CFC gas from STEP 1.

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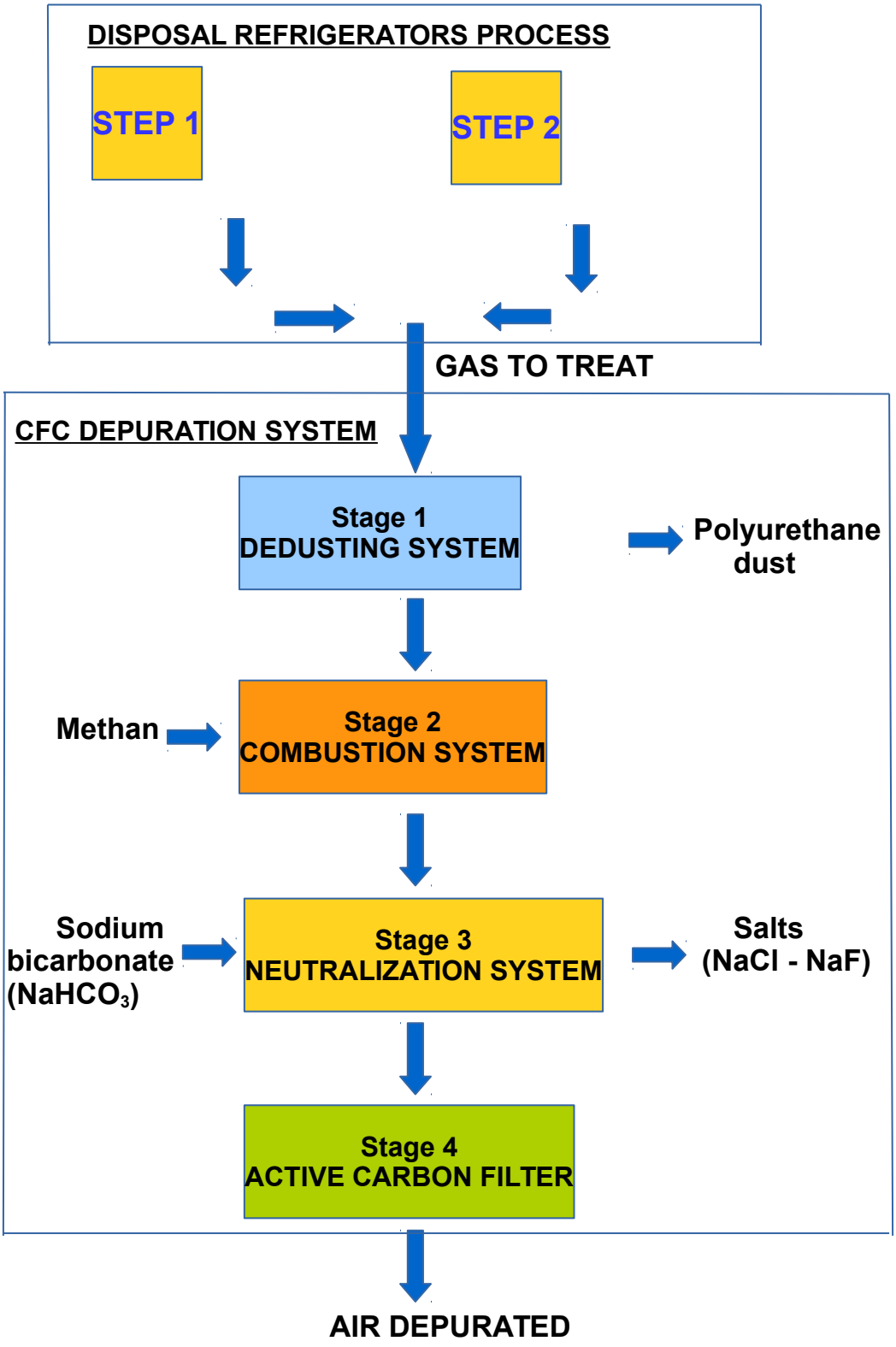
Purification process has four depuration stage.



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Stage 1
Dedusting system, gas sucked from shredder have inside some dust (mainly polyuretan dust), before to treat this gas is important remove all dust.

Stage 2
Combustion system, gas from stage 1 is completely oxidated inside a combustion chamber.
Following is possible to see chemical oxidation reaction(1) inside combustion chamber:

$$CCl_2F_2 + O_2 + 2H_2O \Rightarrow 2HCl + 2HF + CO_2$$

From oxidation (combustion) reaction chloride acid (HCl) and hydrofluoric acid (HF) are formed.
These compounds cannot be emitted into atmosphere, consequently gas with these compounds must be treated.

(1): in the example is used dichlorodifluoromethane (R12) because it's one of more common CFC, however CFC oxidation reactions are all similar.

Stage 3
Goal of Stage 3 is depurate gas from chloride acid and hydrofluoric acid.
Process applied in this depuration stage is a technology commonly well-known as Neutrec Process.
Neutrec is a neutralization reaction, it consists to create contact between gas with acids and basic compound (sodium bicarbonate).

Following is possible to see neutralization chemical reactions:

$$NaHCO_3 + HCl \Rightarrow NaCl + H_2O + CO_2$$

$$NaHCO_3 + HF \Rightarrow NaF + H_2O + CO_2$$

These two reaction form two salts, sodium chloride (NaCl) and sodium fluoride.
The salts are generally stocked in big-bags.

Stage 4
Last depuration stage is a active carbon filter.
Active carbone filter is used as “guard filter”.

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3.2 - Devices description

Depuration system consists of four depuration stages in series, constituted respectively by:
• bag filter as the first stage of reduction of dry powders of polyurethane derived from the shredding process;
• regenerative combustion plant with three towers is the second stage to remove the volatile organic compounds;
• gas/solid reactor and bag filter as third depuration stage, in this stage hydrochloric acid and hydrofluoric acid (generated by CFC's combustion) are removed with sodium bicarbonate;
• the final depuration stage is a active carbon filter.

FIRST FILTRATION STAGE
The first depuration stage consists of a bag filter, dusty air enters into the filter and crosses the sleeves from outside to inside.
The sleeves are cleaned with compressed air, cleaning cycle is commanded by a special electronic control unit.
The polyuretan dust is discharged into a container below the filter.

SECOND FILTRATION STAGE
After the first stage of depuration fume enters in the second stage of reductions, the three towers regenerative combustion system.
This combustor is composed of a combustion chamber and three preheating towers able to preheat air and to recover energy, the system is made of carbon steel and coated internally with ceramic fiber of suitable thickness and density.
The preheating/recovery towers are filled with inert ceramic material of high quality which form three distinct masses of high thermal capacity.
The operation of the system is cyclical, and uses either the heat capacity of three ceramic beds to heat the entering gas and to recover heat from the leaving gas.
The entering gas is preheated at the expense of the heat accumulated in the ceramic bed and due to oxidation of the VOC in the combustion chamber, in the combustion chamber there is a burner that provides the calories necessary to complete the SOV oxidation
and ensure a temperature above 950 ° C.
Due to the permanence of smoke to that temperature for a period larger than 1 second, the organic substance is completely oxidized to form carbon dioxide, water,
hydrochloric acid and hydrofluoric acid.
Leaving the combustion chamber the purified air passes through a ceramic bed relatively cooler, and gives it most of its heat content.At regular intervals of 60 / 90

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seconds, the direction of flow of gas in the combustion chamber is reversed so that the three
ceramic beds exchange the function of preheating and recovery.
The airflow always impinges two ceramic beds, while the third is on standby.
The tower placed on stand-by contains polluted air so, to drain this tower is sucked enviromental air.
This design allows achieving a continuity in the results of VOC removal, also when changing the valves.

THIRD FILTRATION STAGE
CFC's combustion generates hydrogen chloride and hydrogen fluoride, in order to purify these pollutions the gas is sent to an acid neutralization system.
This one is a neutralization system with sodium bicarbonate in powder form, the system is formed by a mixing reactor and a bag filter to collect the salt obtained by the reaction.
Into the reactor is obtained the intimate contact between fumes including hydrogen chloride and hydrofluoric acid and sodium bicarbonate.
Bicarbonate is stored in big-bag and is measured into the reactor by a mill.
The fumes mixed with the neutralizing reagent arrive at the bag filter, through a process that provides adequate contact time to ensure completion of the reaction.
Within such a filter is the separation of the reaction products from the gas, the reaction products are collected in a big bag underneath the filter.

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FOURTH FILTRATION STAGE
The fumes coming out from the neutralization system are sent to an activated carbon filter.
The carbon filter is equipped with a hot air reactivation system on-site.

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