

A GUIDE TO A UNIT FOR DISTILLING AROMATIC PLANTS

1 - PRESENTATION

1-1 Nature of the Activity

The work of this unit directly follows plant harvesting (result of cultivation or gathering). The process consists of extracting fragrant and volatile oils from plants. The essences or essential oils differ from fixed oils (lipids) in their volatility.

The goal is to extract, concentrate, and stabilize the plant aromas, which are used in the cosmetic, Agro-food, and pharmaceutical industries.

Essential oils are complex blends : they are classified according to their principal contents : terpenes ("limonene"), alcohols (menthol), phenols(eugenol), aldehydes ("citral"), cetones ("thuyone").

1-2 Alternatives

* Raw Materials :

Essences concern a large quantity of plants. However, they are more abundant in certain families of plants (conifers, futaces, umbellifers, myrtaces, labies) ; all the plants organs contain varying proportions (flower heads, roots, leaves, rhizomes, bark, wood, seeds).

Thus, there is a double distinction in supply methods :

- type of plant and organ concerned,
- local or non-local origin of supply:
 - . local : for problems in transportation costs, freshness, or rapid deterioration,
 - . non-local : for easily transportable and stable plants (dried leaves, seeds, wood , etc).

* Finished Products :

The usual finished product is whole essential oil (all of the aromatic components : head, body, stalk). There are over 400 known essences, of which about 100 are commercialized. However, for certain uses and according to their rough state (affected by distilling-extraction) whole essences are often put through a second transformation : rectification, partial deodorizing, deterpenation, isolation of one component, blending, production of absolute alcohol.

In this case, the distillation unit should be followed by a second unit whose activity is closer to pure chemistry.

This kind of activity is usually practiced only by enterprises specialized in fine aromatic bases. They produce aromatic blends which are ready to use for industry.

* Technology :

Technology varies with the plants used (more or less hard or tender), the nature of the essence produced (more or less volatile or fragile), the quality desired (in its entirety, purity, etc.), the final use (perfume, food, pharmaceutical), and the size of the unit.

Several large groups of extraction procedures can be considered:

- "Expression" and "Flowering" : old techniques used for only a few specific plants ("hesperides", rose water) and little used today.
- Using steam : used for the majority of plants. This is literal distillation or hydrodistillation. It can be static or dynamic ; continuous or discontinuous ; per ascendum or descendum (vertical direction of the steam).
- Extraction with solvents (hexane, benzene, etc.) : this yields a "solid", that is, a fatty substance more or less thick according to the type of plant (including, besides aromatic substances, other oily compounds : grease, wax, pigments, etc.).
- Extraction with supercritical fluids : (usually CO₂). This is a new process of selective extraction of plant constituents, according to their respective molecular weights (wax, oil, resin, essence, alkaloïds, etc), essential oil being a particular case for extraction. Investment is high (over 10 MF for a small unit) and handling requires specific adjusting of the parameters of processing for each product (pressure, temperature, speed).

* Packaging :

Regardless of the essence, preservation and storage should be done in such a way as to avoid heat and light.

Metal barrels (varnished or tinned) or stainless steel barrels are used to avoid all possible chemical reactions between the essence and the containers. The volume of a barrel varies with the value of the essence (40 F/kg up to 40000 F/kg) = 1 to 200 litres.

1-3 Types of Possible Units

Considering the wide range of plants and their related essences, each plant is an individual case.

Equipment, distillation time (30 min. to 24 hrs), the extraction yield (intervals from 1 to 10 and more), the parameters of the extraction process all vary considerably according to the raw material, the nature and the fragility of its components, their volatility, etc.

Technological options (equipment and procedure) should be strictly adapted to the plant treated and the essences produced.

In this guide, focus will be on the steam procedure, (the most economical and multi-faceted procedure) and limited to atmospheric pressure treatment (more common than the use of high pressure).

3 possible units will be considered :

- **Unit A** : a static discontinuous distillation unit. Simple process of distillation with atmospheric pressure, composed of two stainless steel stills, 3000 l each. Processing in batches with top loading and unloading.

Products treated : tender, slightly ligneous plants (leaves, flower heads, mint or lavender type).

Capacity : about 1 t of plants per hour, therefore an average production of about 20 l of essence per hour.

- **Unit B** : dynamic continuous distillation : better exploitation of the plants, less vapour consumption, shorter processing time. Altogether more efficient than unit A. The unit consists of a series of horizontal modular tubes, mounted in series and fed gravitationally in a series of falls. The plants are continuously pushed, by an endless screw, from top to bottom, creating periodic plugs which are transpierced by a flux of steam (counter-current).

Products treated : same as A. Plants need subtle pretreatment (pre-crushing and automated conveyance).

Capacity : 2-3 tons of plants/hr, or 40-50 l of essence/hr.

- **Unit C** : multi-purpose unit with turbo-extractor/distiller. The most efficient process with regard to speed of treatment and the quality of the finished products (greater recuperation of volatile portions in their entirety).

The unit is composed of a still (heat by double envelope) inside of which is a blade turbine which finely grinds raw materials suspended in water (no oxidation risk). It can utilize

solvents, coupled with other specific equipment (evaporator, vacuum finisher, rectifier).

Products treated : all kinds of plant material (leaves, wood, roots, seeds) with

pre-preparation for voluminous products (granulating-machine, cutter).

Capacity : 1000 l still which can process 600-800 kg of leaves/hr, 100 kg of plant material/hr - long distillation (wood, seeds), or 500-1000 kg or fruits/hr.

2 - TECHNICAL AND ECONOMIC GUIDE

2-1 Description of the Unit

2-1-1 Finished Products

LINE	A Static discontinuous distillation	B Dynamic continuous distillation	C Turbo-extractor distiller
Product range	Whole essential oils	Whole essential oils	Essential oils Hydrosolubles aromas Floral waters Solids Oleoresins
Products treated	Leaves, flower heads after drying	Leaves, flower heads dry or green	All types of plant material
Production - hourly - annual	1000 Kg/hr	2000 to 3000 Kg/hr depends on raw material supply	600 to 800 Kg/hr

2-1-2 Technological Choices

OPERATIONS	TECHNOLOGICAL OPTIONS	SOLUTIONS		
		LINE A	LINE B	LINE C
Drying	- Optional - Most often on site (pre-wilting)	Depend on type of raw material		
Preparation	- Tender raw material (leaves, flowers) asis, hacking, cutting - Hard raw material : . seeds : broken or whole . wood/bark : crushing or cutting	as it breaking (poorly suited line) crushing (poorly suited line)	hacking inadaptable crushing	cutting whole cutting
Extraction	- With steam or solvent - Continuous or not - Static or dynamic - Atmospheric or high pressure	steam discontinuous static atmospheric pressure	steam continuous dynamic same as A	steam or solvent discontinuous dynamic same as A
Condensation	- One or several condensers (varying temperatures) - Recycling condensation water	varies with raw material possible	same as A impossible	same as A possible
Separation Decanting	- Closed system or in open air - Cyclone separator or florentine vase	choice choice	same as A same as A	same as A same as A
Loading and unloading (solid phase)	+ or - automated and mechanized	manual : baskets and hoist	entirely automated	semi-automated

2-2 Economic Analysis

2-2-1 Investments

	LINE A		LINE B		LINE C	
	Description	FOB price \$ US	Description	FOB price \$ US	Description	FOB price \$ US
EQUIPMENT						
Preparation raw material loading	hoist loader conveyor	25 000 \$	hopper conveyor crusher	\$ 50 000	cutter elevator	\$ 30 000
Still condenser separator	still static 2 x 3000 l stainless steel	130 000 \$	continuous distiller 3 x 5 x 6 m distilling tubes	\$ 250 000	distiller extractor humid crushing	\$ 275 000
Steam generator + cooling post	550 kg/hr steam boiler	\$ 30 000	1000 kg/h steam boiler	\$ 50 000	300 kg/h steam boiler	\$ 25 000
Solvent extraction					discontinuous evaporator 500 hl/h alcohol vacuum finisher solvent rectifier annex	\$ 160 000 \$ 55 000 \$ 100 000 \$ 110 000
EQUIPMENT TOTAL		\$ 185 000		\$ 350 000		\$ 755 000
Buildings	Surface area : 400 m2 plant storage hangar : 1000 m2 Land : 3000 to 4000 m2		Surface area : 400 m2 storage hangar : 1500 m2 Land : 4000 to 5000 m2		Surface area : 400 m2 (of which 200 m2 explosion proof) Hangar : 1000 m2 Land : 3000 to 4000 m2	
Other investments						
- electrical power	10 Kw		65 Kw		30 Kw	
- water cooling	5 m3/hr		15 m3/hr		4 m3/hr	
- measure and test lab	\$ 25 000		\$ 25 000		\$ 35 000	
TOTAL INVESTMENT	\$ 300 000 to 350 000		\$ 500 000 to 600 000		\$ 1 to 1.2 million	

2-2-2 Functioning

	LINE A	LINE B	LINE C
Labour			
- Process skilled	1	1	1
unskilled	3-4	1-2	1-2
- Administrative commercial, land	2	2	2
Consumption			
Raw materials	10 t/day slightly ligneous plants	30 t/day fresh plants	steam extraction 7 t/day tender plants or 1 t/day hard plants or 10 t/day fruit Solvent extraction 1 to 1,5 t/day
Energy	100 Kwh/day	650 Kwh/day	300 Kwh/day
Water	50 m3/day	150 m3/day	40 m3/day

3 - KEY FACTORS TO THIS PROJECT'S SUCCESS

3-1 Supply

- The raw materials are very fragile : strict discipline in harvest, storage, and transportation is necessary in order to maintain the qualitative and quantitative potential of the plants to be treated. Close contact with producers and a unit plan are necessary.
- To work the unit as much as possible, store non-perishable raw materials (cloves, vanilla) or expand the range of raw materials treated (exploiting the range of the various harvests).

3-2 Technology and Equipment

Choose equipment according to the unit's range, optimization of the "extraction, condensation, separation" parameters, and electric consumption. Lower the steam consumption/oil yield ratio.

A solvent-extraction unit and its supplementary equipment has been included in unit C. This easily doubles the equipment cost, and is only an option for specific conditions. Usually, it is better to abandon solvent-extraction in favour of hydro-distillation. Industrialized countries are moving towards banning solvent extracted essences from a large number of uses.

3-3 Personnel

This unit requires someone who is specialized in both aromatic plants and the extraction-distillation process. The delicate know-how comes from years of experience : the unit's chief must constantly adapt the process to the characteristics of the raw material, and the market demand.

Users' reactions are crucial for optimizing the unit's output.

3-4 Quality Control

Raw material tests: sample analysis to determine harvest date, and to act upon farming techniques. Maturity of the essence and yields are tested.

Finished product tests: establish precise identity guides for each essence (communicated to the clients), which helps improve the power of negotiation and control production (product quality stabilization).

3-5 Distribution and Commercialization

The market for essences is international. It is essential to have international partners who are either distributors or users.

The setting up of the unit in an area well known for a specific essence constitutes a crucial commercial argument (importance of image) : ylang-ylang from the Comores, geranium from Reunion, lavender from Provence.

Strive to develop a specific and typical product range, to impose a certain image, and to avoid being subject to the market's speculative tendencies.

3-6 Financing

This depends on the quantity and diversity of raw materials as much as the possible sale prices.

Nonetheless, in normal working conditions (more than 6 months out of 12), and with average prices, the annual turnover/investment ratio is quite a bit greater than one. The working capital needed depends on the method of paying the farmers and the users' terms of payment (payment with orders, upon delivery, etc.).

4 - INDUCED ACTIVITIES

- This activity allows for the development and stabilization of diverse agricultural production.
- It can supply and promote regional valorization/processing activities : cosmetics, perfumes, hygiene and health products, pharmaceutical and food products...