

Company_ **ARY eco**

Equipment_ **CONVERTER®**

Result_ **STERILISATION
OF INFECTED HOSPITAL WASTE**

INTRODUCTION TO THE PROBLEM

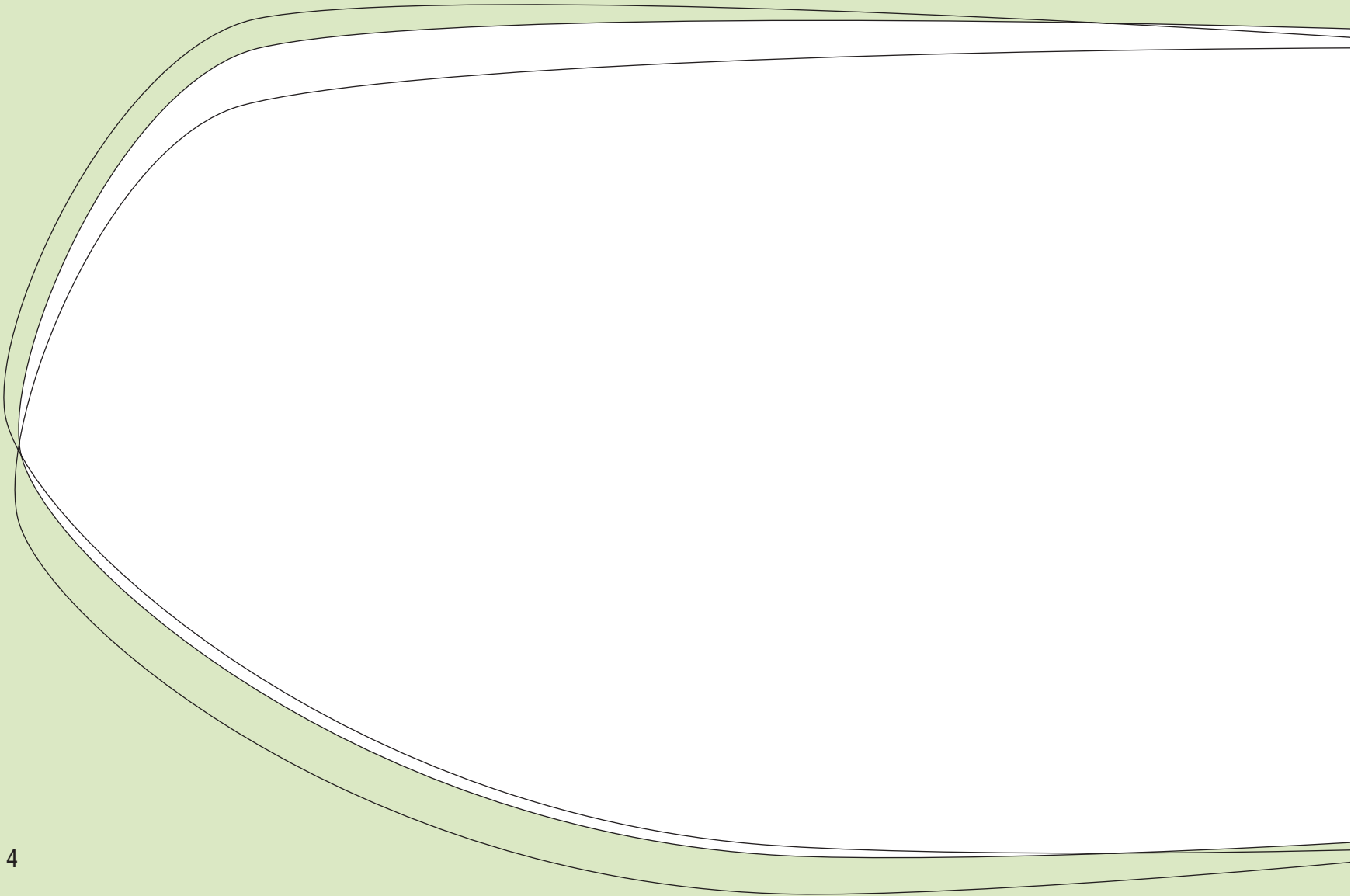
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01_ **PROBLEM-SOLUTION**

What solution is it preferable to choose in order to dispose of potentially infected hospital waste?

Not incineration.
Because of the fear of hazardous atmospheric emissions, incinerators, rightly or wrongly, are being met with increasing public opposition and are thus unlikely to represent a feasible solution. Furthermore, the most recent regulations require extremely complex and costly installations.

Sterilisation is undoubtedly a better solution. Provided that the product obtained from the treatment can be utilised.

We offer you the Converter solution, which enables you to obtain a useful product and savings, with a minimal environment impact and the guarantee of constant sterilisation.



02_ ADVANTAGES



IT IS NOT_an Autoclave

IT IS NOT_an Incinerator

IT DOES NOT WORK UNDER_Pressure

IT DOES NOT REQUIRE_Qualified staff

IT DOES NOT USE_Flames

IT HAS NO_Environmental impact

...all this in complete observance
of the strictest standards and
regulations

03_ THE PROBLEM



COMPOSITION OF HOSPITAL WASTE

Sharp and cutting objects, syringes, needles, disposable scalpels, test tubes, cannulae, catheters, cellulose and synthetic materials, dressings, bandages, tampons, fabrics of varying nature, sanitary towels, paper, plastic films, materials for dialysis, plates with connecting tubes, filters, boxes, bags, bottles, containers, surgical waste, waste from infectious diseases wards and food waste.

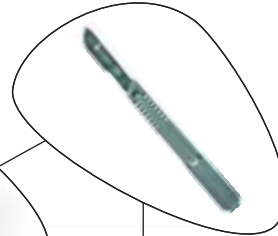
LEVEL OF BACTERIAL CONTAMINATION IN HOSPITAL WASTE

Due to the microbial multiplication that occurs in the materials present as well as the possible presence of laboratory cultures from microbiology laboratories, the level of bacterial contamination may reach as high as 10^{12} c.f.u. (one trillion micro-organisms). This is enormously higher than the level of contamination – approximately 10^2 - 10^3 c.f.u. – that is considered normal in hospital environments for new materials or thoroughly cleaned materials to be submitted to sterilisation prior to subsequent medical use.

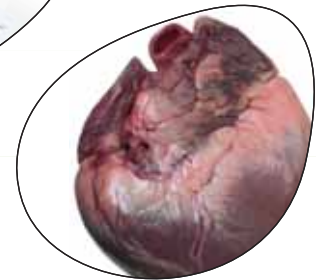
04_ AVERAGE COMPOSITION OF HOSPITAL WASTE

18%

non-combustible materials:
glass, syringes, needles,
scalpels



2%
surgical
waste

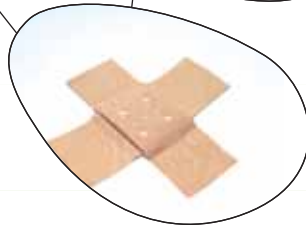


45%
dry cellulose:
paper, bags, packets

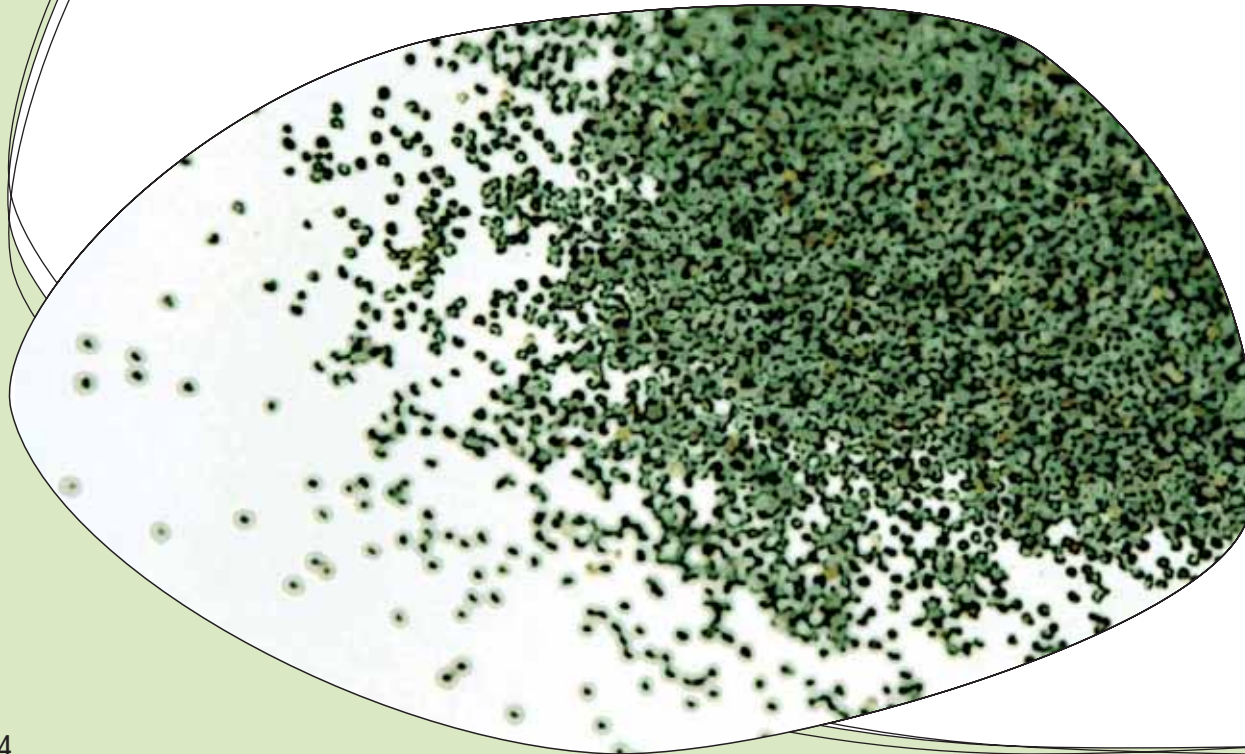
1%
silicone rubbers

18%
damp cellulose:
sanitary towels, dressings

16%
polyolefinic plastics:
tubes, boxes, fabrics,
masks, disposable gowns



05_ **DIFFERENCES BETWEEN
STERILISATION
AND DISINFECTION**
IN THE TREATMENT OF POTENTIALLY
INFECTED SOLID HOSPITAL WASTE



DISINFECTION

Reduction of bacterial contamination by pathogenic micro-organisms.
As it is practically impossible to establish the actual quantity and type of bacteria contained in the waste,
disinfection is an operation which achieves an indeterminate reduction in the bacterial count.

STERILISATION

Elimination of all living micro-organisms that may be present in the batch of waste to be treated, so that the probability of still finding a viable micro-organism (SAL – sterility assurance level) **is equal to or less than 1 case out of a million treatments (10^{-6}).**

If sterilisation treatments are performed in working conditions that are unable to guarantee a SAL of 10^{-6} starting off from the maximum level of biological contamination foreseeable in the worst possible conditions, the result of the treatment may be considered equivalent to simple disinfection.

06_ BACTERIAL CONTAMINATION TO BE ELIMINATED

10^{12} c.f.u. =
biological contamination
in hospital waste

10^{-6} =
allowed probability of a
viable micro-organism
being present

10^{18} =
minimum reduction
factor

In hospital waste, due to the bacterial multiplication that occurs in the materials present as well as the possible presence of laboratory cultures and biological specimens from microbiology laboratories, **the level of bacterial contamination to be eliminated is equal to around 10^{12} units**, thus well above the level of approximately 10^2 - 10^3 c.f.u. that is considered normal in hospital environments for new materials or thoroughly cleaned and washed materials submitted to sterilisation for subsequent medical use.

The reduction factor that is normally required of sterilisation apparatus used to treat materials for medical use is 10^8 , i.e. 8 logarithms, which is necessary to achieve a probability of 10^{-6} starting off from a contamination of 10^2 units.

In such cases, a saturated steam treatment (autoclave) at $121\text{ }^{\circ}\text{C}$ (1-2 bars) for about twenty minutes is sufficient, since at that temperature the most heat resistant

ambient micro-organisms will be decimated in about two minutes (D-value).

Hospital waste is an entirely different matter:

a) The decimation time does not necessarily fall within the two minute interval required for ordinary ambient micro-organisms

b) The reduction factor necessary in order to achieve a probability of 10^{-6} starting off from a contamination of 10^{12} c.f.u. is 10^{18} (18 logarithms).

Therefore, when dealing with potentially infected waste, much stronger measures must be adopted in order to have a sufficient guarantee of achieving sterility, rather than simple disinfection, irrespective of the level and type of contamination that may be concerned.

If we consider autoclave sterilisation at 121 °C in the case of a microbial population of 10^{20} units having a decimation time of 4 minutes at 121 °C, the time necessary solely for the actual sterilisation process would be $4 \times 20 = 80$ minutes, to which we must add the time required for loading, the vacuum phase, final cooling, unloading, etc., so that an operating cycle of over 2 hours would be necessary.

Converter® machines, by contrast, can guarantee total elimination of every possible micro-organism at any level of contamination in less than half an hour.

Converter machines have been conceived specifically for hospital waste and rely on:
_A very fine pre-crushing and continuous mixing of the material in order to control

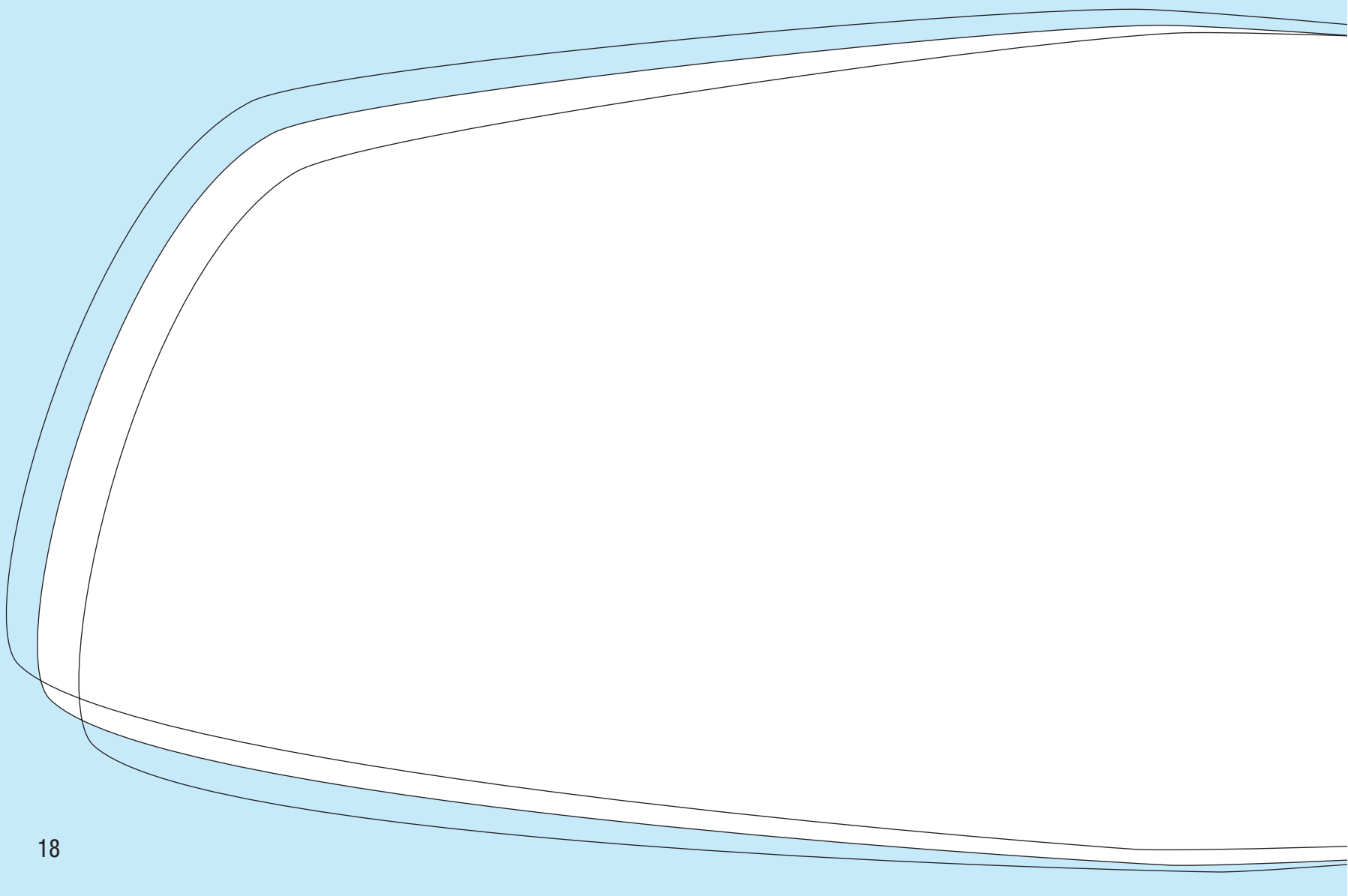
the process in every point of the mass.

_An infrared temperature monitoring system providing real-time measurements of the actual temperature of the material submitted to treatment.
_A temperature that is decidedly higher than can be obtained with autoclaves.

Since the phenomenon is governed by an exponential law, whereby for every 10 degree increase in the treatment temperature the D-value, i.e. decimation time, is reduced by one tenth, it can be easily calculated that at the temperature of 150 °C adopted by the Converter cycle the time required to guarantee a reduction of over **20 logarithms** is reduced to **just a few seconds**.

This makes it possible to obtain a high reduction factor in decidedly short operating times.

In order to obtain the same reduction factors, autoclaves or other similar systems would either have to use very high pressures, with consequent safety problems, or very long cycle times, resulting in modest production yields. Generally speaking, autoclave systems using injected or microwave-produced steam can guarantee a maximum reduction factor of 8 logarithms.



THE CONVERTER®

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01_ INTENDED USE



Converter® units are designed to

**treat and sterilise
potentially infected
hospital waste**

which is dangerous for humans
and animals because of the possible
presence of pathogenic micro-organisms.
**The process is carried out simply
and automatically.**

02_ WORKING PRINCIPLE

The treatment of hospital waste involves the following steps:

- a_ Crushing**
of infected waste, which has the effect of increasing its temperature due to friction
- b_ evaporation of humidity**
- c_ sterilisation**
carried out at a temperature of 150 °C with the injection of water and generation of saturated steam
- d_ cooling of the solid material and discharge**

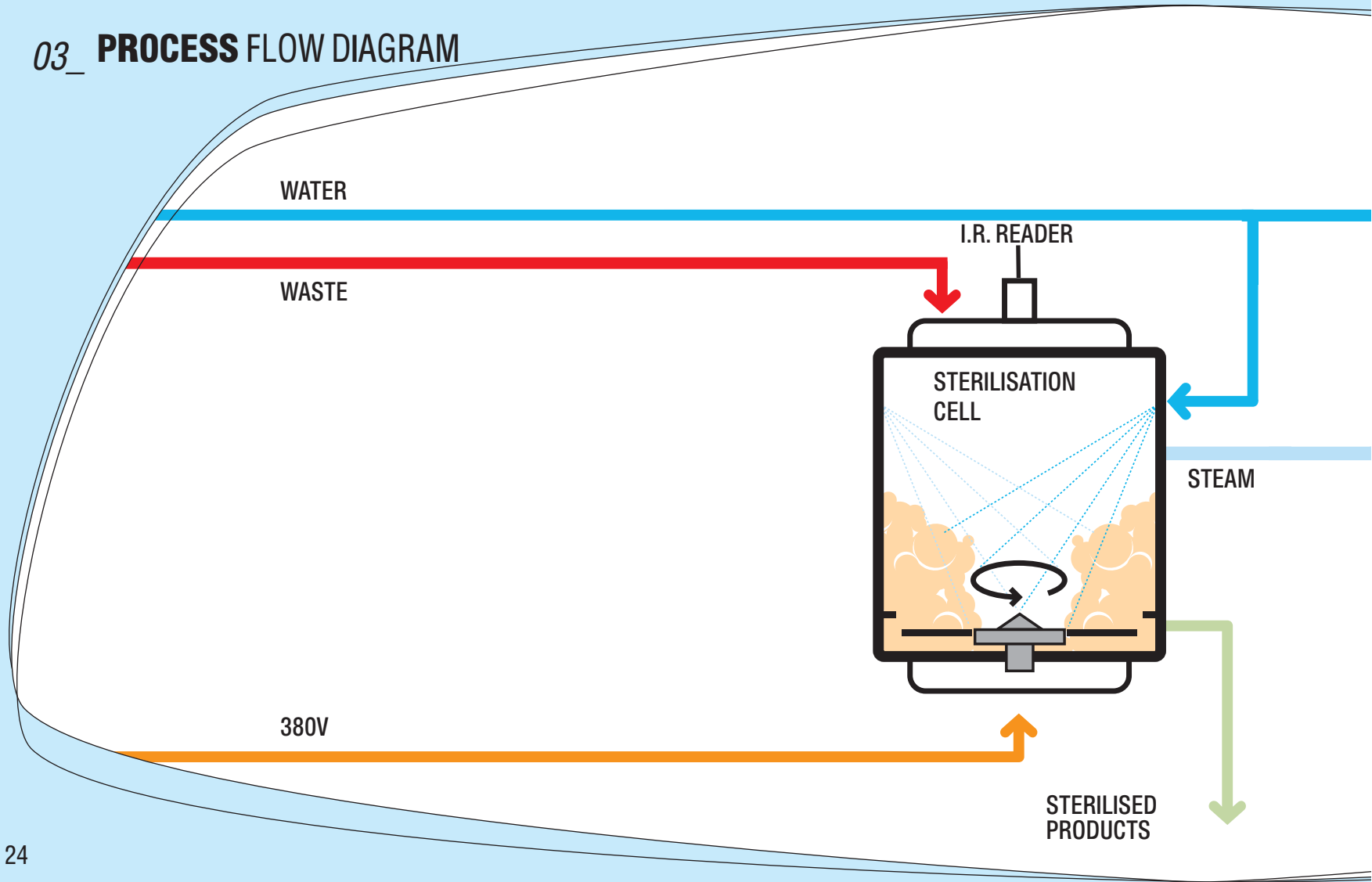
The Converter® receives contaminated waste directly from hospital departments, without any need for pre-treatment.

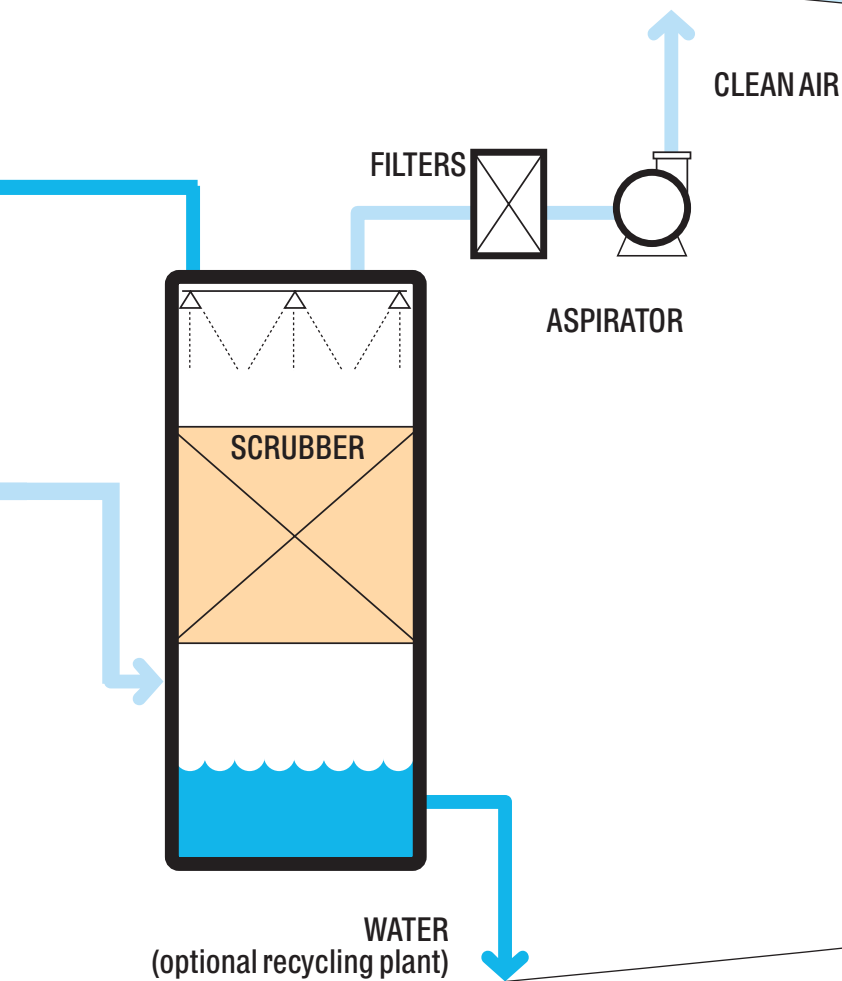
The material obtained
is in dry granular form,
with a particle size
of about 2-3 mm.

100%
sterile



03_ **PROCESS** FLOW DIAGRAM





Converter® machines are designed to treat solid hospital waste at high temperatures (150°C) in the presence of saturated steam and rely on a particular working principle which makes it possible to obtain the required sterilisation temperature and humidity conditions without the use of pressurised systems.

Fig. 1

04_ **PROCESS**_DESCRIPTION

As shown in Fig. 1, the Converter® machine is composed of a **cell with an internal rotor** connected to a **steam absorption column and an air filtering system**. **The whole system is kept constantly under a slight vacuum by means of an aspirator situated immediately before the point of release of exhaust gases into the environment.**

This fact is of great importance, as in the case of an imperfectly sealed system, at worst there may be air infiltrations from the outside towards the inside of the system.

In pressurised systems on the other hand, an imperfectly sealed system causes leakage of dangerous aerosols into the environment, resulting in hazards of biological contamination for staff. The cycle starts with a first phase during which **the boxes containing the waste are loaded into the cell**, without any previous manipulation. After the boxes have been loaded, **the cell is closed** and a powerful and sturdy rotor located on the bottom of the cell starts turning.

The waste is rapidly chopped up and the mass is heated, **thanks to the energy produced by the rotor through friction** with the material itself, until reaching the programmed temperature of **150°C**. At this point a **controlled injection of water** takes place. On coming into contact with the **hot** material it generates an effect known as “**moist heat sterilisation**”, **without the need for any pressure**. An infrared reader permits **constant real-time monitoring** of the temperature of the material.

At the end of the cycle, **the mass is cooled to about 40 °C by injecting further quantities of water and applying a vacuum**, so that the material obtained is **cold and dry** and automatically **discharged by centrifugal force** simply by opening a valve located on the bottom of the cell. The water which evaporates during the process is passed through a condensation system and drained into the sewer system or stored in a tank. The water used to cool the condenser is drained into the sewer system or made to re-circulate by means of an optional cooling system.

05_ **PROCESS**_TEMPERATURE/TIME DIAGRAM

Sterilisation takes place using what is known as the "***moist heat***" method, which consists in placing water into contact with the material in very high temperature conditions. The combination of time, temperature and humidity causes a chemical reaction that breaks down the proteins of micro-organisms, resulting in their death.

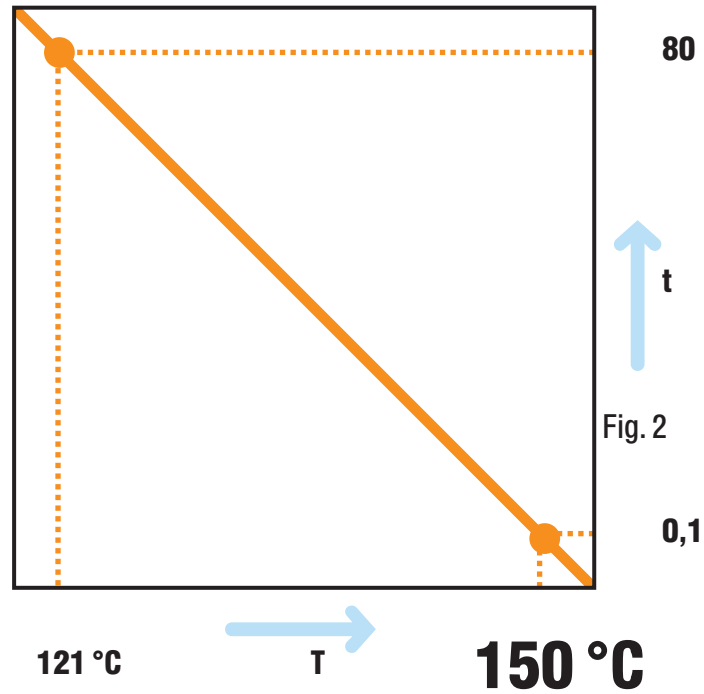
The time necessary at the reference temperature of 121 °C (value derived on the basis of studies initially conducted in the USA at 250 °F) can be calculated by multiplying the decimation time (D-value) at that temperature by the required reduction factor.

Considering a D-value of 4 minutes at 121 °C, in order to achieve a reduction of 20 logarithms the time necessary for the sterilisation phase is $4 \times 20 = 80$ minutes. The required time is an inverse exponential function of temperature.

Once we know the time that is necessary at 121 °C, we can then calculate the time necessary at temperature t using the following well-known formula:

$$t = t_{121} / 10^{(T-121)/10}$$

As can be observed in Fig. 2, by applying the formula and raising the temperature from 121 to 150°C, the time decreases from 80 minutes to 0.1 minutes, i.e. just 6 seconds.



06_ **PROCESS**_CYCLE DIAGRAM

After **phase n. 1**, in which the material is loaded, the cover is closed and the rotor starts turning.

In **phase n. 2** the material is finely crushed up and brought up to a temperature of 100 °C.

In **phase n. 3** the temperature is maintained constant until all the humidity is removed from the waste by evaporation.

In **phase n. 4** the material is further heated until reaching the programmed temperature of 150 °C.

Phase n. 5 is the sterilisation phase, during which water is injected and evaporates on coming into contact with the material. The injection takes place in such a way as to balance the heat generated by the rotor with the heat absorbed due

to evaporation of the water; as a result, the temperature remains constant for the programmed time of 3 minutes.

In **phase n. 6** a greater amount of water is injected, causing the temperature to fall. The application of a vacuum brings the temperature down to around 35 °C.

In **Phase n. 7** the sterilised material is discharged after the cycle has ended. All phases of the cycle are carried out in a completely automatic fashion.

- 1_loading**
- 2_crushing**
- 3_dehydration**
- 4_heating**
- 5_sterilisation**
- 6_cooling**
- 7_discharge**

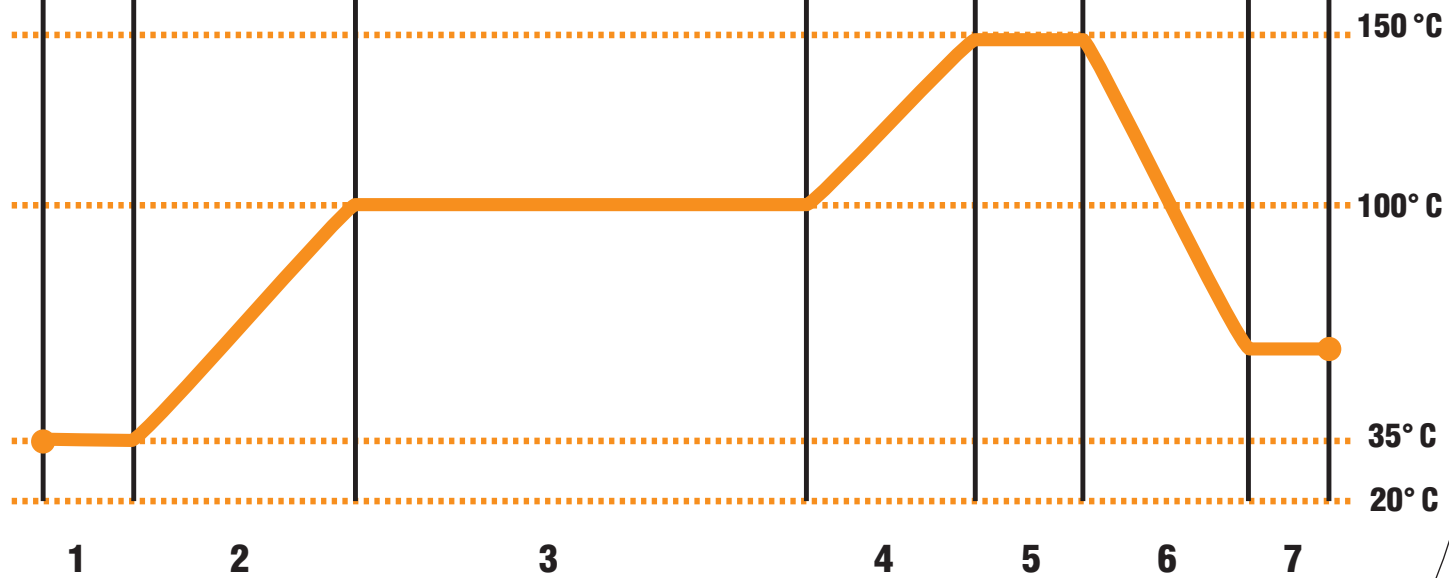


Fig. 3 Cycle phases

07_ **CHARACTERISTICS OF THE FINAL MATERIAL**





_sterilised 100%

_Dry

_Odourless

**_Finely
crushed**

**_High calorific
power**

_Sterilisation is always achieved at any level of bacterial contamination.

_Possibility of treating waste with a high moisture content.

_70% average reduction in volume.

_30% average reduction in weight, equivalent to the humidity present in the waste.

_The product is dry, stable, devoid of any sharp or pointed fragments or elements and easy to transport; it can be packed into common waste bags and treated as common waste

_The product is inert and can be handled without any risk.

_30% weight

_70% volume

07 – CHARACTERISTICS OF THE FINAL MATERIAL

During treatment, the waste is sterilised and physically transformed.

The final material has the following characteristics:

- _ Uniform colour and appearance.
- _ Absence of recognisable parts.
- _ Completely dehydrated.
- _ No odour or only a very slight odour, never unpleasant.
- _ Reduced volume (on average 30% of the volume of the initial waste).
- _ Reduced weight (on average 70% of the weight of the initial waste).

The material obtained is in the form of

dehydrated granules

measuring about

3 millimetres

The treated material is free from cutting or sharp edges, since glass is finely pulverised and sharp metal objects are reduced into particles of the same size as the other granules, while the edges are rounded thanks to the action of the rotor.

In terms of appearance, this new material no longer bears any resemblance to the initial waste, nor does it any longer possess the original sensory characteristics:

it is stable and safe for all practical purposes

The granules are dry regardless of the amount of water contained in the waste to be treated (the humidity contained in waste usually accounts for 30% of the weight). This implies a weight reduction of 30% and, for the same reason, a 70% reduction in volume (average values).

Being dry and free from any sharp or pointed objects, the granules obtained with the Converter® treatment can be packed into economical plastic bags for disposal just like common household waste.

08_ DISPOSAL AND USE OF THE TREATED WASTE

**Following the Converter
sterilisation process,
the product obtained is
suitable to be reused.**

Autoclave treatment processes result in a material one does not exactly know what to do with and which needs to be placed in rigid containers, since it is dripping and contains glass shards and sharp and pointed objects. The only option is to send the material to an incinerator, or a landfill site where permitted.

By contrast, the product that comes out of the Converter process can be delivered to plants which use or produce Refuse-Derived Fuel (RDF), since the material obtained is dry and has a calorific power of approximately 6000-7000 kcal/kg, 70% that of crude oil. The final product can of course also be disposed of as normal municipal solid waste.

09_ PATENTS AND CERTIFICATIONS

Converter® machines comply with standard “**UNI 10384 1A - Sterilisation Systems and Processes**”, as required by Italian law.

Unlike other systems, Converter® operates under vacuum pressure, as is disclosed in European patent EP0710125 and other international patent issues and extensions originating from Italian patent TO93A000547 and international patent WO 95/03072.
Devices built in accordance with these patents have been in operation since 1995.

10_ COSTS

I Converter® implements a patented technology which enables the attainment of results described previously at

lower operating costs

compared to systems based on autoclaves or incinerators and also provides savings in terms of packaging, transport and disposal costs, etc.

Zero Costs

for the transport of hazardous waste if Converter machines are installed directly in the hospital

Zero Costs

of disposal and minimum transport costs
if the final material is used to recover energy

Minimum Costs

of disposal if the dehydrated material obtained
is disposed of as normal municipal waste

11_ **OPTIONALS**

WATER RECYCLING System

To reduce the consumption of mains water, an optional system can be supplied which includes a cooling tower and related accessories.

**Reduction of
consumption
from 18 to 0.3
litres of water
per kg treated**



12_ **ADVANTAGES OF CONVERTER®**

The advantages of Converter® units compared with other technologies are:

- _ Sterilisation and not only disinfection.
- _ Sterilisation starting from **any level of bacterial contamination**.
- _ **70% average reduction in the volume of the final waste.**
- _ **30% average reduction in weight**, equal to the moisture content of waste, which means savings in subsequent disposal of the treated material.
- _ **The process does not release any polluting liquids.**
- _ **The process does not release fumes or odours.**
- _ The final result is a **dry product**, therefore one that is stable over time and no longer fermentable, free of unpleasant odours, suitable for long-term storage and transportable without any risk of leaks.

_ The treated product is free from sharp or pointed objects and **can be handled without risk**; it does not need to be packed in special or watertight containers.

_ The product is **completely inert**, easily disposed of and characterised by a high calorific power, making it suitable for the production of energy.

_ **Vacuum system**: with no risk of vapours or aerosols being released into the environment.

_ **No treatment outside** the sterilisation chamber.

_ **Maximum level of safety**: simple, safe emergency procedure in the event of a failure.

_ **Maintenance and repairs can be carried out by generic workers** (no pressurized components, no microwave generator, etc.).

_ **No building work required** (pits, foundations, etc.)

_ **The unit can be rapidly installed and moved**

_ **No problems of electromagnetic compatibility.**

ASSESSMENT AND COMPARISON OF THE STERILISATION CAPACITIES OF DIFFERENT SYSTEMS

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01_ INTRODUCTION

The bacterial count reduction factor is an important parameter for comparing the different systems.

In fact:
a higher bacterial count reduction factor corresponds to a greater assurance of always achieving sterilisation.

Choosing a system which ensures a high reduction factor is crucial given the practical impossibility of determining the initial bacterial population present in waste on a case-by-case basis.

FINAL CHARACTERISTICS OF THE TREATED PRODUCT

The various systems available on the market differ not only in terms of sterilisation capacity, but also as regards the final characteristics of the treated waste.

The characteristics of treated waste will influence:

- _operator safety
- _the environmental impact
- _transport (methods and costs)

The ultimate form of the product treated by the various systems examined can be classified into one of the following categories:

Category 1_ dry, without no sharp or pointed objects, finely crushed or pulverised

Category 2_ moist, with sharp or pointed objects, coarsely crushed.

“Dry” means a residual humidity either equal to or lower than 5%. Systems that cannot ensure a substantial reduction in the weight of treated waste will necessarily result in a product classifiable as moist.



02_ INCINERATION

Incineration systems burn waste relying on fuel.

- _ They are large installations requiring on-site construction of foundations, a chimney at least 15 m tall and the opening of a building site.

- _ There are two types of incinerators:

- _ *Discontinuous*

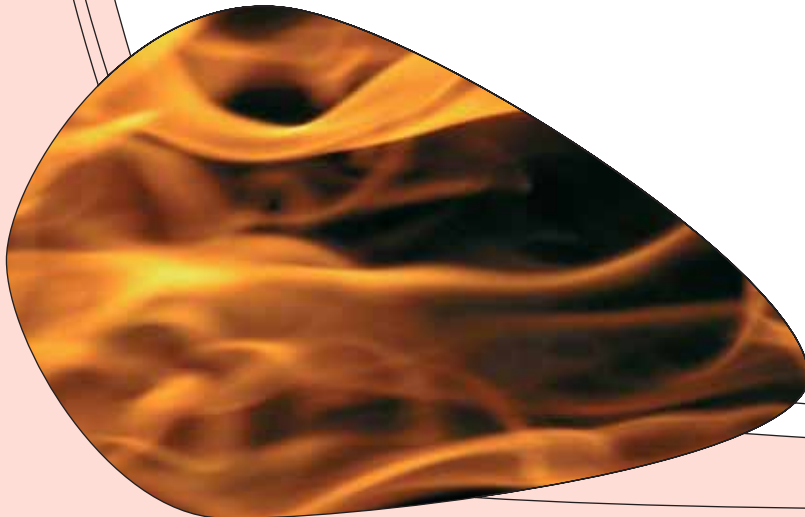
- _ They lacking the characteristics needed to guarantee the quality of the emissions.

- _ *Continuous*

- _ Installations whose purchase and running costs are much greater than those of the other systems examined here.

- _ They require highly specialised operators and instrument engineers.

- _ Both types emit pollutant gaseous effluents (dioxins and NOx), even during normal plant operation.



PROS



- _Sterilisation is achieved irrespective of the level of bacterial contamination present in the initial waste.
- _The treated material is in a dry, pulverised form, without any sharp or pointed objects.

CONS



- _Very high environmental impact both during normal plant operation and in the case of malfunctions (e.g. release of dioxins, NOx).
- _Problems in having them accepted by the population.
- _High purchase and running costs.
- _Additional pollution caused by road transport.

03_ AUTOCLAVE

Waste treated by blowing of high pressure steam.

— The material obtained is unstable and ferments rapidly, resulting in unpleasant odours and the need for a prompt removal and disposal of modest quantities with high transport costs.

— Heights requiring installation in special rooms.
— The material discharged is still hazardous

to operators, being only coarsely crushed (the presence of sharp and pointed objects such as shards of glass, needles, etc. requires the use of costly liquid-tight rigid containers).

— Quality of the material following treatment: Category 2 (page 45)
System requiring the availability of incinerators for the disposal of the material obtained.

— Average reduction in volume: 80%.

— Need for specialised staff.
The steam generator requires the presence of qualified personnel.

— Need for foundations.

PROS



_Historically used process

CONS



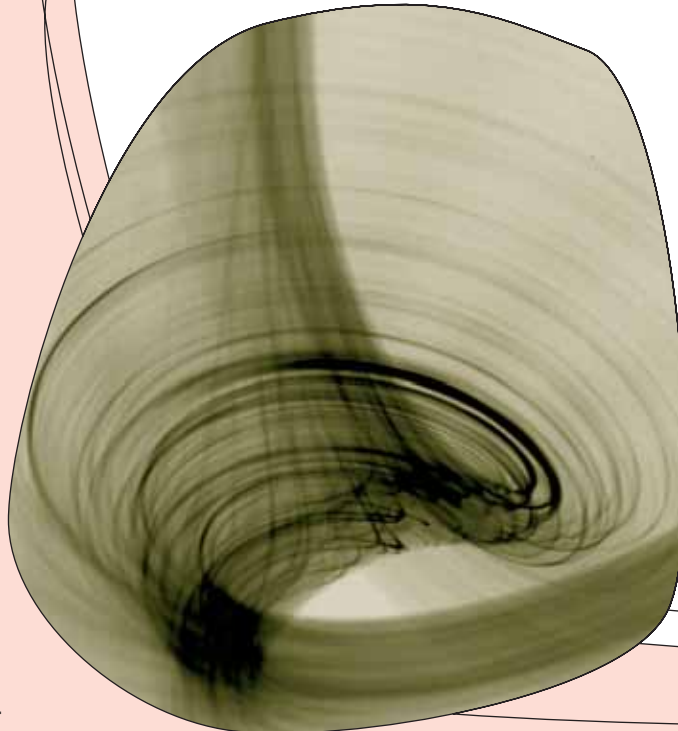
_ **Pressure vessel:** risk of contaminated aerosols being released into the work environment. Need for testing in compliance with the law.

_ **Guaranteed bacterial count reduction factor of only 8 logarithms.**

_ The material is discharged hot and has a water content of over 50% (the process increases the weight of the treated material), generating fumes and odours upon discharge.

04_ MICROWAVES

Waste treated by means of microwaves that heat the waste to a temperature of approximately 130°C (in a closed pressurised environment) by energising molecules of water, which must be added to the waste itself.



_ The material discharged is still hazardous to operators, being only coarsely crushed (the presence of sharp and pointed objects such as shards of glass, needles, etc. requires the use of costly liquid-tight rigid containers).

_ Generation of strong electromagnetic fields.

_ Sparks and localised overheating in metal parts,

with the consequent risk of starting a fire following discharge.

Quality of the material following treatment:
Category 2 (page 45)

_ Guaranteed bacterial count reduction factor of only 8 logarithms.

_ Average reduction in volume: ~80%

_ The final waste is moist, only coarsely crushed with the presence of sharp and pointed objects.
Waste stored without additional treatment may undergo fermentation.

PROS



_No need for a steam generator.

CONS



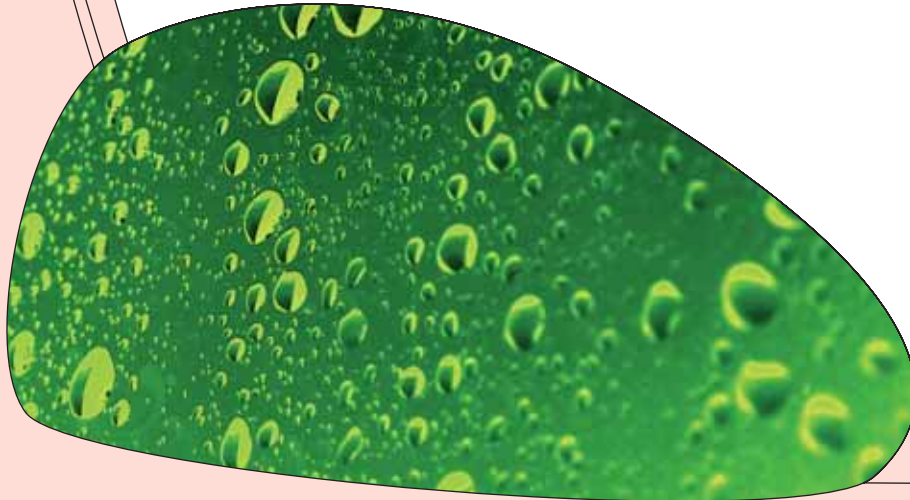
_Pressure vessel: risk of contaminated aerosols being released into the work environment. Need for testing in compliance with the law.

_Need for specialised staff.

_The material discharged is subject to rapid fermentation, resulting in unpleasant odours and the need for a prompt removal and disposal of modest quantities with high transport costs.

05_ **CHEMICAL STERILISATION**

Waste treated by submersion in chemical solutions.



PROS



_ Possibility of treating **large quantities** per hour.

CONS



_ Reactants are **only effective** if the **waste is finely crushed**.

_ **Moist, dripping** waste.

_ Problems due to the emission of chemical substances into the environment.

06_ OTHER SYSTEMS

Systems employing ionising radiation
(Alpha, Beta, Gamma rays) to reduce
bacterial contamination are characterised
by

very high investment costs.

PROS

_None.

CONS



_Extremely high costs for safety systems and for the containment of radiation.

_High degree of specialisation required of operators.

_Maintenance can only be performed by highly specialised firms.

_High treatment costs.

07_ **CONVERTER® PROCESS**

— **Models available** for treatment of 10 to 1500 kg/h (H10, H25, H75, H200, H500, H1500).
Quality of the material following treatment:
Category 1 (pg. 45)

— **Unlimited sterilisation factor.**

— **Average reduction** in volume: -70%.

— The product obtained is **completely dry**, finely crushed, devoid of any sharp or pointed elements, inert.

— **Reduction in weight** equivalent to the initial humidity present in the waste (average -30%).

— **No release** of polluting effluents.

— **Low running costs.**

— The process is carried out under vacuum.
No risk of aerosol leakage into the environment.

PROS



- _ High bacterial count reduction factor: greater than 10^{20}
- _ The product obtained is completely dry, finely crushed, devoid of any sharp or pointed elements, inert and stable.
- _ No release of polluting effluents.
- _ Conversion from infected waste into RDF (refuse-derived fuel).

CONS



- _ It requires a DC power supply. However, the energy that may be recovered from the final material results in a better overall energy balance compared to the other systems.

08_ **BRIEF COMPARISON**

	Dry	Physically inert	Sterilised	Weight reduction
Incineration	●	●	●	●
Autoclave	●	●	●	●
Microwaves	●	●	●	●
Converter® Process	●	●	●	●

Volume reduction	Safety	No building work needed for installation	No polluting effluents
●	●	●	●
●	●	●	●
●	●	●	●
●	●	●	●