THE TBF ROTOCLAVE® MSW SOLUTION

One of the most pressing problems faced by societies all over the world is related to their ability, or inability, to properly handle all the waste they produce without causing irreparable damage to our common environment. World population growth further compounds this problem, due to the corresponding, ever growing volume of Municipal Solid Waste (MSW) generated by this growth.

Historically, all waste generated was indiscriminately disposed along riverbeds, dumped from barges or ships into the oceans, used as fill in swampy areas, or burnt in open piles. As societies evolved and became aware of the environmental damages caused by such disposal practices, the use of Controlled Landfills began. Soon thereafter, protective liner membranes were required by regulations on new landfill specifications.

The numerous negative environmental impacts of landfills, aggravated by limited regulatory guidance and oversight, has resulted in extreme difficulty in approving new landfills. Strong public opposition, associated with the negative impacts of MSW landfills, has resulted in legislation and policies aiming to reduce the volume of MSW disposal in landfills. These policies have led to the development of:

- Curbside Recycling
- Drop-Off Centers
- Single Stream Material Recovery Facilities (MRFs) which process source separated recyclables
- Mixed MSW Material Recovery Facilities which process raw mixed garbage (nicknamed Dirty MRFs).
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MRF's have proven costly to build and operate and are relatively ineffective in recovering recycled materials.

Landfill liners were designed to protect against contamination of our drinking water aquifers, yet liner companies typically only warrant their membranes for twenty years. It is obvious that these membranes will eventually leak, making it imperative to avoid allowing organic materials from reaching solid waste landfills.

Many developed nations have begun implementing strict regulations establishing "time and weight specific targets" to reduce landfill disposal of harmful organics and valuable recyclables contained in MSW, with the ultimate goal of reaching an 80% - 90% recovery (recycling) of all MSW generated. Several countries, such as those forming the United Kingdom, have legislated financial incentives and penalties associated with each progressive MSW diversion goal.

As an answer to landfilling and dirty-recycling, various alternative technologies have been developed.

Thermal processes (such as incineration, gasification, pyrolysis, and plasma arc) were developed to dispose of the MSW as generated, and some of these technologies were coupled with steam and/or electrical power generation facilities. As a result, the waste was diverted from the landfills, and useful energy was generated for the municipalities that implemented them. Unfortunately, incineration (and some of the emerging technologies) still produced various gaseous emissions. This was the result of combustion, or conversion, of chlorinated plastics and waste ash containing inorganic contaminates from the mixed, unsorted MSW. Such thermal processes cannot fully minimize carbon emissions, residual ash quantities, and toxicity without separation of inorganics and plastics prior to processing.

Carbon emissions avoidance and maximum landfill diversion are critical requirements of many new Request for Proposals (RFPs) by public and private waste entities.

Following a different pathway, biochemical technologies have also emerged (such as Anaerobic Digestion and Hydrolysis). These technologies, although useful and effective, are limited to single waste streams. The result is large quantities of residuals containing a mix of inorganic and organic materials unsuitable for beneficial reuse.

Environmentally Safe Handling of MSW… A Global Requirement

The global awareness of the negative environmental impact, which traditional MSW disposal methods have created, has brought about the development of International Agreements regulating polluting practices, including the disposal of MSW.

Understanding the difficulties associated with MSW, any MSW Handling and Material Recovery Method selected by a community must comply with the following requirements:

- Positive Environmental Impact
- Effectively reduce MSW "Weight Quantities" below required Targets
- Allow the Mechanical Recovery of Useful and Marketable Materials in MSW
- Residual materials to be landfilled must **NOT** be Toxic, Polluting, or Hazardous
- Capable of Expanding Processing Capabilities as Population Grows
- Capable of operating in Privately or Publicly Owned Facilities
- Financially Viable and **NOT** increasing Tax Liability

The T&B Fabrication Treatment of MSW… The Key for an Effective Material Recovery

The **T&B Fabrication** treatment of MSW is centered around the ***Rotoclave***® processing vessel. The ***Rotoclave***® is a static steam autoclave pressure vessel, fabricated with a patented

unique internal rotating drum, and fitted with angular surfaces designed to load, move, agitate, and discharge the totality of materials contained in the internal drum.

The ***Rotoclave***® is a batch operated system with a loading, processing, and unloading batch time, which typically ranges from 60 to 120 minutes per batch. The ***Rotoclave***® process is being widely used around the world and treats a broad variety of waste-streams. Currently there are more than seventy (70) ***Rotoclave***® systems worldwide, with more than one hundred (100) ***Rotoclave's***® of various sizes in operation.

The ***Rotoclave***® process allows the treatment of **ALL** MSW, without the need for "Pre-Separation". This process makes it possible to process the MSW as it is collected from every Residential, Commercial, and Industrial neighborhood, including any "unpredictable" content variability in composition, mix, volume, density, and moisture.

Although the ***Rotoclave***® does not require "pre-sorting" of the waste stream, most of the post ***Rotoclave***® treatment separation equipment will have some problems handling oversized (or bulky) materials (such as refrigerators, dishwashers, furniture, and/or long fabrics like carpet rolls or draperies). Most facilities remove these large items prior to feeding the "raw MSW" into the ***Rotoclave***® processing vessel.

Additionally, depending on the post-treatment technologies selected to achieve the client's financial goals, many materials do not possess market value but do produce high energy value. These materials would reduce energy value while exposed to the operating parameters of the ***Rotoclave***®. The pre-treatment separation of materials is not only desirable, it is highly suggested.

The **T&B Fabrication *Rotoclave***® technology subjects the raw MSW to agitation, pressure, heat, and moisture from the injected saturated steam. This combination of pressure, high temperature, and moisture, in conjunction with the unique method of agitation, ensures that the totality of the MSW materials being processed will be exposed to the sterilizing live steam.

Extreme processing conditions in the fully automated ***Rotoclave***® process allows for applications across a wide variety of fields:

- Regulated Medical and Pathological Wastes (RMW)
- Port Wastes (airports and seaports)
- Laboratory and Veterinary Wastes
- Abattoir Waste and Dry Digestion Processing
- BSE Processing
- Raw Pulp for Cardboard and Paper production

- Municipal Solid Wastes (MSW) (for which it was originally designed)

The ***Rotoclave***® process sterilizes all waste while eliminating any pathological condition that might be present in the MSW, whether due to organic putrefaction, discarded infectious waste in the MSW stream, or from other sources. These sterilizing capabilities not only provides a peace of mind to the operator, assuring its workers that they will not be exposed to health dangers, but also provides full compliance with strict regulatory rules established by some countries to handle specific types of wastes (such as Abattoir waste, Animal Meat preparation and trimming plants, Restaurant and Supermarket waste, whether from residual food preparation or discarded outdated of putrefied food).

Additional to the sterilization benefit associated with the ***Rotoclave***® process, the mechanical agitation of the MSW created by the rotating internal drum generates a Significant Volume Reduction.

The resulting product of the ***Rotoclave***® process is a Completely Sterile and Volume Reduced Waste steam. This is the "Key" to effective separation of Organic Fiber and Clean Recyclates by existing industry proven mechanical equipment. Effective mechanical separation of Recyclates in the ***Rotoclave***® system, without the need of the costly and cumbersome curb recycling or dirty MRF programs, provides Clean and Inexpensive Organic Fiber, Metals, and Plastics Recyclates which are easily sold in existing markets worldwide.

Recovery of the Organic Fiber from the MSW

The ***Rotoclave***® effectively breaks down and pulps all biodegradable materials in the MSW stream, (including cardboard, diapers, paper, etc.) and transforms them into a fibrous pulp. This fibrous pulp, or flock, is easily separated from the balance of the treated MSW materials through the use of mechanical screens (trommels, vibratory, etc.) and proprietary density separation systems. This allows efficient separation, recovery, and beneficial reuse of organic materials in the MSW.

The recovered / recyclable fibrous pulp / flock (largely cellulose and hemi-cellulose) can be directed to several emerging, environmentally friendly biomass "Conversion Technology" applications. Proper selection of the conversion technology drives the application of specific biomass pre-treatment equipment (such as density separation, dewatering, size reduction, drying, and/or densification options).

Some of the multiple environmentally friendly markets for recovered biomass include:

- Acid, alkaline, or enzymatic hydrolysis for production of ethanol and / or other specialty chemicals.

- Gasification, with renewable energy production, from produced synthetic gas via engine generator sets, highly efficient turbine systems or fuel cells, or conversion syngas to liquid biofuels (such as butanol, ethanol, synthetic gasoline, or synthetic diesel).
- Pyrolysis with conversion of produced pyrolysis oil to renewable power or liquid biofuels.
- Anaerobic Digestion for renewable power generation.

T&B Fabrication recycling systems can:

- Facilitate diversion of organic waste from landfill, thus eliminating creation of landfill methane. Fugitive emissions of methane are widely recognized as a major contributor to global warming, as methane gas is many times more harmful than carbon dioxide or carbon monoxide.
- Facilitate recovery of virtually all recyclable metals, plastics, glass, and textiles for beneficial use.
- Eliminate future creations of hazardous landfill leachate associated with landfill of organic waste.
- Facilitate displacement of non-renewable forms of electricity and / or transportation fuels and reduce our Nations' dependence on foreign crude oil.

The implementation of the **T&B Fabrication** recycling system results in the diversion of Over 70% of MSW from landfill, while doubling recovery of recyclables over the average curbside collection program. Limited remaining landfill life is increased by as much as four to five times.

The ***Rotoclave's***® effective transformation of biodegradable materials into pulp (typically averaging 60% of the total MSW waste stream), allows for easy separation by standard mechanical separators. This is the key factor allowing the high rate of recovery of recyclable materials with market value, using existing proven technologies.

Recovery of the Metals from the MSW

The ***Rotoclave***® effectively processes Ferrous and Non-Ferrous Metals, maintaining their structural integrity. During the typical batch processing, inks and paper labels are removed from the metal surfaces.

The Ferrous Metals are separated using well proven Magnetic Separators, and the Non-Ferrous Metals using proven Eddy-Current Separators. These can then be baled, using standard baling equipment, directly from the cages holding the recovered metals. The baled Recyclates are then transported to the recycling markets by standard commercial means.

Some metals in the MSW are difficult to separate due to their manufactured nature (such as electrical wires and/or metal shelving covered or coated with plastic). Each facility would then determine whether to provide additional laborious separation stations to recover these materials, or to dispose of them into landfills. The material would then be included in the discarded percentages of the total weight processed.

Recovery of the Plastics from the MSW

Plastics processed in the ***Rotoclave***® system will alter their physical state to various degrees, depending on their chemical structure and density. The deformation temperature of the various plastics will have great bearing in the extent of its change / modification during the processing in the ***Rotoclave***® vessel.

PET or PETE materials (such as in drinks/ liquids containing bottles, food containers, microwavable trays, etc.), will slightly shrink and/or flatten, but remain intact. These materials can be separated using conventional Optical Sorters and / or Other Plastic Recognition Technologies.

HDPE materials come in different shapes, thicknesses, and densities. Lighter HDPE materials (such as retail/ grocery bags) will deform and form into small balls. These materials can mostly be separated from the organic fibrous stream after the metal separation using inorganic screens and separators. All other HDPE will be deformed to an extent, depending on the thickness of its application: Milk, water, and juice bottles will flatten; shampoo, dish / laundry detergent, household cleaner bottles / containers, and shipping containers will mostly retain their shape and size. These materials can be separated using conventional Optical Sorters and / or other Plastic Recognition Technologies.

PVC materials come in different thicknesses and will be affected differently by the ***Rotoclave***® processing. Most PVC packaging (bags for bedding, shrink wrap, deli, meat wrap, etc.) will shrink greatly, forming balls such as described under HDPE materials. Most of this separation occurs after the metal separation at the inorganic screens and separators. Other PVC applications (such as liquid containing bags, tubing, wire, and cable insulation) is separated using conventional Optical Sorters and / or other Plastic Recognition Technologies, alongside the rigid containers and floor tiles, etc.

LDPE materials come in different thicknesses and will also be affected differently by the ***Rotoclave***® process. All packaging materials (such as laundry bags, garbage bags, frozen food, produce bags, etc.) will deform, and their recovery mostly depends on their volume and commercial viability. They can be separated from the organic fibrous stream, after the metal separation, using the inorganic screens and separators. Other LDPE (such as the ones used in toys, beverage cups, container lids, squeezable bottles, etc.), can be recovered using conventional Optical Sorters and / or other Plastic Recognition Technologies.

PP materials are slightly deformed by the process heat and recovered at various streams, depending on the material sizes. Small bottle caps and closures can be mostly separated from

the organic fibrous stream, after the metal separation at the inorganic screens and separators. Larger sizes (such as yogurt, margarine containers, takeout food containers, medicine bottles, food bottles, etc.), can be recovered using conventional Optical Sorters and / or other Plastic Recognition Technologies.

PS materials typically retain their shape and slightly deform depending on the size of the container, or whether it is fabricated with other materials (such as rubber in High Impact Polystyrene (HIPS) applications). Typically, materials such as food service items (cups, plates, bowls, cutlery, hinged takeout containers, meat / poultry trays, rigid food containers for yogurt, etc.) are slightly deformed. Other applications (such as those used in the fabrication of toys, video cassettes, cloth hangers, electronic housings, cable or thread spools, compact disks cases and / or medicine bottles) will mostly retain their shape and size, and can be recovered using conventional Optical Sorters and / or other Plastic Recognition Technologies.

Rubber Tires and/ or Large Plastic Furniture materials can be recovered either at the pre-processing separation stations, or at the Oversize Overflow coming out of the organic fiber vibrator or trommel separators.

What to do Next… Does the Solution Solve All the MSW related Problems?

As has been addressed in this document, local communities must assume responsibility over the disposal method selected to resolve all problems created by the MSW their community presently generates. ***THE T&B FABRICATION ROTOCLAVE® ALLOWS COMPLIANCE WITH ALL OF THE FOLLOWING REQUIREMENTS.***

1. The MSW disposal method selected **MUST** provide a ***Positive Environmental Impact***, thus protecting the Environment for all present and future generations. This method must address all polluting sources and elements known, as well as addressing important issues such as the Green-House-Effect, Water Conservation, Aquifer Contamination, Degradation or Destruction of local Fauna and Flora, among others.

2. The MSW disposal method selected **MUST** ***Effectively Reduce MSW Weight Quantities Below Specific Targets*** provided by national, state and / or local regulation. This will drastically reduce the MSW quantities presently being disposed of in their permitted landfills. National, State, and Local Legislations must establish Financial Incentives, as well as Fines, associated with specific incremental target reductions and dates. These actions are aimed to increase the participation of private business in achieving positive and permanent solutions to the MSW disposal, resulting in "Win-Win" situations benefitting the whole community.

3. The MSW disposal method selected **MUST** ***Allow the Mechanical Recovery of Useful and Marketable Materials in MSW***, which will reduce their recovery cost, while

increasing their viable marketability. The recovery of these materials, mostly metals and plastic, is directly related to a "Carbon Positive Footprint". The establishment of Carbon Trade Markets by many countries have created great business incentives associated with material Recyclates from MSW.

4. The MSW disposal method selected **MUST** assure that any ***Residual Materials to be Landfilled must NOT be Toxic, Polluting, or Hazardous.*** This allows its deposit in permitted landfills without any possibility to pollute any aquifer in the event of a liner leak or failure.

5. The MSW disposal method selected **MUST** be ***Capable of Expanding Processing Capabilities as Population Grows,*** enabling local communities and governments to plan its growth without affecting or losing its initial, or present, investment.

6. The MSW disposal method selected must be ***Capable of Operating in Privately or Publicly Owned Facilities.*** This allows any community the control of its own destiny by the following means:

a. Develop and own a Processing and Material Recovery Facility (PMRF) and lease the operation with a private firm

b. Contract their generated MSW to be delivered to a privately developed, owned, and operated PMRF prior to a non-recoverable MSW disposal into their local landfill.

7. The MSW disposal method selected **MUST** be ***Financially Viable NOT increasing Tax Liability***.

Political Leaders, Environmentalists, Economists, the Scientific Community, and the General Population are all in agreement that it is necessary to implement a Practical and Economic method for the recovery of the great majority of reusable materials contained in today's MSW.

The T&B Fabrication Rotoclave® provides you NOW with the Permanent Solution to your MSW Disposal Dilemma, fully complying with the Required Benefits of Environmental Conformity and Financial Viability.

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