

BENEFICIAL USE OF MUNICIPAL WASTEWATER BIOSOLIDS THROUGH DRYING AND PELLETIZING

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ABSTRACT

The federal ban on the ocean dumping of municipal wastewater treatment sludges was a call to action for many coastal communities. The response to these regulations has resulted in the diversion of this waste from ocean disposal to beneficial use through land application, composting and pelletization. This paper describes the design, start-up and operations of the new wastewater biosolids drying and pelletizing facility located in New York City's Bronx Borough.

BACKGROUND

For more than fifty years New York City had disposed of the sludge from its waste water treatment plants through ocean dumping. The end of this practice began when the U.S. Congress enacted the Ocean Dumping Ban Act in 1988, which required the phase out of all ocean disposal. The City entered into a consent decree with the EPA to have new sludge dewatering facilities 100 percent operational by June 1992 and to arrange for interim and long-term land based sludge disposal services.

Since New York City had limited experience with other sludge disposal options, input was gathered from the more than 150 responders to the NY Department of Environmental Protection's (DEP) requested Expressions of Interest for a land-based disposal program. Ultimately, 39 bidders submitted qualification proposals to the DEP in September 1989. The list of interested parties was further reduced when 12 detailed technical and financial proposals were submitted for evaluation to the DEP that December. In February 1990, a request was made for additional information, revised technical plans and sealed cost proposals

which resulted in the top five proposers being invited to commence final contract negotiations.

During this multi-step effort, it became apparent that treated wastewater sludge is more appropriately called biosolids, based on its value as a nutrient-rich, organic material. The top five proposals covered a broad spectrum of proven disposal and beneficial use techniques: (1) Drying and pelletizing, (2) Chemical stabilization, (3) Landfill disposal (4) Agricultural landspreading and (5) Composting. In October 1991, after more than a year of negotiation, legal review and public hearings, the City issued a Notice to Proceed to the New York Organic Fertilizer Company (NYOFCO) to design, build, own and operate a drying and pelletizing facility to handle up to 300 dry ton/day (272 metric TPD) of biosolids. NYOFCO also provided land based biosolids management services from January, 1992 through the successful start-up of the dryer facility in August, 1993. This facility, located on the East River in the Bronx, is a model success story for public and private sectors working together to enhance our environment converting a "waste" to a beneficial use.

OVERALL PROCESS DESCRIPTION

West Biosolids Receiving/Handling

The NYOFCO plant can handle over 1200 wet TPD of biosolids from any of the dewatering facilities located throughout New York City (see Figure 1). All material received at the plant is delivered in sealed trucks, which are weighed prior to discharging into one of three live-bottom receiving pits. The biosolids are conveyed out of the pits by a series of shaftless screw conveyors which discharge onto one of two belt conveyors. Each receiving pit and

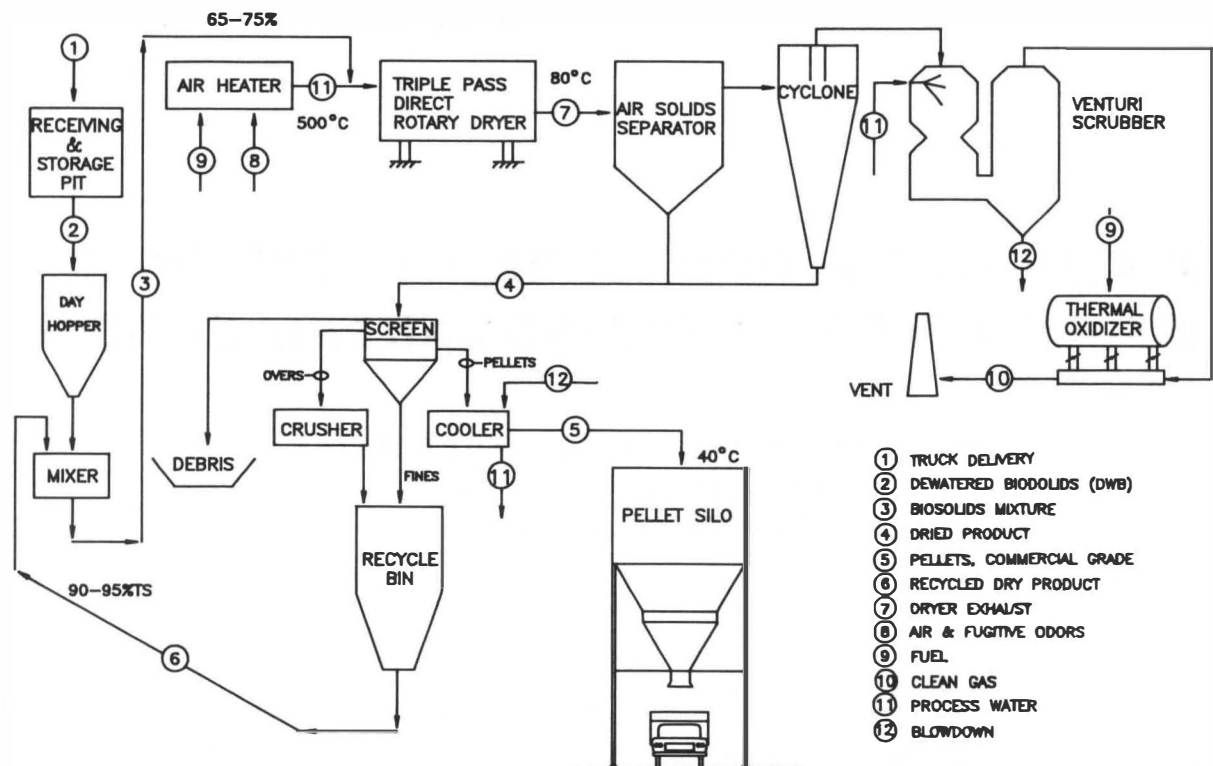


FIG. 1 BIOSOLIDS DRYING AND PELLETIZING SYSTEM

conveyer system is totally independent of the others for redundancy and ease of maintenance, and can handle the full production of the plant.

Each belt conveyer travels the full length of the process building. Five pneumatically operated belt scraper stations and the end discharge serve to direct the biosolids into the day hoppers for each of the six dryer trains. The cake is then transported by shaftless screw conveyors to a rotary pin mixer, and combined with recycled dried pellets. The rates of the wet and dried biosolids are controlled to produce a dryer feed mix at 65–75 percent solids to avoid handling problems common with wetter, stickier material and to produce a high quality pellet.

Rotary Dryer

A natural gas fired furnace is used to preheat the air entering the rotary dryer to 400°–550°C. If there is an interruption of the natural gas supply, then kerosene is available as a back-up fuel to heat the air for the dryer. The inlet temperature is controlled by the dryer outlet gas temperature set point of 80°C. This constitutes a Process for the Further Reduction of Pathogens, or PFRP, and ensures proper drying and pathogen reduction of the wet biosolids. The drying takes place in a triple-pass direct rotary dryer, which is constructed of three concentric cylinders. As the material falls in the dryer, it is pushed along by the flow-

ing hot air and a series of lifter plates. The rotary action of the dryer creates a tumbling action to permit continual contact of the biosolids with the heated air stream and the uniform formation of spherical shaped pellets. The dryer discharges into an oversized conical bottom vessel to permit separation of the gas stream from the dried pellets.

Pellet Handling

The solids leaving the dryer are conveyed to the top of a multi-deck vibrating screen. Material greater than 15 mm is largely debris, and is scalped by the top screen and discarded. The product passing through the course screen and greater than 10 mm is directed to a sealed roll crusher. Oversized material is reduced in size and combined with the fines that passes through all screens for recycle back to the dryer. The careful control of the wet/dry mix rates, the rotary action of the dryer and the screening/crushing and recycling of the dried product collectively result in the uniform production of a spherical pellet. The final classified product, which is approximately 6–8 mm in diameter, is directed through a water-cooled plate bulk flow heat exchanger to reduce the pellet temperature to less than 40°C. The cooled pellets are then pneumatically transported to one of eight storage silos which have a combined storage capacity of over 4500 metric tons. The pellets are conveyed to a bulk weigher prior to railcar or truck loadout.

AIR QUALITY CONTROL PROCESS

Other than the natural gas burners in each air heater and thermal oxidizer, no combustion takes place in the drying/pelletizing process. Hence, the air emissions and operating permit limits are very low. During the permitting the primary focus was with fugitive odors and gases that would be released through handling of the biosolids and during the drying process. The NYOFCO facility includes the equipment and system necessary to control these emissions, as listed in Table I.

Odor Control

All material delivered from the dewatering facilities is transported fully covered in sealed dump trucks which have single use locks on the cover and tailgate. The seals, which are numbered and load manifested, are broken by the loadmaster only after the truck is inside the enclosed tipping area. This procedure provides chain-of-custody for quality control and ensures that odors do not escape during the transportation from the eight dewatering facilities.

All of the make-up air required for the process enters through air handling units located on the building roof. These units are operated to supply a portion of the process needs, with in-leakage from vents and doors providing the balance. This was done to keep the contiguous Process and Receiving Buildings under negative pressure to minimize any chance of odor release. This large volume of makeup air first enters through the main process building to maintain a sound working environment for the operators before passing into the receiving building. A large plenum located adjacent to the storage pit distributes the air to each of the gas-fired air heaters. Fugitive odors are then destroyed as they pass through the process train and air emission control equipment.

As an added precaution, an odor absorbing agent is periodically pressure atomized above the storage pits, transport belts and in other areas of the process building. This reduces the normal odor level inside the process building and controls odors when the process equipment is off-line. The air used in the dense phase Pneumatic Conveying System to transport the pellets to the silos is directed through a baghouse and activated carbon filter. This effectively controls any odors and dust that could be released during the final handling of the pellets.

Air Quality Control Equipment

The dust and impurities that are released during the drying process are collected and/or destroyed prior to final discharge of the gases to the atmosphere. The larger dust particles are captured in a low-pressure drop cyclone for recycling back into the process. The fine particulate is collected by a high-efficiency wet venturi scrubber that reduces the dust concentration below the 0.008 gr/dscf per-

TABLE I AIR EMISSION SUMMARY

	OPERATING PERMIT	COMPLIANCE
	LIMIT	TEST RESULT
Particulate	0.008 gr/dscf	0.0006 gr/dscf 1.4 (mg/dscm)
NO _x	3.2 lbs/Hr	2.9 lbs/Hr (22.2 gm/sec)
CO	2.0 lbs/Hr	1.3 lbs/Hr (9.8 gm/sec)
SO ₂	0.7 lbs/Hr	0.3 lbs/Hr (2.6 gm/sec)
VOC*	12 ppm	5.0 ppm
Cadmium	6.6 x10 ⁻⁵ lbs/Hr	ND
Lead	7.3 x10 ⁻⁵ lbs/Hr	ND
Mercury	1.6 x10 ⁻⁵ lbs/Hr	ND

* Reported as total Non Methane Hydrocarbons

ND = Not Detected

mit limit. The pH of the venturi liquor is kept below 6.0 in order to remove the soluble ammonia that is released during the drying process. This is to prevent the conversion of NH₃ to NO_x in the subsequent afterburner chamber. The gases then pass through a cyclonic demisting chamber to remove excess moisture, then through an induced draft fan and through the Regenerative Thermal Oxidizer (RTO).

The dust free gas travels through a multi-chamber RTO where it is heated to 875°C to destroy carbon monoxide, odors and volatile organic compounds (VOCs). A unique damper arrangement alternately directs the gas through three ceramic filled chambers that serve to preheat the gas stream as it enters and cool the gas stream as it exits the RTO. This allows high temperature operation to destroy more than 980 percent of the VOCs while minimizing heat loss from the RTO. A continuous emission monitoring system analyzes the exhaust gas for CO₂, VOC, O₂ and opacity prior to release up the stack.

Ammonia and NO_x Control

The physical and chemical properties of the wet sludge coming to the plant from the City's 14 wastewater treatment plants and eight de-watering facilities are variable. One of the more unpredictable characteristics that impacts the drying plant is the quantity of free ammonia contained in the sludge. Part of this ammonia, released during the 30-minute drying process, results in concentrations ranging from 100 to 2000 ppmv in the dryer exhaust gas. The ammonia must be collected to prevent conversion of the NH₃ to NO_x at the elevated temperatures in the thermal oxidizer. Fortunately, gaseous ammonia is highly water soluble and can be readily controlled in the wet venturi scrubber. The NO_x emissions are thus limited to those resulting from natural gas combustion in the dryer and RTO burners. The combination of low NO_x burners, the venturi

scrubber and the RTO have proven successful at controlling the gaseous emissions of NO_x, CO and VOCs.

CONSTRUCTION AND START-UP HISTORY

Construction Schedule

When the City issued the Notice to Proceed in October 1991, only preliminary process engineering and layout work had been completed. Since the contract terms required that the facility complete performance testing by August 1993, the Consulting Engineer, Tighe & Bond, immediately dove into the project with full force. Meanwhile, demolition and subsurface investigation teams mobilized on site. As can be illustrated in Table II, the fast track schedule resulted in startup activities beginning less than one year after the first foundation was placed. The facility was operating commercially 16 months after the first foundation pile was placed.

Site Conditions

The ten acre site, characterized by warehousing and light industry, is located on the East River in the South Bronx. Prior to its current use for the NYOFCO facility, the site was used as a fuel terminal. Fuel barges would tie up at the pier and transfer various fuels to on site storage tanks prior to loading into trucks. Almost immediately after receiving the notice to proceed in November 1991, the wrecking crew arrived on site to remove three round steel fuel oil tanks, a 240'-by-240' square multi-chambered steel tank, the old administration and boiler buildings, the truck terminal, and most of the existing foundations. Recycled steel was sold to a local scrap dealer, and brick and concrete were sent to a crushing plant for conversion to aggregate. Demolition continued through March 1992.

Because of tight schedules, certain construction activities had to be authorized based upon preliminary design information. The Process Building had to be released for fabrication prior to final equipment layout. Piling had to begin prior to finalizing the building column loadings. Conduit runs and duct banks were placed underground based upon a conceptual electrical plan so concrete could be poured. Equipment foundations were being poured while mechanical equipment dimensions were being finalized. Needless to say, a lot of just in time engineering was taking place in order to keep pace with construction activities.

In a three month period from January through March 1993 over 90 percent of the equipment was set in place and electrically wired. Electrical and control loop testing, motor alignment and rotational checks started in April leading to May 21 when the first load of biosolids was received at the facility.

TABLE II

Notice to Proceed	11/91
Site Demolition Began	11/91
Test Borings	12/91
First Piling	4/92
First Concrete	5/92
Final NYC Building Permits	9/92
First Building Steel	9/92
First Arrival of Equipment	10/92
Peak of Construction at 350 men	3/93
Transformer Energized	3/93
First Sludge Delivery	5/93
Performance Test/Connected Operation	8/93

SPECIAL CHALLENGES

Many routine problems needed to be worked out in the period between the first biosolids delivery and the beginning of performance testing. Each of these challenges was addressed by a cross functional team from Engineering, Operations, Construction and the cooperative equipment suppliers.

Early on, several small capacity direct-coupled motors on the shaftless screws in the wet handling system failed. It was concluded that these variable speed drives were undersized and that some motors were not correctly specified for extreme, inverter rated duty. On Memorial Day weekend, an experimental set-up on one train, which utilized larger inverter-rated motors coupled by belts and pulleys, was installed and proved successful in handling wet cake up to design conditions. Identical modifications were made on all six pairs and permanent replacements were ordered for future installation.

Once wet feed could be reliably conveyed to the mixers, an assortment of other challenges confronted the start-up team. The dry recycle feed conveying system could not provide the proper flow to maintain the targeted mixture solids content. This required that six screw conveyors and six bucket elevators were resheaved to increase speed by 20 percent. Also, the dryer feed chute plugged frequently and required the installation of several doors and interior deflector plates to reduce build-up and to facilitate on-line cleaning and sampling of the feed mixture. The pin mixers were not adequately combining the dry and wet material and would frequently trip on motor overload, requiring a messy and labor intensive effort in disassembling the shell and cleaning out the packed material. Eventually, this problem was resolved by modifications to the pins, paddles and discharge chutes.

The venturi scrubbers posed a rather vexing problem during the first month of operation when the level controllers quickly became fouled by hair, string and thick solids in the scrubber recirculation loop, causing total lack of level control. Several types of level instruments were

tried, with a "tuning fork" probe proving most suitable for this application. The installation of vortex breakers and pH control decreased foaming in the vessel, which was being carried over to downstream equipment as well as falsely signaling the level controls.

The blowdown stream from the wet scrubbers is transferred to lamella type clarifiers for solids removal prior to sewerage the clear water. However, the clarifiers had difficulty responding to the constantly changing solids carrying over from the dryers and never worked efficiently. Modifications in this area included the installation of a premix tank for polymer and pH adjustment and the ultimate replacement of the clarifiers with centrifuges.

Even with knowledge of the experiences from drying plants in Quincy, MA, Milwaukee, WI and Hyperion in Los Angeles, a lot was learned during start-up regarding the need for good explosion protection. Inherent to its nature, dried sewage sludge dust can create an explosive environment when proper fuel, oxygen and a source of ignition conditions exist simultaneously. During start-up, several small deflagrations occurred, fortunately without any harm done to equipment and operating personnel. To minimize this potential operating hazard, several key items must be followed which include: minimizing air infiltration to equipment handling dried sludge by means of rotary air locks; careful control and monitoring of draft pressure and temperature at the dryer inlet and outlet; and incorporating relief vents on conveyors and chutes.

Also, from the experiences at a similar plant in Quincy, MA it became known that the dried product has a tendency towards self-heating and combustion if stored in bulk under the right conditions. This problem was addressed by

the addition of a water cooled plate type heat exchanger that would precool the pellets to 40°C prior to storage and shipment. Unfortunately, this system couldn't be installed prior to startup, so operational practices were put into place that called for continual monitoring of pellet temperature in the silos and an off loading schedule to ensure that the silos were emptied every night until the cooling system was completed.

The plant successfully completed performance testing in July and August of 1993. Each of the six trains was tested and demonstrated the ability to produce well over the required 50 dry tpd of product. All of the subsystems were proven to operate as intended and the City accepted the plant into commercial operation.

SUMMARY

The dried and pelletized biosolids produced by NY-OFSCO, an operating division of Wheelabrator Technologies, Inc., are being successfully marketed as a fertilizer and soil amendment in Ohio, Pennsylvania, Colorado, Florida and other states. The process is flexible enough to alter some of the physical and compositional characteristics of the pellets to meet the varying needs of the customers. This, of course, is very important to meet the overall project goal of diverting what was once a waste from disposal to beneficial use. The start-up and operation of this new facility in New York City follows several other commercially successful operations around the country that collectively demonstrate that drying and pelletizing of municipal wastewater biosolids is a viable alternative for other communities.