Pneumatic Waste Collection Systems as a New Utility Infrastructure in Modern Developments Today

A Case Study on Automated Waste Collection in Al Raha Beach Abu Dhabi
1.0 INTRODUCTION

Until recently, the only method used in transporting and moving solid waste has been the “dreaded” rear loader or side loader compactor refuse trucks, technically known as RCVs (refuse collection vehicles) with manual labour to support the movement of bins to the vehicles. This method has not changed since the days of the horse drawn carriage to the present deplorable diesel engine trucks. The vehicle may have changed but the method still involves extensive labour, appalling stench and spillage of toxic leachate. Garbage left by the streets and in open and closed bins also results in breeding grounds for all kinds of pests, insects and rodents.

From an environmental perspective, more damage is caused today with the volumes of waste generated with the population rising and with the greater utilization of the “dreaded” compactor trucks that are heavily dependent on fossil based fuels.

In many progressive cities today, visionary planners and developers are adopting a new and unique solution to the problem of refuse collection in highly populated areas. This solution of pneumatic waste systems, also popularly known as Automated Waste Collection System (AWCS), transports refuse by vacuum in underground pipes offering a solution to match the evolutionary process of moving infrastructure below the ground.

AWCS works on the principal of solid waste being conveyed pneumatically by underground pipelines from its place of generation (landed properties, apartment blocks, commercial facilities, etc.) to a
central collection facility where it is loaded into sealed containers and compacted before being transported using regular hook lift trucks to a treatment center.

Pneumatic conveying is based on the physical principle that air, under certain conditions, is able to convey heavy materials. In nature air can carry many substances, such as sand, leaves and seeds. Pneumatic conveying causes air to flow by creating a pressure difference between the start and end of the pipe. To allow solid matter (in this case solid waste) to be transported, the driving flow forces of the air must be larger than the forces – weight, friction and inertia – acting on the particle. This airflow in the pipe using the measured air velocity of 18-23m/s is ideal to move all general solid waste material from one determined location to another.

2.0 DISCUSSION THROUGH A CASE STUDY

Along a beautiful coastline in the city of Abu Dhabi, stretching 11 kms long, an area of over 6.8 mil square meters is being developed into a waterfront marvel. A new dynamic business district is starting to pierce the skyline, where a charismatic marina is surrounded by iconic towers. The business district is also home to the new Abu Dhabi World Trade Center building. Several hotels will allow visitors a taste of this fresh outlook on waterfront life, to explore its attractions and cruise the bays. Some classify it as the realization of the ultimate waterfront city, boasting the paramount in urban design and lifestyle. The planned development is expected to take 12 years and so far 4 Precincts have been completed with ALDAR’s headquarters in a unique geometric circular shape standing out like a welcoming beacon representing Abu Dhabi’s vision for 2030. The 23-storey building voted the “Best Futuristic Design 2008” by the Building Exchange (BEX) is completely fitted with this operational new refuse vacuum utility – the AWCS by Stream.

The Al Raha Beach development was conceived by some of the best architects in the world with every aspect of the environment being considered during the master plan phase. ALDAR’s vision of Al Raha Beach is to be the best development of its kind, with every building being a “Green” building that requires to be “Leadership in Energy and Environmental Design” (LEED) certified.

Buildings within the development will take advantage of environmental strategies and passive controls together whilst utilizing the natural sunlight to light the building and the natural flow of air to cool it. With a focus on Energy and the Environment Al Raha Beach features extensive use of recyclable materials, prefabricated elements, to ensure minimum waste creation, maximum waste separation and an AWCS system to complement the Vision of the development.

A truly holistic approach could not afford to overlook waste management. Experience had taught that
conventional waste handling method would consume large amounts of energy from trucks and lifts being used to handle waste. Furthermore, the local environment suffers through leachate (garbage juice) spillage during handling, wreaking of odors, and the tendency for waste to enter the sensitive ecosystems. AWCS addressed all of these concerns. Al Raha Beach’s drive to minimize the Carbon Footprint was supported by the replacement of several fossil fuel driven ROV’s by the STREAM AWCS, that allowed a fully sealed underground vacuum pipe network to ensure that no waste or odors entered the surrounding areas. The removal of waste became a STREAM-lined and efficient process which saved energy, protected the environment, and improved air and ground quality immensely.

3.0 HOW THE SYSTEM WORKS

The collection cycle starts at the loading station points of the apartment or office buildings, where garbage, in or out of bags, are put through a hopper door into a vertical pipe better known as the garbage chute. The refuse falls due to the force of gravity into a temporary holding chamber (part of the sealed piped system) just above the discharge valve. The discharge valve connects with a network of horizontal pipes leading to the waste collection facility located up to 2.5 km away. At the central collection point, computer controlled vacuum exhausters generate a negative pressure in the pipes which, when the discharge valve is opened, sucks in the bags of garbage. The refuse travels at speeds of up to 80 km/hour to the collection point where they are separated from the air in a cyclone separator and unloaded into a compactor that compresses the waste into containers. The air moves through a 4-stage filtration system that cleans the air of the smaller particulates and deodorizes it before it is released to the atmosphere.

The network, presently catering for the 4 precincts and modular in nature is formed by 16,000 metres of pipes and 183 discharge valves, is divided into sectors to optimize the number of waste collection facilities and manage the conveying distances. The operation of the system is built on 24/7 reliability. The system is fully computerized and automated and any anomaly in functioning is indicated at the control centre by alarm signals. The frequency of the emptying cycles is easily changed in line with localized circumstances and additional discharging may be programmed for particular areas with higher waste output (food courts, restaurants, etc) at peak times, or on particular days, such as special public holidays or during Ramadhan.

4.0 THE MECHANISM INVOLVED

The pneumatic collection system can be categorized into 3 key separate parts: (1) the central waste handling facility, (2) the transport network, and (3) the loading stations. The process is controlled from the central waste handling facility, where the refuse is handled and the vacuum power necessary to run the system to move the refuse around the whole pipeline network is generated. The garbage transport underground pipe network runs parallel with the other infrastructure services (i.e. chilled water, potable water, stormwater, power cables, telecom cables, etc) of the district. Finally, the load stations and in-plot infra are located inside and outside the buildings, and is the interface between users and the automated waste collection system.
4.1 THE CENTRAL WASTE HANDLING FACILITY (CWHF)

The Central Waste Handling Facilities (CWHF) are 2-level buildings about 10 metres tall and can be located above or below ground level. The CWHF houses the vacuum exhauster room that generates the high airflows required for transport, the compressor that feeds the compressed air circuit that powers the opening of the discharge valves, the control centre for executing all commands automatically and checks on the collection cycles, the waste separators, the 4-stage air filtration system, the waste compactors, the container conveyors for shifting containers and the containers containing the compacted waste.

A typical module has a capacity for 3 containers (2 for mixed waste and 1 for recyclable waste) each of 22m$^3$ capacity, sufficient to handle the waste output 15-20 buildings of 40-storeys height.
4.2 THE TRANSPORT NETWORK

The underground transport network comprises of 500 mm diameter pipes protected externally by a 3-layer PE coating. These are made of mild steel joined by a rigorous welding procedure. The pipe bends are specially designed and manufactured of both mild steel and high abrasion resistant type. At any pipe bends, there is a gradual braking of the waste in the air stream. Higher wear occurs at the bend and this in turn requires special attention such as thicker pipe walls and harder material. The pipes vary in thickness according to the waste load they are to carry generally thinner upstream and thicker downstream. Next to the pipes are PVC conduits containing both the compressed air conduits and the system’s communication control cables.

4.3 THE LOAD STATION SYSTEM

Within the buildings and private spaces are located the throw points, the Load Stations, where the waste enters the AWCS pipe network. On every floor 2 Load Stations are provided – 1 for Mixed Waste and 1 for Recyclable Waste. The Load Stations comprise of volume controlled hopper doors connected to chutes, the temporary storage chambers, the discharge valves, the primary air intake unit and the series of linked horizontal pipes, similar to those of the transport network. The chutes with a diameter of 500mm, link all the floors of the buildings with the discharge valves in the basements. The hopper doors are situated in the communal spaces (landings, corridors, stairwells, next to lift shafts). The primary air intake unit is the entry point of air into the system that is used to convey the waste to the CWHF.
The discharge valves are usually situated in the basements of the buildings, directly above the horizontal pipes. Opening and closing are controlled automatically from the logic based computer system. The option of using a level sensor to indicate a threshold reached is also included for the rare cases of holding areas above the Discharge Valves being overloaded before the programmed transport cycles.

The Electrical and control cables ensure the transmission of electronic and control signals between the load stations on the chutes and the discharge valves as well as to the Control Centre. The compressed air installation powers the opening and closing of all the valves situated throughout the transport pipeline network and are activated by low voltage signals sent from the Control Centre.

The Control Center manages all the key control aspects and the integrity of the operations of the systems. Logs are generated of all system activities, faults detection, alarm generation and preventive maintenance reports.

5.0 PNEUMATIC COLLECTION SYSTEMS, RECYCLING & FINAL TREATMENT

Pneumatic Waste systems have been clearly identified as the best method from source to encourage and facilitate recycling. Clearly the volumetric hoppers on every load station at the chutes act as the first line of recycling control. Large bulky items which are always recyclable are now being forced to be handled separately and hence paving the way for a forced separation at source.

In the case of Al Raha beach an additional dual fragment (recyclable/non-recyclable) loading points were built with clearly 2 chutes with 2 refuse holding chambers and here a far more effective waste recycling system is in play. With this system, each fraction is deposited in a specific hatch which is emptied separately. The disposal schedules are pre-set and the system automatically directs each type of refuse to a separate container at the Central Waste Handling Facility. The CWHF is designed to receive different fractions automatically directed to specific containers (recyclable and non-recyclable).

Waste is then transported in these sealed containers to their respective final treatment plants. Organic and non-recyclable waste gets transported to sanitary landfills whilst recyclable waste gets transported to a materials separation and recovery facility MSRF where the recyclable waste gets segregated and recycled accordingly.
HEAD OFFICE

STREAM Environment Sdn Bhd (906609-U)
11 Jalan Sungai Besi Indah 5/2
Taman Sungai Besi Indah
43300 Seri Kembangan
Selangor
Malaysia
Tel: +60 3 8941 8118       Fax: +60 3 8941 8228
Email: info@stream-environment.com
www.stream-environment.com

We have offices in other countries.
For further details, please visit www.stream-environment.com

Singapore
United Arab Emirates
Qatar