PNEUMATIC REFUSE COLLECTION

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There is little technical literature describing the use of modern nonconventional methods of refuse collection. Until not long ago, only conventional methods were used, which basically have been the same for the last few centuries. Refuse is collected onto vehicles and transported as far as possible from its place of origin for its final treatment.

This century, horse-drawn vehicles have been replaced by trucks, which in latter decades have been equipped with crushers and compactors designed to reduce the volume of the refuse. But conventional refuse collection is still a manual method: 80% of its total cost is accounted for by labour.

Similarly, little improvement has been seen in the health and environmental aspects of conventional collection. In most highly developed countries, refuse is still left in the street before being collected by trucks, which leads to environmental problems in many cities.

In many countries, the only non-conventional method being implemented at present is pneumatic refuse collection, which offers a new and completely different solution to the problem of refuse collection in residential areas.

Pneumatic collection means that refuse is conveyed pneumatically by underground pipeline from its place of origin (housing, commercial premises, etc.) to a collection centre or particular truck, where it is loaded into hermetically sealed containers and compacted before being conveyed to the place for final treatment. The method could be defined as a pneumatic sewer system in which the refuse is collected and transported automatically.

The purpose of this article is to describe and analyse all aspects of pneumatic refuse collection, in order to provide everyone interested in the subject with a basic knowledge of the system's possibilities.

INTRODUCTION

For the 1992 Olympic Games the city of Barcelona succeeded in recovering 80 hectares of industrial land along the coastal strip as habitable surface. This is the Olympic Village, sited in the old industrial neighbourhood of Poble Nou, which may be regarded as the flagship project that best defines the transformation of the city in recent years.

As the most relevant data for this area, we would highlight more than 300,000 m^2 of habitable surface area with new build, equivalent to 3,000 new dwellings to be increased to 5,000 in coming years.

The various urban services were designed on the basis of modern municipal engineering techniques, and so the development is equipped with modern service galleries which rationalise the routes of the underground services.

Along the same lines it was decided to fit the dwellings and commercial premises with a pneumatic refuse collection system that would enable residents to dispose of their refuse on the landings of apartment blocks, thus eliminating all the inconvenience associated with the classical systems, as well as the encumbrance of bins and skips on the public thoroughfare and the impact of nightime collection.

Current technology offers two variants of the pneumatic collection system:

One is the so-called **static system**, in which a fixed installation contains all the elements necessary for operation of the process. This is the system currently in use in the Olympic Village.

The other option, known as the **mobile system,** is the one most suitable to programmes of gradual implementation programmes coordinated with staggered urban development schemes. This system is now being put in place in the main street Gran de Gràcia.

SYSTEM WITH CENTRAL COLLECTION POINT (OLYMPIC VILLAGE)

1. DESCRIPTION OF THE PROCESS

The collection cycle (page 3) starts on the landings of the apartment buildings, where the refuse, in the traditional bags or binliners, are put through a hatch (1) into a vertical pipe acting as downpipe (2). The refuse falls due to the force of gravity as far as the valve (3) installed in the basement and kept closed, where the refuse is stored. The pneumatic valve connects with a network of horizontal pipes leading to the collection point under the streets. At the central collection point, turboextractors (11) generate a depression in the pipes which, when the valve (3) is opened, sucks in the bags of refuse. These travel at a speed of between 50 and 60 km per hour to the collection point where they are separated from the air in one cyclone cycle (7) and unloaded into a compactor (8) which moves them

into containers (9). The air is taken to a filtering circuit, purified and returned to the exterior.

The network, which is formed by 12,000 metres of pipes and 244 valves, is divided into sectors by section valves (6) to optimise the number of turboextractors. The collection cycle lasts approximately two hours and is usually carried out once in the morning and once at night. The system is fully computerised (15) 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 local circumstances and additional emptyings may be programmed for particular areas with higher refuse output (warehouses, restaurants, etc) at peak times, or on particular days, such as special public holidays.

2. THE PARTS OF THE SYSTEM

The pneumatic collection system is divided into three separate parts: collection centre, general network, and internal networks. The process is controlled from the collection centre, where the refuse is handled and the power necessary to move the refuse around the whole pipeline network is generated. The general network is formed by the underground pipelines in the street network of the Olympic Village. Finally, the internal networks run under and inside the buildings and link up the collection points (hatches) with the general network.

2.1. GENERAL AND CENTRAL NETWORK

The general network comprises pipes with a diameter of 50 cm. These are made of steel with soldered joints. The pipes vary in thickness according to the refuse load they are to carry: 5 mm near the collection points and 25 mm on the approach to the collection centre. Next to the pipes are PVC conduits containing both the compressed air feed pipes of the valves and the system's command cables.

The collection centre is a three-storey building 8 metres tall. In the basement is the turboextractor room (4 units with a power of 90 Kw) and the compressor that feeds the compressed air circuit via the refuse valves. On the ground floor is the control centre: the entire system operates automatically. The computer is responsible for executing all orders and checks on the collection cycles. On this floor too is the air treatment system, the compactor and the loading and control platform for the containers. This platform has a capacity for three containers of 30 m^3, which means that the output of three days can be stored. Finally, on he first floor is the separator (cyclone) where the refuse sinks due to the force of gravity and is separated from the air used to transport it.

2.2. INTERNAL NETWORKS

Situated within the private spaces and financed by the relevant developers, the internal networks link all buildings where refuse is produced with the general network and the collection centre (page 4). The internal networks comprise a series of horizontal pipes, similar to those of the general network, valves and downpipes, where the disposal hatches are installed. Each branch of the internal networks ends in an air valve, the entry point into the system of the air that will convey the refuse to the collection centre.

The refuse and air valves are usually situated in the basements of the buildings, directly above the horizontal pipes. Opening and closing are controlled automatically from the collection centre. In special cases (commercial premises, restaurants...) the downpipe may have a photoelectric cell which controls levels and informs the centre when the valve should be opened.

The downpipes, which have a diameter of 45 cm, link all the floors of the buildings with the valves in the basements. The disposal hatches are situated in the communal spaces (landings, corridors, staircases...). These have a diameter of 32 cm, so residents are obliged to use the traditional standard binliner or bag.

For commercial premises, hotels, etc., special hatches measuring 400 x 500 were designed to admit bags of 120 litres. In all, 932 residential hatches and 88 commercial hatches are installed.

Finally, in specific areas (the leisure port, gardens and landscaped spaces) linked directly to the general network, there is a total of 36 direct drop boxes to handle large outputs.

MOBILE SYSTEM (GRAN DE GRACIA)

A mobile system of pneumatic solid urban waste collection is formed by a network of underground pipes, drop boxes, refuse storage deposits and collection points. The system requires both a vehicle fitted with special machinery for suction of the refuse and the appropriate equipment for automatic control of the whole interrelated collection process.

These elements are arranged as follows:

Beneath the outdoor drop boxes on the public thoroughfare is the storage tank, where the refuse is deposited in between collection periods.

A pipe network connects each and every one of the tanks with collection points strategically situated in easy-to-park areas.

The collection truck sucks all the refuse stored in the tanks at this small number of collection points, as often as required, frequency being determined according to the output of the area.
Below is a detailed description of each of these elements:

- **Drop boxes**

The boxes have a disposal hatch at the top, about 1.5 metres above the ground and the diameter of the downpipe is 0.4 - 0.5 metres.

The diameter of the disposal hatch is limited to 280 mm, to ensure circulation of the bags within the pipes.

The circular glass hatch opens horizontally, since gates that open downwards are difficult to keep clean.

These boxes are usually situated close to the pavements and in open spaces, at a comfortable distance from entries to dwellings which is determined by their area of influence.

The boxes are made of cast steel, which ensures good wear and tear and protection against vandalism.

- **Storage tanks**

The storage tanks are made of steel and installed underground; they have a theoretical capacity of 2.5 m^3, of which approximately 80% may be considered useful for storing the different amounts of refuse.

The tanks are fitted with three pneumatically operated valves:

- One at the top of the container element which closes off the downpipe into the tank during collecting cycles.

- One at the outlet which when open allows refuse to be removed during collection procedures.

- One at the bottom for intake of the air used to transport the refuse.

In addition, the tanks are fitted with an electronic control box governed from the *Program Logical Computer* (PLC) of the computer in the truck, for carrying out the automatic collection cycles.

- **Pipe network**

The network of pipes is responsible for transporting the refuse from the various storage tanks to the suction points.

The outside diameter of the pipe may vary between 250 and 325 mm, its thickness varies between 5.0 and 8.0 mm. All pipes are made of carbon steel, with soldered joints.

The underground sections of the pipe network have an outside coating of plastic to prevent corrosion.

Parallel to the pipe network is a conduit network containing both the compressed air pipes for the pneumatic action of all the valves and the cable for sending and receiving control signals during collection cycles.

- **Electrical cables**

These ensure the transmission of electronic signals between the collection vehicle and the sequential valves installed in the storage tank.

- **Compressed air installation**

All the valves situated throughout the transport pipeline network are activated by compressed air. This is generated in the collection truck and distributed through plastic pipes which run parallel to the refuse transport pipes.

The compressed air network links the air compressor in the collection truck with all the valves in the storage tanks, and follows the same route right through the transport pipe network.

- **Suction points**

The suction points are strategically placed for the best possible coverage of the area served by the network. They are usually installed on the pavement and in places with easy access for the truck, but they may also be placed under the pavement or roadway.

- **Collection vehicle**

As well as the compactor and container for reception and storage of refuse, the collection truck is fitted with all the machinery required for the system to be operational; and also with the control system for automatic operation of the installation.

The entire collection process may be viewed from the truck at the control system terminal. Similarly, any incident in the collection cycle will show up immediately on the terminal.

There are two types of collection truck: the monoblock version and the type with a collection unit that can be removed from the chassis. In the latter, the chassis used must have a rear loading hook of the universal type.

Only one person is required for the truck and all the operations described above.

1. OPERATION

The system is fully automatic. Manual action is required only for the operation carried out from the collection truck, which includes connecting and disconnecting the hose pipe from the truck to the suction points.

The collection processes are carried out according to the pre-set program and are controlled by the computer in the collection truck.

During these processes all the refuse from the various storage tanks are sucked into the truck.

The collection process may be repeated several times a day, depending on the needs that arise.

Bags of refuse may be thrown into the disposal hatches at any time, both when the system is inactive and during collection cycles.

1.1. SEQUENCE OF OPERATIONS

The collection process is executed as follows (page 8):

The users of the system deposit their refuse in the drop boxes on the public thoroughfare. This may be done at any time of the day or night, the only restrictions being those established and/or recommended by the Municipal Technical Services.

The bags of refuse fall by gravity into the storage tanks, where they remain until the truck starts the collection cycles. When the truck has parked at the suction point and the hose, air compression pipe and control cable have been connected, the process starts as follows:

- The engine of the collection truck is left running at low revolutions. The control system automatically checks the position of all the valves corresponding to the various storage tanks connected to the suction point. Any error or anomaly is immediately registered at the terminal in the cabin of the truck.

- When the checking process is complete, the computer gives the order to start the emptying cycle in the first storage tank. This takes only a few seconds.

- The refuse inlet valve at the top of the tank closes, and immediately afterthis the outlet valve opens. The end of stroke of the outlet valve sends a signal to the truck to increase the number of revolutions of the engine.

- A vacuum is created in the network and the truck reaches 40 Kpa in approximately 10 seconds. During this process, the noise level of the truck reaches its maximum, as measured 6 mts from the side of the vehicle.

- The air inlet valve at the bottom of the tank opens and at the same time a high-speed air current enters. This air current causes the bags of refuse to revolve and moves them towards the outlet valve at the end of the tank.

- After approximately 10 seconds, the air valve closes and negative pressure is established again. This sequence is repeated three times for each storage tank, which ensures complete emptying.

- Then the valves return to their original positions and the truck engine drops to low revolutions.

- The entire collection process for one storage tank lasts approximately 90 seconds.

- This procedure is repeated until all the tanks connected to the suction point have been emptied.

- When the operation at the point in question is complete, the truck continues on its route to the next suction point, where the sequence described above is repeated.

The entire collection process is automatic, manual operation being required only for connection/disconnection of the suction hose and for handling the command and compressed air terminals. The process may take 5 minutes per suction point at the most.

When necessary, if appropriate the emptying process can be carried out manually and operated from the control boxes in the storage tanks.

1.2. DIAGRAM: OPERATION OF THE MOBILE SYSTEM

1. Downpipe
2. Disposal hatch
3. Outdoor drop box
4. Storage tank
5. Tranport pipe
6. Suction point
7. Collection truck

(page 8)

PNEUMATIC COLLECTION AND RECYCLING

Selective collection is generally accepted as being the best way to promote recycling of solid urban waste.

To make selective collection truly effective, it must be carried out at origin, by citizens, but the environment must also be provided with sufficient means to enable citizens to dispose of the fractions of refuse sorted at home.

It is not realistic to expect an acceptable response to selective collection if too great an effort is demanded of the citizen. With this system, each fraction is deposited in a specific hatch which is emptied separately. This may be complemented with pre-set disposal schedules. The system automatically directs each type of refuse to a separate container at the collection centre.

Static SUW collection systems may be adapted to the fractions to be collected selectively. The collection centre is designed to receive different

fractions which the system will automatically direct to specific containers.

In the case of mobile pneumatic collection systems, the system can be adapted to selective collection in two ways.

The first is to use a collection truck with a compactor and single containers (page 9), which would carry out the selection at pre-set times for the different fractions. The truck will collect different fractions on different routes.

The second method is to use a truck with a double compactor and double container (page 9), which would collect the two fractions selected on a single route.

In principle, in both cases the result is the same; totally automated selective collection.

Another feature worth highlighting is that with these systems, optical selection of different fractions may be made by refuse bag colour.

The different fractions are selected at origin by citizens who put them in bags of different colours (page 10). For example, a black bag for the organic fraction and white for the rest. All the bags are thrown into the downpipe and go to a specially designed plant where they are selected optically by colour.

The entire process is automatic.

MIXED SELECTIVE COLLECTION SYSTEMS

When many fractions are to be collected selectively, the combination of the selective collection systems already in place, such as glass, for example, with a pneumatic SUW collection system may also be a good solution. In this case, some fractions are collected pneumatically and others by the traditional selective method.