“An Environmental Choice Plumbing System in a Building—“Vacuum Plumbing System”

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Abstract — In this technology world, we are running through various changes in each and every field. In this paper there is a description of a technology related to plumbing system in a building in India. The concept of this system has been taken from the plumbing system used in aeroplanes. The vacuum plumbing system is one of the emerging concepts in the field of plumbing. This paper explains the design principles of Vacuum plumbing system. And it describes how to achieve a high quality system that functions effectively and is cost-effective and sustainable. This paper also describes the installation, operation and maintenance of vacuum plumbing system. Plumbing design Parameters are also explained in a descriptive way. Vacuum plumbing system is not common in India, so this paper aims to highlight the importance of this system in various buildings like hotels, restaurants, hospitals etc.. With this technology we can control the wastage of water to some extent. This paper also recounts the benefits of the vacuum plumbing system. There are many benefits which vacuum plumbing offers, the water and waste treatment savings are one of the most important features of this technology. The water savings can be lacs of and rupees of liters per year for larger applications. Vacuum systems are a viable and usable drainage solution as described in the latest edition of the IPC (international) and UPC (uniform) Codes.

In addition, many local and state plumbing codes have also accepted vacuum plumbing as an approved alternative for a variety of waste types including condensate, grey water, sanitary waste and grease waste. Vacuum plumbing system provides a best solution for routing waste piping through congested, space restricted areas. Around existing mechanical, electrical or structural elements, without impacting floors below.

II. WHY TO USE VACUUM PLUMBING

We are going to calculate the water consumption of typical Commercial Office Building – 500 people WC

Water use with gravity low flush fixtures.

250 MALES:
250 x 3 flushes/day x 1.9 liters /flush (urinals) x 75% usage= 1068.7 L/DAY
250 x 3 flushes/day x 6.1 liters /flush (water closets) x 25% usage =1143.7 L/DAY

250 FEMALES:
250 x 3 flushes/day x 6.1 liters /flush (water closet) =4575 L/DAY

Total water demand with gravity system:
• Approx. 13.6 litres per person per day.
• 6741.8 liters per day.
• 1685453.8 litres per year

We are going to calculate the water consumption of typical Commercial Office Building – 500 people WC

Water use with vacuum flush fixtures.

250 MALES:
250 x 3 flushes/day x 1.9 liters /flush (urinals) x 75% usage= 1068.7 L/DAY
250 x 3 flushes/day x 1.9 liters /flush (water closets) x 75% usage =118.7 L/DAY

250 FEMALES:
250 x 3 flushes/day x 1.9 liters /flush (water closet) =1425 L/DAY

*Total water demand with vacuum system:

• Approx. 13.6 litres per person per day.
• 6741.8 liters per day.
• 1685453.8 litres per year

In this technology world, we are running through various changes in each and every field. Vacuum plumbing systems are simple, unpretentious and operable alternatives to underground piping that uses the combined energies of vacuum pressure and gravity for the collection, conveyance and disposal of waste through a piping network that can be routed above ground. The vacuum plumbing system is one of the emerging concepts in the field of plumbing. Vacuum drainage operates on the principal of having a majority of the plumbing system under a continuous vacuum. There are many benefits which vacuum plumbing offers, the water and waste treatment savings are one of the most important features of this technology. The water savings can be lacs of and rupees of liters per year for larger applications. Vacuum systems are a viable and usable drainage solution as described in the latest edition of the IPC (international) and UPC (uniform) Codes.
Total water demand with vacuum system:
- Approx. 5.7 liters per person per day
- 2839.1 liters per day
- 709764.4 liters per year

Estimated water and sewage process savings approx. 257,750 gallons per year or 58% annual requirement. It’s the Environmental Choice!

III. COMPONENTS OF VACUUM PLUMBING SYSTEM

A vacuum drainage system consists of components, materials, and hardware organized to provide a waste transportation system that does not depend entirely on gravity for the conveyance of waste products from their point of origin to their eventual disposal in a conventional gravity sewer system. System piping and components are routed and accessible within one level of the building, providing further containment of wastewater and eliminating the possibility of contamination of other levels.

- From fixtures – toilets, sinks, showers, refrigerator cases, etc.
- Through a closed piping network flexibly located in the building, instead of buried underground.
- To a temporary collection center and then automatically to the sewer main or water treatment center.

A vacuum drainage system is organized into three interactive and interdependent, subsystems

A. Waste Collection Points
B. The Vacuum Drainage Piping Network
C. The Vacuum Generating Station.

A. Waste Collection Points

FIGURE 1. Waste Collection Points

These collection points are connected to the main piping network via a Vacuum Interface Valve and for non-flushing fixtures a Buffer is also required. The normally closed vacuum interface valve separates the vacuum in the piping from atmospheric pressure surrounding the fixture. When activated by the Controller, it allows waste to be introduced into the vacuum waste piping network and transported to the vacuum centre. For flushing fixtures e.g. toilets, the interface valve is connected to the waste outlet, separating the toilet from the piping network. When the flush valve is activated, the Controller opens the Interface Valve, allowing atmospheric pressure at the toilet bowl to push waste through the waste outlet, through the Interface Valve and into the waste piping. Because air is used to transport wastewater, no water is required to initiate the flush cycle. The Controller also activates the flush water valve for rinse and re-fill of the bowl. The opening and closing of the Interface Valve is precisely controlled so that all waste is completely removed from the bowl. Since only 1.0-1.8 litres of water per flush is required, Vacuum toilets provide a significant reduction in water use and sewage output. The reduced water requirement also allows water supply line sizing to be significantly smaller than that required for flush valves. In addition, conventional waste venting is not required. For non-flushing fixtures such as showers, basins, skinks, grey water drains, the waste drainage process is similar, but typically includes the use of a Buffer. As waste drains from the fixture, it is temporarily collected at the Buffer. Upon reaching a set point, the controller activates the interface valve. This causes air to enter the Buffer, mixing with the waste and transporting the resultant emulsion into the piping network.

B. The Vacuum Drainage Piping Network

FIGURE 2. Piping network
The vacuum drainage piping network can be directed where most appropriate, including overhead or through voids in ceiling spaces. This allows for transportation of waste from its point of origin to the vacuum generating station. The Vacuum Drainage Piping is a closed piping network. It is typically maintained under a continuous vacuum pressure of 55 – 65 kPa. The transport proceeds in slugs as a result of difference in pressure in front of and behind this slug. The drainage piping network consists of “risers” or “droppers” that helps in the transportation of the collected waste vertically from the point of origin to horizontal mains. Branches are leading to the Vacuum Centre. The mains and branches are typically installed with a slope toward the Vacuum Centre which allows the movement of waste that to be assisted by gravity.

C. The Vacuum Generating Station

The vacuum generating station includes vacuum pumps to create a continuous vacuum pressure within the piping network, and storage tanks that collect and discharge the waste, typically into the facilities sewer main. In the case of sanitary waste, the Vacuum Centre waste storage tanks are directly linked to sanitary sewer waste lines. Vacuum systems which provide drainage for greasy waste from food storage, display, or food preparation utility sinks are designed to allow for drainage from Vacuum Centre waste collection tanks into grease interceptors, while vacuum systems processing condensate and grey water typically drain to a sanitary sewer, but can be routed for reuse in toilet flushing etc. Operation of the vacuum pumps and waste collection tanks is fully automated by controls provided with the Vacuum Centre. The Vacuum Center produces the working vacuum pressures for the piping network and vacuum interface components,

It consists of:
- Vacuum Pumps
- Storage tanks
- Controls to integrate their operation

IV. WORKING OF VACUUM PLUMBING SYSTEM

The water closet Extraction Valve is connected to the toilet waste outlet, separating the toilet from the piping network. When the flush valve is activated, the Controller opens the Extraction Valve, allowing atmospheric pressure at the toilet bowl to push waste out of the bowl, through the Extraction Valve, and into the waste piping. No water is required to initiate the flush cycle because air is used to transport wastewater. The Controller also activates the flush water valve for rinse and re-fill of the bowl.

All waste is completely removed from the bowl due to the opening and closing of the Extraction Valve which is precisely controlled.

Figure 3. Vacuum Waste System Schematics


V. BENEFITS OF VACUUM PLUMBING SYSTEM

A. Cost Savings Benefits Of Vacuum Plumbing

- Construction Costs-
  Save weeks in the overall construction cycle.

- Post Tension Slab or Structural Slab Renovation-
  Eliminates the costly expense of having to x-ray the slab to find specific locations that are free of cables where a hole or trench could be cored for piping or waste pipe connection.

- Water Savings –
  Reduces potable water consumption for toilets by as much as 68% and reduces sewage waste discharge with a ½ gallon toilet flush.

- Installation Materials and Labor-
  Labor and material costs are reduced since the installation is above ground and smaller diameter water and waste piping are used. The costs associated with vent stack piping and expensive roof penetrations are also eliminated. The above-ground installation saves construction or remodel time and labor.
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• **Other Cost Saving Benefits** –
  • Avoid problems with mislocation of floor drain stub-ups, floor sinks and cleanouts.
  • Reduces to some extent cost impact and work required for engineering or design changes.
  • Can significantly minimize sewage impact fees.
  • Reduces customer inconvenience and increases safety for staff and customers when used in commercial retail project renovations.
  • Reduces any potential plumbing renovation impact on lower level tenants in multi-story buildings.

B. **Service And Maintenance Benefits Of Vacuum Plumbing**

• **Reliable** –
  
  With hundreds of installations, small and large, worldwide, our systems have a proven track record of providing reliable and efficient performance.

• **Low Maintenance** –
  
  The vacuum interface components have been tested to well over one million cycles without failure. These components have no regular preventive maintenance requirement.

• **Plumbing Issues** –
  
  The operational dynamics of a vacuum system results in blockages of fewer main-lines, reduction in maintenance and disruptions.

C. **Health, Safety And Welfare Benefits Of Vacuum Plumbing**

• **Indoor Air Quality** –
  
  Since there is no waste line trenching required, issues associated with concrete dust or asbestos abatement are eliminated and a healthier, safer environment can be maintained on renovation projects.

• **Maintain the Existing Slab** –
  
  No open trenches during the installation of the system eliminates construction safety issues.

• **Environmental** –
  
  A vacuum toilet uses only ½-gallon of water per flush. This provides significant savings in the water supply and sewage disposal costs. These features may contribute to LEED or green construction credits.

• **Safety** –
  
  Designed to provide complete redundancy on all primary Vacuum Center components. This includes dual collection tanks and multiple pumps.

VI. **GREEN RATING**

Specifying and incorporating vacuum plumbing systems into a building project can contribute to earning points toward LEED certification. Some of the possible categories that the system may contribute to include:

• Water Efficiency
• Water Use Reduction
• Innovative Wastewater Technologies
• Materials and Resources
• Building Reuse
• Innovation in Design

VII. **CONCLUSIONS**

Water Saving in waste disposal forms the basis of vacuum plumbing. While maintaining full hygienic condition in indoor. Cost possible water-saving technique if vacuum toilets used piping sizing, etc.

Design flexibility in Vacuum Plumbing system is also one of the important aspect for the Architect, gives freedom on arranging sanitary fixture anywhere according to design. However in India it is still not used, depicts the Indian approach towards sustainability. However it is totally a machine driven system is also the reason.

Vacuum system should be used in Indian building industry to certify it’s compatibility in Indian context. However separate system is need to install for grease waste transport like kitchens, Butcheries, stores etc. Government should also introduce this system as good alternative to the conventional system in NBC or other codes at least that the system exists. As UPC, IPC, etc does. Ability to easily separate grey water and black water.

Vacuum systems virtually eliminate clogged piping. Debris which affects gravity drainage systems generally does not affect performance in vacuum systems. Its Good alternative to gravity system.

**REFERENCES**

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