Introduction to Vacuum Wastewater Collection and Plumbing Systems

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1 **How it works**

- Defining vacuum plumbing
- Vacuum system drainage overview

2 **Benefits**

- General benefits of vacuum plumbing
- Benefits for specific building types

3 **When and where to consider**

- Identify general applications
- Solutions for various building types

4 **Conclusion**

- Cost considerations and payback
- Wrap-up

Introduction to Vacuum Plumbing

What is it?

- Sometimes conventional gravity plumbing doesn't meet design goals, or just won't work
  - Vacuum plumbing is a simple concept
  - Often overlooked
    - Mostly thought of as relating to airplanes and cruise ships
  - Vacuum technology is becoming more well known for the land-based projects
  - Offers solutions and benefits to the building sector that conventional gravity plumbing cannot, such as hygiene & water savings

How it works

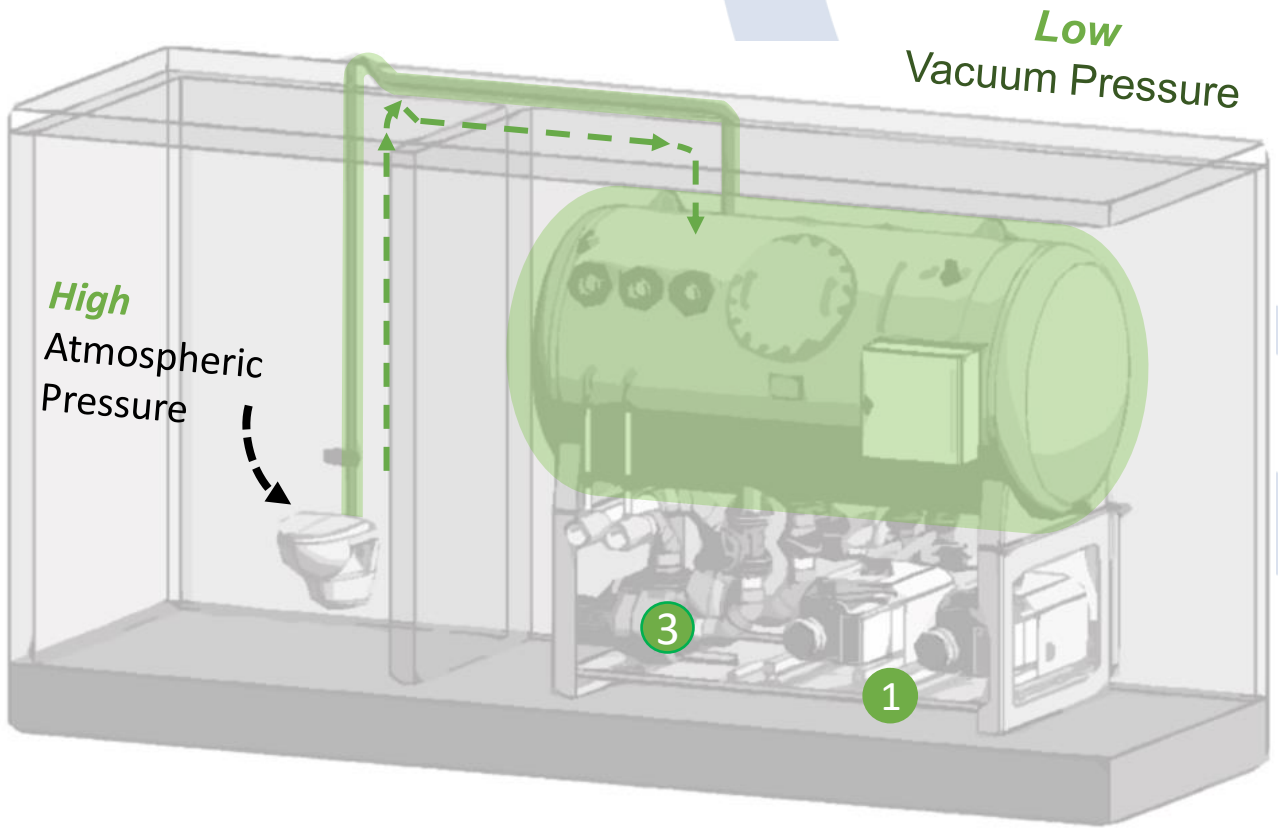
Defining vacuum plumbing
Vacuum Collection System Overview

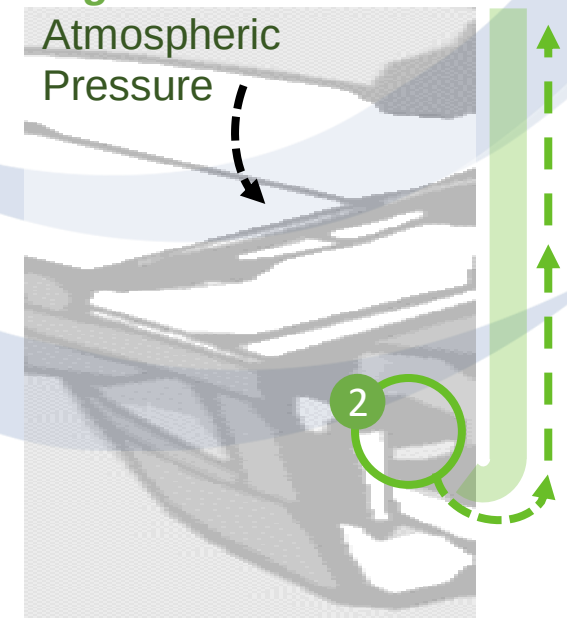
Defining Vacuum Plumbing

Collect and Dispose

1. ***Vacuum Generation***
   Vacuum pumps create pressure differential
2. ***Vacuum Interface Valve***
   Closed *discharge valve* separates high from low pressure
3. **Discharge Pumps**
   Increased flow, improves sediment drainage

Negative Flow System





Back of toilet

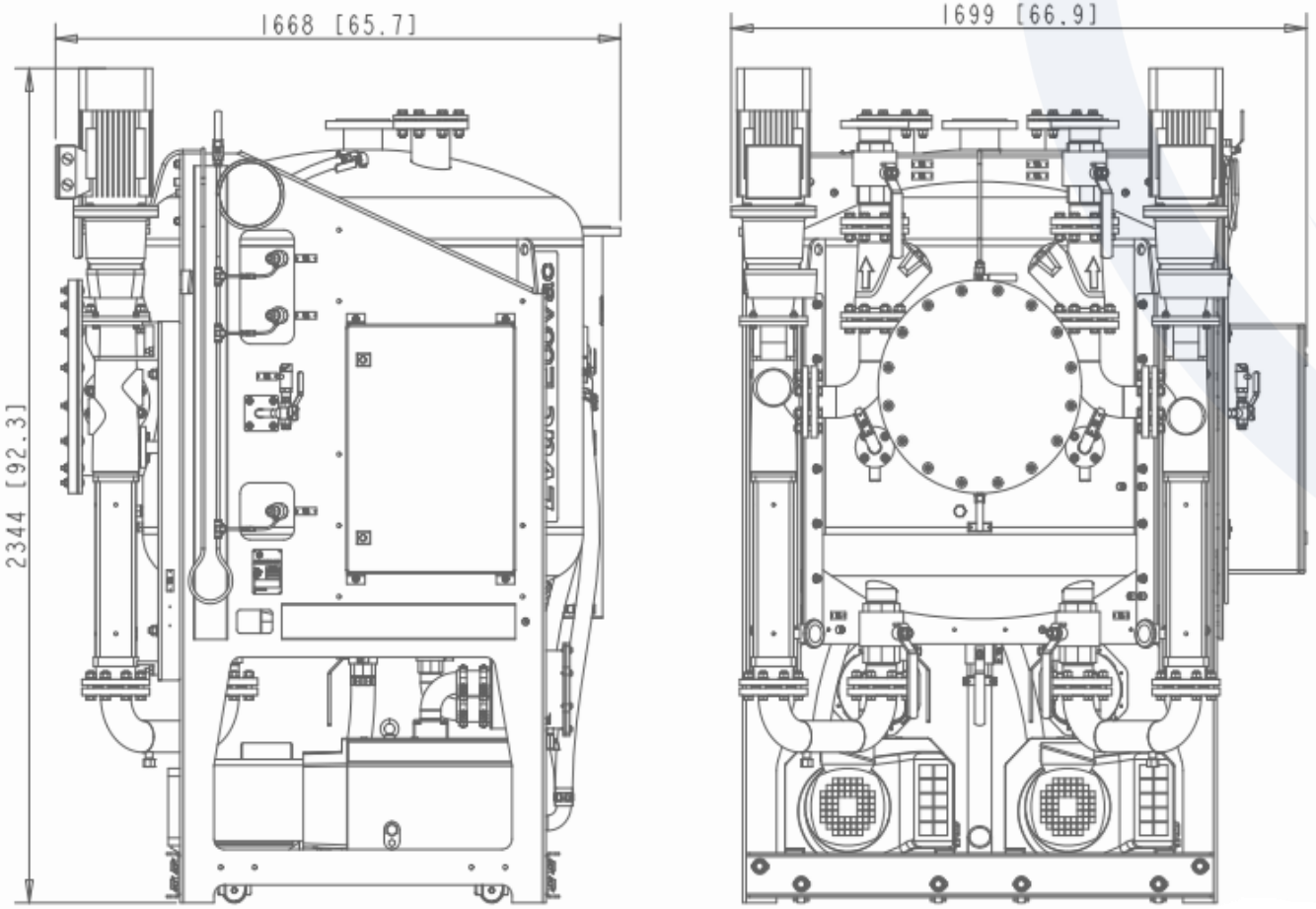
System Design and Sizing Considerations

Different Options Depending on Project Requirements

- No tank vs one tank vs multiple
- Volume of tank
- Multiple vacuum pumps and varying Horsepower
- Gravity drainage vs forced drainage
- Control panels and level sensors
- Piping network




Footprint for palletized system = ~5.5’x5.5’



Vacuum System Drainage Overview

Collection Fixtures & Devices

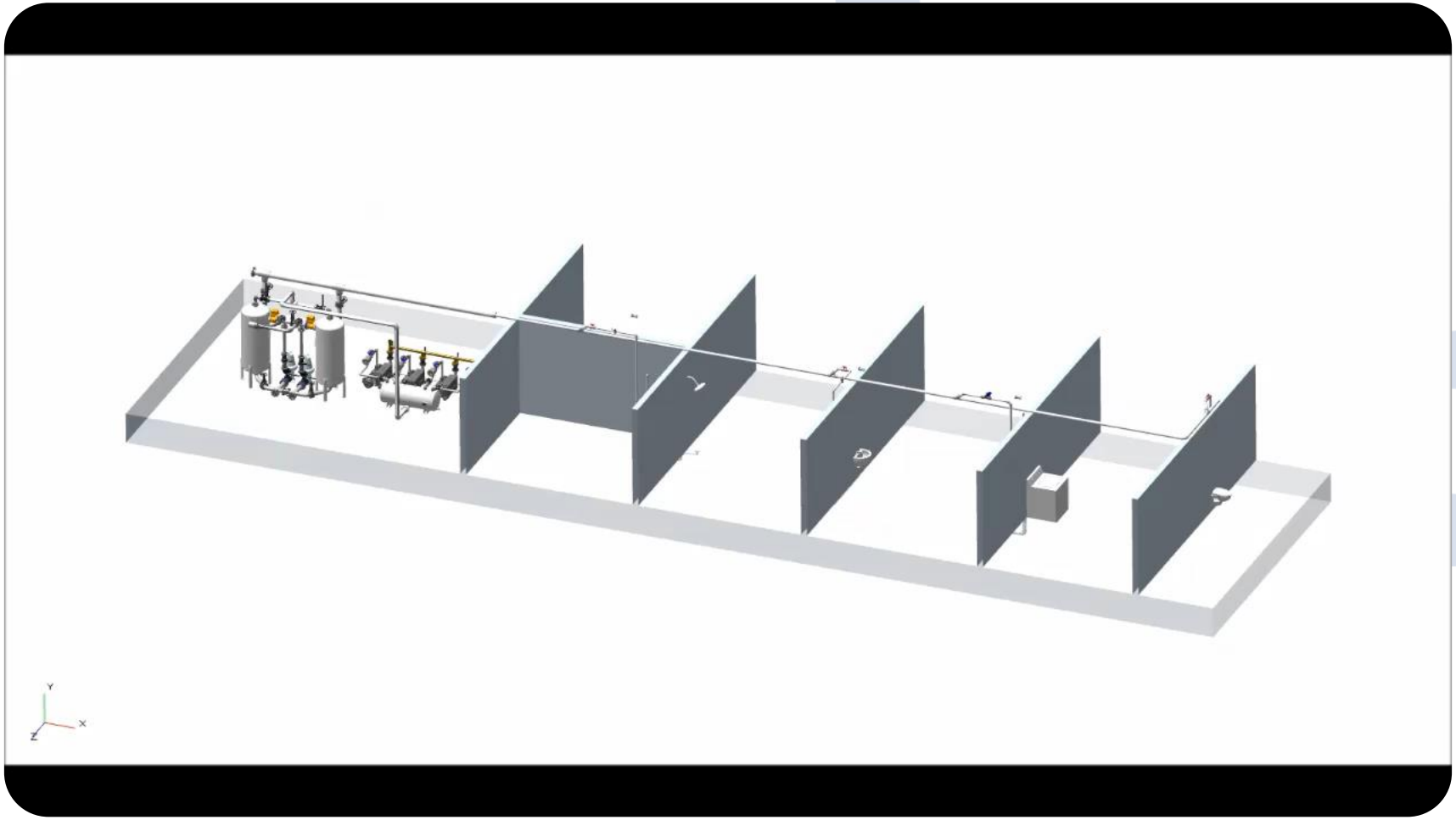
1. Vacuum Toilet
2. Vacuum Urinal
3. Vacuum Shower Drain

Vacuum System Drainage Overview

Piping Network

1. Vertical Riser
2. Horizontal Header
3. Water Slug Reform Pocket
4. To Main

Piping and Fixture Network - Gravity Tie-in



Vacuum System Drainage Overview

Collection Fixtures & Devices

1. Buffer Assembly
2. Vacuum Interface Valve
3. Control Device – Activator
4. Sensor Tube

Toilet and Urinal Operation

- **Pneumatic Push Button**
- **Signal sent to Control Mechanism**
- **Discharge Valve and Water Valve open**
  - **Water Valve**
    - Opens and rinse water cleans bowl with no misting
  - **Discharge Valve**
    - Normally closed
    - Opens and air at atmospheric pressure pushes waste into vacuum piping network
    - Eliminates cross contamination

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Vacuum Toilet Piping Options

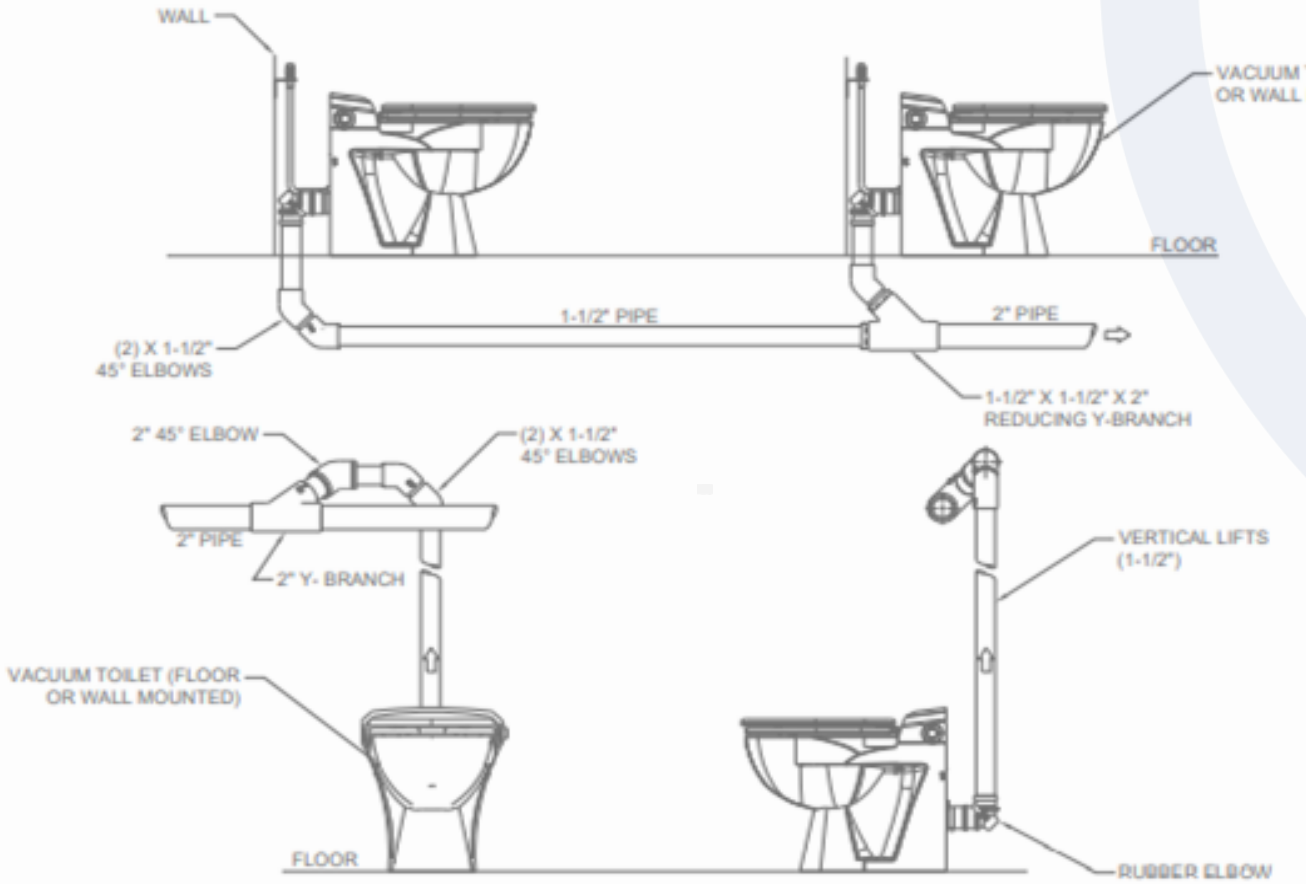


FIGURE 1 VACUUM TOILET PIPING

Vacuum Toilet Piping Options

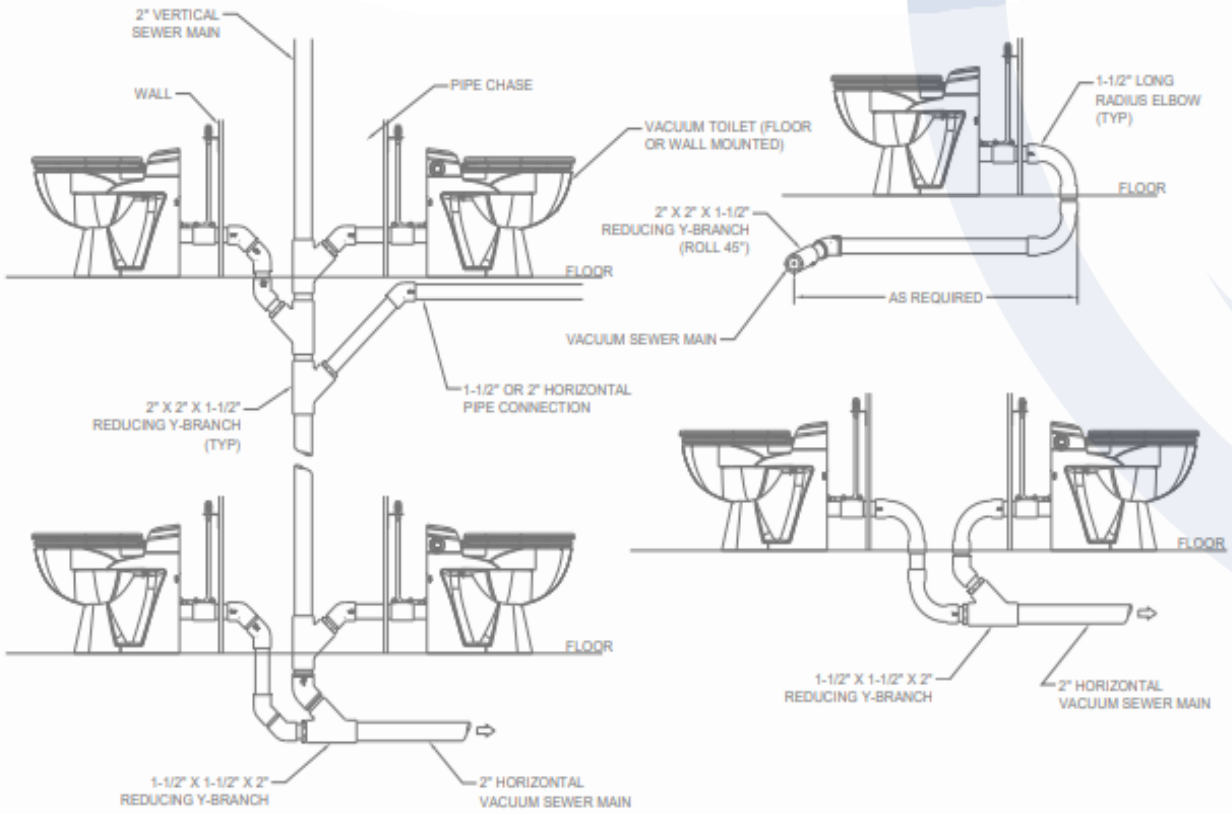
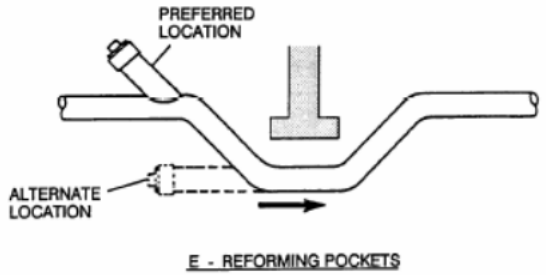
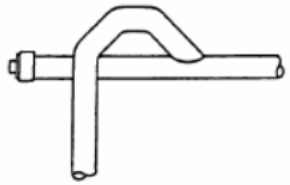
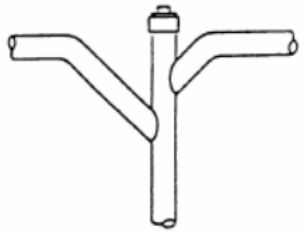


FIGURE 2 VACUUM TOILET PIPING

Cleanouts

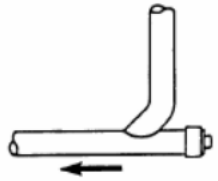






Possible Cleanout Locations

End of horizontal main lines
Top of vertical trunks
At horizontal intervals of 50 ft+
At 90-deg turns
At reform pockets due to obstructions



System Design and Sizing Considerations

Black Water, Gray Water, and Condensate Collection

Vacuum generation type (supermarkets vs. other building installations)

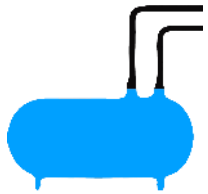
Piping design criteria and restrictions (lift heights and piping diameter)

Flow Rates of Individual Fixtures (Air, Water, and Solids)

Toilets, urinals, showers, sinks, washing machines, freezer cases

Tank(s), vacuum pumps, discharge pumps (if needed)

System Design and Sizing Considerations

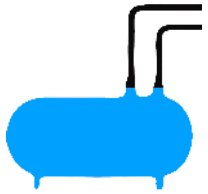


Quantity and Diversity Requirements of Fixtures
Differences between correctional and other buildings

Redundancy Requirement
Best practices, customer requirements

Installation Specific Characteristics
Sewage grinders, system controls

Project planning and design



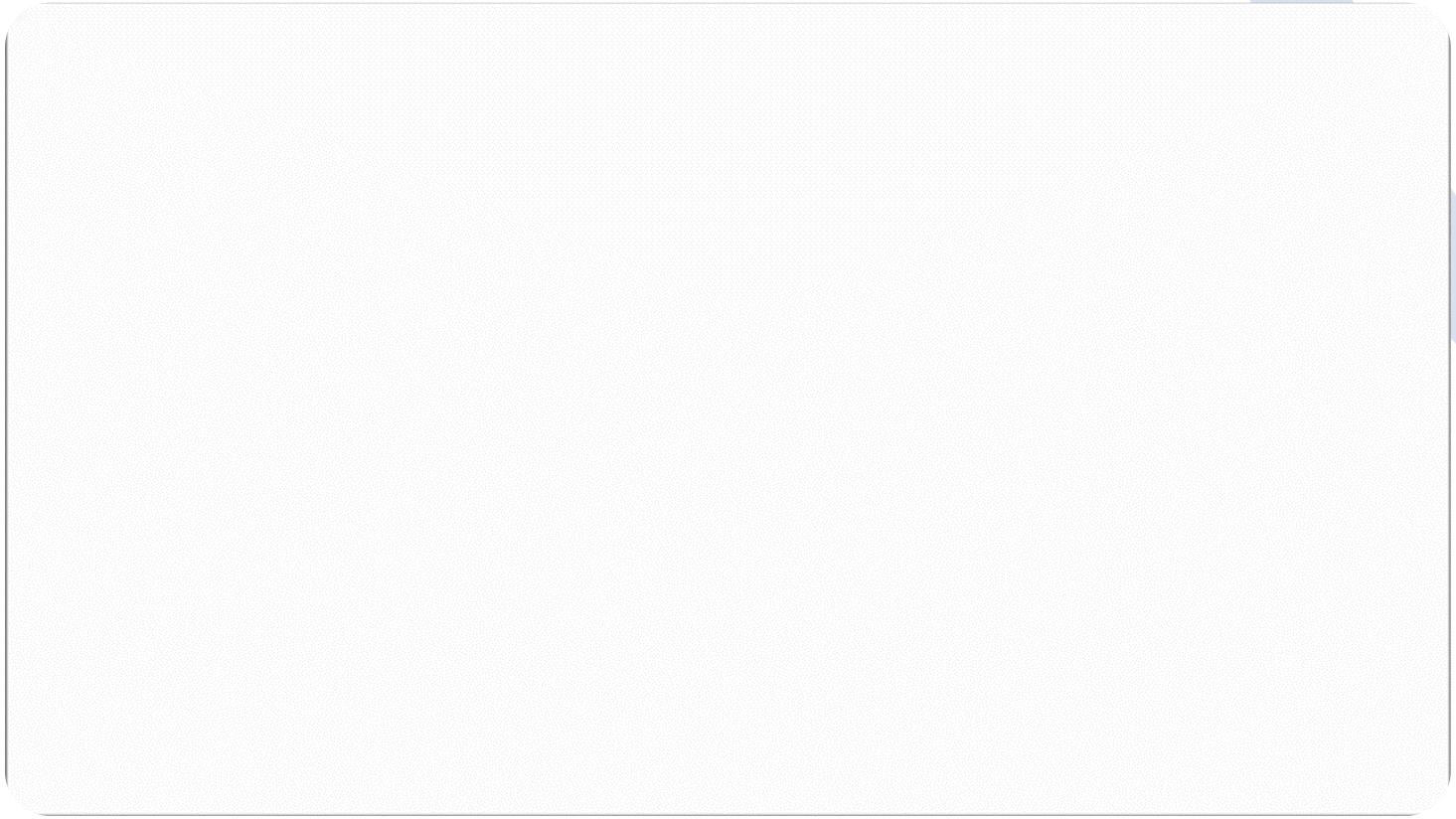
Quantity and Diversity of Requirements for Fixtures

- Is the building for public use?
- Should hygiene be a factor?
- Is water savings important?
- Number of toilets/Urinals – The higher the qty/usage of fixtures, the greater chance for bacteria transmission
- Medical clinics such as Dialisys or anywhere bio waste is introduced to the system
- Is the project remote? Tanks would need to be pumped rather than dumped
    - If Bio waste – specialty pumping/disposal companies
- Placement of vacuum fixtures is flexible due to the piping network flexibilty and can be done with hygiene/bacteria as part of the process

Installation Specific Characteristics

- Building Type?
- Sewage grinders, Discharge Pumps & System Controls

Design Flexibility



General and Healthcare Benefits

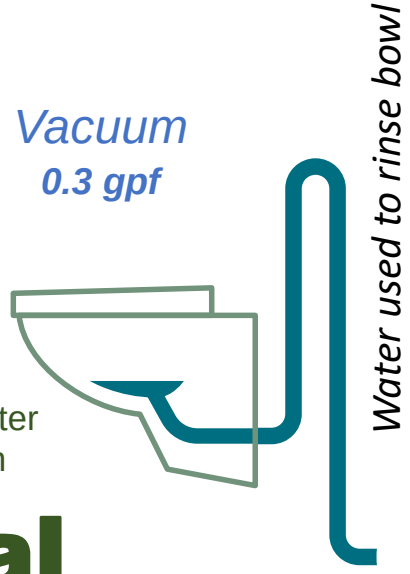
Up to 90 % Water Savings – Get Help With LEED, BREEAM, or Other Green Building Certifications

Water consumption

vacuum vs. gravity toilet

Vacuum

0.3 gpf

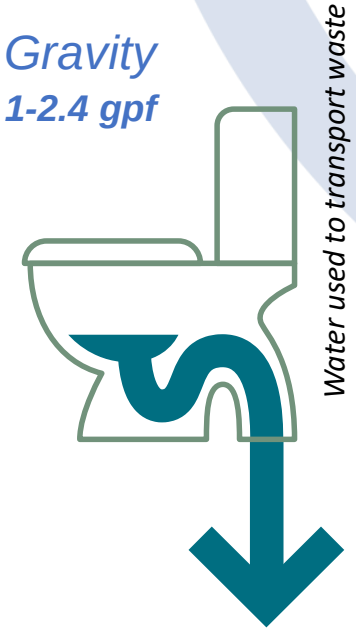


Evac vacuum toilet uses water per each flush

.3 gal

Gravity

1-2.4 gpf



Gravity toilet uses water per each flush

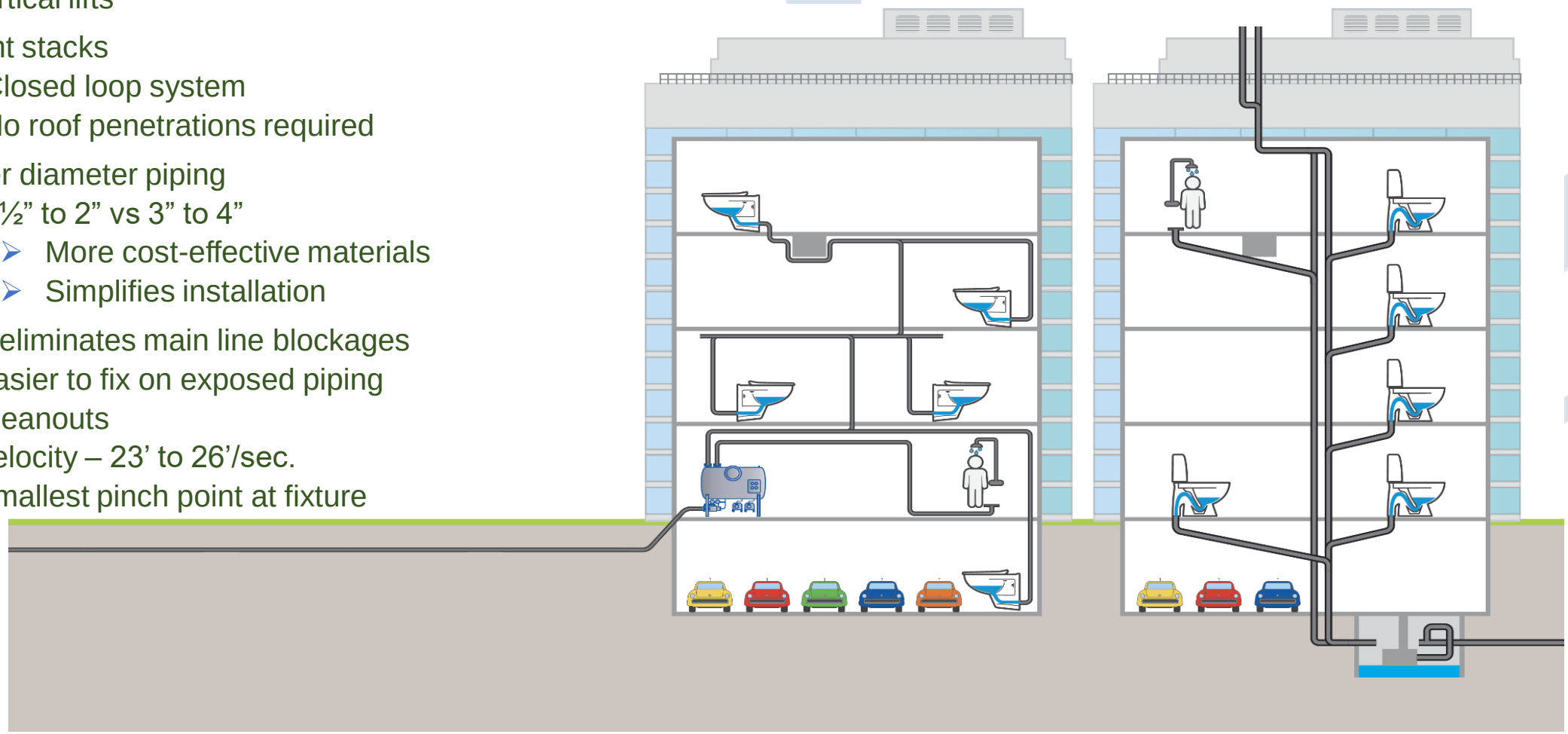
1-2.4 gal

A Comparison to Gravity Plumbing for New and Renovation/Historic Buildings

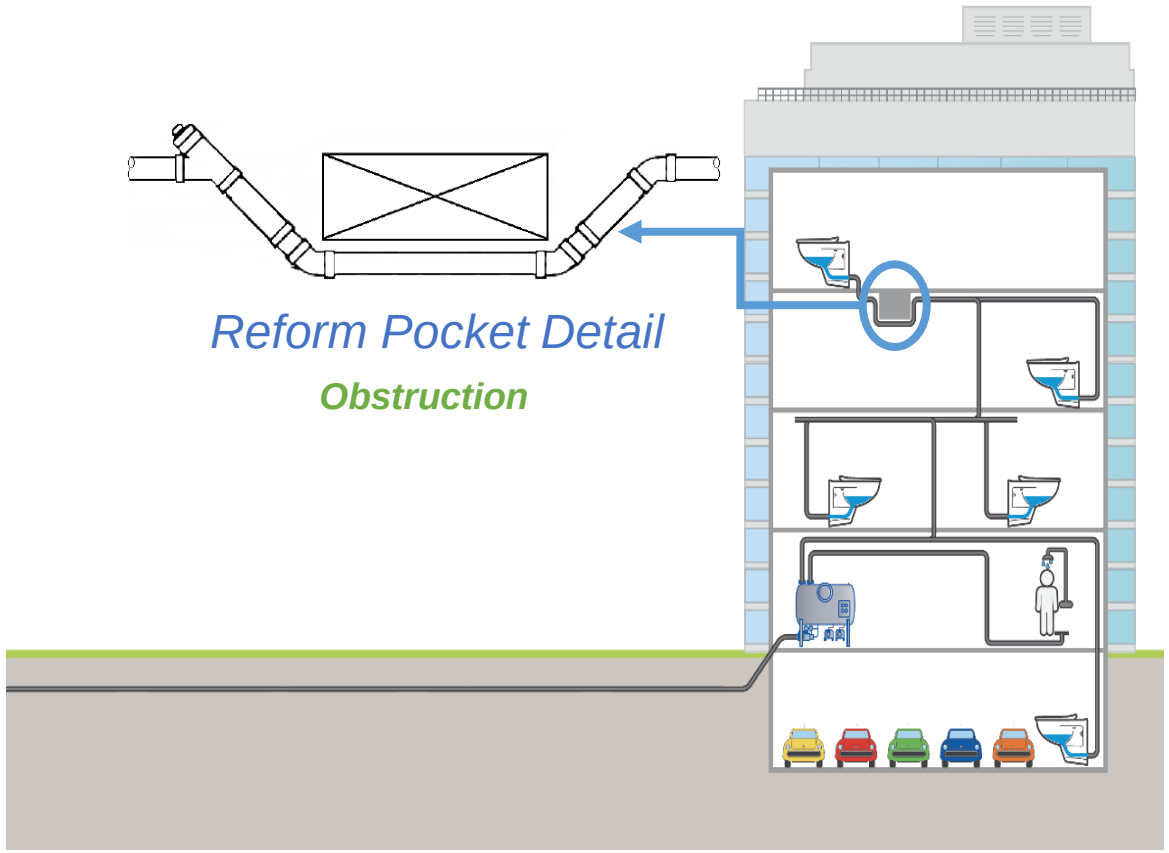
- Significant time reductions to design and install vacuum
- Construction sequencing flexibility
- Re-use of existing buildings
- No need to penetrate slab
  - piping can sit on top
- Ease of remodeling
  - Cost savings in labor and time to saw-cut slab, trench, locate existing piping network & vent stacks

Benefits Related to Piping Network

- Run vertical lifts
- No vent stacks
  - Closed loop system
  - No roof penetrations required
- Smaller diameter piping
  - 1 ½” to 2” vs 3” to 4”
    - More cost-effective materials
    - Simplifies installation
- All but eliminates main line blockages
  - Easier to fix on exposed piping
  - Cleanouts
  - Velocity – 23’ to 26’/sec.
  - Smallest pinch point at fixture



Benefits Related to Piping Network



- Route around obstacles with reform pockets
  - Potential obstacles:
    - Mechanicals
    - Architectural and structural features
- Great for second use buildings and/or historic preservation sites
- Decreased slope requirement
  - 1/16th" per foot
  - No need for continuous slope
    - Slope make-up with reform pockets
  - Limits dead space

Piping Network Benefit Summary

- Great design flexibility due to:
  - Vertical lifts
  - Horizontal runs
  - No longer have the conventional vent stack dictating where fixtures go
  - Decreased slope requirement
  - Reform Pockets
  - Smaller diameter piping

Benefits For Healthcare, Hygiene, and Comfort

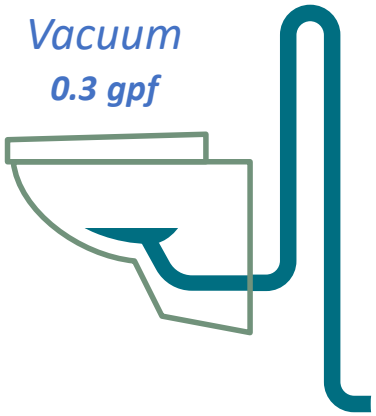
A 1,000-bed facility can save 8 million gallons of water per year

Evac vacuum toilet uses water per each flush

.3 gal

Vacuum

0.3 gpf

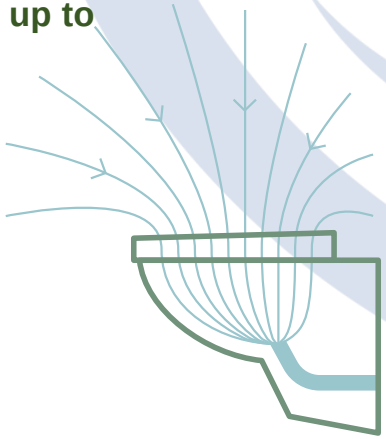


Vacuum toilet made of antimicrobial material reduces the bacteria on the surface up to

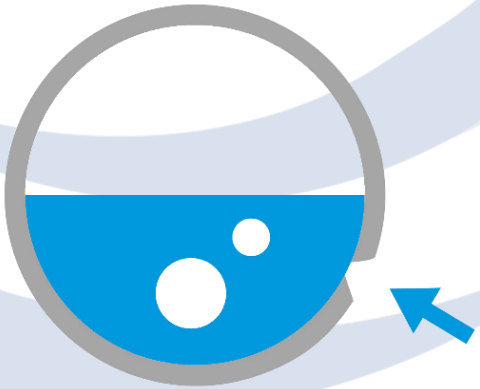
99.99%

60-70L

of odors, mists, and bacteria



Iatrogenic Disease and Radioactive Contamination Control



Pipe leak -
Air leaks in
vs water leaking out

Preventing The Spread of Viruses and Bacteria

Gravity

Overspray of up to

80,000

polluted droplets, stay suspended 1 meter in air for hours

NSF *(National Sanitation Foundation)* Microbiological Overspray Testing Results

Contamination Pictograph – (diagram not to scale)

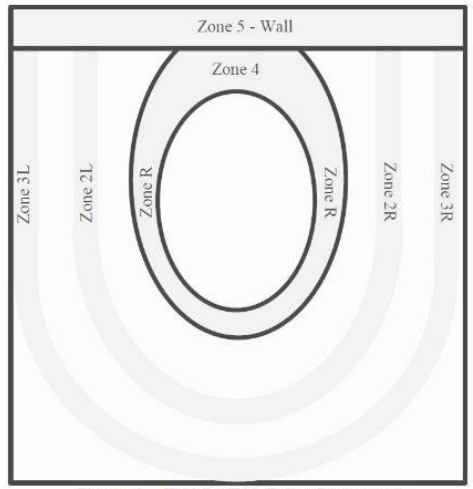


Figure 3 – EVAC VT93 Toilet Pictograph

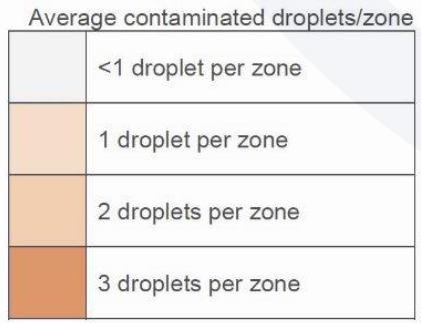


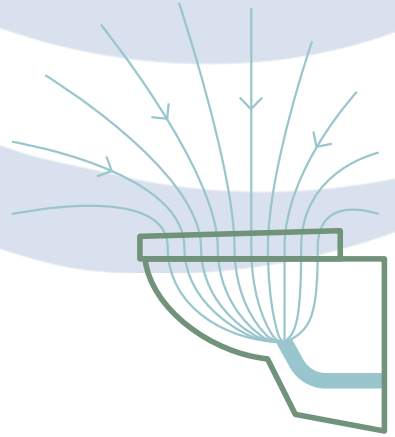
Figure 4 – Color Key

Vacuum

Flush

60-70

of odors, mists, and bacteria



No Misting = A More Hygienic Solution

NSF International (National Sanitation Foundation) Report – March 2019 – nsf.org

- Vacuum toilet filled with E. Coli suspension
- Flushed w/ standard water supply
- Overspray measured with Petri dishes
- 3 Trials
- 2h 30±5 post flush plates collected

J-00303443	FLUSH #1 contaminated droplets/plate						
PLATE #	ZONE R	ZONE 2L	ZONE 2R	ZONE 3L	ZONE 3R	ZONE 4	ZONE WALL
1	<1	<1	<1	<1	<1	<1	<1
2	<1	<1	<1	<1	<1	<1	<1
3	<1	<1	<1	<1	<1	<1	
4	<1	<1	<1	<1	<1	<1	
5	<1	<1	<1	<1	<1		
6	<1	<1	<1	<1	<1		
7	<1	<1	<1	<1	<1		
8	<1	<1	<1	<1	<1		
9	<1			<1	<1		
10	<1			<1	<1		
11				<1	<1		
Total contaminated droplets/zone	<1	<1	<1	<1	<1	<1	<1

J-00303443	FLUSH #2 contaminated droplets/plate						
PLATE #	ZONE R	ZONE 2L	ZONE 2R	ZONE 3L	ZONE 3R	ZONE 4	ZONE WALL
1	<1	<1	<1	<1	<1	<1	<1
2	<1	<1	<1	<1	<1	<1	<1
3	<1	<1	<1	<1	<1	<1	
4	<1	<1	<1	<1	<1	<1	
5	<1	<1	<1	<1	<1		
6	<1	<1	<1	<1	<1		
7	<1	<1	<1	<1	<1		
8	<1	<1	<1	<1	<1		
9	<1			<1	<1		
10	<1			<1	<1		
11				<1	<1		
Total contaminated droplets/zone	<1	<1	<1	<1	<1	<1	<1

J-00303443	FLUSH #3 contaminated droplets/plate						
PLATE #	ZONE R	ZONE 2L	ZONE 2R	ZONE 3L	ZONE 3R	ZONE 4	ZONE WALL
1	<1	<1	<1	<1	<1	<1	<1
2	<1	<1	<1	<1	<1	<1	<1
3	<1	<1	<1	<1	<1	<1	
4	<1	<1	<1	<1	<1	<1	
5	<1	<1	<1	<1	<1		
6	<1	<1	<1	<1	<1		
7	<1	<1	<1	<1	<1		
8	<1	<1	<1	<1	<1		
9	<1			<1	<1		
10	<1			<1	<1		
11				<1	<1		
Total contaminated droplets/zone	<1	<1	<1	<1	<1	<1	<1

Benefits For Healthcare – A Hygienic Flush

Designing for Crisis: Designing For the Future

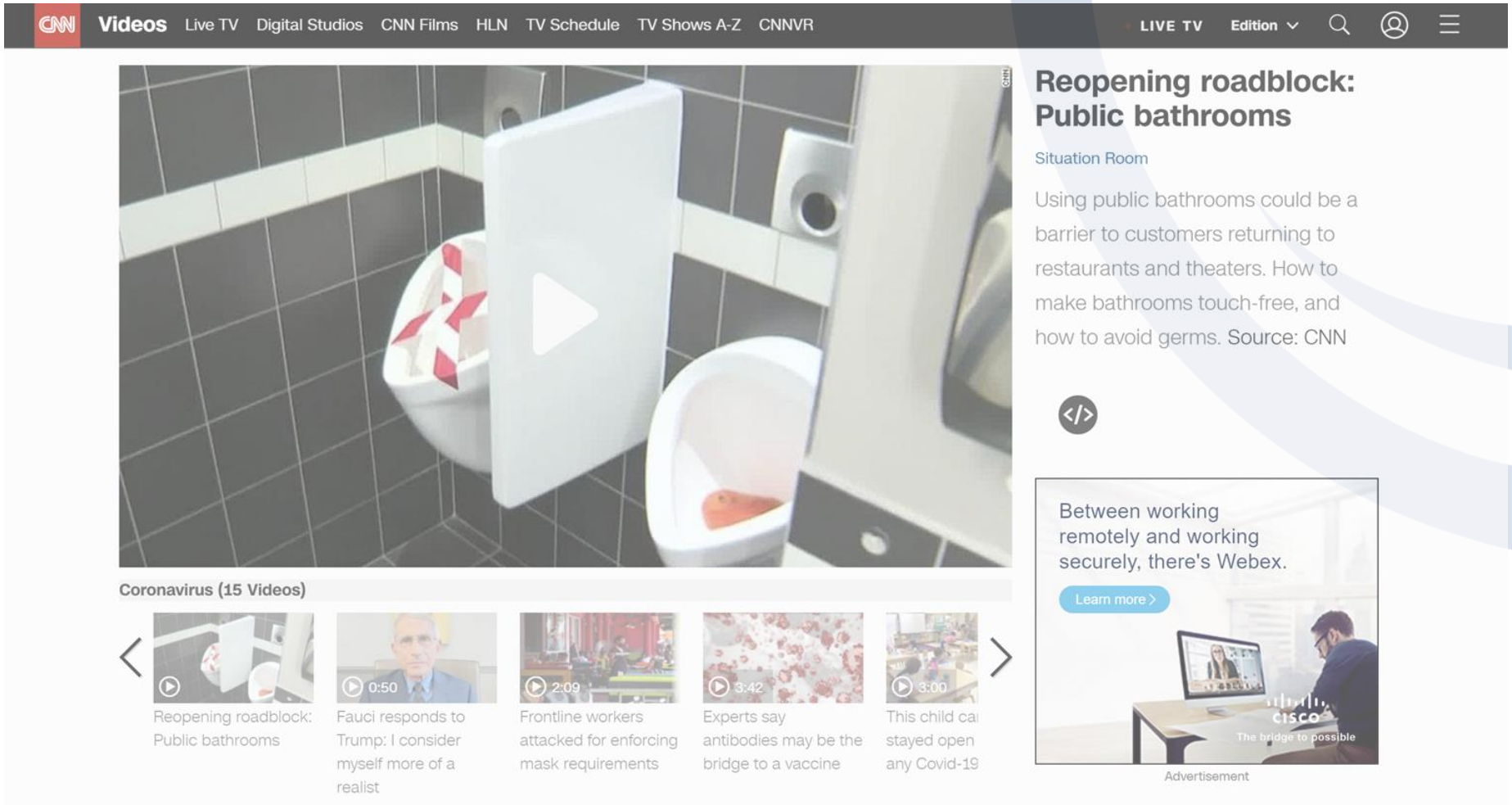
The Changing Senior Living Design Landscape

Published on April 13, 2020

Jeffrey Anderzhon, FAIA
Senior Architect/Planner - Specializing in Senior Living Environments
10 articles ✓ Following

Unless one has the foresight of Jules Verne, it is impossible to predict the future. One thing is certain, however, when it comes to senior living design: tomorrow's design approaches will be significantly altered as a result of the COVID-19 pandemic. As designers, it is our duty to seriously consider how the built environment can be in the forefront of infectious disease control and prevention. While acute care environmental designers have long been

Reopening Roadblock: Public Restrooms



When and Where to Consider Vacuum

General applications
Solutions for various building types

Solutions For Various Building Types

Supermarkets, warehouses and shopping centers

Correctional facilities

Healthcare facilities and laboratories

Leisure and hospitality facilities

High traffic areas

Transportable facilities

Universities, offices and institutions

Solutions For Healthcare Buildings

Healthcare facilities and laboratories

Up to 90% Water Savings

- Large cost savings in facilities with multiple beds
- Less radioactive/bio waste
  - Fewer & smaller disposal tanks

Improve Hygiene and Comfort

- **Flush 60-70 liters** of odors, mists, and bacteria

Iatrogenic Disease & Radioactive Contamination Control

- Pipe leak – **Air leaks in** vs waste leaking out

Reference

National Healthcare Provider
Amherst, *New York*
Cancer Care Center
Russia
Hospital
China
Why was vacuum chosen?

- Did not have enough pitch to meet sanitary drainage requirement
  - Vacuum eliminated need for pitch
  - Waste is force discharged into city sewer
- < Added benefits

Solutions For Supermarket/Grocery/Cold Storage Buildings

Supermarkets, warehouses and shopping centers

Piping

- No trenching required
- Can run piping overhead

Flexibility

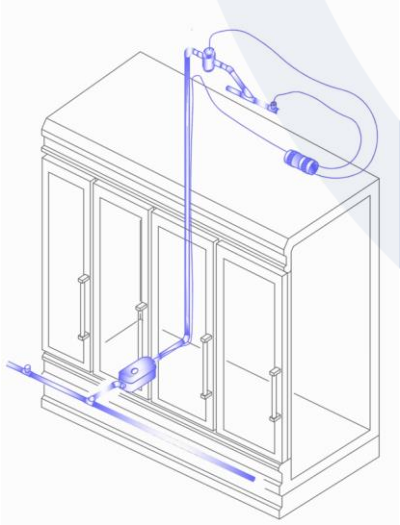
- Move refrigerator cases as desired
- No requirement for floor drains
- Vertical Lift up to 24’ to main

CAPEX

- Vacuum system can be capitalized

Renovation

- Quick changeover for existing buildings

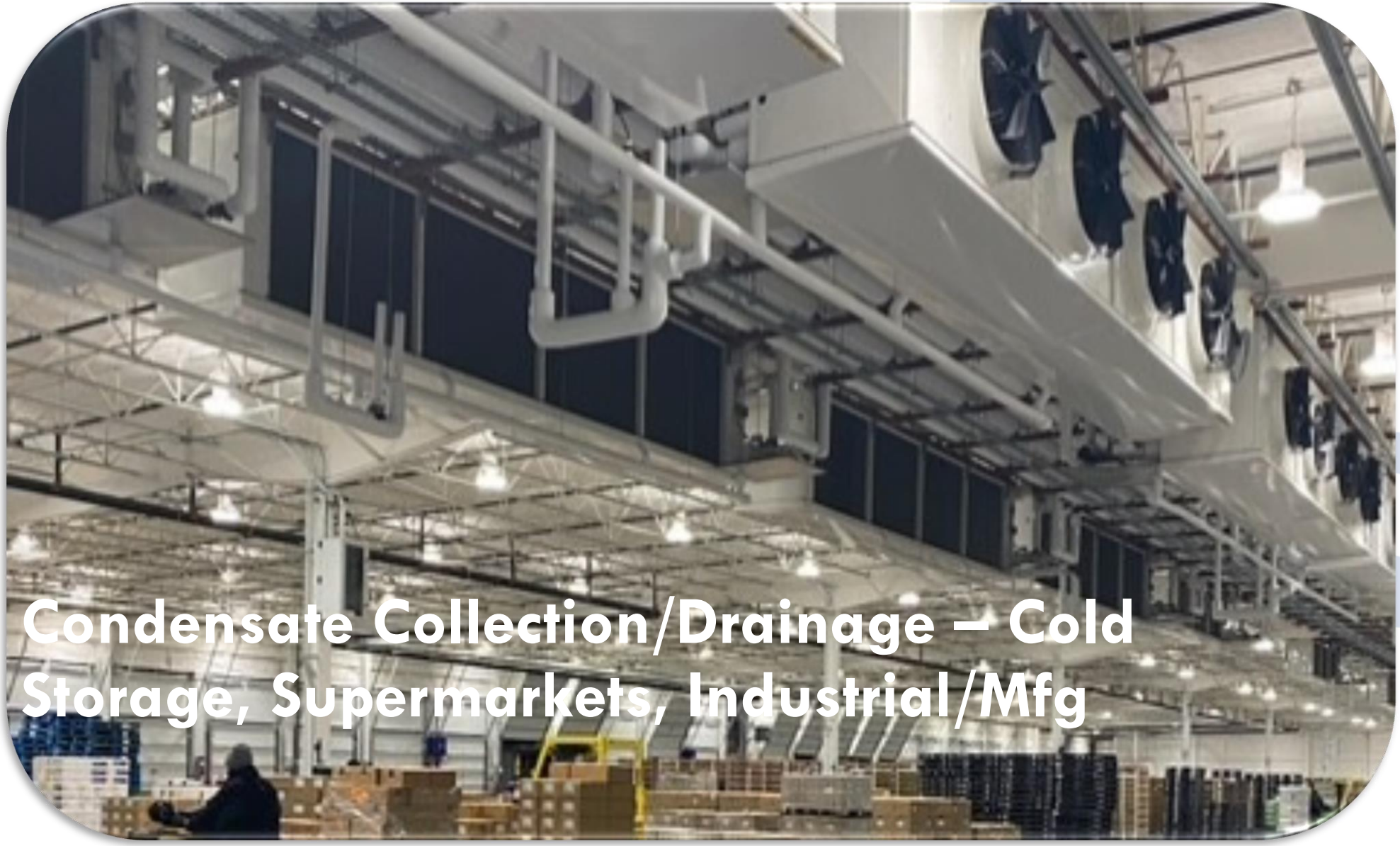


Reference

Some of the Largest Retailers Worldwide

Why was vacuum chosen?

- Move refrigerator cases as desired
- Eliminated need for floor drains
  - No need to penetrate slab
  - More sanitary
- Easier to access, maneuver, and simplify addition of single fixtures



Condensate Collection/Drainage – Cold Storage, Supermarkets, Industrial/Mfg

Solutions For Correctional Buildings

Correctional facilities

Security

- No longer one main connecting multiple toilets
  - Eliminates:
    - passing of contraband between cells
    - “Toilet Talk”- closed valve system
- Each cell/pod can be isolated from system to identify abusers

Maintenance

- No blocks due to velocity (23-26 feet/sec) and smallest pinch point at fixture
- Problems with piping can be easily located and rectified
- Access to system outside of cell

Water Savings

- A 1,000-bed facility can save up to 8 million gallons of water per year

Reference

Correctional Facility
Cheltenham, *Maryland*

Why was vacuum chosen?

- Water savings
- Security

Solutions For Transportable Facilities

Design Flexibility

- Can run piping vertically
- Transportable via container/pod/module
- Can add fixtures easily

Timeline

- Quick and easy to install

Reference

Concert Venue
Europe

Why was vacuum chosen?

- Quick and easy installation

Solutions For All Building Types

Up to 90% Water Savings

- Mountainous/Remote location =
  - no available ground water
  - Less water required on site
  - Cannot drain to conventional sewer system

Cost Savings

- Large cost savings in trucking waste
  - Less frequent black water removal trips

Reference

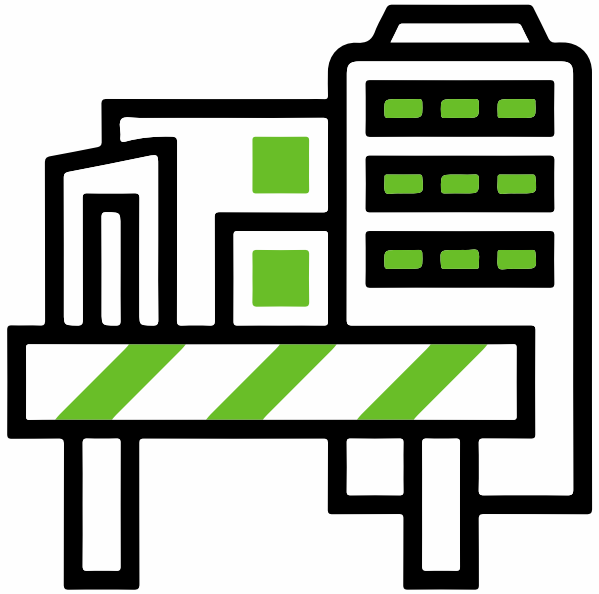
Cascade, *Colorado*

Why was vacuum chosen?
Water/Cost Savings

Owner Requirements and Preferences

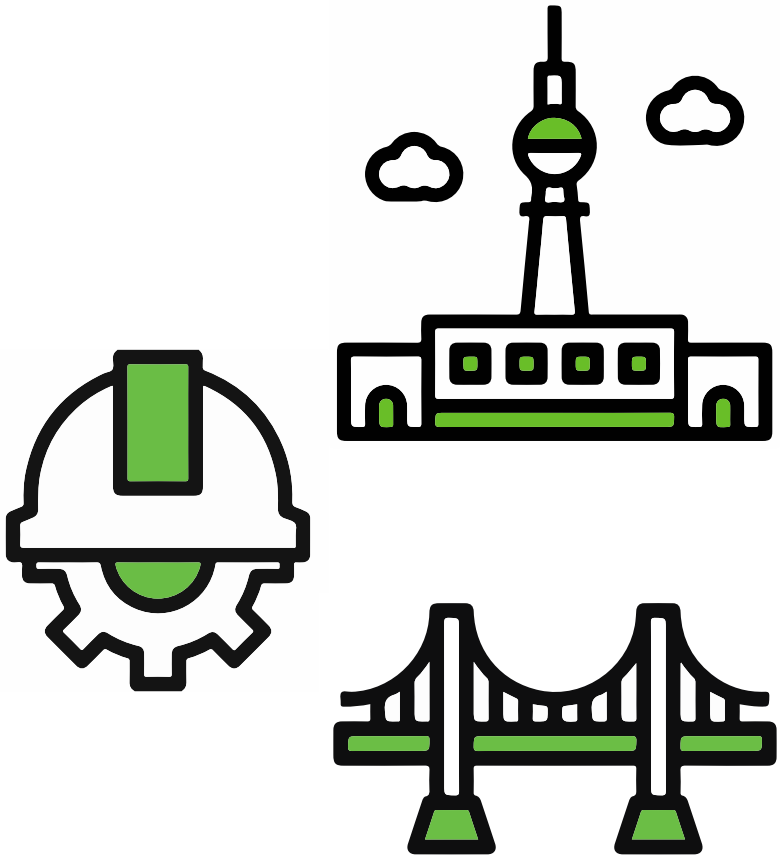
- Fixture Planning / Layout
- Operations / Usage
- Aesthetics
- Accelerated Schedule
- Sequencing
- Design Flexibility
- Coordination Between Customer & Tennant (Multi-Level Facilities)
- Health & Safety Hazards (Existing Sewer Lines, Construction Debris, Asbestos, Etc.)
- Expandability & Redundancy

Site Conditions and/or Obstacles For Gravity



- Embedded Contaminants (Asbestos)
- Unkown Location of Existing Utilities (Under or Embedded In Slab)
- Multi-Level Work (Especially Above Operational Tenant Spaces)
- Historic Buildings/Slab Penetration
- Bedrock
- Poor Soil Conditions
- Contaminated Soil
- High Water Table
- Methane (Land Fill)
- Impossible Inverts
- Building Categorization (Historical)

Architectural, Structural, and Engineering Considerations



- LEED Certified
- Invert Obstacles
- Pipe Routing Obstacles
- Post Tension Slab
- Structural Slab
- Slab Composition
- Slab Thickness
- Grade Beams
- Steel Placement
- Zero-Penetration Barriers
- Environmental Barriers
- Complexity Of Structure
- Floor X-Rays
- Slab Penetrations
- Core Drills
- Saw Cuts / Trenching
- Multi-Level Facility
- Parking Garages
- Dual-Use
- Roof Penetrations

Cost Considerations, Payback, & Summary

Conclusion

Entire System Comparison – Installed

Cost Consideration and ROI

- **Quantitative:**
  - Operational cost savings in water
  - Cost savings in piping size (labor and material)
  - Potential cost savings in space
  - Ability to avoid costly structural, design, and construction obstacles
  - Maintenance costs
  - Initial investment in CAPEX
- **Qualitative:**
  - Employee and patient health and wellness benefits related to bathroom hygiene for ALL high traffic buildings with public restrooms
  - Costs saved on employee sick days and extended patient stays due to illness

Summary

- **Vacuum plumbing provides many solutions that conventional gravity plumbing cannot:**
  - Cleaner/Hygienic
  - 80-90% Water savings
  - Simplifies construction challenges while reducing costs over time
  - Freedom/flexibility in design and implementation
  - Eases remodelling
  - Reduces construction time
  - Flexibility for new construction & remodelling
  - Can preserve historical and architectural features
  - Can help a building achieve great water savings

Questions?

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CEU Reminder

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