Extreme
Water Savings

The Next Frontier in Drainage and Plumbing Systems

Program Registration

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Learning Objectives

At the end of this course you will be able to:

- Compare the performance of vacuum plumbing systems with gravity plumbing systems in terms of ***sustainability, health and safety***, ***cost, design*** *and* ***construction flexibility***.
- Calculate the dramatic **water savings** and related environmental benefits of vacuum plumbing systems in various building types.
- Evaluate the key components of vacuum plumbing systems and how their **design and selection** fits into the system's efficient overall operation.
- Discuss the **performance** of vacuum plumbing systems in specific challenging situations such as leaks, power failures, large simultaneous demands and other conditions in the field.

Course Outline

- **Lesson One:** **The What & Why of Vacuum Plumbing**
- **Lesson Two:** **Systems Operation & Design**
- **Lesson Three:** **Worst Case Scenarios and FAQs**
- **Case Studies:** **Vacuum Plumbing Systems in Action**

Course Outline

- **Lesson One: The What & Why of Vacuum Plumbing**

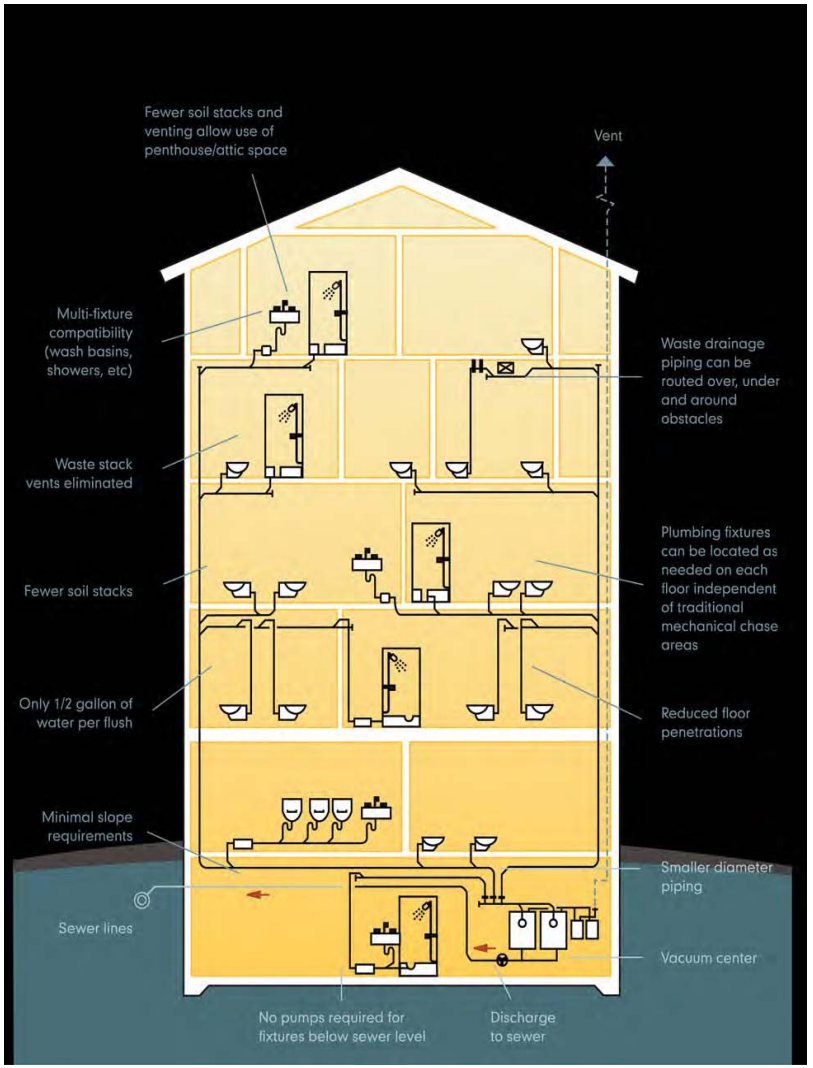
Vacuum Plumbing Basics

What is vacuum plumbing?

Vacuum plumbing systems use a powerful combination of differential pressure and gravity to collect and transport waste and gray water

Vacuum Plumbing Basics

- 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



Vacuum Plumbing Basics

The Basic Differences between Vacuum Plumbing and Gravity Plumbing

- Ordinary plumbing systems basically rely on gravity: digging, trenching for underground piping and drains
- Vacuum plumbing systems rely primarily on vacuum pressure: piping routed above grade, laid out horizontally or vertically

Vacuum Plumbing Basics

The Basic Differences between Vacuum Plumbing and Gravity Plumbing

- Gravity plumbing involves waste stacks, and extensive venting involving roof and floor penetrations
- Vacuum plumbing systems are virtually self-venting. No waste stacks. Air removed from the piping network by the vacuum pumps becomes the vent for the system

Vacuum Plumbing Basics

The Basic Differences between Vacuum Plumbing and Gravity Plumbing

- Gravity plumbing - even with low flush toilets - require an estimated 1.2 - 1.6 gallons per flush, and splash with every flush
- Vacuum plumbing systems' powerful, super-efficient flush requires ***ONLY 1/2 gallon of water per flush***.

NO splash!
NO wasted water!

Vacuum Plumbing Basics

Vacuum Plumbing Basics

- Proven application for all types of facilities, since 1979
- National Sanitary Foundation recognized
- Meet codes and standards
  - IAPMO
  - UPC and IPC

- Working in thousands of projects around the world

Office buildings
Schools
Hospitals
Restaurants
Courthouses
Supermarkets
Condominiums
Resorts
Casinos
Retail stores
Museums
Prisons

Why Vacuum Plumbing?

Vacuum Plumbing Systems Advantages

Superior performance in:

- Water Conservation and Sustainability
- Health, Safety and Security
- Cost Reduction
- Design and Construction Flexibility

Why Vacuum Plumbing?

Water Conservation and Sustainability

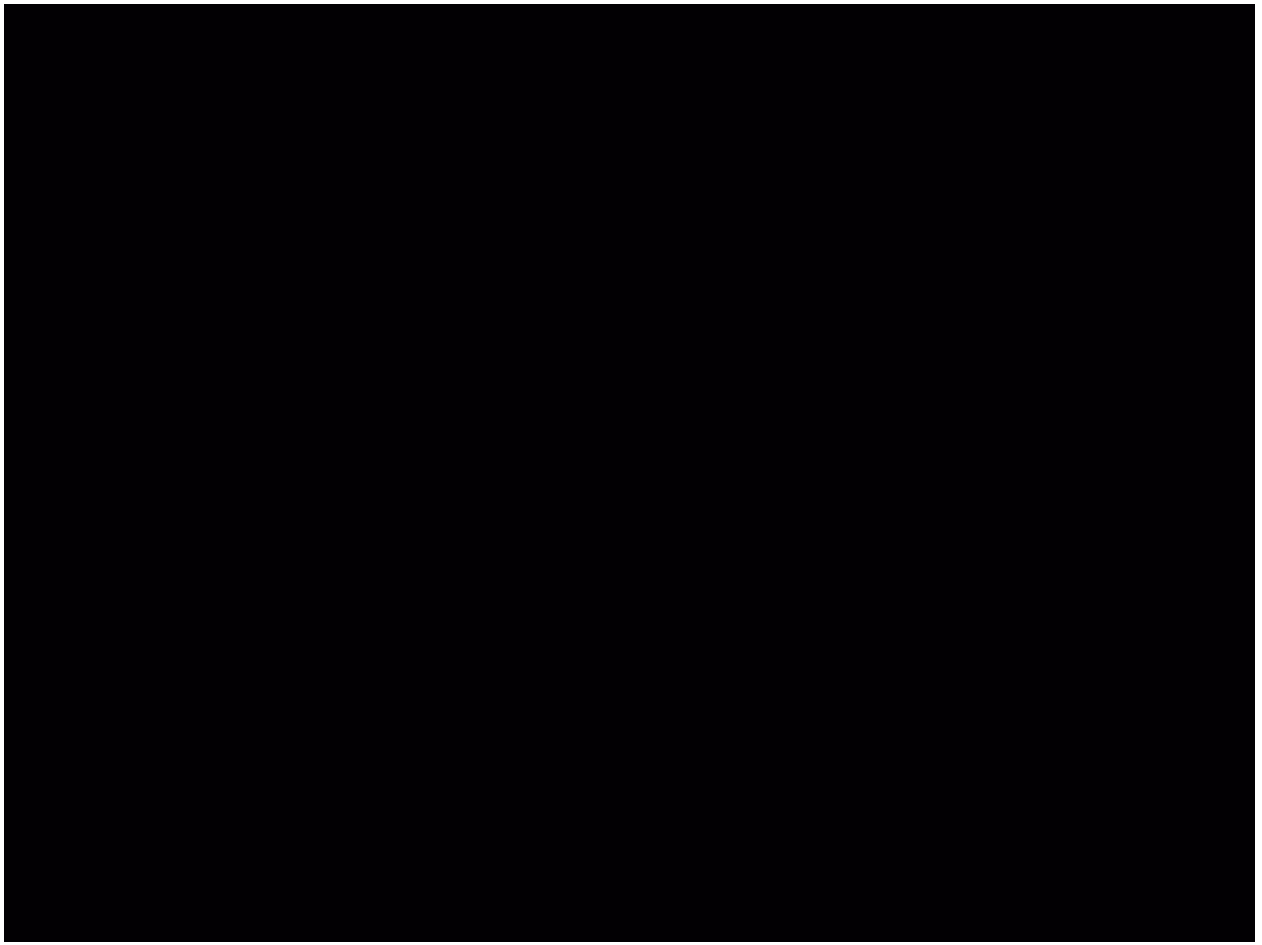
- Gravity plumbing requires average **1.6 gallons per flush**

- Vacuum plumbing systems save extremely large amounts of water, requiring **ONLY .5 gallon per flush**

Gravity Plumbing 1.6 gpf

Vacuum Plumbing 0.5 gpf

Why Vacuum Plumbing?



Why Vacuum Plumbing?

Water savings in every building type are dramatic!

Examples follow:

- Commercial office building
- Department Store
- Restaurant
- Prisons

Why Vacuum Plumbing?

Commercial Office Building – 500 people

WC Water use with **gravity** low flush fixtures

- 250 males:
  - 250 x 3 flushes/day x .5 gallons/flush (urinals) x 75% usage = 281 gallons per day
  - 250 x 3 flushes/day x 1.6 gallons/flush (water closets) x 25% usage = 300 gallons per day
- 250 females:
  - 250 x 3 flushes/day x 1.6 gallons/flush (water closet) = 1200 gallons per day

Total water demand with **gravity** system:

- Approx. 3.6 gallons per person per day
- 1,781 gallons per day
- **445,250 gallons per year**

Why Vacuum Plumbing?

Commercial Office Building – 500 people

WC Water use with **vacuum** flush fixtures

- 250 males:
  - 250 x 3 flushes/day x .5 gallons/flush (urinals) x 75% usage = 281 gallons per day
  - 250 x 3 flushes/day x .5 gallons/flush (water closets) x 25% usage = 94 gallons per day
- 250 females:
  - 250 x 3 flushes/day x .5 gal/flush (water closets) = 375 gallons per day

Total water demand with **vacuum** system:

- Approx. 1.5 gallons per person per day
- 750 gallons per day
- **187,500 gallons per year**

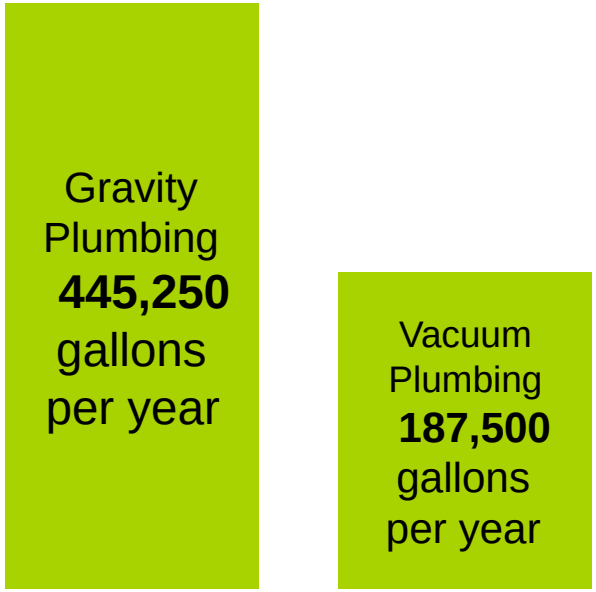
Why Vacuum Plumbing?

Commercial Office Building – 500 people

WC Water use with **gravity** low flush fixtures

VS.

WC Water use with **vacuum** flush fixtures



Estimated water and sewage process savings approx. 257,750 gallons per year or 58% annual requirement

Why Vacuum Plumbing?

Example: Department Store

- Approx. 100,000 shoppers per week
- Staff and shoppers 50% male, 50% female
- Male urinal use estimated to be 85 % of total male fixture use (slightly higher than ASPE estimate of 75%)
- Males 10,000 urinal flushes per week, 1,500 water flushes closet per week
- Females 11,500 water closet flushes per week

Why Vacuum Plumbing?

Example: Department Store

- Using **gravity** low flush drainage fixtures:

  Projected annual water supply and sewage output = **1,341,600 gallons**

- Using **vacuum** flush water closets and gravity urinals:

Projected annual water and sewage process savings approx. 598,000 gallons per year

BONUS:

Does not include potential savings from recycling gray water from sinks for use in toilets, which would increase water efficiency

Why Vacuum Plumbing?

Example: Restaurant

- Average 5,000 guests per week (does not include staff)
- Males 50%, females 50%
- Guest usage approximately 70%
- Male urinal use estimated to be 85 % of total male fixture use (slightly higher than ASPE estimate of 75%)

Why Vacuum Plumbing?

Example: Restaurant

- Using **gravity** low flush drainage fixtures:

  Projected annual water supply and sewage output = **206,180 gallons**

- Using **vacuum** flush water closets and gravity urinals:

  Projected annual water and sewage process savings approx. 91,052 gallons per year

BONUS:

Does not include potential savings from recycling gray water from sinks for use in toilets, which would increase water efficiency

Why Vacuum Plumbing?

Examples of annual water & sewage SAVINGS per year!

- Commercial office building 257,750 gallons
- Department store 743,600 gallons
- Restaurant 115,128 gallons

In specialized cases such as correctional facilities, savings can be ***even more dramatic!***

Why Vacuum Plumbing?

Water savings translate directly into additional environmental benefits

- Gallon for gallon, directly decreases impact on sewer and treatment systems
- Pipes and fittings can be up to **50 %** smaller, saving material cost
- Underground leaks and ground contamination eliminated
- **LEED** Point Potential

Why Vacuum Plumbing?

LEED Point Potential Under Water Efficiency Section

Water Efficiency Section

- Innovative Wastewater Technologies
- Water Reduction **20-40%**

LEED for New Construction

LEED for Commercial Interiors

LEED for Existing Buildings

LEED for Healthcare

LEED for Schools

Why Vacuum Plumbing?

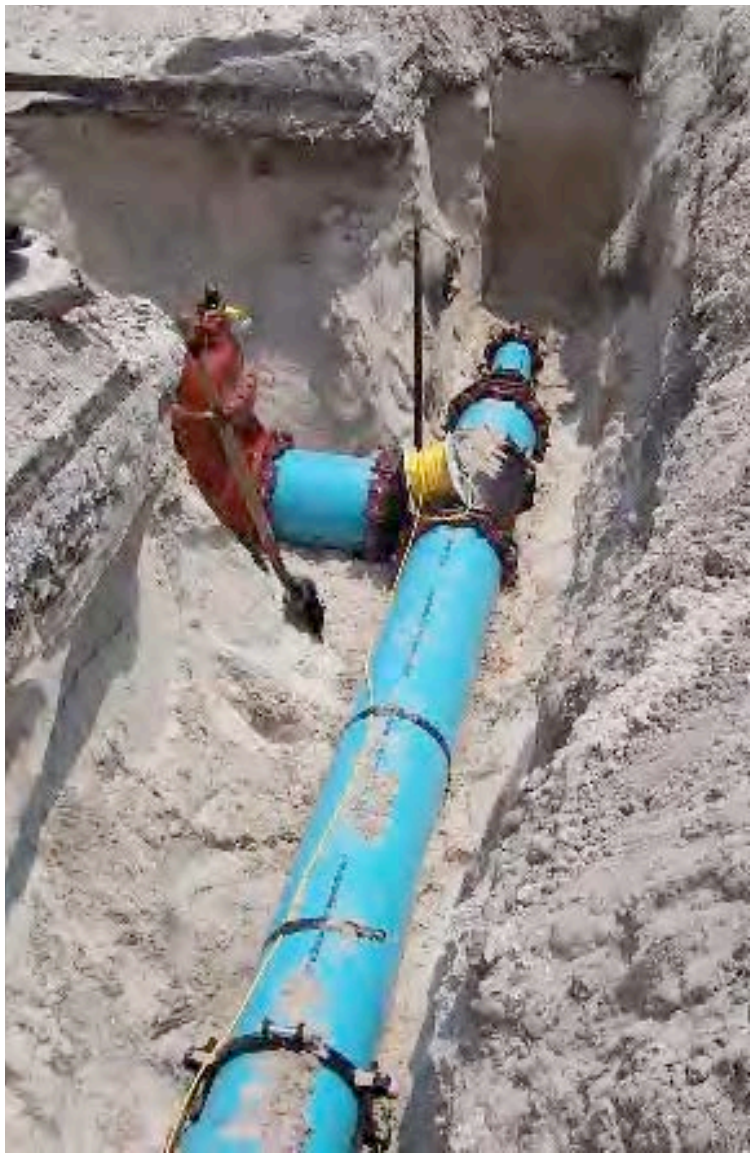
Health, Safety and Security

- Hygienic flush. Does not splash!
- Complies with IAPMO, UPC, IPC and many local codes and standards
- Leaks easily identified and repaired
- Leaks force air in, not wastewater out
- Virtually eliminates mainline blockages

Why Vacuum Plumbing?

Health, Safety and Security, cont'd.

- No digging or trenching, dangers to workers and public reduced
- Security, particularly in correctional facilities: no communication through waste stacks, easy identification of contraband, more control



Why Vacuum Plumbing?

Cost Savings

- Cost of water ***1/3*** of gravity systems
- Cost of sewage connection fees
- Saves materials: smaller piping, fittings, fewer drains and stacks
- Self venting, fewer roof penetrations
- Saves cost, time,
  labor of cutting floors,
  trenching, digging

Why Vacuum Plumbing?

Cost Savings, cont'd.

- No delays in construction due to inclement weather
- Maintenance reduced; mainline blockages virtually eliminated. Leaks and problems quickly identified and corrected

Why Vacuum Plumbing?

Cost Savings, cont'd.

- Vacuum systems considered capital equipment. Can be depreciated. Can be moved to another location
- Many "hidden" costs associated with gravity plumbing decreased or avoided with vacuum

Why Vacuum Plumbing?

Cost Savings, cont'd.

Vacuum systems **avoid** costs of:

- Lost sales and profits due to longer construction or remodeling time
- Additional labor hours, days, weeks, cost of trenching (floor cutting, excavation, restoration)
- Cutting existing in-slab electrical refrigeration, tension, structural, or sewer lines
- Slab x-rays, test core drilling and/or drain line photo scans
- Asbestos, methane or other ground contamination abatement
- Added roof penetrations

Why Vacuum Plumbing?

Cost Savings, cont'd.

Vacuum systems **avoid** costs of:

- OSHA compliance as result of open trenches while project open to public
- Incorrectly located floor drain stub-ups, drains or cleanouts
- Engineering change orders
- Sewage impact fees potentially reduced
- Customer inconvenience
- Potential damage or conflict with lower level tenants
- Overcoming invert obstacles such as rock, ledge, structural slab, etc.

Why Vacuum Plumbing?

Design and Construction Flexibility

- Saves space, self venting, no vent stacks or roof penetrations
- Flexibility in waste pipe routing
- Piping horizontal or vertical
- Fewer floor penetrations

Why Vacuum Plumbing?

Design and Construction Flexibility, cont'd.

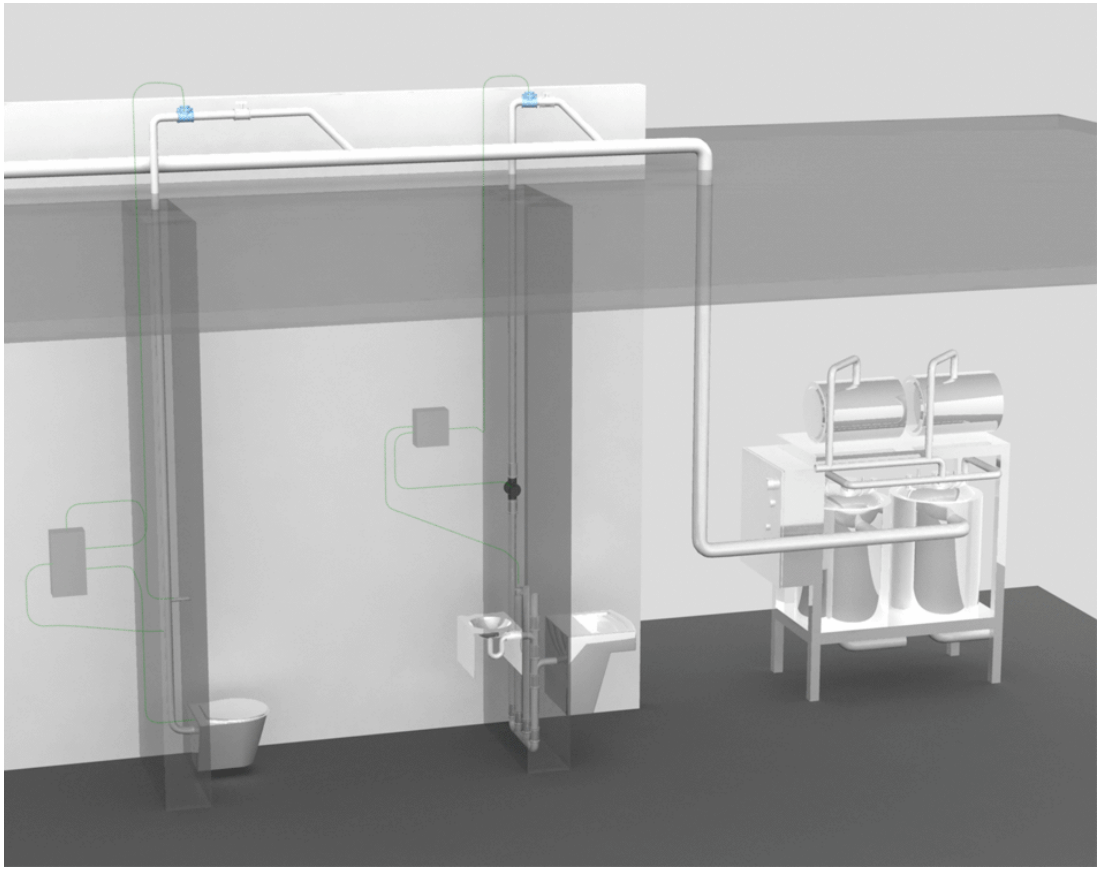
- Supermarket advantages
  - Flexible layout
  - Relocation of systems
- Renovation advantages
  - Structural limitations (e.g., existing post tension slab foundations, etc.)
  - Restrictive sites (e.g., bedrock, historical classification, etc.)
  - Embedded contaminants (e.g., asbestos in floors)

Course Outline

- **Lesson Two: Systems Operations & Design**

Systems Operation and Design

Vacuum Plumbing Systems Basic Components



Systems Operation and Design

Key Components, cont'd.

- Accumulator
  - Operation
  - Includes sensor
  - Activates Extraction Valve

Accumulator

Pipe Accumulator

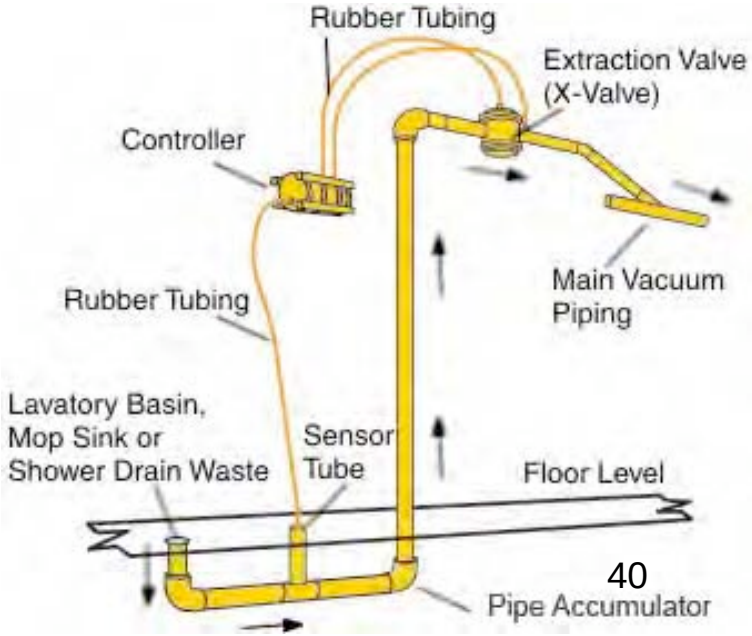
Systems Operation and Design

Key Components, cont'd.

- Extraction Valve and Controller
  - *"Normally closed" pinch valve*
  - *Opened and closed by Controller*
  - *Toilets, activated by flush button*
  - *Sinks, lavatories, etc. activated automatically*

Extraction Valve

Operation Diagram



Systems Operation and Design

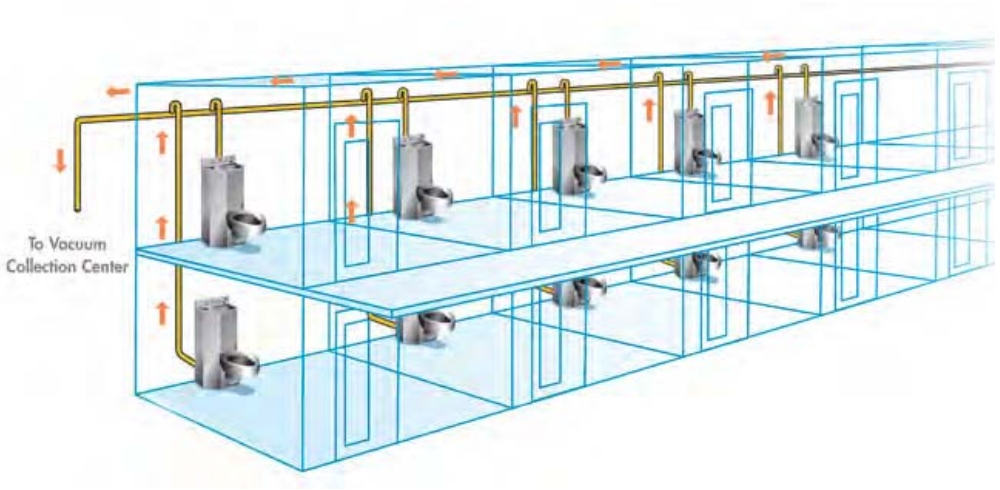
Key Components, cont'd.

- Vacuum Piping Network
  - System always under vacuum pressure
  - Materials – smaller diameter, smooth internal bore piping with standard sweep style fittings.
  - Risers, droppers, sub-mains, mains
  - Slope 1/8", compared to gravity systems

Systems Operation and Design

Key Components, cont'd.

- Fixtures
  - Standard plumbing fixtures
  - Designed to flush ***0.5 gallon*** toilets



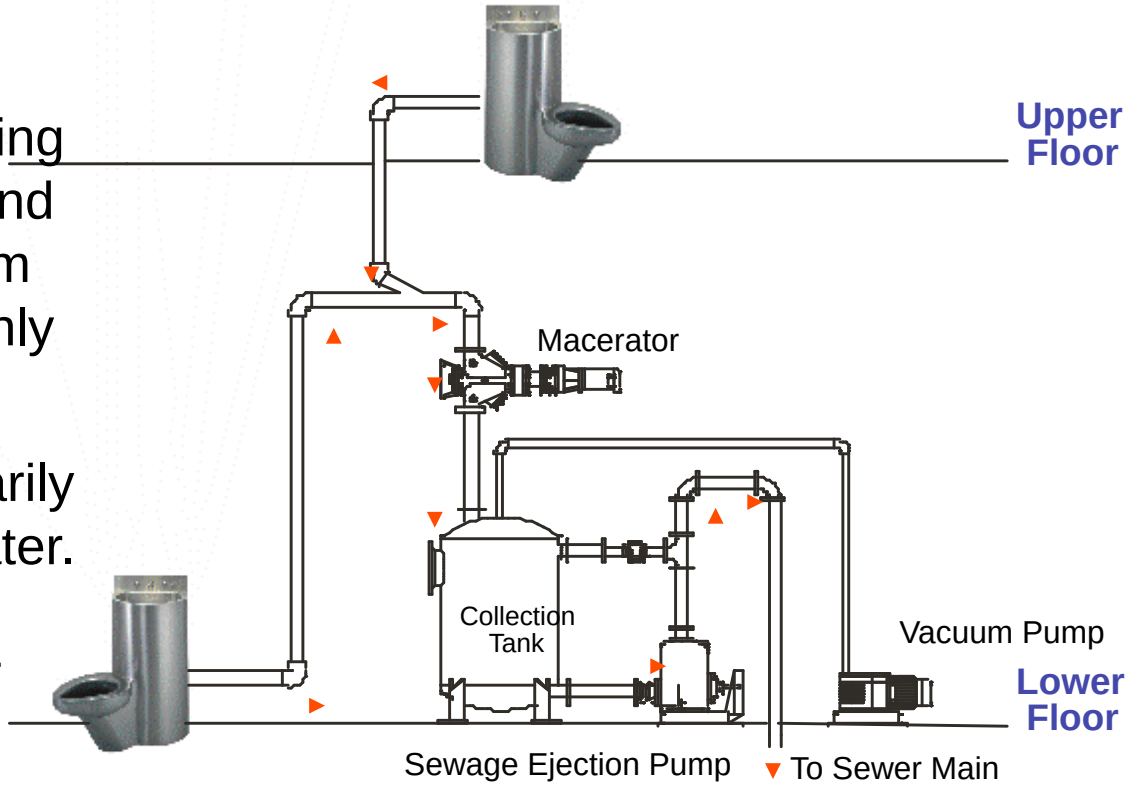
- Electronic Valve Control System
  - Networked for Remote Visibility and Control

Systems Operation and Design

Key Components

Vacuum Center

- ***Pumps:*** liquid ring pumps create and maintain vacuum pressure, run only on demand
- ***Tanks:*** temporarily collect wastewater. Discharge automatically or manually
- ***Controls:*** fully automated, redundant



Systems Operation and Design

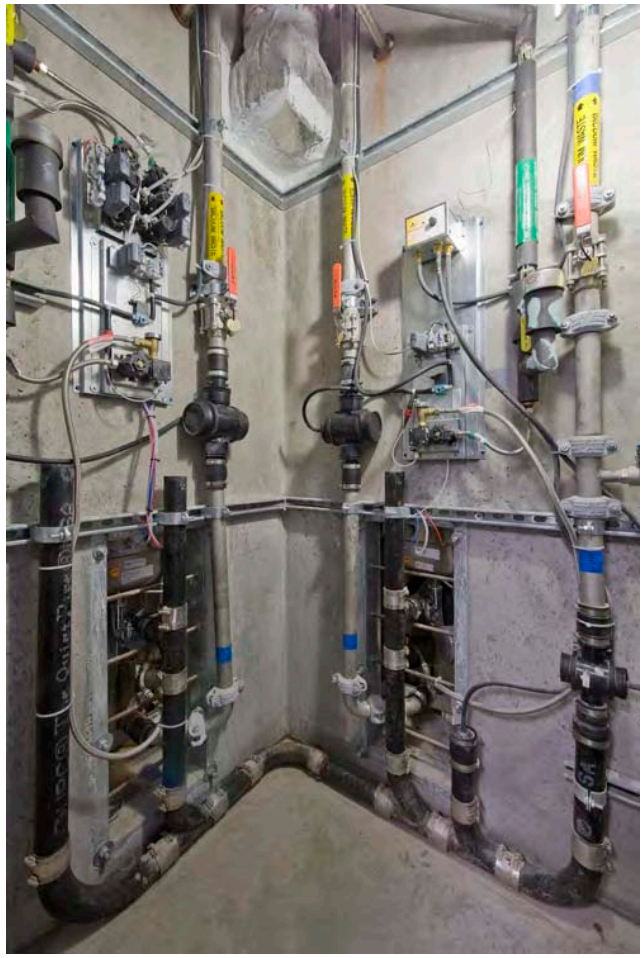
Sizing and Design Considerations

- Vacuum Center
  - Automatic operation
  - Location, delivery, operation
  - Sizing factors
    - Lift Points, Equipment, Other

Systems Operation and Design

Sizing and Design Considerations, cont'd.

- Vacuum Piping Network
  - Materials
  - Sizing
  - Routing
  - Manufacturers design assistance



Systems Operation and Design

Sizing and Design Considerations, cont'd.

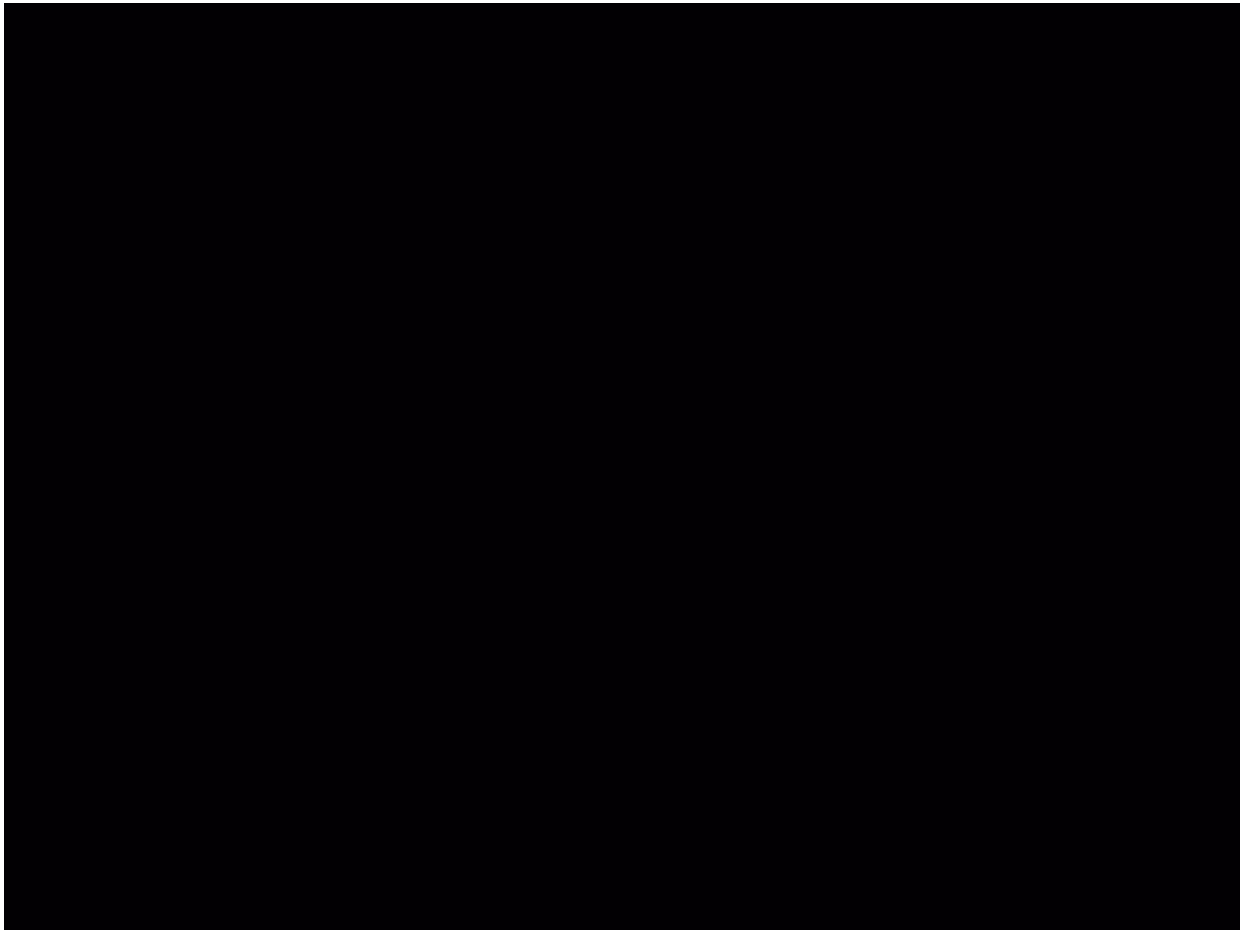
- Accumulator
  - Sizing is key
  - Flow rate and volume

- Extraction Valve
  - Sizing
  - Location

- Controller Options
  - Electronic and/or pneumatic

Systems Operation and Design

System Components and Design



Systems Operation and Design

What to Look for in a Supplier

- Project Experience
- Engineering, design expertise and assistance
- Ability to assist and evaluation of code and standard compliance
- Ability to provide assistance in evaluation of vacuum for LEED point criteria
- Spare Parts Available
- Sizing Criteria
- Manufactured in US
- Ability to test and design for unique applications

Systems Operation and Design

Worst Case Scenarios and FAQs

Q. What happens if the vacuum piping network develops a leak?

A. Piping is maintained under continuous vacuum. Leaks draw air INTO pipes, not waste OUT

Systems Operation and Design

Worst Case Scenarios and FAQs

- Vacuum Center alarm features
- Leaks in interior structure easily found compared to leaking underground pipes

Course Outline

- **Lesson Three: Worse Case Scenarios & FAQs**

Vacuum Plumbing FAQs

Worst Case Scenarios and FAQs, cont'd.

Q. What about a catastrophic piping failure such as breakage due to earthquake?

A. Unlike underground piping, any break in the piping of a vacuum system, regardless of cause, can be immediately identified and easily repaired.

Q. What happens if power fails?

A. Many facilities add the Vacuum Center to their standby power generating system. Control and hardware options can accommodate needs of standby power sources.

Vacuum Plumbing FAQs

Worst Case Scenarios and FAQs, cont'd.

Q. What happens during multiple simultaneous use scenarios, such as in large office buildings or correctional facilities?

A. Proper engineering ensures that the system is sized for such events. Vacuum systems are designed to accommodate exceptionally large water flows.

Q. *What happens when debris gets into the system?*

A. Vacuum systems virtually eliminate clogged piping. Debris found in gravity drainage systems does not affect performance in vacuum systems.

Vacuum Plumbing FAQs

Worst Case Scenarios and FAQs, cont'd.

Q. In supermarkets, is the system odor free?

A. Yes. Odors contained, discharged. Sealed drains eliminate odors on the sales floor.

Q. *In supermarkets, since the drainage piping is in the ceiling space, does the Accumulator act as a trap? Can waste back up into a case?*

A. No. The Accumulator is separated from the overhead piping by the closed Extraction Valve. Unlike gravity systems, the area underneath the case is never exposed to sewer waste.

Course Outline

- ***Case Studies & Demos:*** *Vacuum Plumbing in Action*
  - Supermarkets and Retail Facilities
  - Commercial Facilities
  - Hospitals and Health Care

    * Renovation
  - Institutional Facilities

Case Studies & Demos

Case Studies and Demonstrations

- Retail Facilities
  - Supermarkets example
  - Comparison of Gravity and Vacuum
  - How Condensate and Gray Water Systems Work
  - Vacuum Grease Waste Systems

Case Studies & Demos

Retail\Supermarket, cont'd.

Comparison Between Vacuum and Gravity Systems

- Layout not limited by location of floor sinks and drains
- Piping installed overhead, not underground. No venting required. Material cost reduced
- No floor cuts, trenching,

  cutting of in-slab

  electrical lines

Case Studies & Demos

Retail\Supermarket, cont'd.

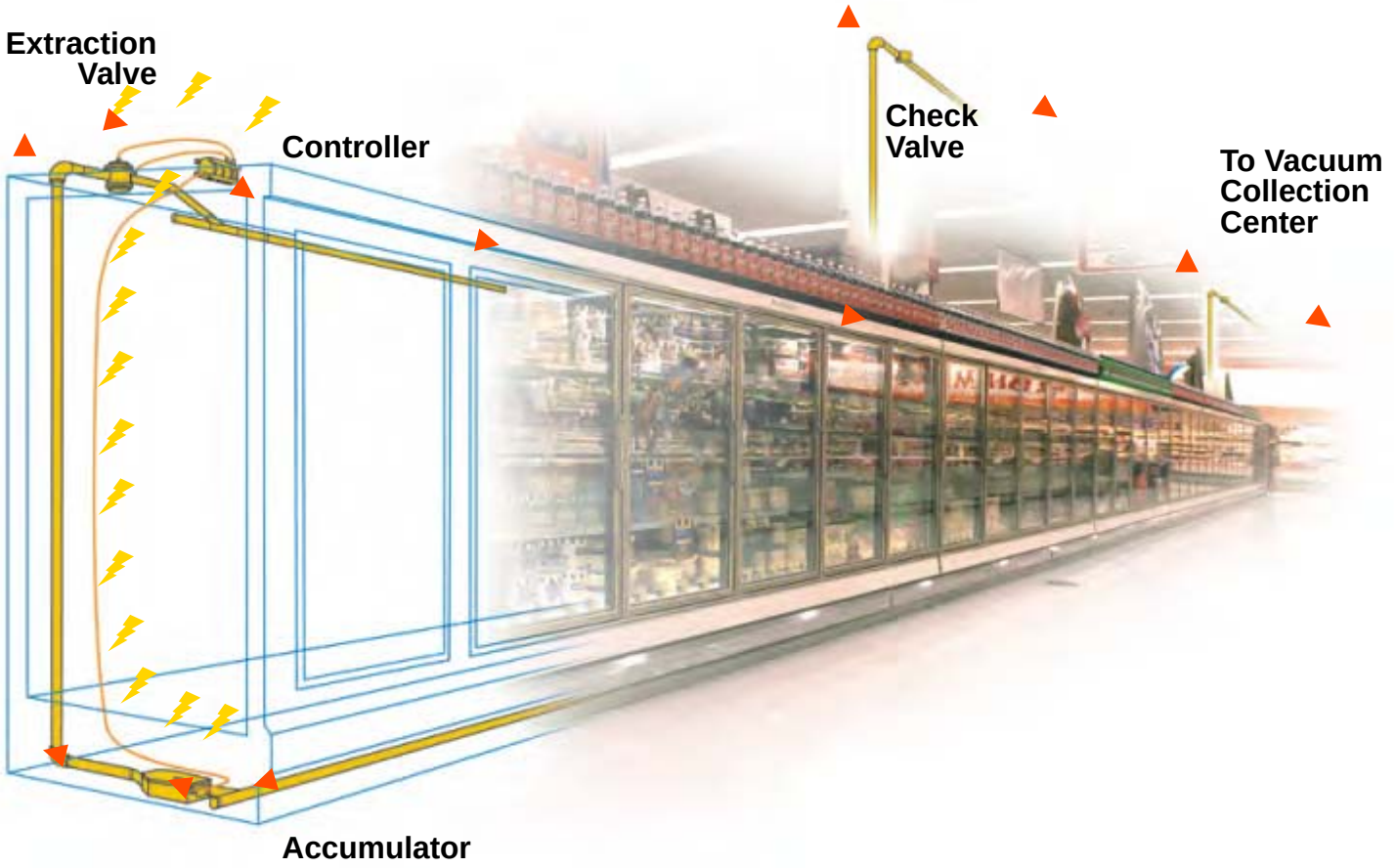
Comparison Between Vacuum and Gravity Systems

- If leak occurs, air comes in, instead of wastewater going out causing potential ground damage
- Construction schedules not affected by weather, under-slab conditions, asbestos in floor, engineering issues, etc.
- Impact or sewer inspection fees reduced

Case Studies & Demos

Retail\Supermarkets, cont'd.

How Condensate and Gray Water Collection Systems Work



Case Studies & Demos

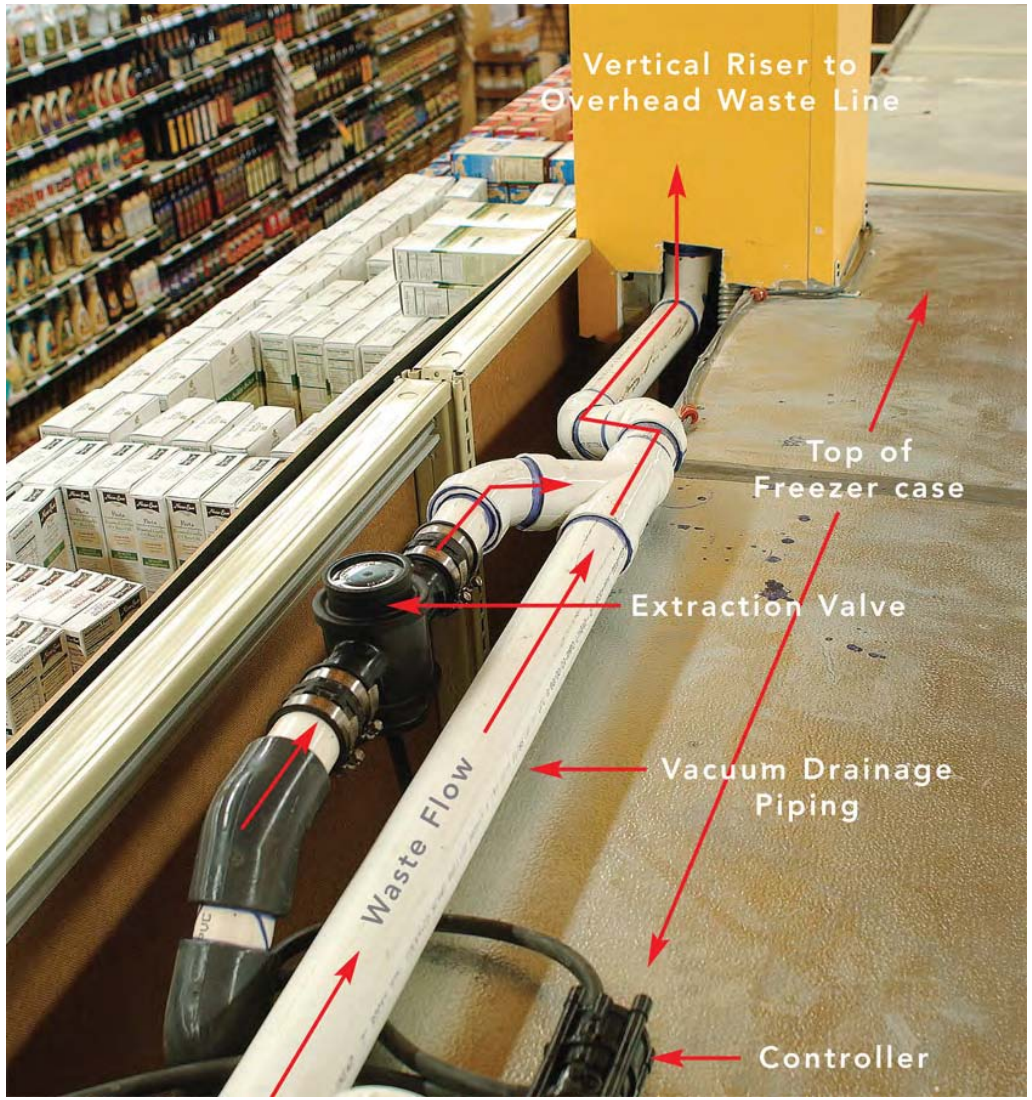
Retail\Supermarkets, cont'd.

How Condensate and Gray Water Collection Systems Work

- Condensate generated
- Reaches pre-set level in Accumulator
- Controller triggers Extraction Valve
- Piping and valves concealed overhead, above cases
- Wastewater transported under pressure to Vacuum Center
- Tax advantages for capital depreciation
- System can be relocated

Case Studies & Demos

Retail\Supermarkets, cont'd.



Case Studies & Demos

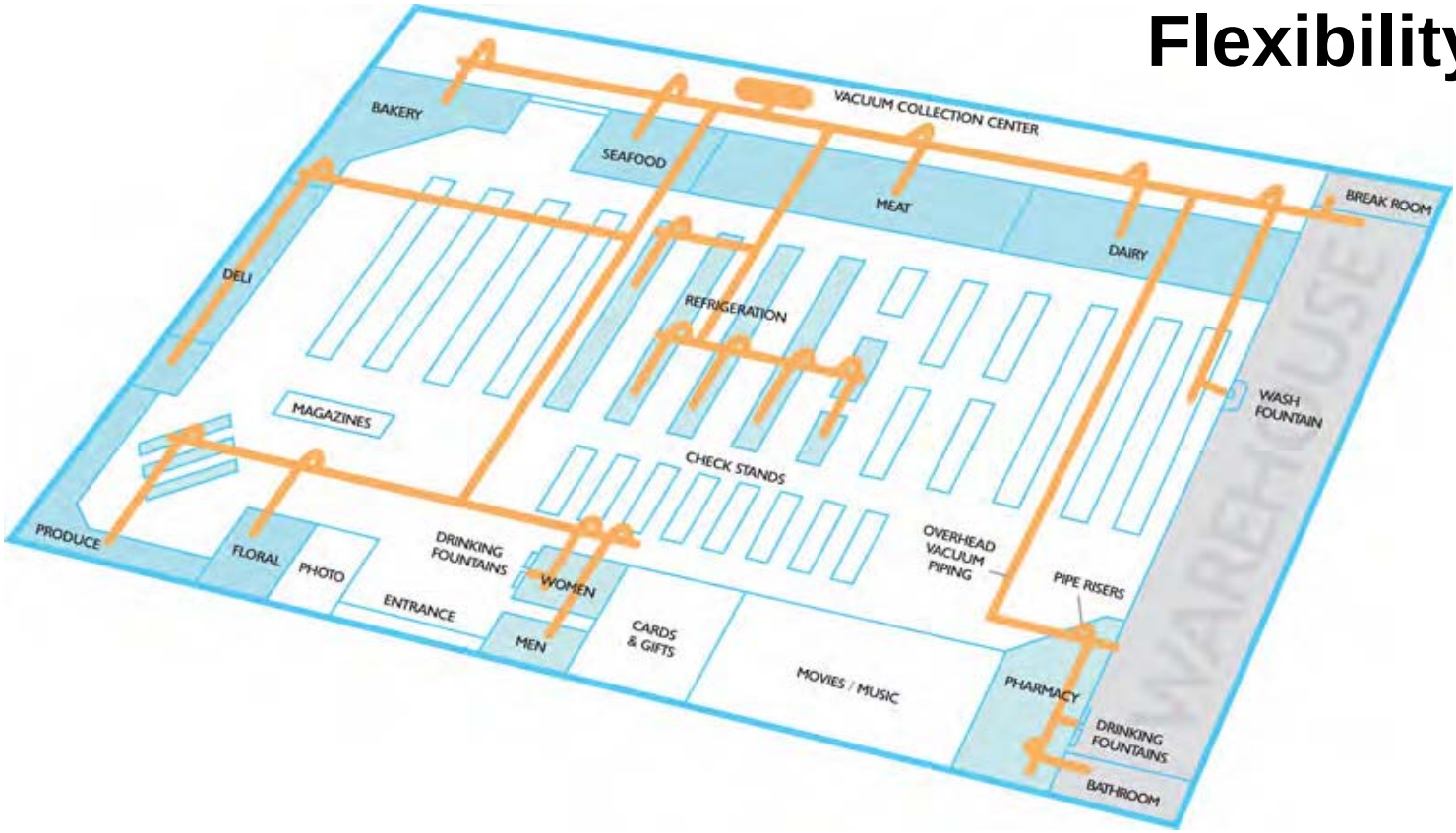
Retail\Supermarket, cont'd.

Comparison Between Vacuum and Gravity Systems

- Soil condition and type no longer a factor in design or construction.
- Layout renovations don't require saw cutting, digging and trenching = potential significant cost and time savings
- Minimizes risk of cutting in slab electrical

Case Studies & Demos

Design Flexibility



- Future layout flexibility

Case Studies & Demos

Retail\Supermarket, cont'd.

Comparison Between Vacuum and Gravity Systems

- More uniform and sales floor
- Minimizes risk of cutting in slab electrical

Case Studies & Demos

Retail\Supermarkets, cont'd.

Vacuum Grease Systems

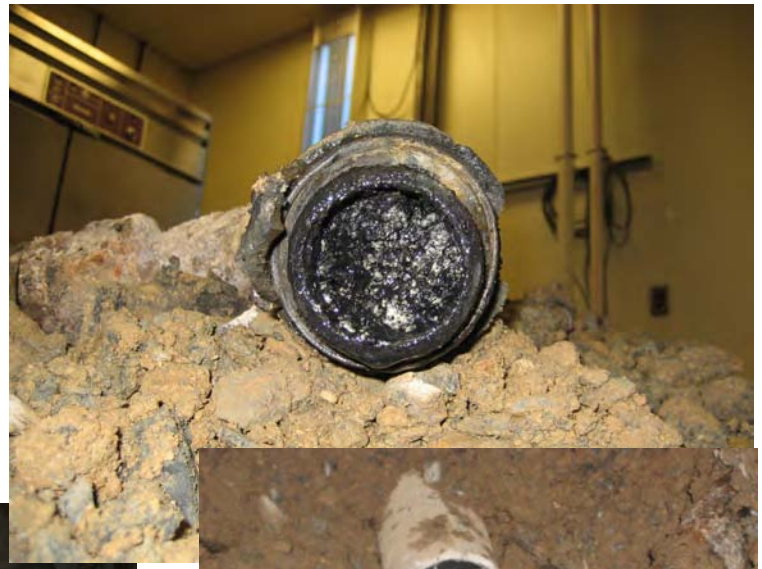
- UL and NSF approved
- Eliminated:
  - *Grease interceptors on sales or service floor*
  - *Costly waste line maintenance*
  - *Odors and inconvenience*
  - *Potential for ground contamination*

Case Studies & Demos

Retail\Supermarkets, cont'd.

Vacuum Grease Systems

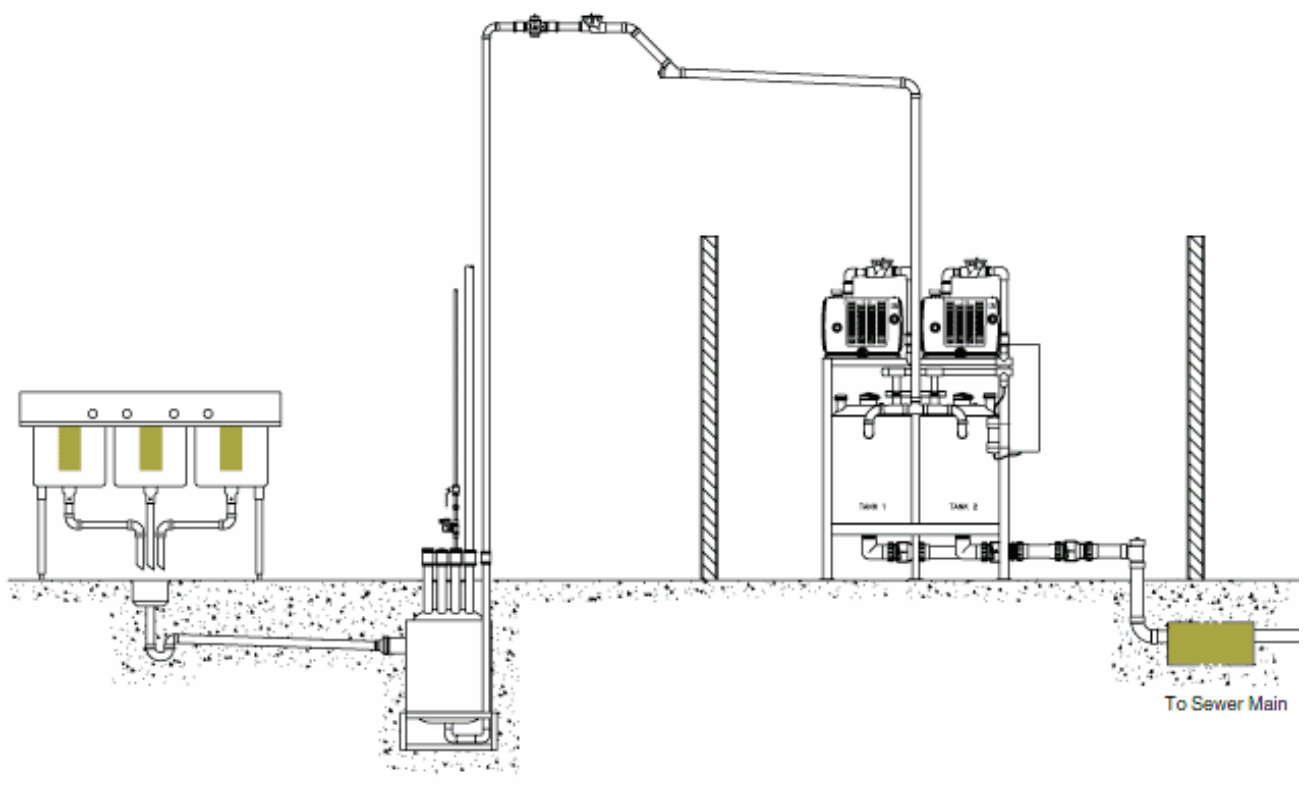
- Reduces clogged grease waste lines
- Eliminates under ground contamination



Case Studies & Demos

Retail\Supermarkets, cont'd.

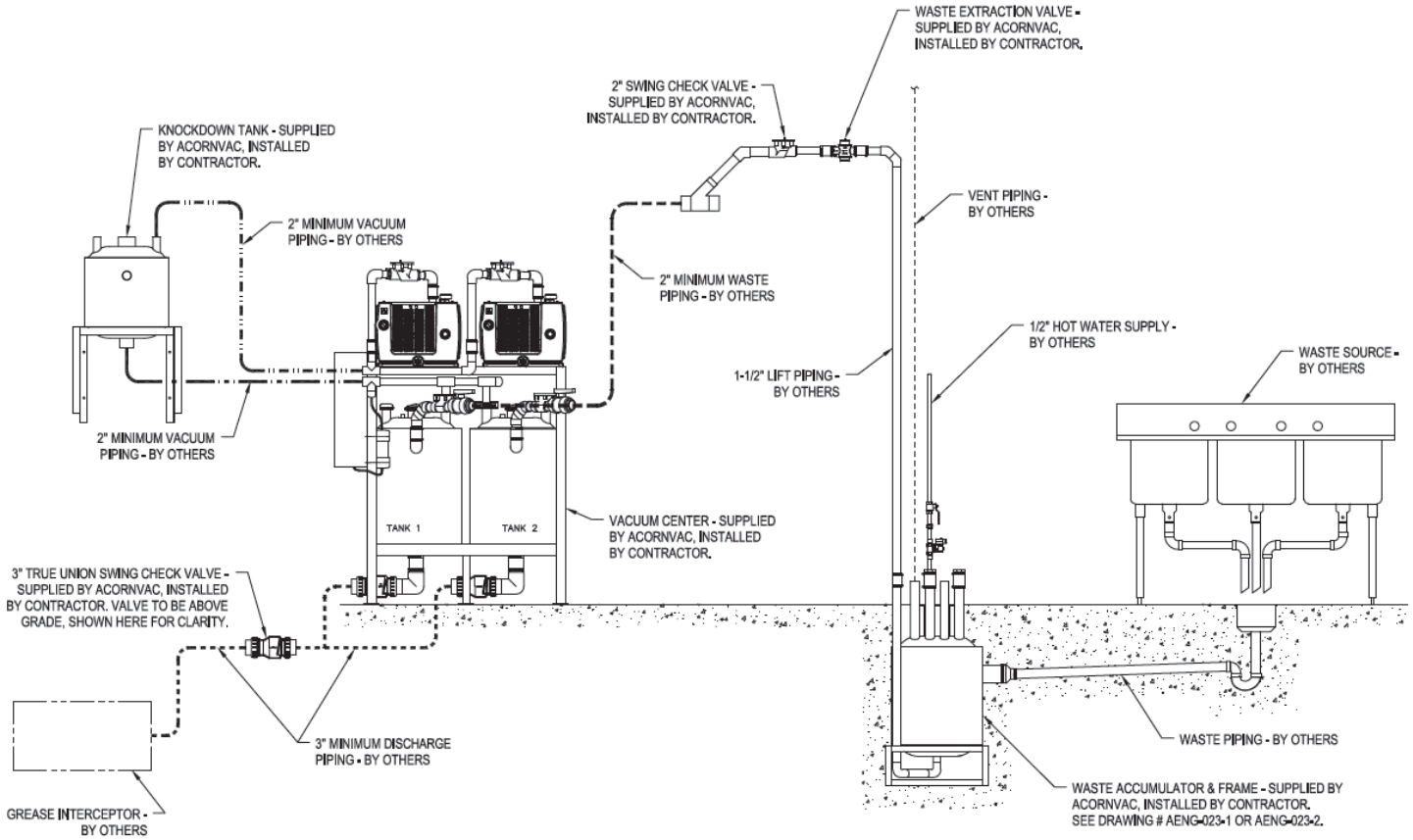
How Vacuum Grease Waste Transport Works



Case Studies & Demos

Commercial Facilities, cont'd.

How Vacuum Grease Waste Transport Works



Case Studies & Demos

Case Studies and Demonstrations

- Commercial Kitchen Renovation
  - Historical building housing facility cafeteria
  - Relocation of kitchen fixtures and plumbing equipment in below grade level.
  - Grease waste drainage requirements without appropriate invert remaining for connection to grease interceptor equipment due to rock

Case Studies & Demos

Case Studies and Demonstrations

- Vacuum Grease Waste Systems Benefits
  - Design flexibility and adaptation to site and structural conditions

Case Studies & Demos

Commercial Facilities, cont'd.

Commercial\Kitchen Renovation Facilities

Associated benefit

- Construction schedules not affected by under-slab conditions, structural issues, engineering issues, site conditions, etc.

Case Studies & Demos

Commercial Facilities, cont'd.

Commercial Renovation – Additional potential benefit

- Grey water can be ***captured and processed then redirected*** for landscape irrigation or flush water.

Case Studies & Demos

Case Studies and Demonstrations

- Sutter Novato Medical Clinic - Novato, CA
  Medical Office Building and Outpatient Surgical Center

Case Studies & Demos

Case Studies and Demonstrations

- Sutter Novato Medical Clinic - Novato, CA
  Medical Office Building and Outpatient Surgical Center

Construction Challenges:

- Structural slab foundation
- Partially occupied building
- No readily available “as built” drawings

Case Studies & Demos

Case Studies and Demonstrations

- Sutter Novato Medical Clinic - Novoto, CA
- Medical Office Building and Outpatient Surgical Center
  - Vacuum drainage system able to accommodate specialty health care and medical facility plumbing fixtures and equipment

Case Studies & Demos

Case Studies and Demonstrations

- **Benefits**
  - Half gallon vacuum flush toilet reduces water consumption and minimizes spread of bacteria by pulling air into the toilet and eliminating splash during flush cycle.

Case Studies & Demos

Case Studies and Demonstrations

- Correctional Facilities
  - Example of Water Savings
  - Comparison of Gravity and Vacuum Systems
  - Case in Point: Western Virginia Regional Jail
  - Payback Chart

Case Studies & Demos

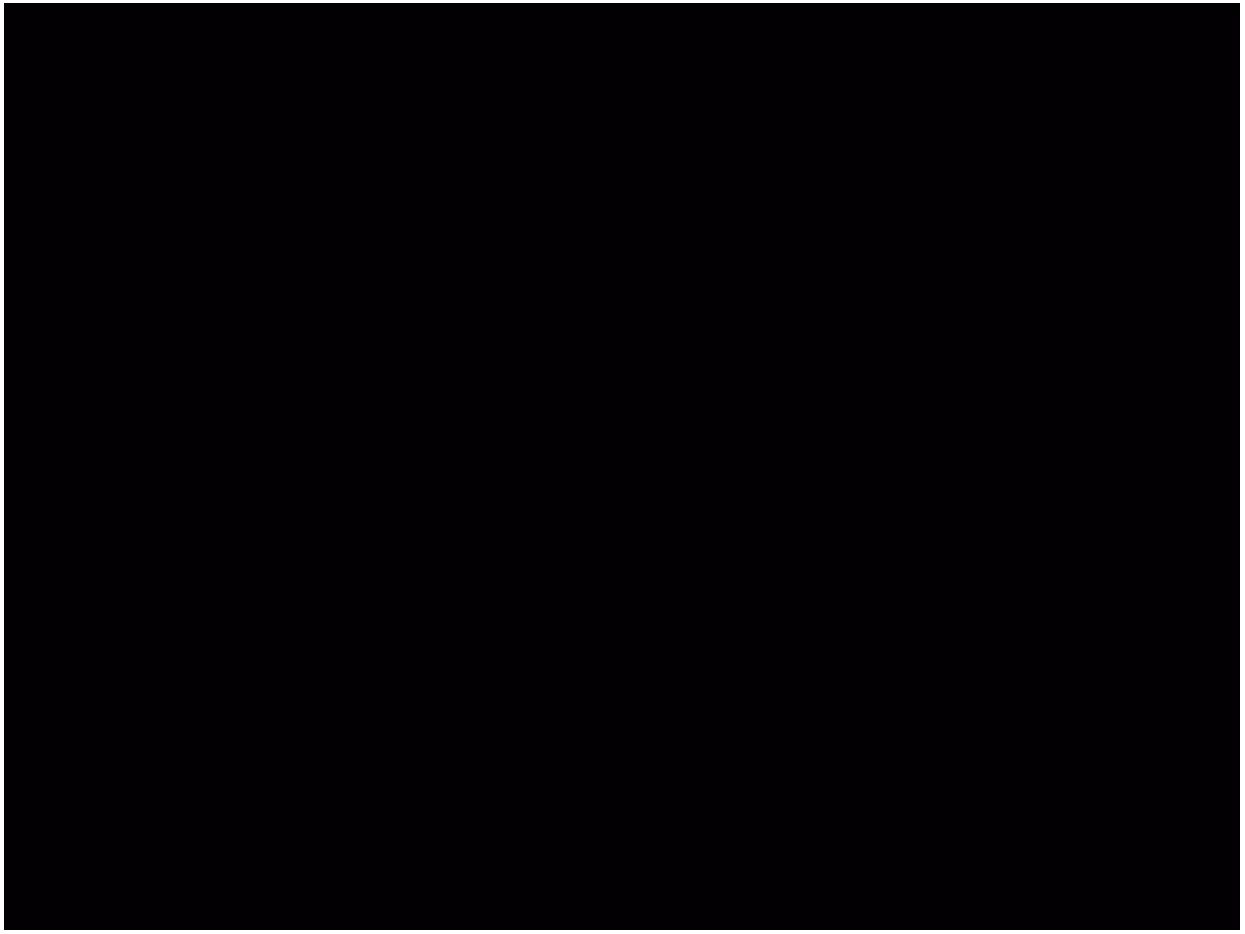
Correctional Facilities, cont'd.

Comparison of Vacuum and Gravity Systems

- Gravity offers potential abuse of system by flushing contraband into system for retrieval by others. ***Vacuum retains contraband.***
- Gravity offers communication through waste stacks. ***Vacuum systems: Extraction valve "normally closed"***
- Vacuum systems give staff ***control*** from remote location of individual toilets, or by section

Case Studies & Demos

Correctional Facilities, cont'd.



Case Studies & Demos

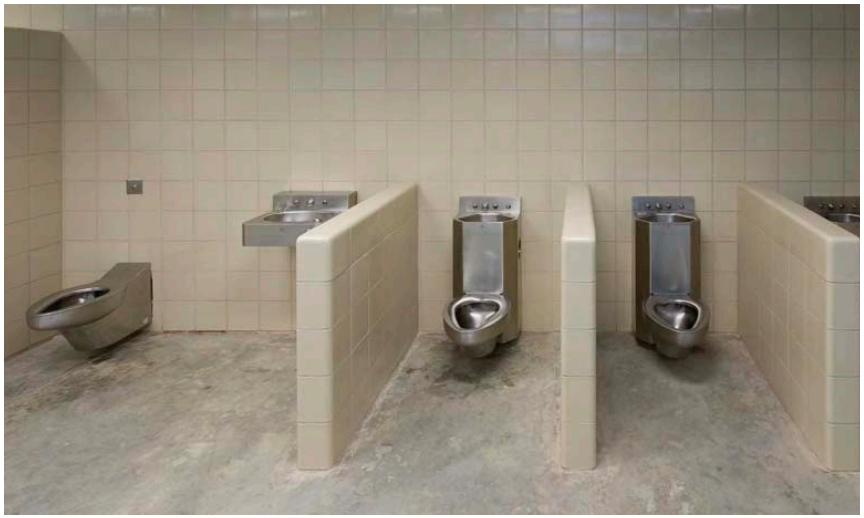
Correctional Facilities, cont'd.

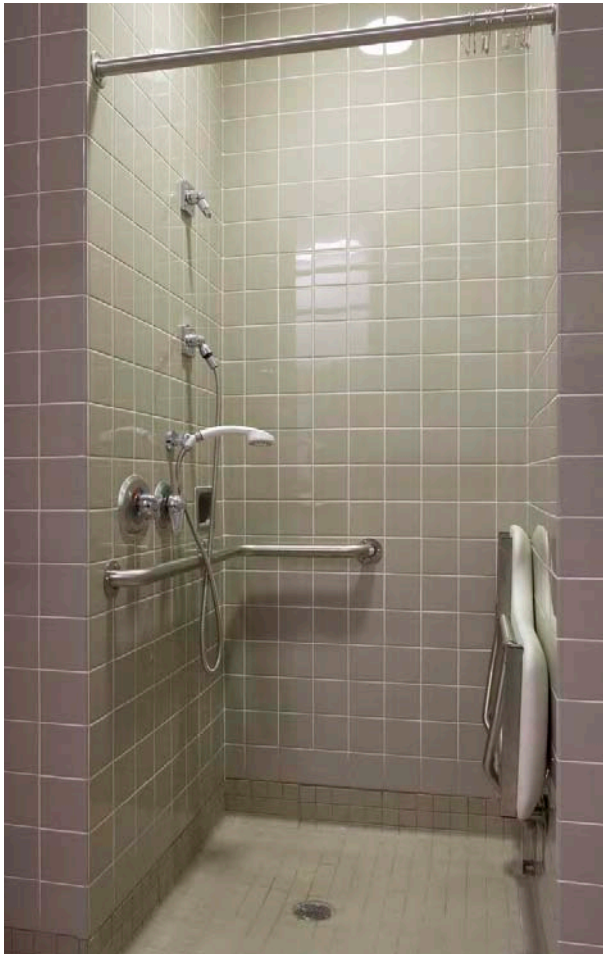
Case in Point: Western Virginia Regional Jail

- One of the 1st **LEED** certified prison in the US
- Estimated savings up to **4 million gallons of water** savings and sewage reduction

Case Studies & Demos

Western Virginia Regional Jail Plumbing Fixtures





Case Studies & Demos

Correctional Facilities - 500 inmates, 275 cells

24 flushes a day per inmate

WC Water use with **gravity** low flush fixtures:

- 500 inmates:
  - 500 x 24 flushes per day x 1.6 gallons per flush = 19,200 per day

Total annual water demand = 19,200 gal per day x 365 = approx. 7,000,000 gal/year

Case Studies & Demos

Correctional Facilities - 500 inmates, 275 cells cont'd.

WC Water use with **vacuum** flush fixtures

- 500 inmates:
  - 500 x 24 flushes per day x .5 gallons per flush = 6,000 gallons per day

- Total annual water demand with gravity systems = 6,000 gal per day x 365 = approximately 2,190,000 gallons per year

Estimated water and sewage process savings of approximately 4,800,000 gallons per year

Case Studies & Demos

Western Virginia Regional Jail Payback Chart

Typical estimated payback for incorporated LEED items:

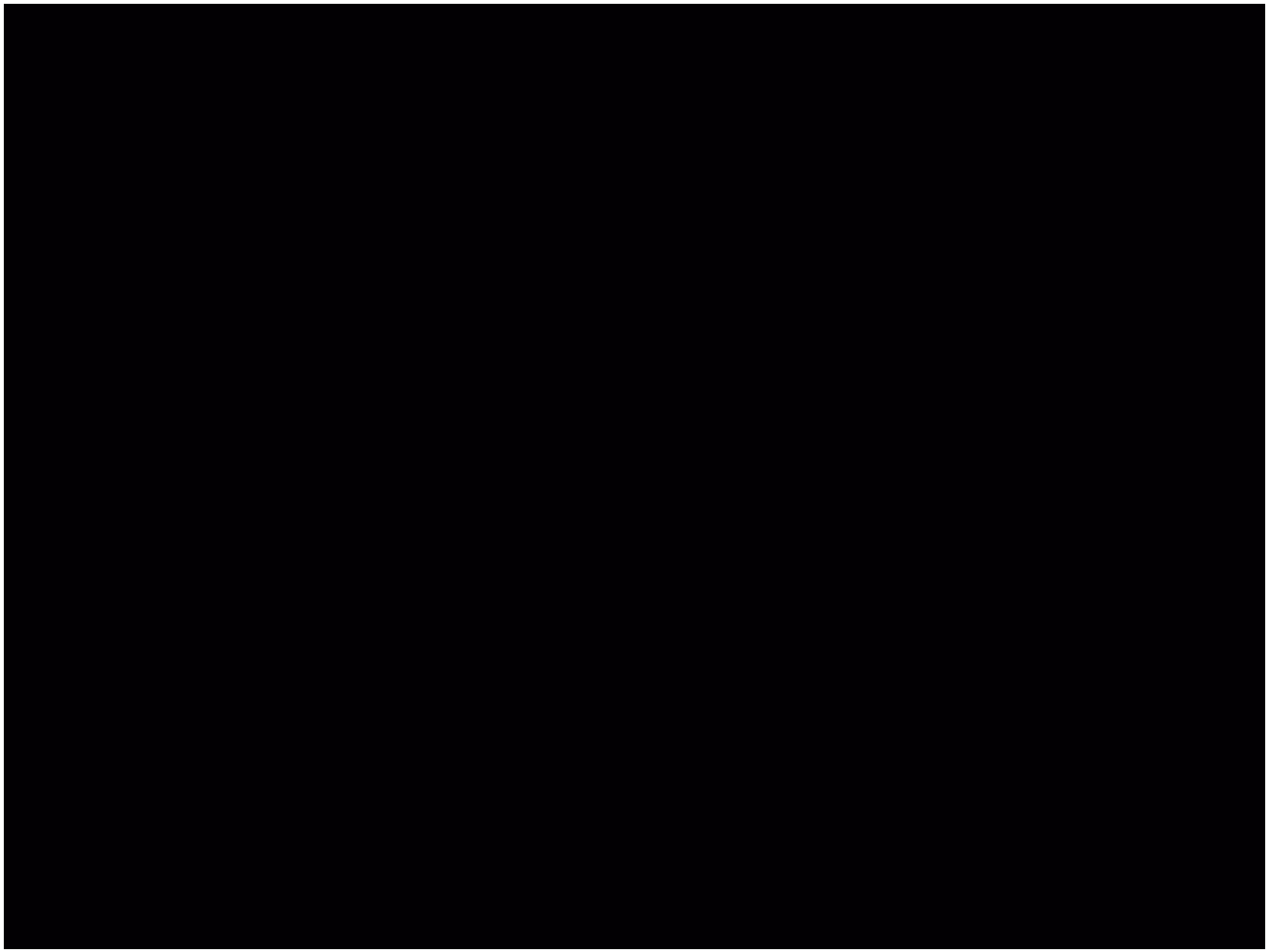
- Storm water recycling: 3 years
- Motion sensor faucets in admin area: 5 years
- Energy Star roof: 15 years
- Low E Glass in admin area: 10 years
- LEED commissioning: 10 years
- Carbon dioxide sensors to control outside air quantity: 10 years
- Motion detectors to control admin area lighting: 5 years
- **Vacuum toilets: 1 year**

Case Studies & Demos

Case Studies and Demonstrations

- **Benefits**
  - Water and waste savings
  - Security and control
  - Reduced maintenance associated with line blockages
  - Future expandability
  - LEED point opportunities
  - Reduction in construction timeline

Case Studies & Demos



Thank You

Thank you for your time.

This concludes the AIA Continuing Education Systems Program.

Questions?

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