Presented for COAA

Plumbing and Fire Protection: Systems Overview and Design Innovations

May 16, 2023

Smith Seckman Reid, Inc.

ENGINEERING | TECHNOLOGY + EQUIPMENT PLANNING
COMMISSIONING | SUSTAINABILITY | BUILDING ENCLOSURE

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Roof Consulting
Enclosure Testing
Facility Condition Assessments & Investigations
Design & Design Consulting

CIVIL
Site Planning & Development
Grading & Drainage
Erosion & Sediment Control
Stormwater Management
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Standby Power Facilities
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Power Conditioning
Coordination Studies

ENVIRONMENTAL
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Wastewater Treatment & Collection
Water Reclamation/Reuse
Integrated Water Planning
Financial Analysis
Program Management

FIRE PROTECTION
Wet & Dry Sprinkler Systems
Clean Agent Systems
Foam Systems
Hydraulic Modeling

GEOGRAPHIC INFORMATION SYSTEMS (GIS)
System Design & Implementation
Infrastructure Mapping & Asset Management
Data Migration
Mobile & Web-based Geospatial Solutions
Location Analytics
Training

MECHANICAL
Central Energy Plants
Building Automation Systems
Energy Management
CFD Analysis
Geo-Exchange
Campus Distribution Systems
High Performance HVAC
Cogeneration

PLUMBING
Building Water Supply & Sewer Gas Systems
Water Use Audits & Management
Greywater & Rainwater Systems
Process Pure Water
Solar Water Heating

STRUCTURAL
Foundations, Deep & Shallow
Reinforced, Pre-Stressed, & Post-Tensioned Concrete
Steel Fabrication
Failure Analysis
Seismic Evaluations & Retrofit

SUSTAINABILITY
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Transition Planning
Move Management

TRANSPORTATION
Roadways & Bridges
Signalization
Airports
Port Facilities
Roadway Planning & Safety Audits
Intelligent Transportation Systems
Construction Engineering Inspection

Learning Objectives

- ❑ The lecture will introduce the student to general plumbing and fire protection design concepts and components found in the typical building design as well as the latest innovations of these systems.
- ❑ Gain a baseline understanding of building plumbing systems and applicable design considerations.
- ❑ Gain a baseline understanding of building fire protection systems and applicable design considerations.
- ❑ See/hear an explanation and examples of both traditional and innovative approaches to the design of plumbing and fire protection systems.
- ❑ Gain a fundamental understanding of the role(s) plumbing and fire protection engineers play in the design and construction process

Top Plumbing Systems Design Considerations

- What is the building's use? For example, is it a restaurant, an apartment building, or a hospital
- What are the governing plumbing codes for that location?
- Where are the utility hookups for the domestic water and sanitary sewer services located on-site?
- How will you heat your water? We will use electricity, natural gas, and maybe renewable energy.
- How will rainwater be drained from the roof? It is a sloped roof or roof drains will be provided?

Design Consideration

- Plumbing Codes and Standards

WaterSense Listed

Satisfies Leed Credits

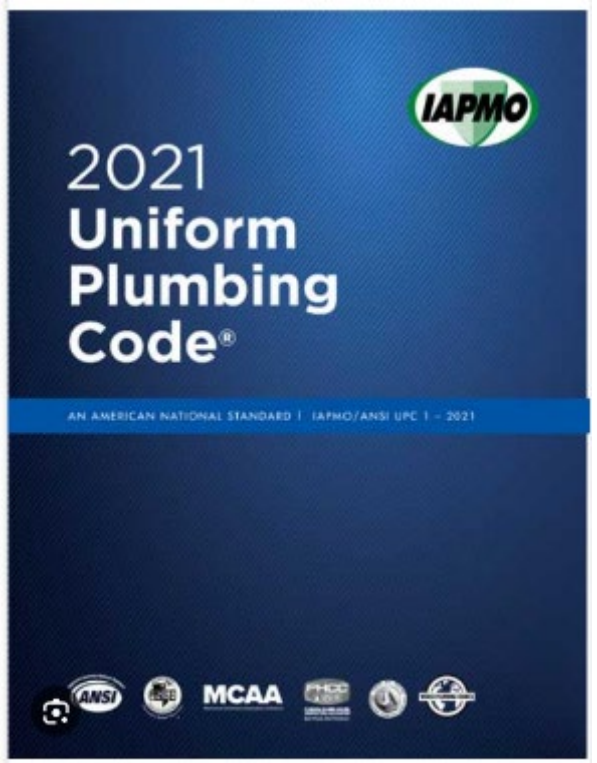
Uniform Plumbing Code Certified

California Green Building Code

Americans with Disabilities Act

Buy American Act

2021 International Plumbing Code®



Uniform Plumbing Code Visit

Building Plumbing Systems

Plumbing

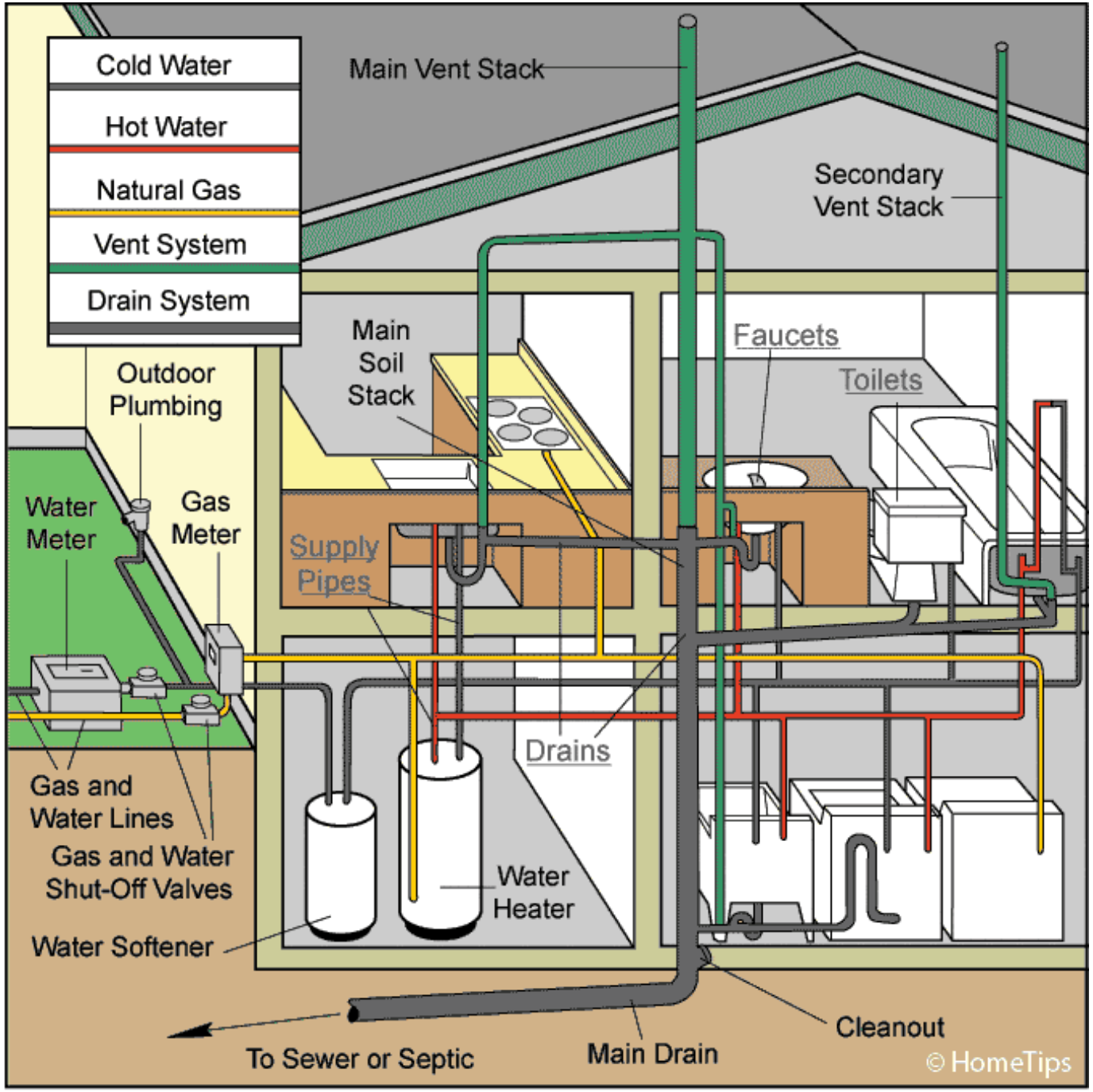
1. Domestic water systems
2. Waste & vent systems
3. Storm water systems
4. Medical gas
5. Natural gas systems

Fire Protection

1. Automatic Sprinkler systems
2. Standpipes
3. Special hazard systems

Building Plumbing Systems

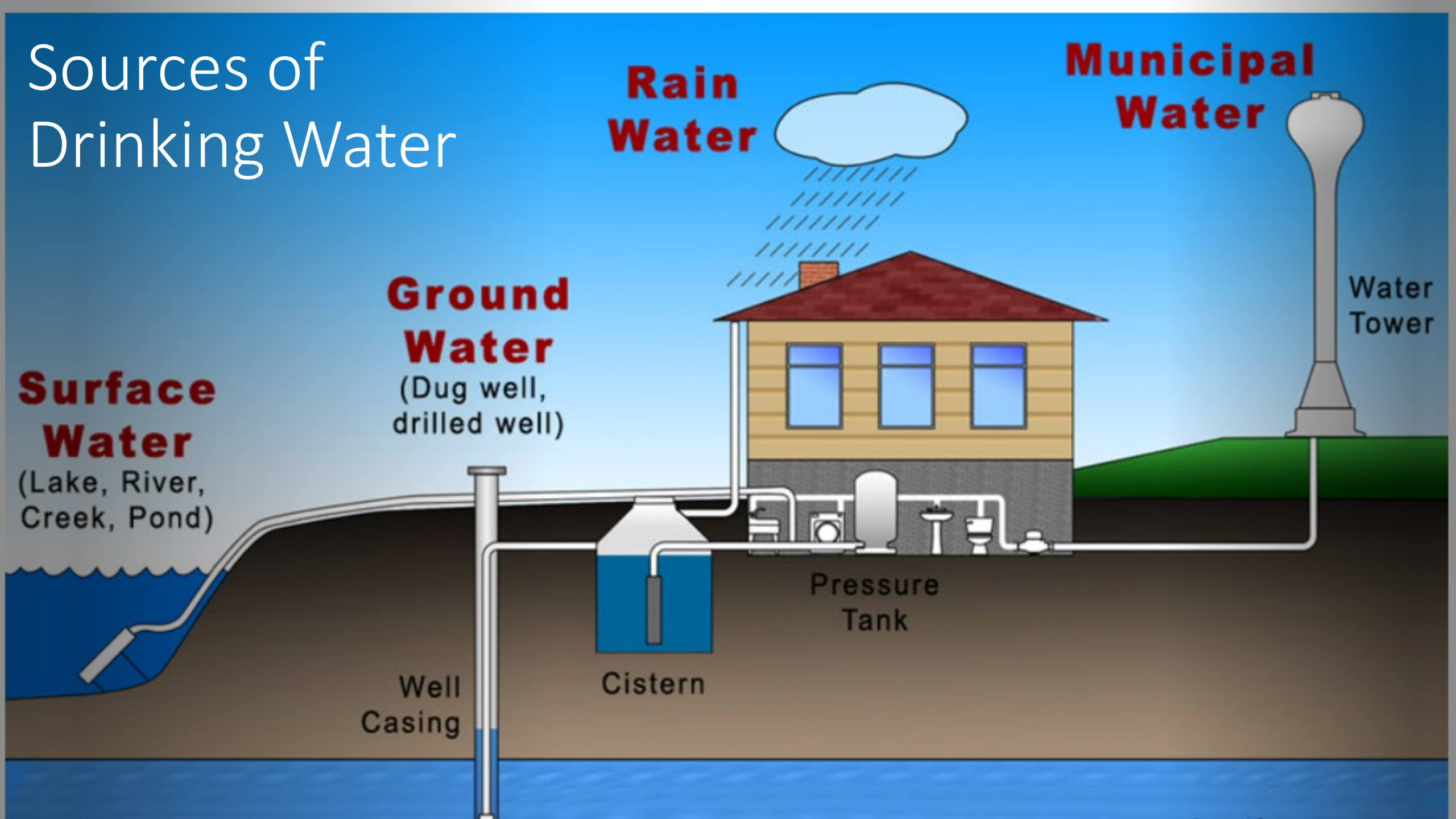
- Water is delivered to a home through water supply pipes from the utility or a well and is then distributed to sinks, toilets, washers, bathtubs, and pieces of equipment.
- The drain-waste-vent system carries away used water and waste to sewers or septic tanks.
- The natural-gas piping system delivers this fuel to gas-burning cooktops, furnaces, water heaters, and clothes dryers.



Domestic Water Systems

- Potable water source
- Backflow prevention method
- Piping, valves and components
- Plumbing Fixtures
- Equipments

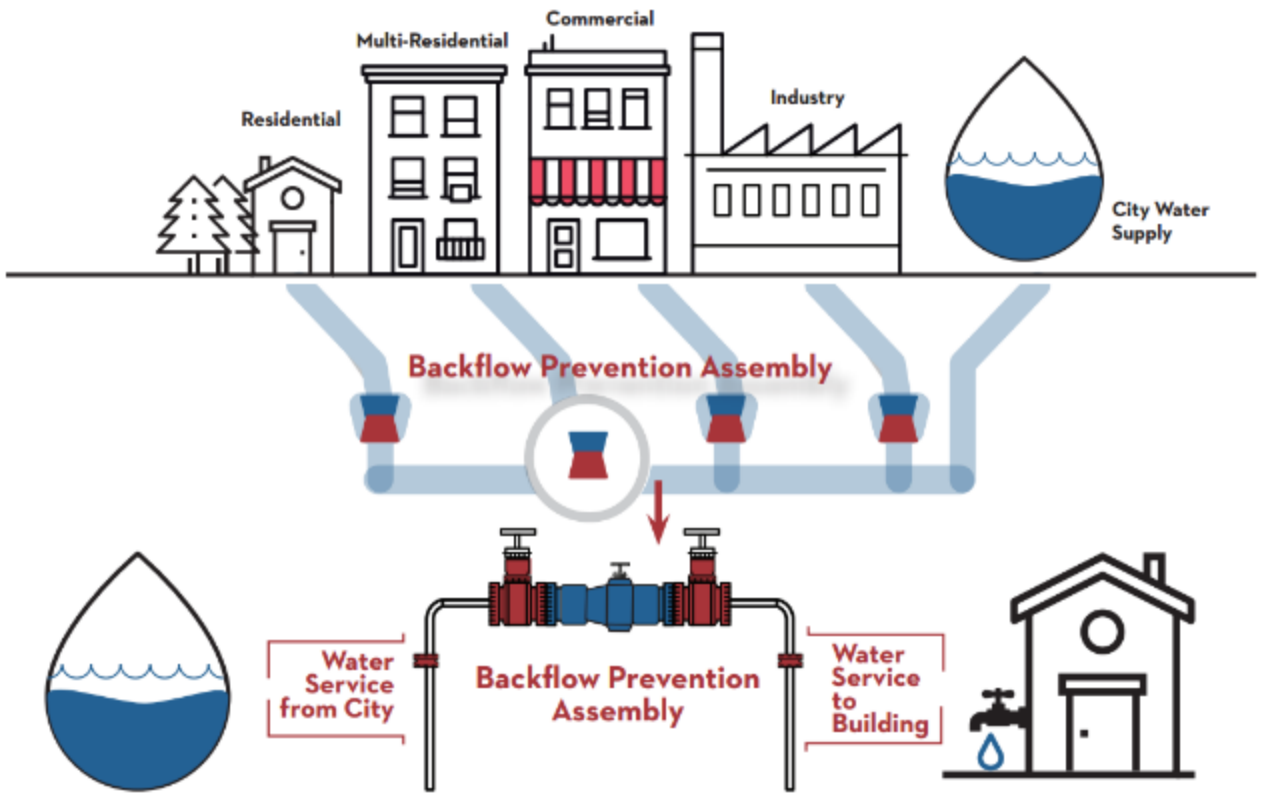
Sources of Drinking Water



BACKFLOW PREVENTION

Cross-Connection

An actual or potential connection between a potable water supply and any non-potable substance or source.



Backflow

The undesirable reversal of flow of water or mixtures of water and other liquids, gases, or other substances into the City's water system.

Backflow Prevention Assembly

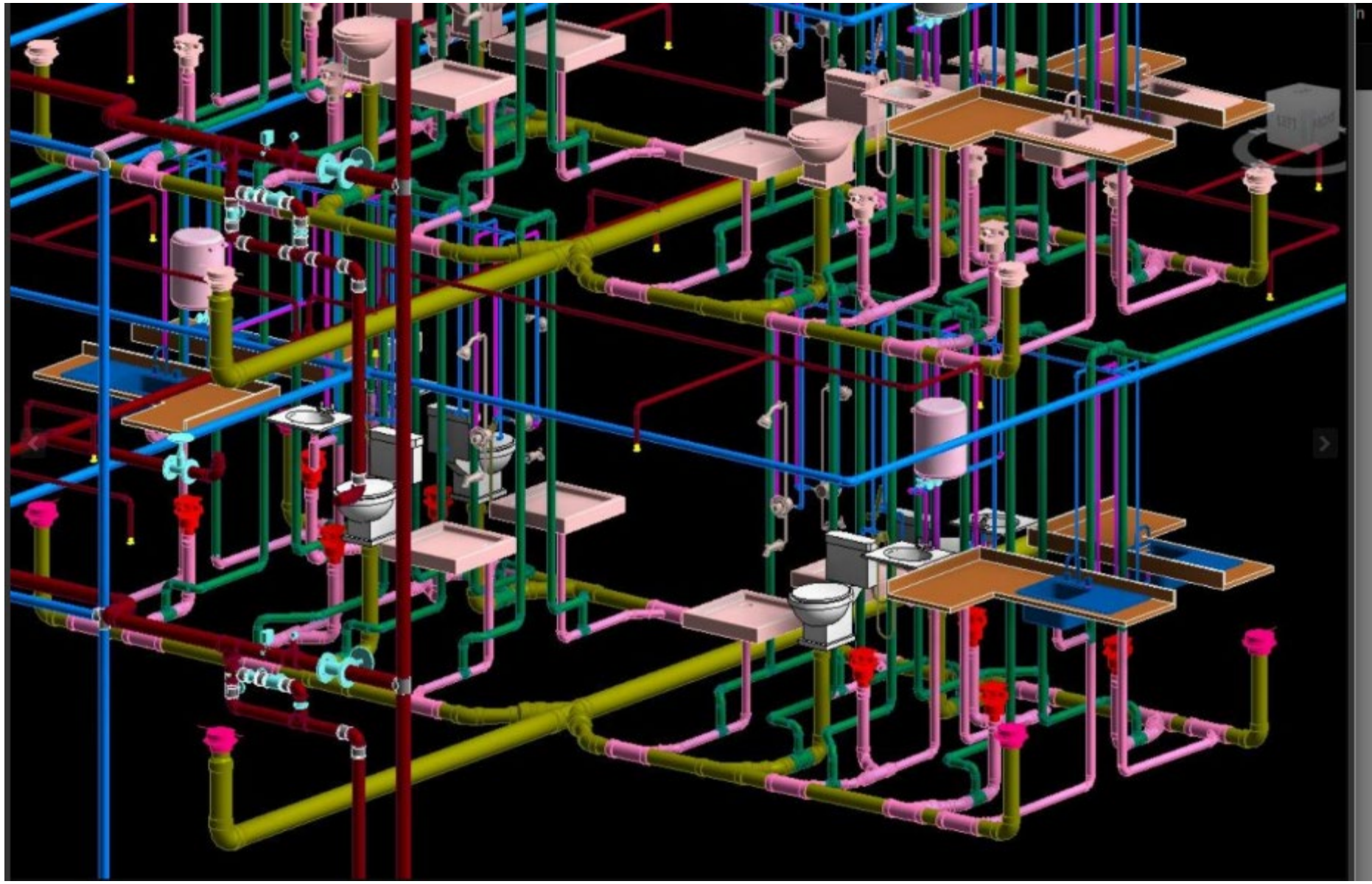
Any approved assembly used to prevent backflow into a potable water system.

COMMON CROSS-CONNECTION EXAMPLES

These common household and commercial connections to the public water system pose a threat to our clean water if not protected by the appropriate Backflow Prevention Assembly.

- Irrigation Systems
- Fire Sprinkler Systems
- Hose Bibs

All wetted areas of components—pipe, valves, fittings—must be Lead-Free to comply with the Safe Water Drinking Act (NSF 61 and NSF 372)

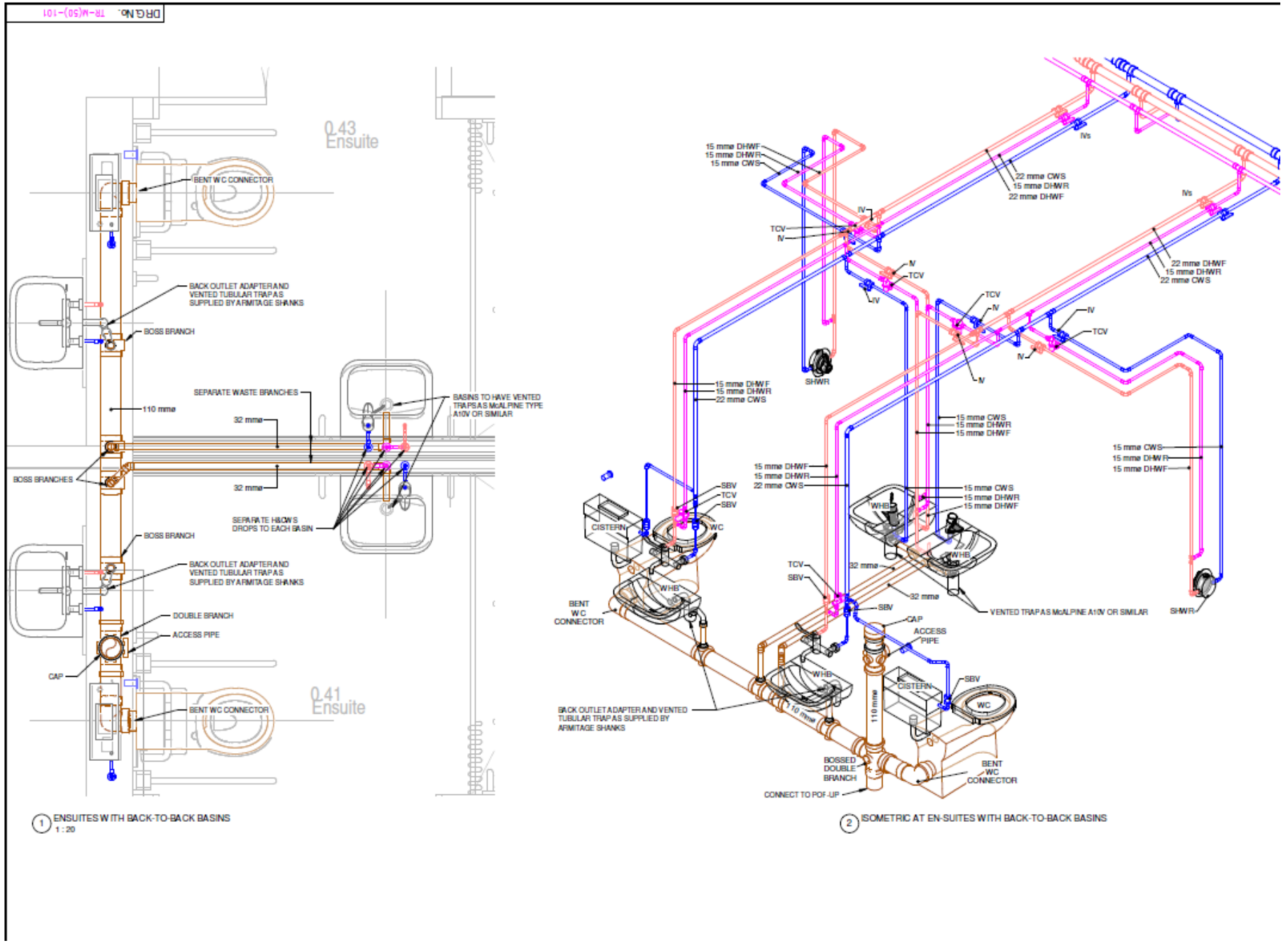


Design Keys

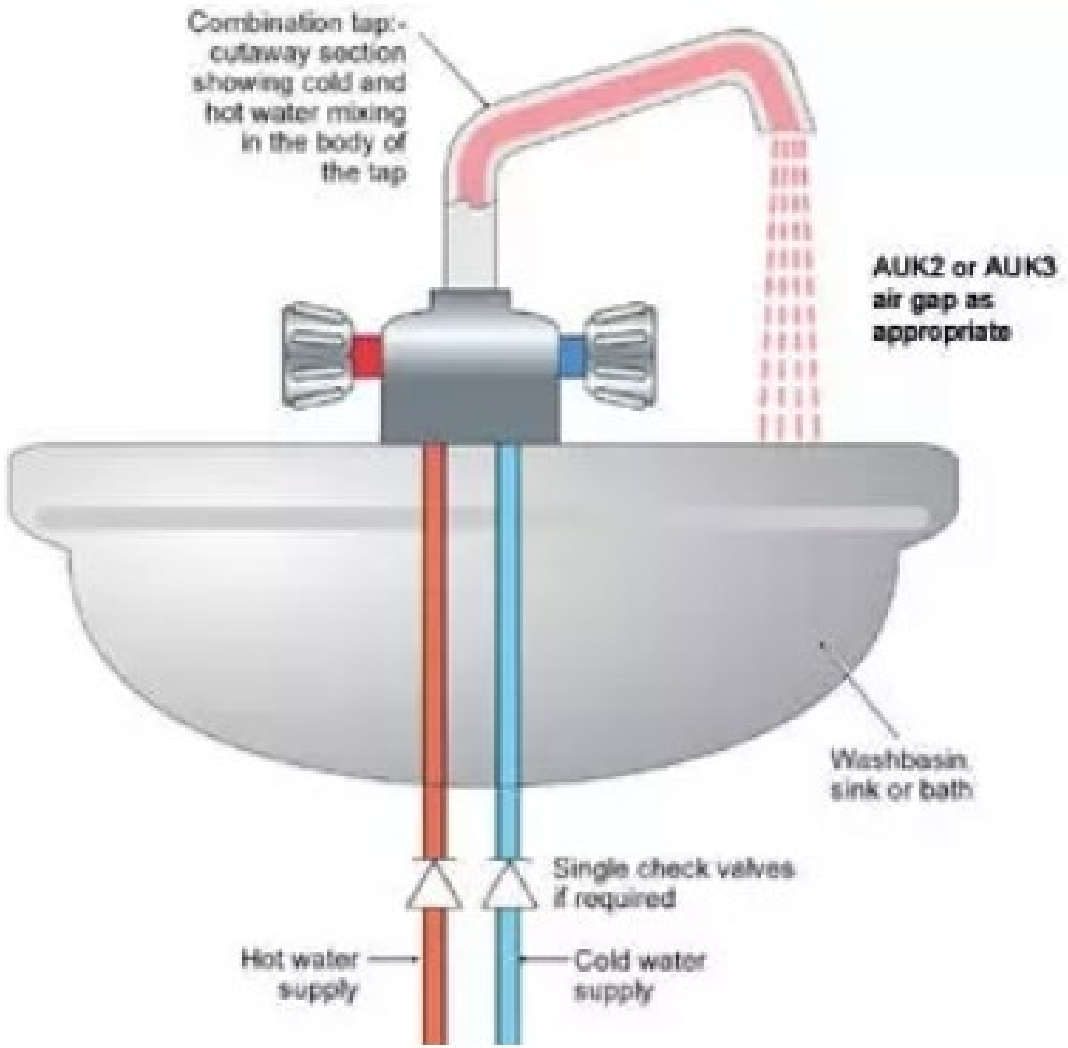
- Incoming water quality – hardness, acidity, bacteria, contaminants
- Valve location for proper isolation of fixture groups, risers, loops, and equipment
- Water demand and pressure
- Hot water is piped on the left side of the faucet, cold water on the right ALWAYS

Incoming water quality – hardness, acidity, bacteria, contaminants

- Valve location for proper isolation of fixture groups, risers, loops and equipment



Hot water on the left, cold water on the right ALWAYS



Plumbing Fixtures

- Water Closets
- Urinal
- Lavatories
- Showers
- Floor Drains

RESIDENTIAL

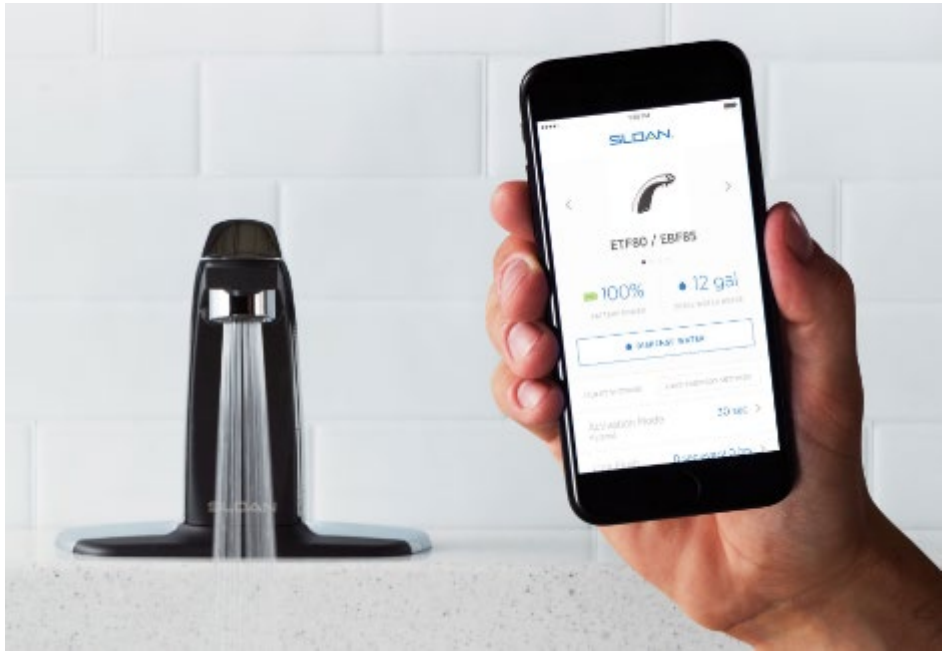
COMMERCIAL

PUBLIC

PRIVATE

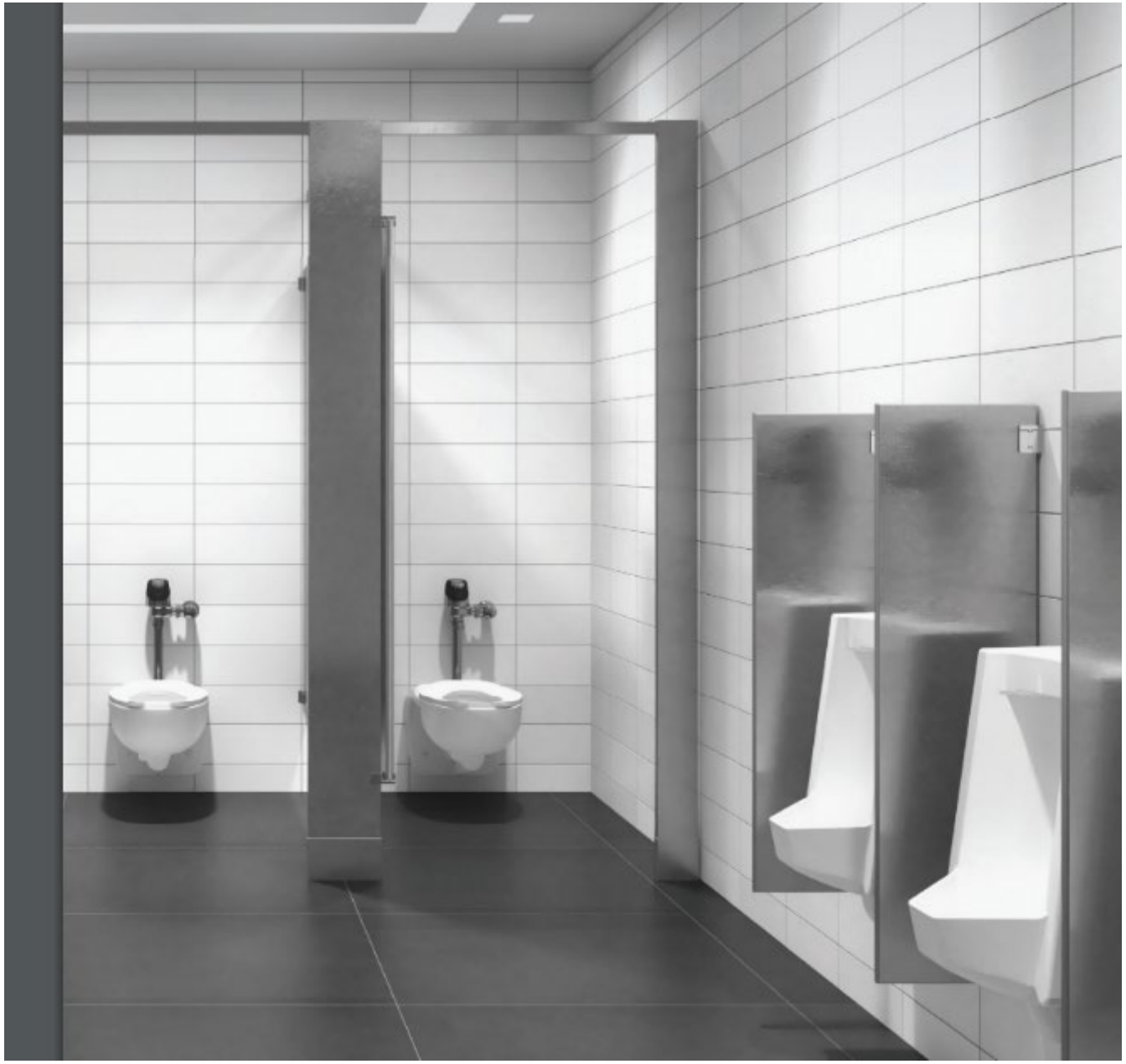
ADA /BARRIER FREE

INNOVATIONS



Incorporated Smarter water management
Water usage, Battery strength, remote change the Sensor settings,
Automated line flush to eliminate stagnant water

sink with electronic sensor faucet, matching soap dispenser, and hand dryer



Combine a water efficiency water closet with a high-efficiency 1.1 gpf flushometers valve and you'll get a system that uses 31% less water than the 1.6 gpf as recommended by the EPA standard.

High-Efficiency Urinals are specifically intended for commercial facilities that need to accommodate many restroom visitors and save water.

Some urinals use as little as 0.125 gallons of water—much less than the 1.0 gpf maximum required by the EPA standard for urinals.

In a world of increasing water shortages—and increasingly strict usage regulations—conserving water has never been more important.

Waterfree and Hybrid Urinals – can be used to reduce the amount of water used by the facility

A Hybrid Urinal automatically flushes up to 1 gallon of water once every 72 hours

Water piping sizing criteria's: IPC Fixture Unit Table

Water Supply Fixture Units (WSFU) is the standard method for estimating the water demand for a building.

This system assigns an arbitrary value called a WSFU to each fixture in a building, based on the amount of water required and the frequency of use.

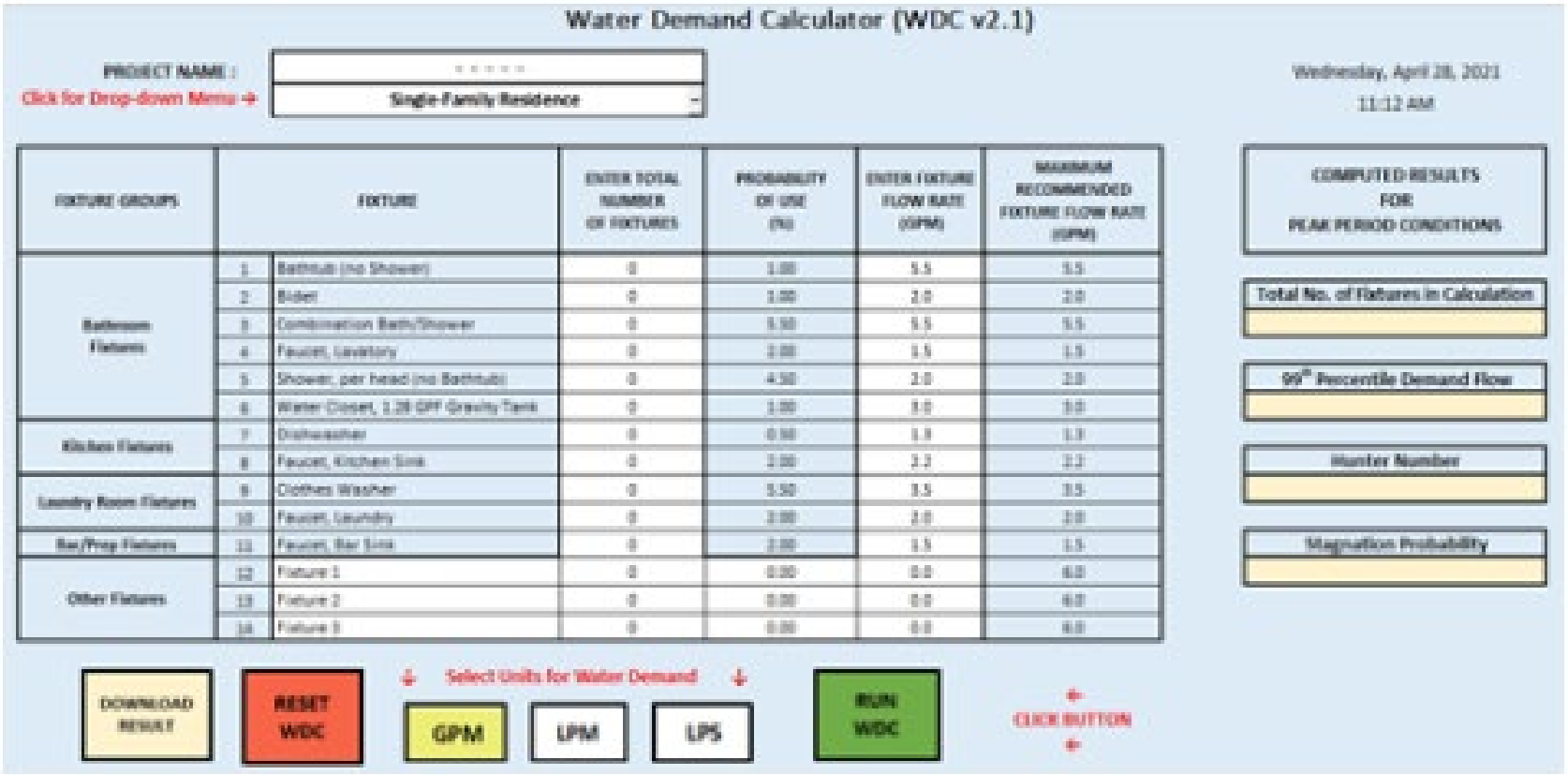
TABLE E103.3(2)
LOAD VALUES ASSIGNED TO FIXTURES[a]

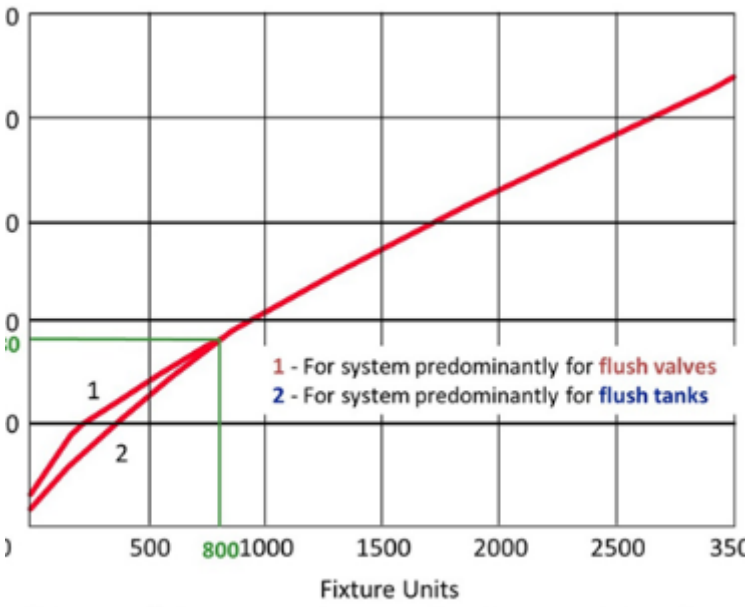
FIXTURE	OCCUPANCY	TYPE OF SUPPLY CONTROL	LOAD VALUES, IN WATER SUPPLY FIXTURE UNITS (wsfu)		
			Cold	Hot	Total
Bathroom group	Private	Flush tank	2.7	1.5	3.6
Bathroom group	Private	Flush valve	6.0	3.0	8.0
Bathtub	Private	Faucet	1.0	1.0	1.4
Bathtub	Public	Faucet	3.0	3.0	4.0
Bidet	Private	Faucet	1.5	1.5	2.0
Combination fixture	Private	Faucet	2.25	2.25	3.0
Dishwashing machine	Private	Automatic	—	1.4	1.4
Drinking fountain	Offices, etc.	3/8" valve	0.25	—	0.25
Kitchen sink	Private	Faucet	1.0	1.0	1.4
Kitchen sink	Hotel, restaurant	Faucet	3.0	3.0	4.0
Laundry trays (1 to 3)	Private	Faucet	1.0	1.0	1.4
Lavatory	Private	Faucet	0.5	0.5	0.7
Lavatory	Public	Faucet	1.5	1.5	2.0
Service sink	Offices, etc.	Faucet	2.25	2.25	3.0
Shower head	Public	Mixing valve	3.0	3.0	4.0
Shower head	Private	Mixing valve	1.0	1.0	1.4
Urinal	Public	1" flush valve	10.0	—	10.0
Urinal	Public	3/4" flush valve	5.0	—	5.0
Urinal	Public	Flush tank	3.0	—	3.0
Washing machine (8 lb)	Private	Automatic	1.0	1.0	1.4
Washing machine (8 lb)	Public	Automatic	2.25	2.25	3.0
Washing machine (15 lb)	Public	Automatic	3.0	3.0	4.0
Water closet	Private	Flush valve	6.0	—	6.0
Water closet	Private	Flush valve	2.2	—	2.2
Water closet	Public	Flush valve	10.0	—	10.0
Water closet	Public	Flush valve	5.0	—	5.0
Water closet	Public or private	Flushometer tank	2.0	—	2.0

For SI: 1 inch = 25.4 mm, 1 pound = 0.454 kg.

a. For fixtures not listed, loads should be assumed by comparing the fixture to one listed using water in similar quantities and at similar rates. The assigned loads for fixtures with both hot and cold water supplies are given for separate hot and cold water loads and for total load. The separate hot and cold water loads being three-fourths of the total load for the fixture in each case.

Water Demand Calculator

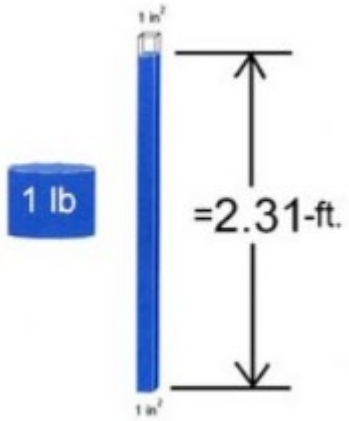




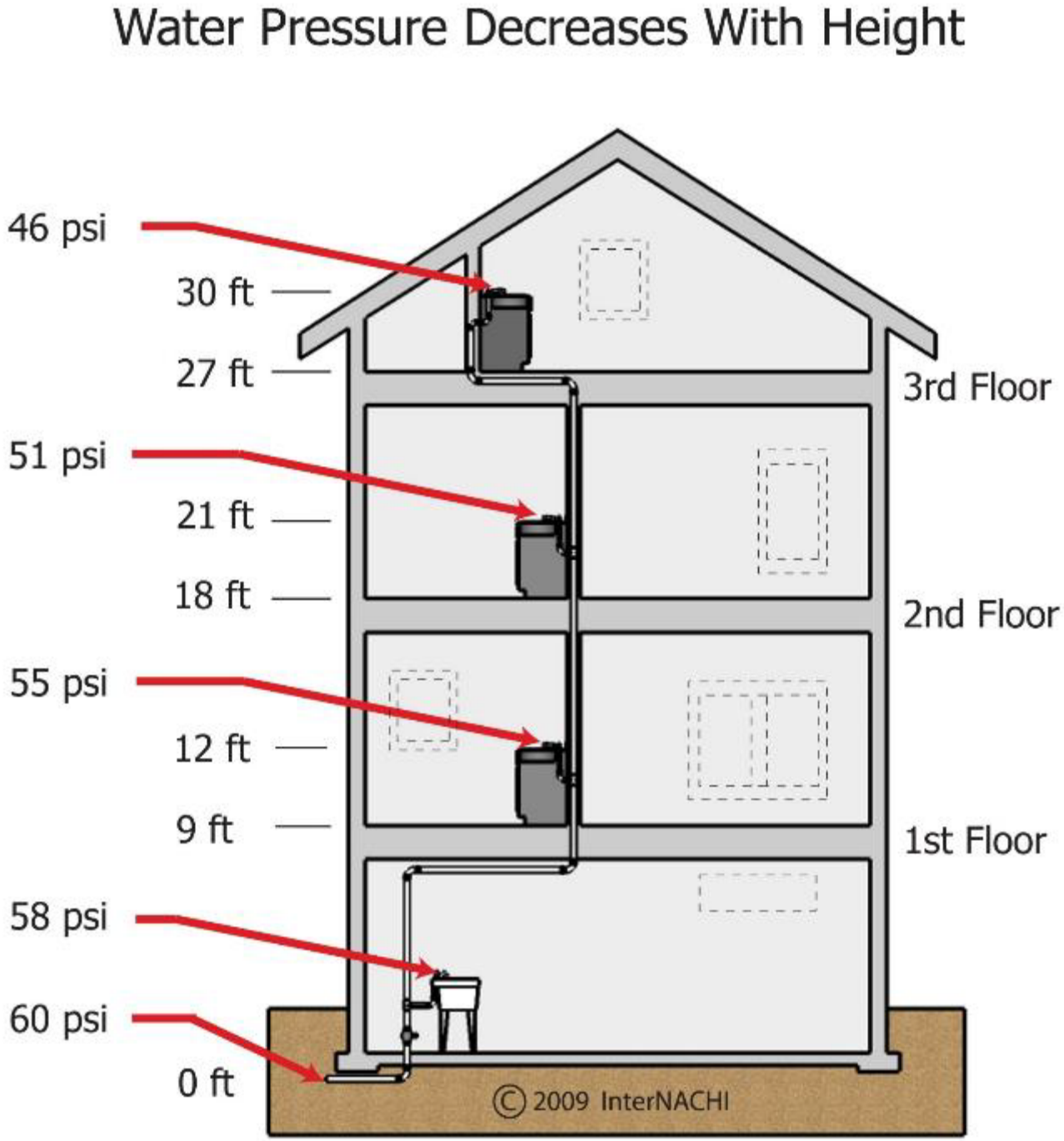
"Hunter" Estimate Curves for Demand Load

The UPC (Uniform Plumbing Code) **Water Demand Calculator** accurately predicts peak **water demand** in single-family homes and apartment buildings.

Every 2.31 feet of building height lowers the water pressure by 1 psi



Calculating booster pump head
(example simplified)
100 feet / 2.31 ft = 43 psi

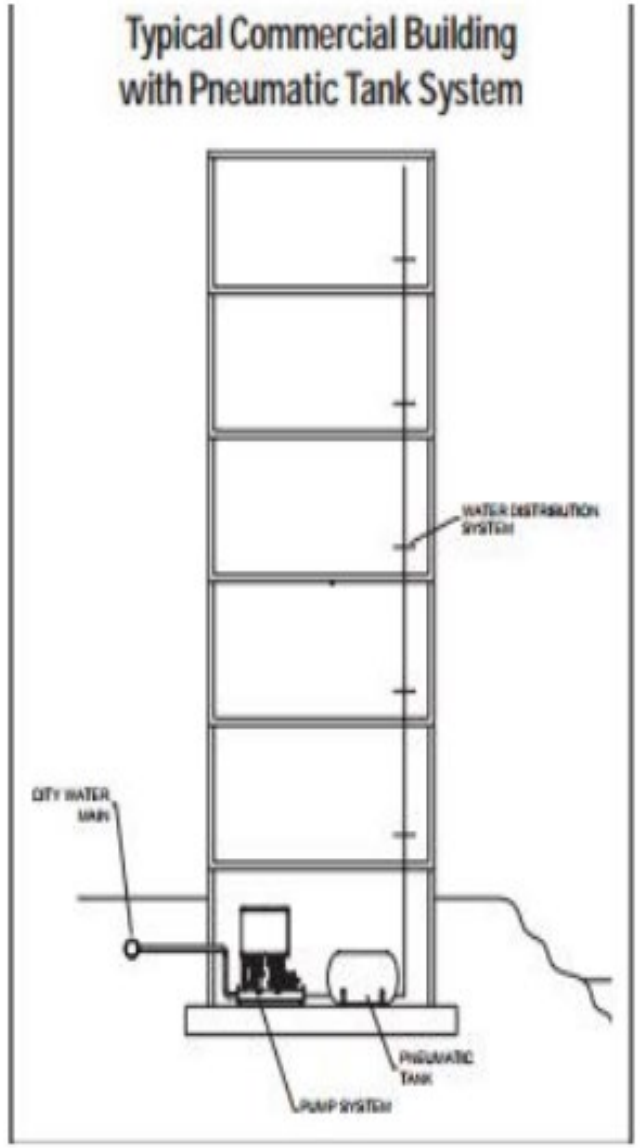


Booster Pump

When sizing a domestic booster pump, you need to measure the current water pressure against the amount of pressure that the booster pump can provide. For instance, a building looking to boost water pressure from 20 to 40 psi will require a booster pump capable of producing 20 psi

Calculating Required Flow

Since varying flow rates occur throughout the day in your building, be sure to calculate the flow rate. For instance, the morning time in an apartment building normally results in peak flow usage. This is because most people get ready for work and school in the morning. The same building may have a minimum flow usage when most people are sleeping. Thus, the flow rate that fixtures use may vary greatly.



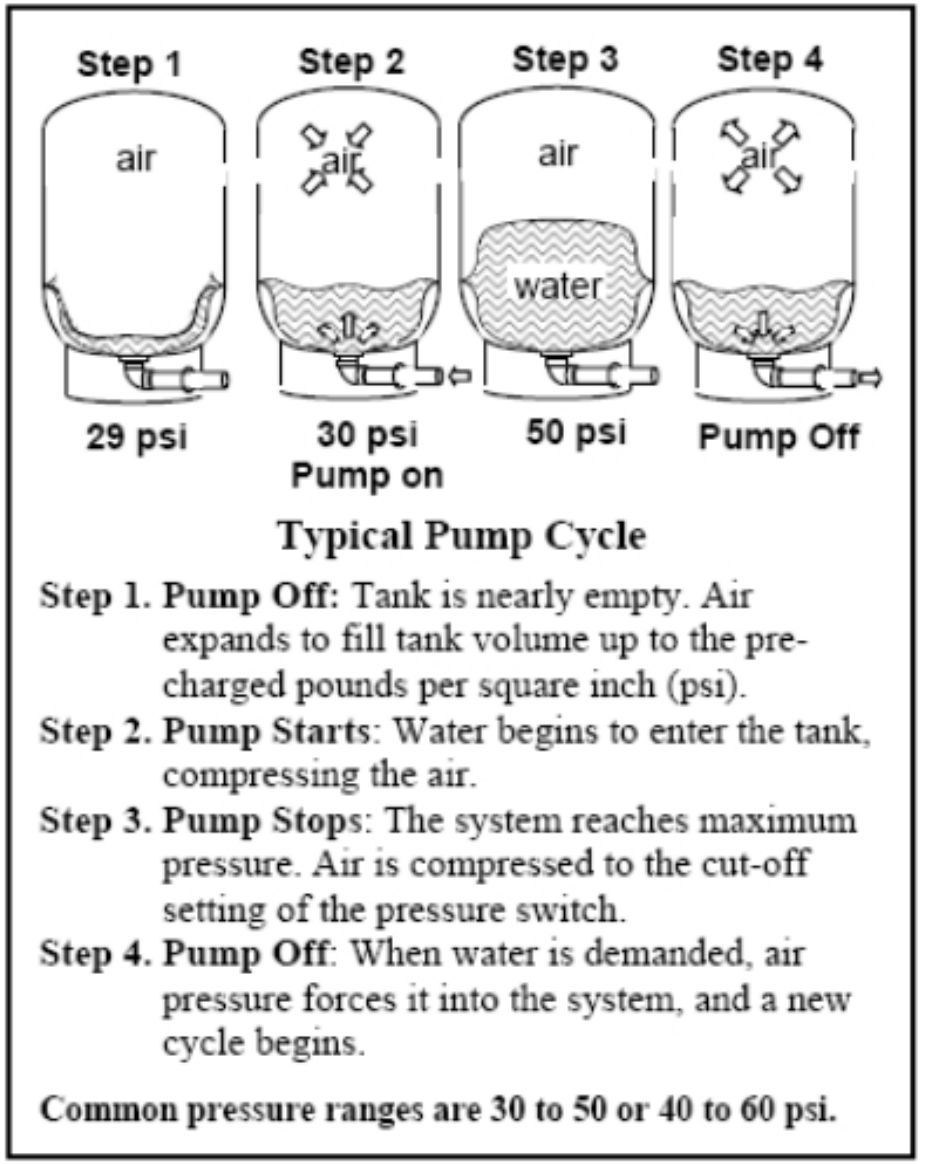
How a bladder pressure tank works

A bladder is a balloon inside a tank that fills with water when there is pressure that is greater than that already in the bladder. A check valve stops the water from flowing backwards and reserves the water and pressure for use by the device it is feeding. This unique design also eliminates the need for a pump, as the bladder will act as a pump that uses no power.

Data points for sizing a pressure tank:

1. Pump Flow Rate
2. Cut-in/Cut-out Pressure
3. Target Run Time of the pump

For VFD systems the minimum flow rate shall be used.



Wessels Tank Sizing Calculator

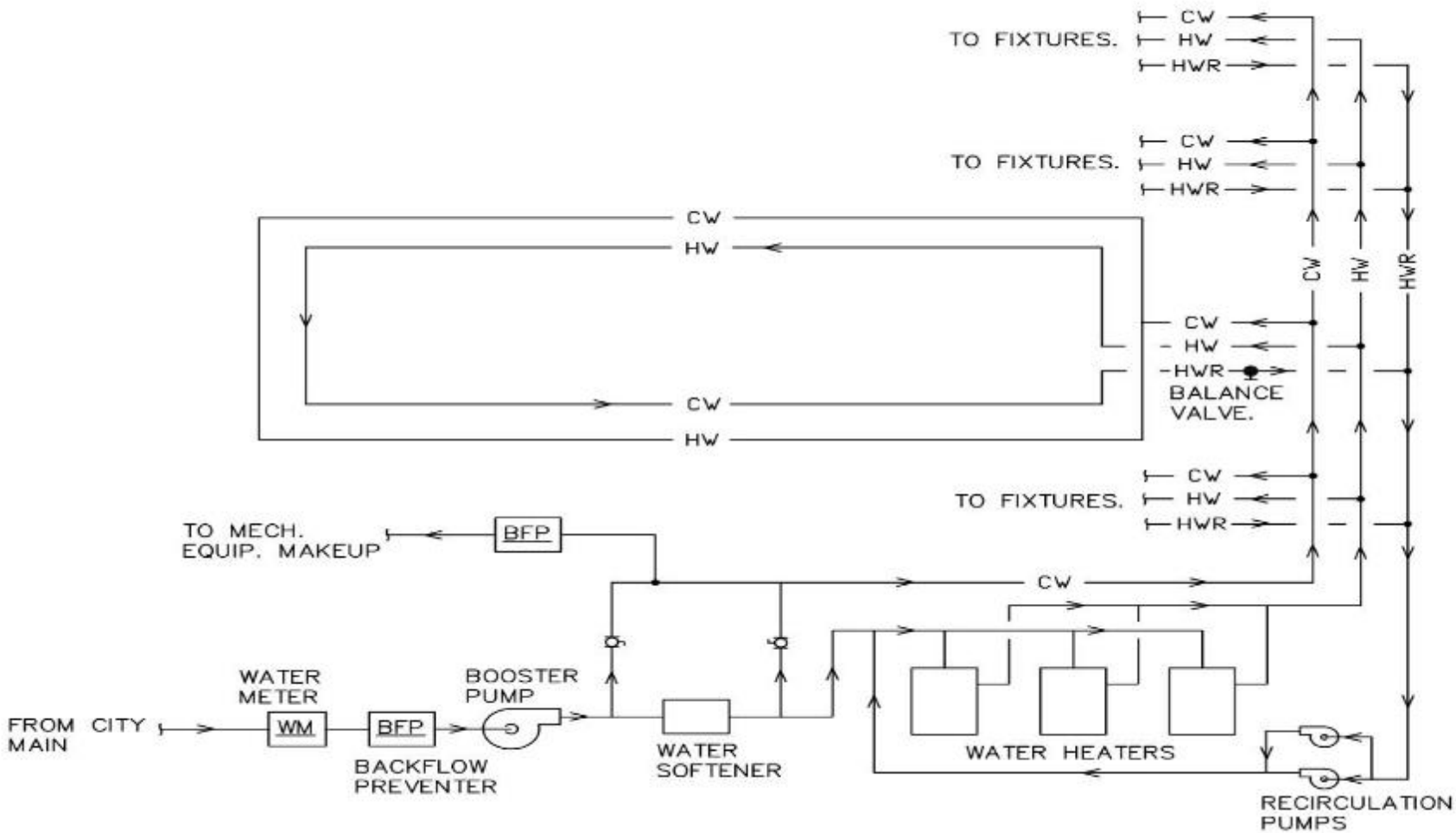
Domestic Hot Water System

A well-designed domestic hot water distribution system should do the following:

- Provide adequate amounts of water at the prescribed temperature to all fixtures and equipment at all times of use.
- Minimize risk to those using the fixtures it serves
- Must be guarded against excessive pressure, temperature, and contamination

Domestic Hot Water Components

- Water Heater Source
- Supply and Return Systems
- Balancing Valves
- Recirculation Pumps
- Thermostatic Mixing Valves


TO FIXTURES.
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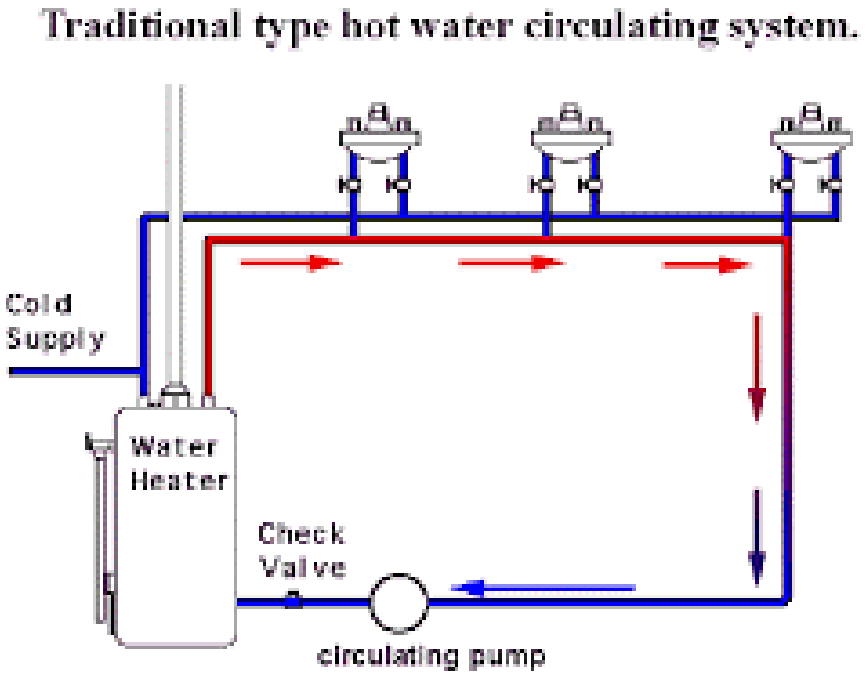
TO MECH. EQUIP. MAKEUP
BFP
CW
WATER METER
BOOSTER PUMP
FROM CITY MAIN
WM
BFP
BACKFLOW PREVENTER
WATER SOFTENER
WATER HEATERS
RECIRCULATION PUMPS

Domestic Hot Water Systems

Hot Water Supply: portion of the domestic hot water piping that supplies hot water to the fixtures

Hot Water Return System: connection to the return system is made near the end of a branch supplying hot water to one or more fixtures. The connection is followed by a balancing valve to throttle the flow and a check valve to prevent flow reversal caused by fixtures discharging. The return system passes the water that has dropped below the design temperature back to the water heater to be reheated.

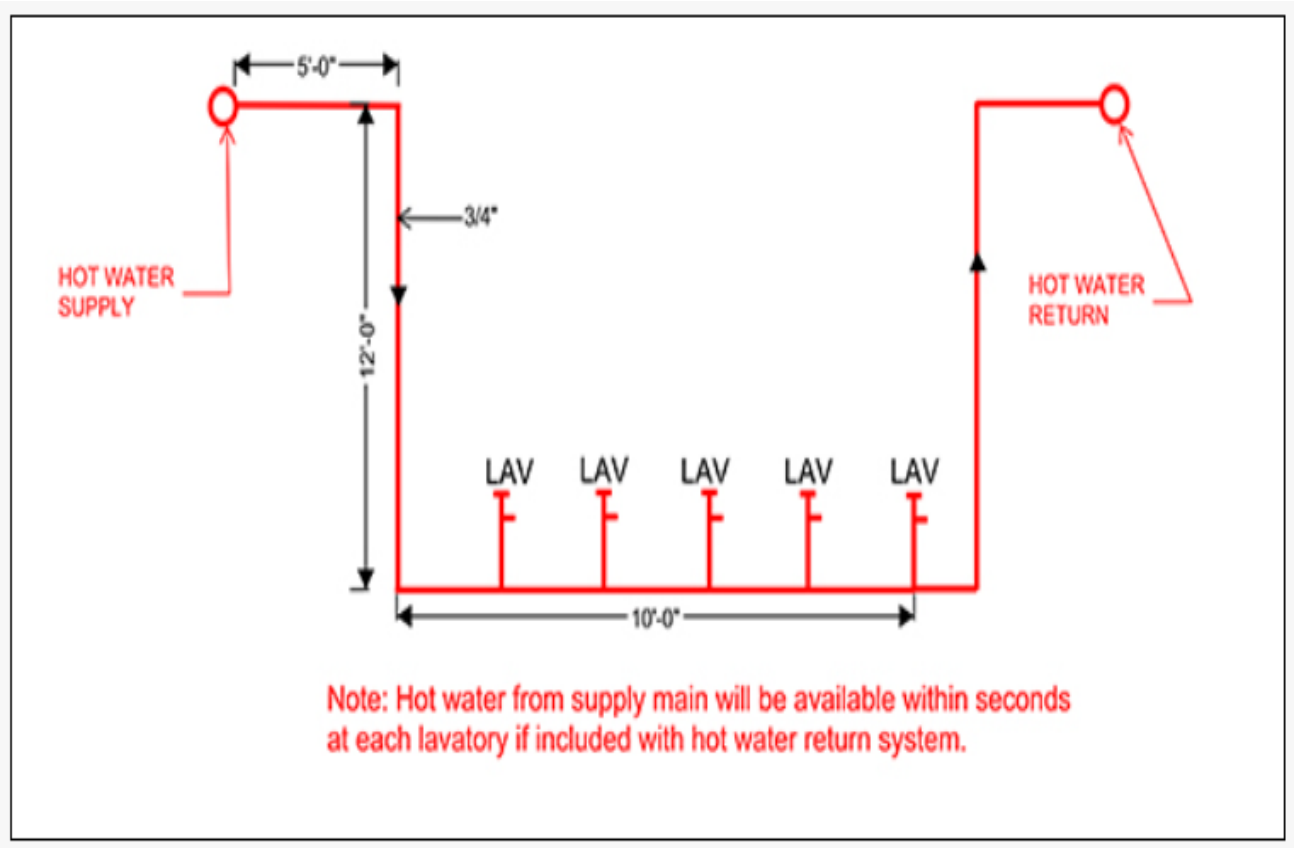


Domestic Hot Water Systems

- Do you wait more than one and one-half minutes for warm water to wash your hands?

- *IECC C405.5.2 Maximum allowable pipe volume method* limits the calculated volume from the source to the termination of the fixture supply pipe to 0.2 oz. for a public lavatory faucet and 0.5 gallons for other fixtures and appliances. The 0.2 oz. and 0.5-gallon numbers are defined in the code text, not in a Table. This volume method is clearly more restrictive than the maximum length option.

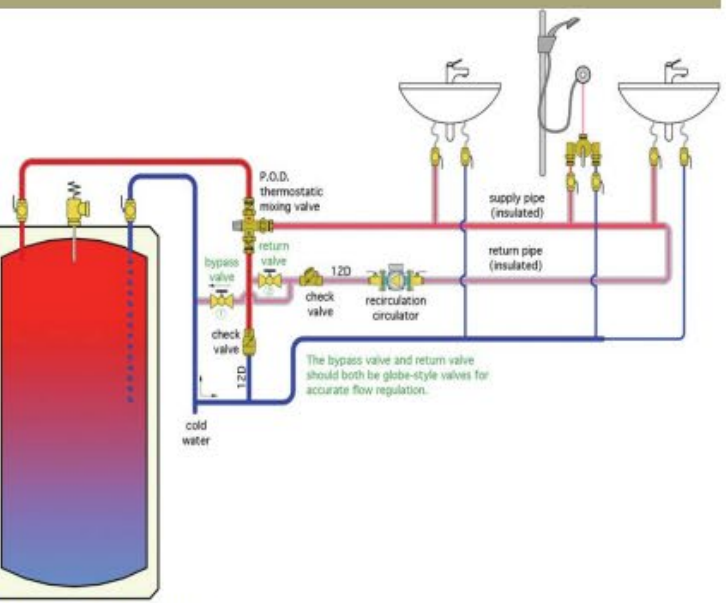
IECC -International Energy Conservation Code



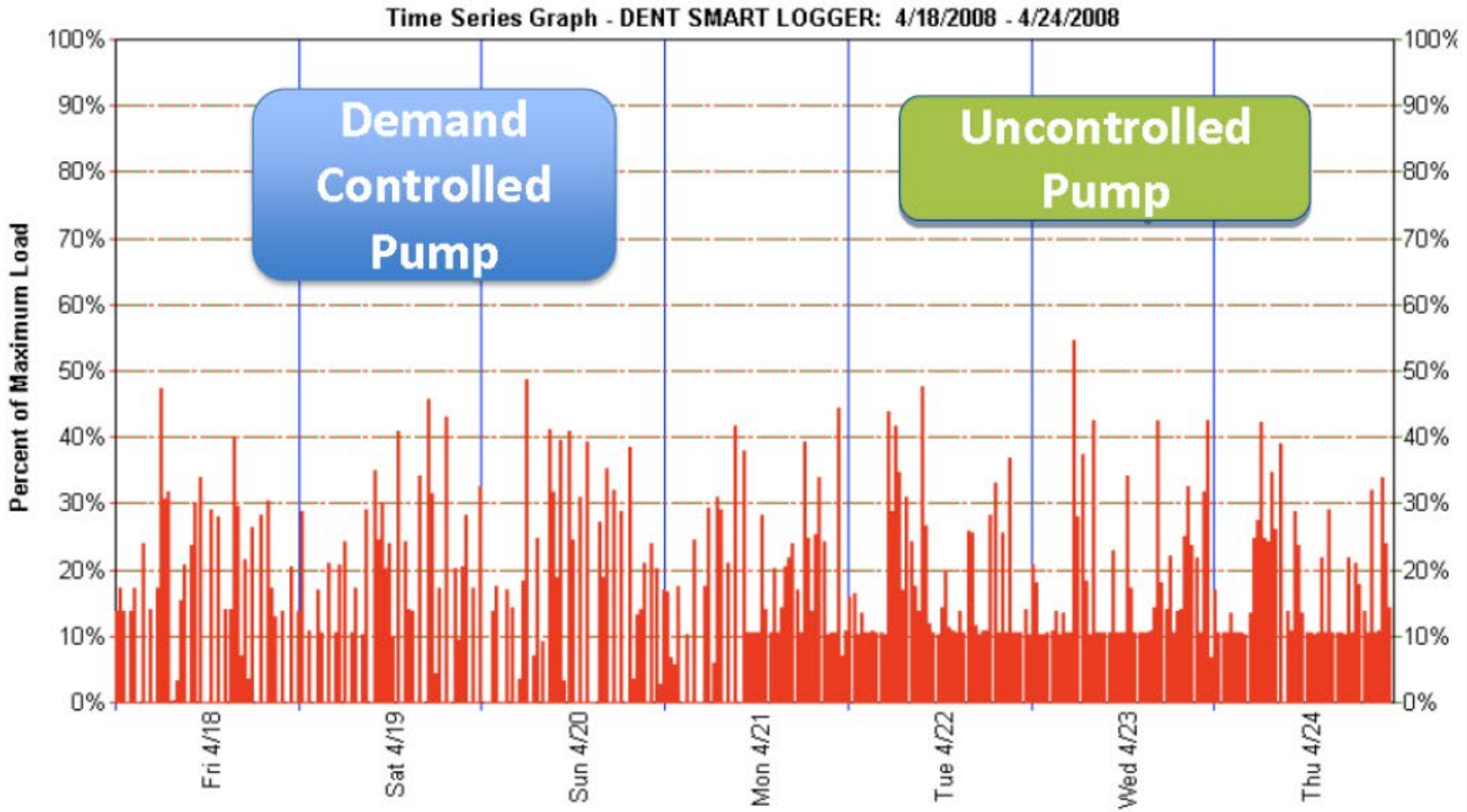
Reduced Water Heater Cycling

"DHW Recirc Design Elements

- Pipe Insulation
- On-Demand Recirculation
- System Balancing
- Crossover Prevention
- Optimized Loop Design"



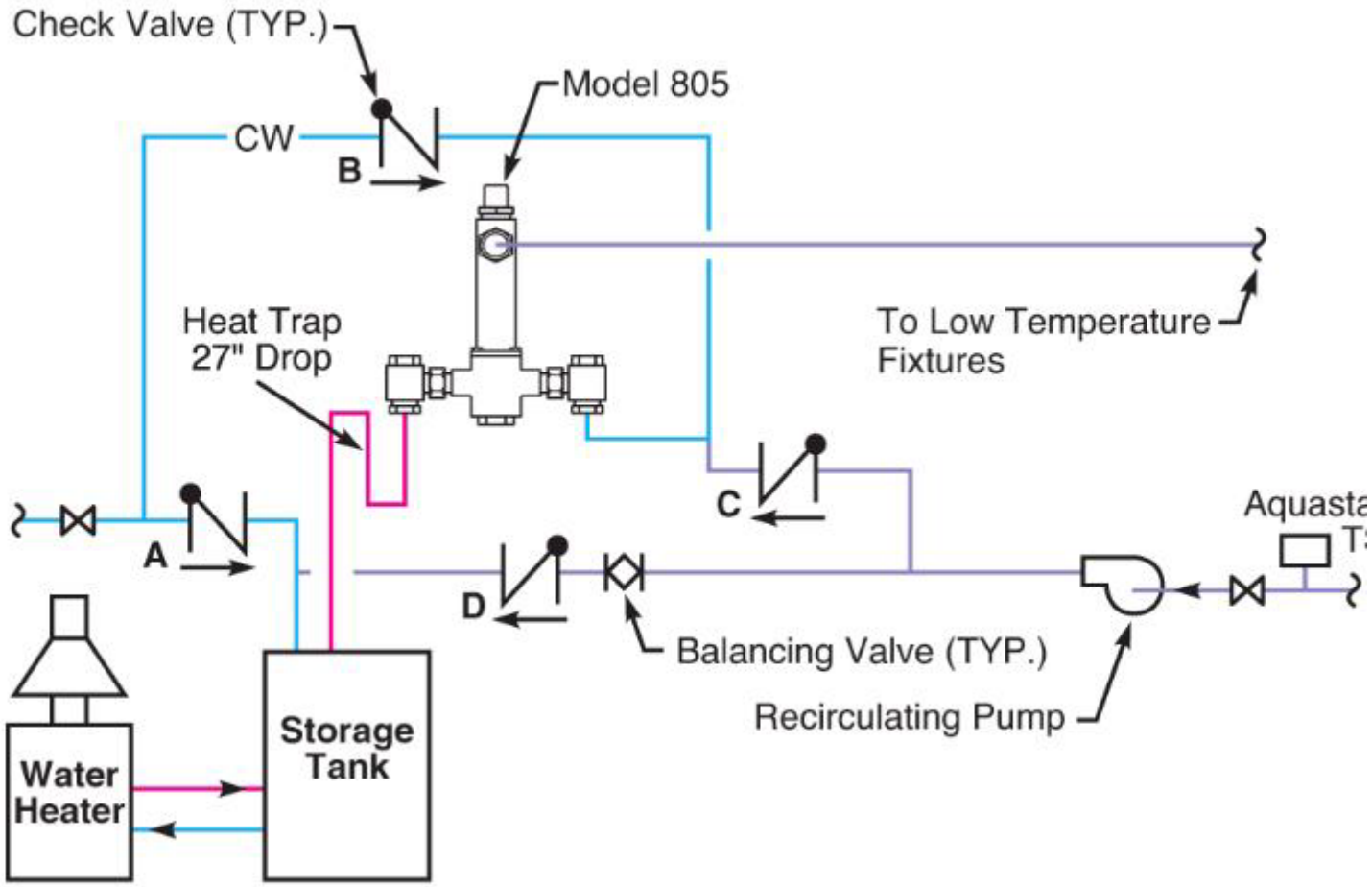
https://www.hpacmag.com



"DOE Zero Energy Ready Home, Efficient Hot Water Distribution in Zero Energy Ready Multifamily Buildings." 4/25/17 By: Gabriel Ayala, gabe@enovativegroup.com

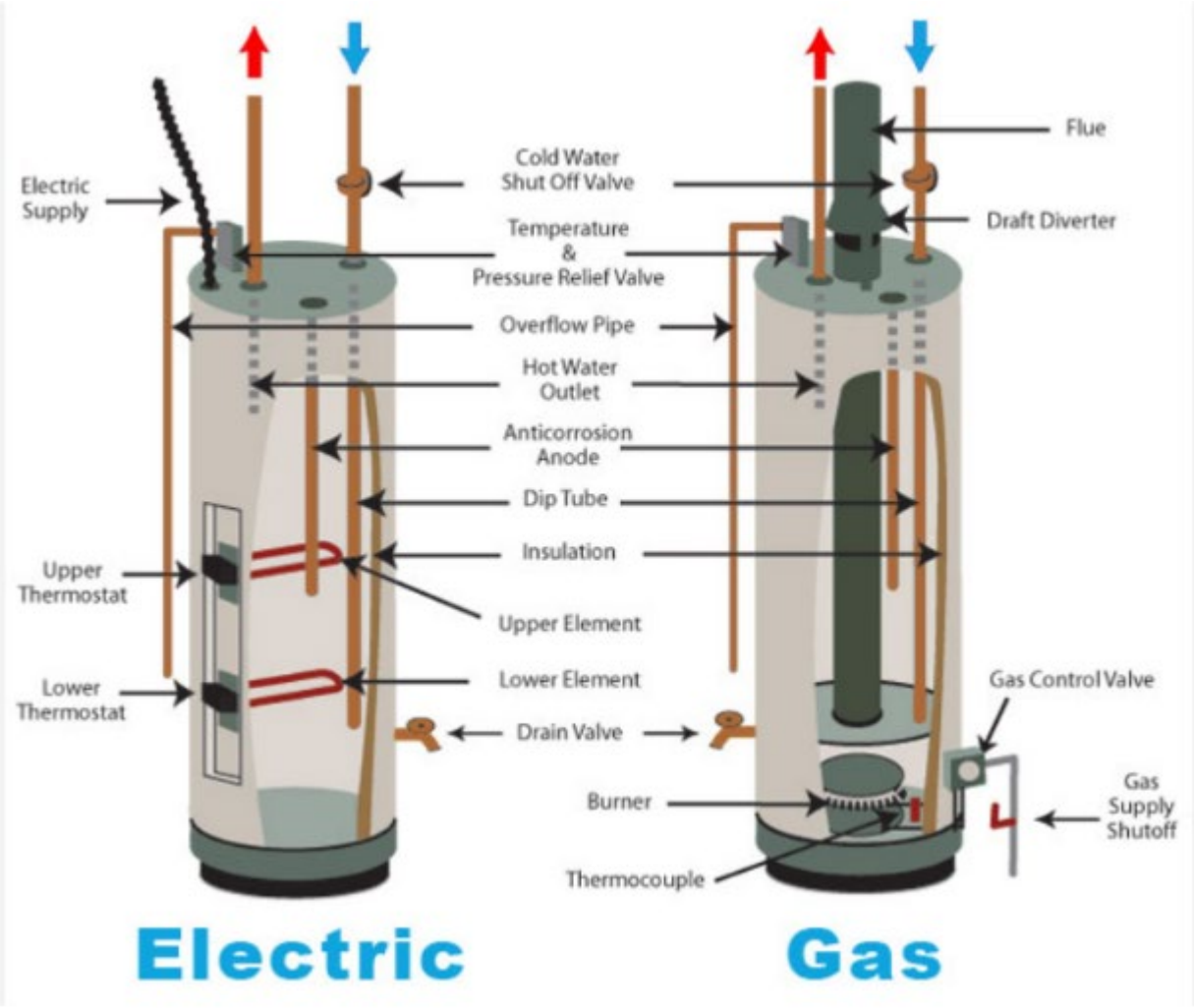
Domestic Hot Water Systems Components

- **Balancing Valves:** The flow through each segment of HWR is a percentage of the total system flow and is regulated by the balancing valves.
- A properly balanced recirculation system will result in the same temperature drop at each balancing valve.
- **Recirculation Pump**
- The total flow through the HW system is selected based on the heat loss from the supply system when fixtures are not in use. This is controlled by the pump. The necessary flow through the system is a function of the heat loss over time and the acceptable temperature drop to the balancing valve.
- **Thermostatic Mixing Valve**
- In systems where the domestic hot water temperature will be lower than the temperature stored in the water heater, a thermostatic mixing valve (TMV) should be used for tempering.

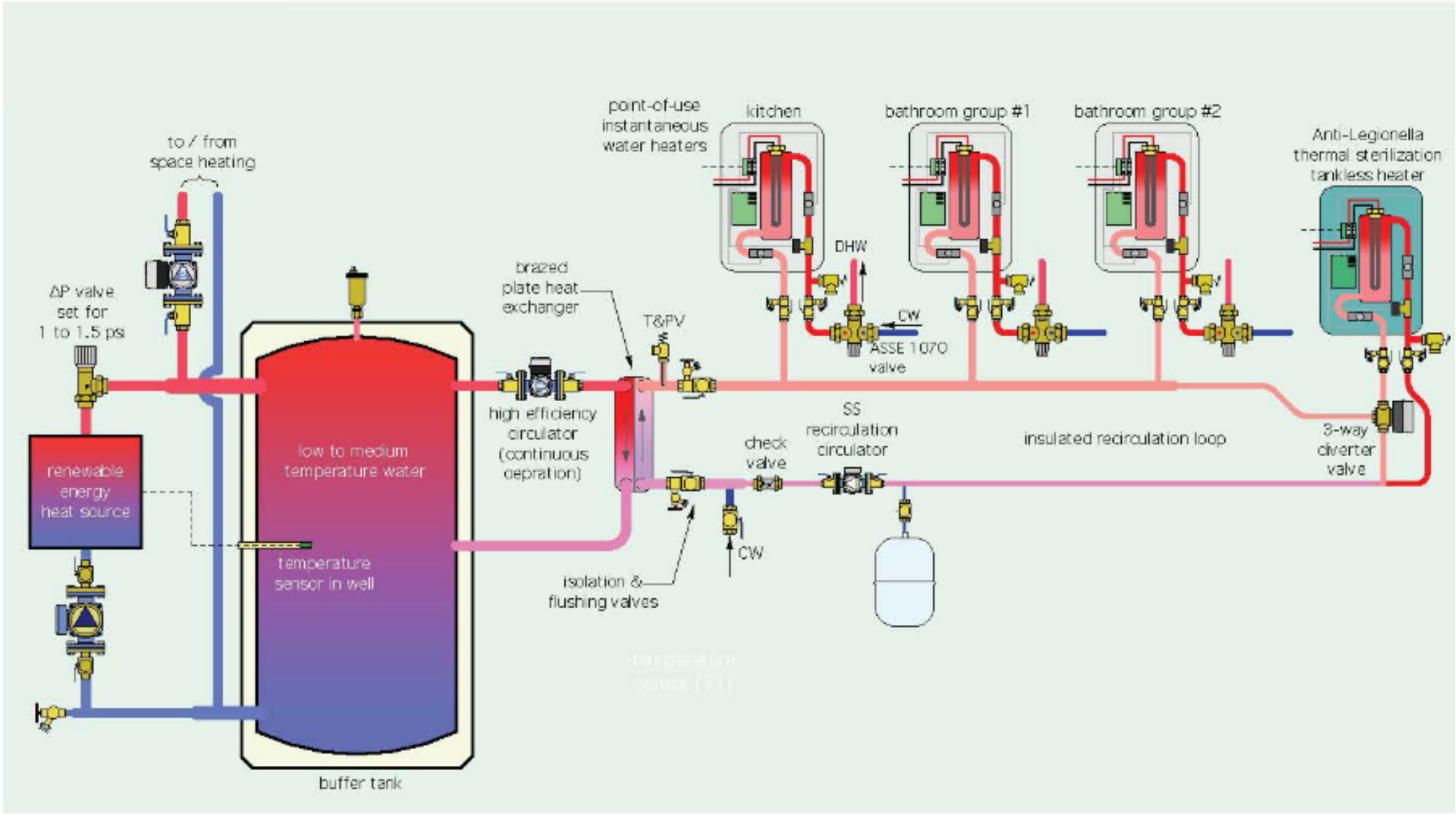


Domestic Hot Water Sources

- Electric/gas storage tanks
- Instantaneous water heater
- Hot water or Steam heat exchangers
- Heat pump water heaters
- Solar collector water heaters

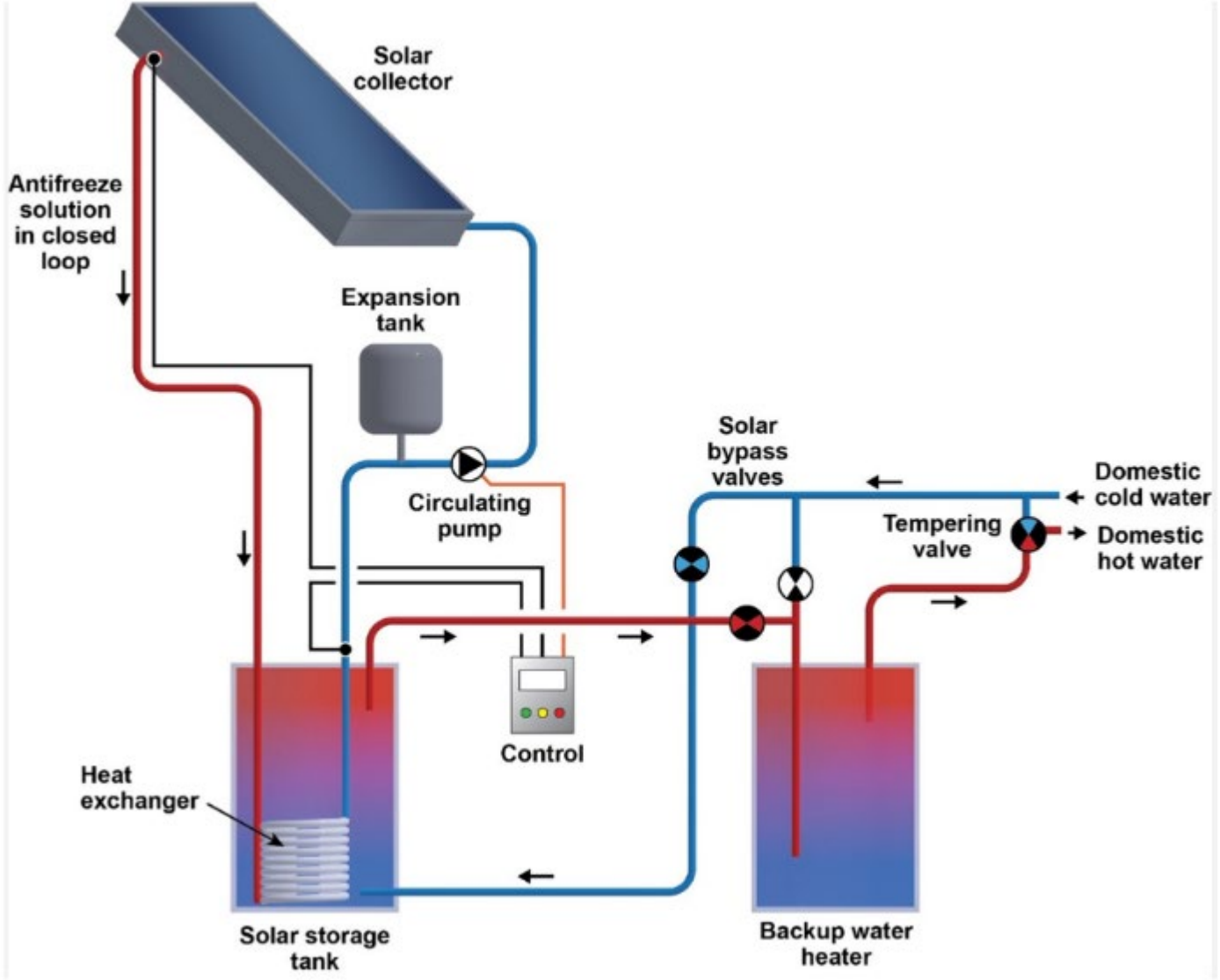


HIGH-OUTPUT, TANKLESS, ON-DEMAND WATER HEATERS

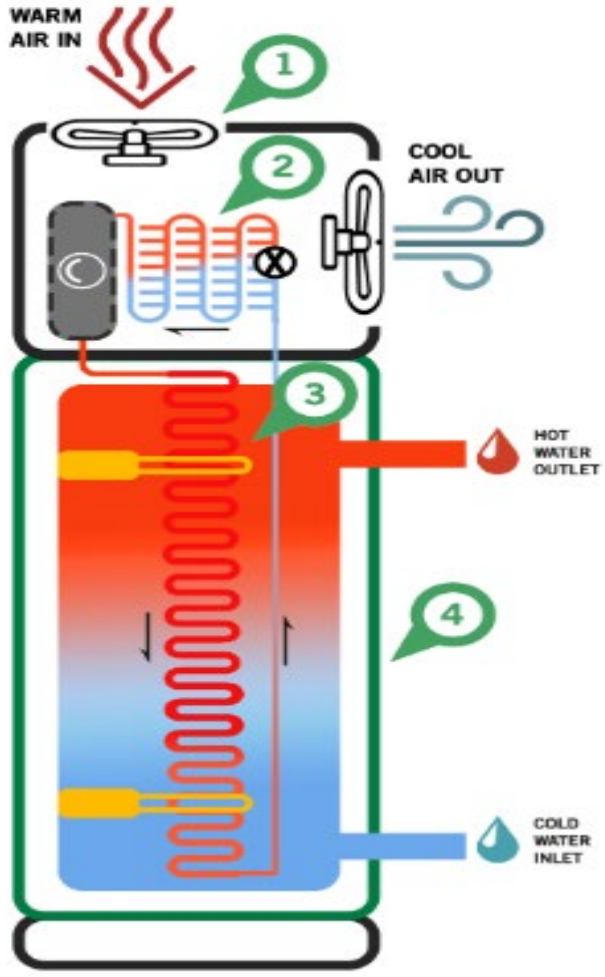


Heat Exchanger Applications

Solar Water Heating System



HOW DOES A HEAT PUMP WATER HEATER WORK?



Hybrid Water Heaters switches to an electric powered heating element when outside air reaches temperatures below 10°C.

A.O. Smith

What is a heat pump water heater?

Heat pump water heaters use electricity to move heat from one place to another instead of generating heat directly. This method makes them 4x more efficient than conventional heaters.

1

Liquid refrigerant absorbs heat in the "evaporator" from the outdoor air, turning into a gas.

2

The refrigerant is put through a "compressor", which raises the pressure of the gas, increasing its temperature.

3

The hot gas flows through "condenser coils" inside the space to be heated, and since it is at a higher temperature than this space, it transfers heat to the room and condenses back into a liquid.

4

It then expands in order to decrease its pressure and cool down to below the room's temperature to repeat the cycle.

source:
https://energyeducation.ca/encyclopedia/Heat_pump

Waste & Vent Systems

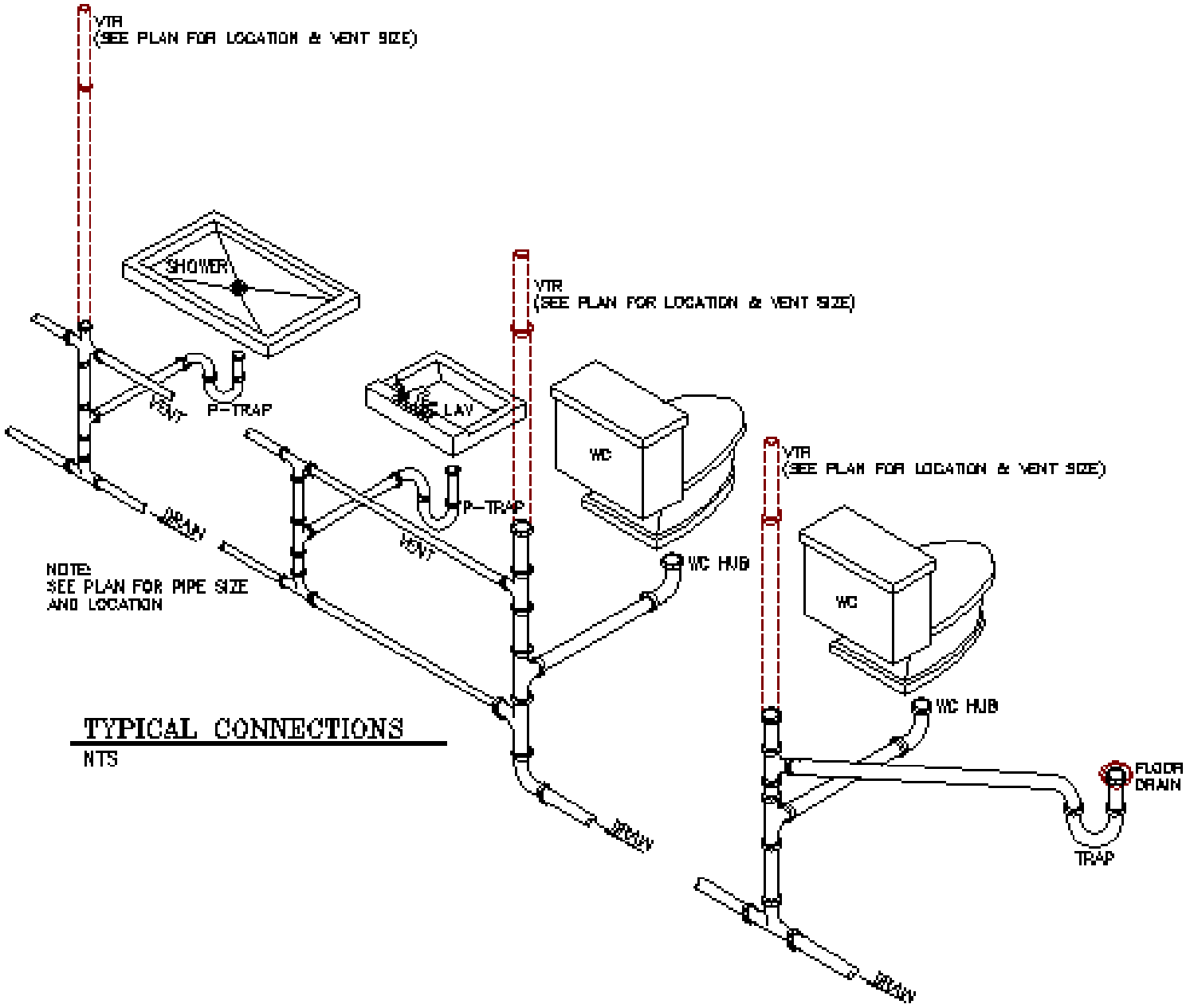
Key Features

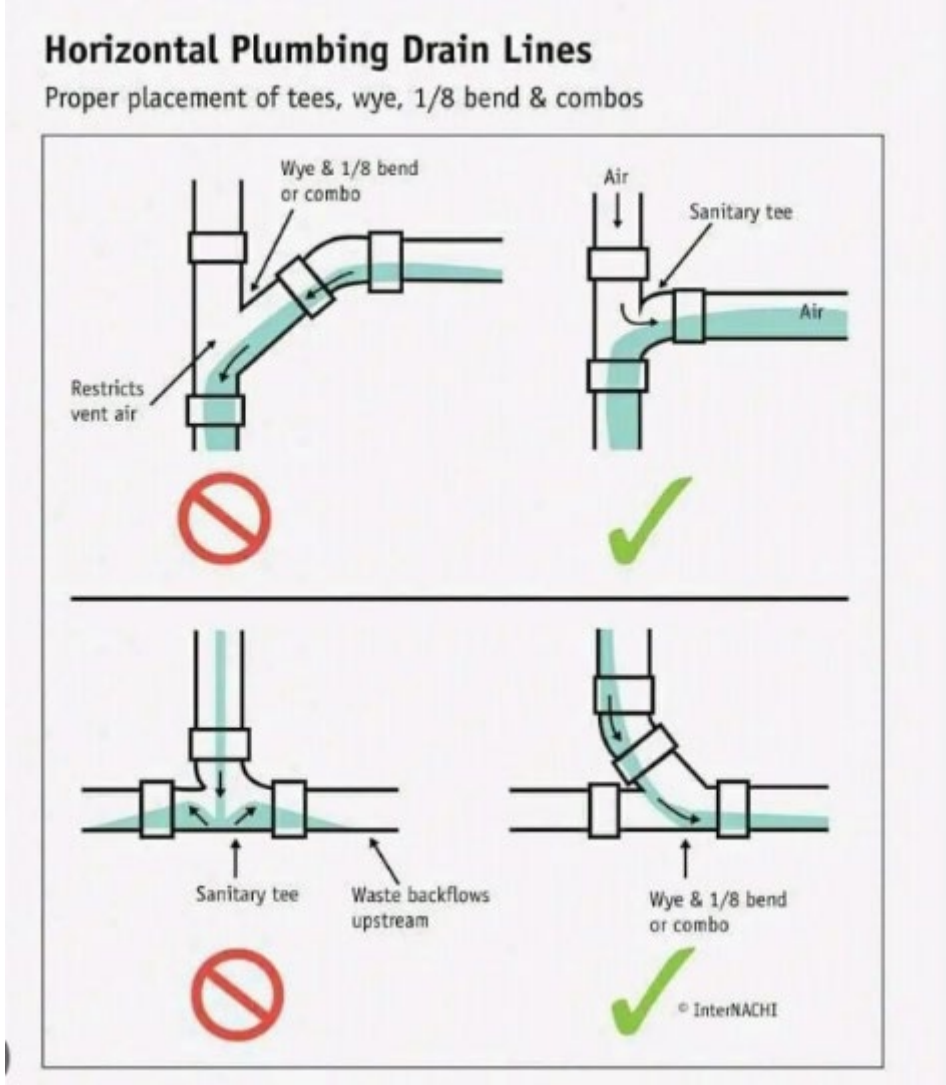
- Drainage System - Gravity flow
- Pipe slope
- P-trap
- Vent piping system

Sanitary Waste Piping System

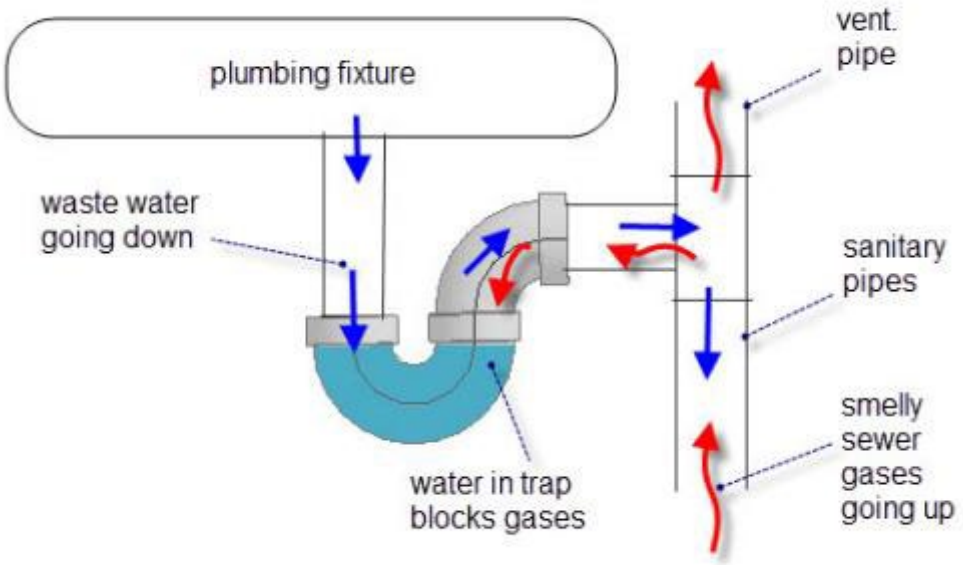
Key Facts:

- Slope 1/8”, ¼” or ½” per foot of pipe.
- Piping is typically run under the floor of the plumbing fixture.

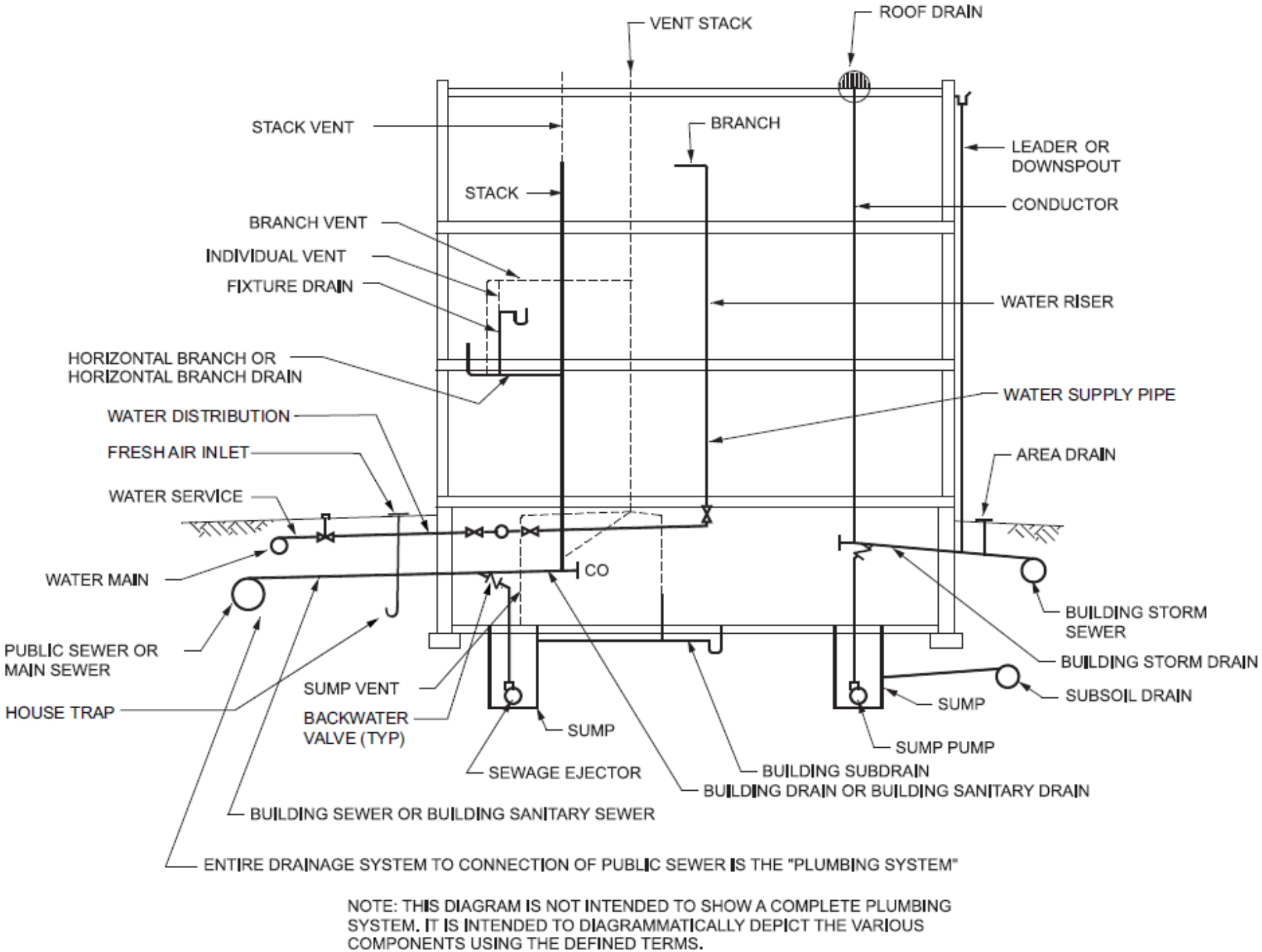




- Provide air to gravity sewer system.
- Vent discharge typically through roof
- Away from fresh air intake or operable windows



P-TRAP



Plumbing Vent

- A pipe provided to ventilate the plumbing system
- A pipe provided to prevent trap siphonage and backpressure
- A pipe provided to equalize the air pressure within the drainage system

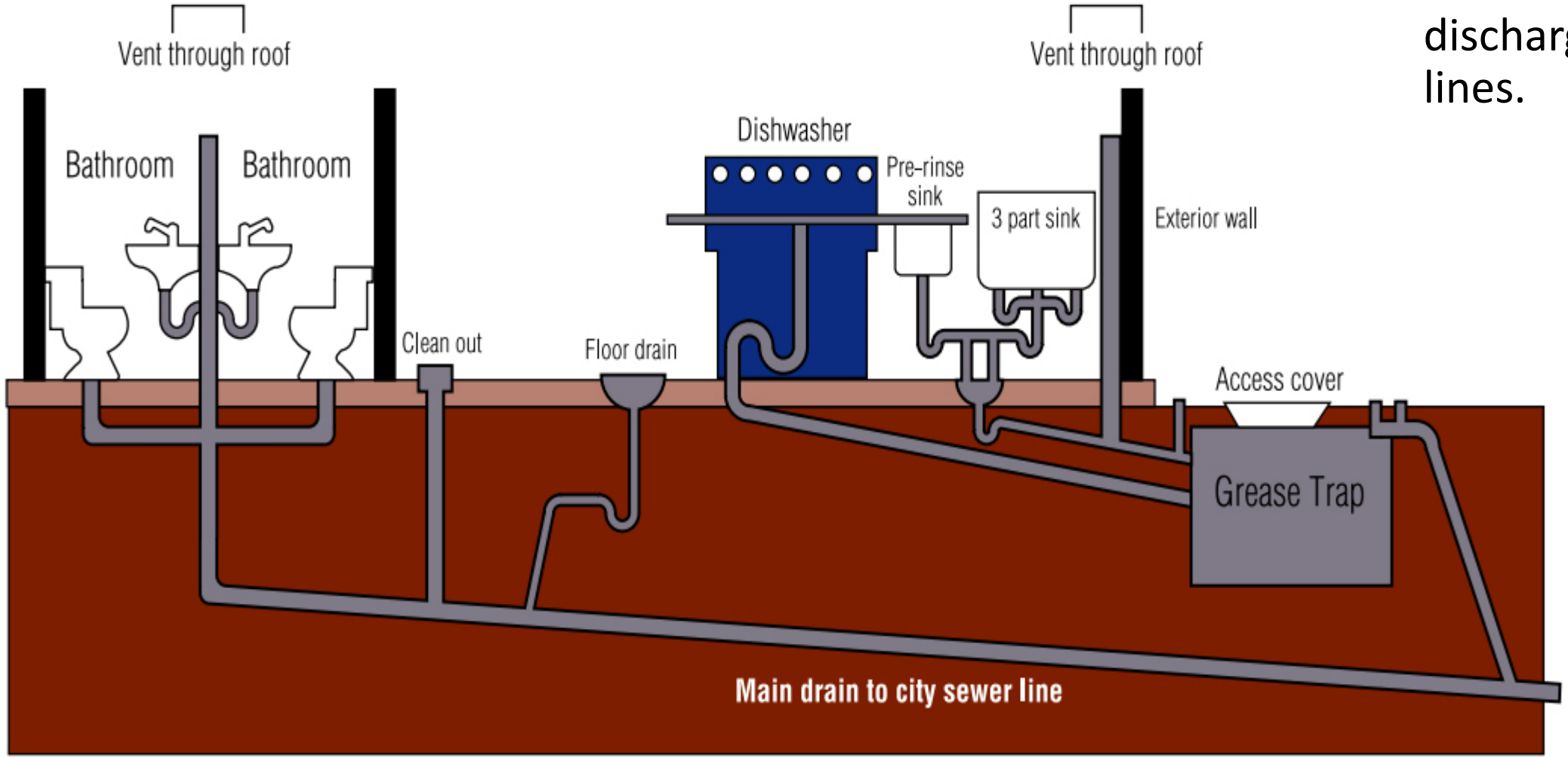
Drainage and Vent piping sizing

DRAINAGE FIXTURE UNITS FOR FIXTURES AND GROUPS

FIXTURE TYPE	DRAINAGE FIXTURE UNIT VALUE AS LOAD FACTORS	MINIMUM SIZE OF TRAP (inches)
Automatic clothes washers, commercial[a,g]	3	2
Automatic clothes washers, residential[g]	2	2
Bathroom group as defined in Section 202 (1.6 gpf water closet)[f]	5	—
Bathroom group as defined in Section 202 (water closet flushing greater than 1.6 gpf)[f]	6	—
Bathtub[b] (with or without overhead shower or whirpool attachments)	2	$1^1/_2$
Bidet	1	$1^1/_4$
Combination sink and tray	2	$1^1/_2$
Dental lavatory	1	$1^1/_4$
Dental unit or cuspidor	1	$1^1/_4$
Dishwashing machine[c], domestic	2	$1^1/_2$
Drinking fountain	$^1/_2$	$1^1/_4$
Emergency floor drain	0	2
Floor drains[h]	2[h]	2
Floor sinks	Note h	2
Kitchen sink, domestic	2	$1^1/_2$
Kitchen sink, domestic with food waste grinder and/or dishwasher	2	$1^1/_2$
Laundry tray (1 or 2 compartments)	2	$1^1/_2$
Lavatory	1	$1^1/_4$
Shower (based on the total flow rate through showerheads and body sprays)		
Flow rate:		
5.7 gpm or less	2	$1^1/_2$
Greater than 5.7 gpm to 12.3 gpm	3	2
Greater than 12.3 gpm to 25.8 gpm	5	3
Greater than 25.8 gpm to 55.6 gpm	6	4
Service sink	2	$1^1/_2$
Sink	2	$1^1/_2$
Urinal	4	Note d
Urinal, 1 gallon per flush or less	2[e]	Note d
Urinal, nonwater supplied	$^1/_2$	Note d
Wash sink (circular or multiple) each set of faucets	2	$1^1/_2$
Water closet, flushometer tank, public or private	4[e]	Note d
Water closet, private (1.6 gpf)	3[e]	Note d
Water closet, private (flushing greater than 1.6 gpf)	4[e]	Note d
Water closet, public (1.6 gpf)	4[e]	Note d
Water closet, public (flushing greater than 1.6 gpf)	6[e]	Note d

- The method of sizing the drainage and vent system is based on Drainage Fixture Units assigned for each plumbing fixture as load factors.

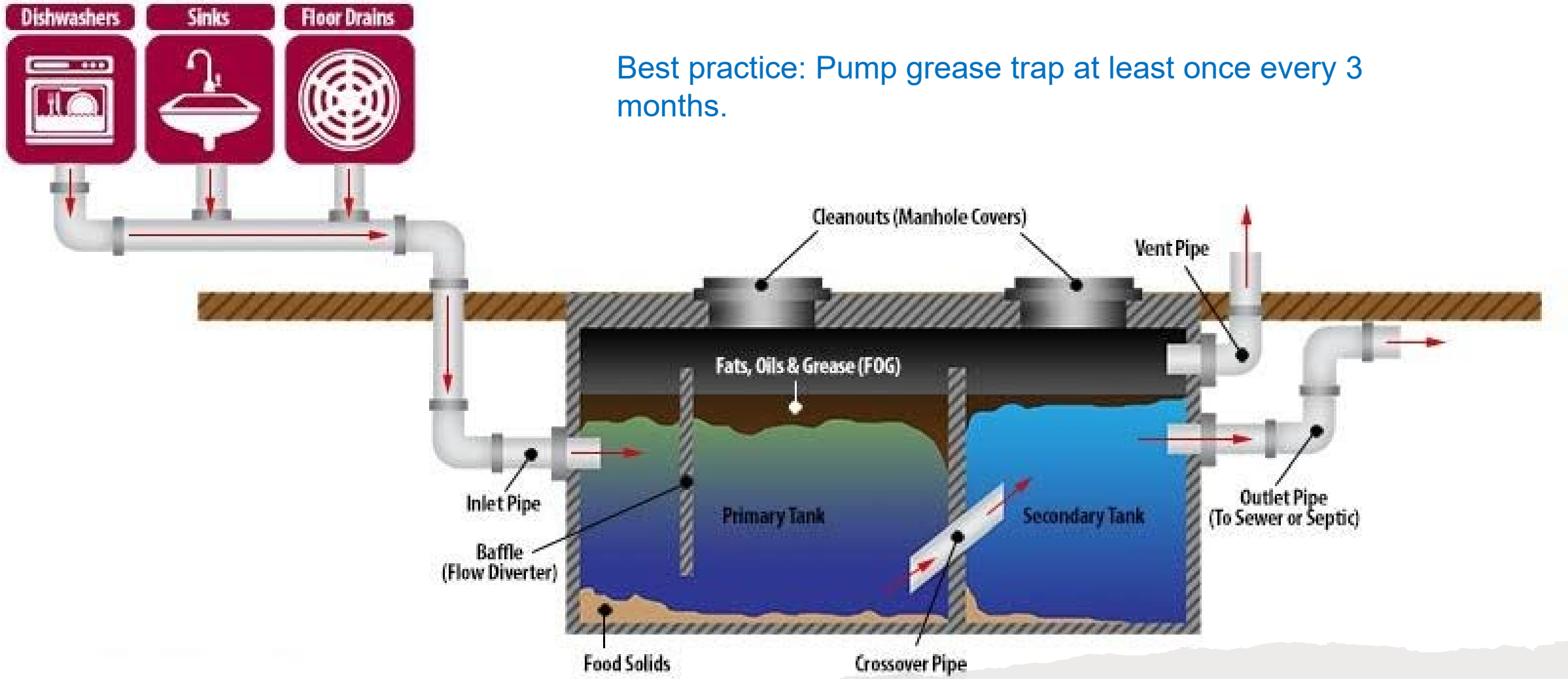
Grease Waste



Plumbing codes do not allow discharges of grease into the sewers because discharges block the lines.

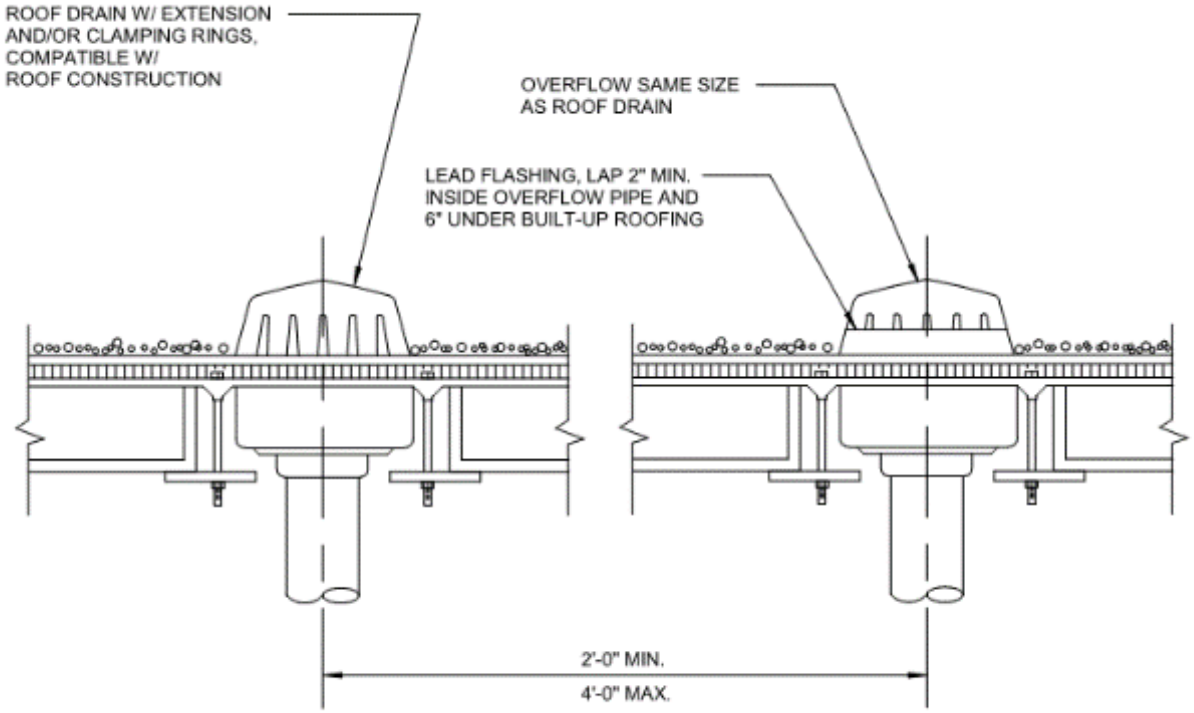
Grease Tank Interceptor

Best practice: Pump grease trap at least once every 3 months.



Storm Water Drainage

- Purpose is to remove rain water to prevent excessive roof ponding which could lead to roof failure and leakage
- No vents or traps required on storm lines
- Must provide 100% redundancy by secondary drainage, scuppers or overflow
  - Gutters and downspouts are not typically our scope



Storm Drainage Sizing Key Factors:

- Rainfall rate in the area
- The projected roof area which drains the rainwater to each individual roof drain

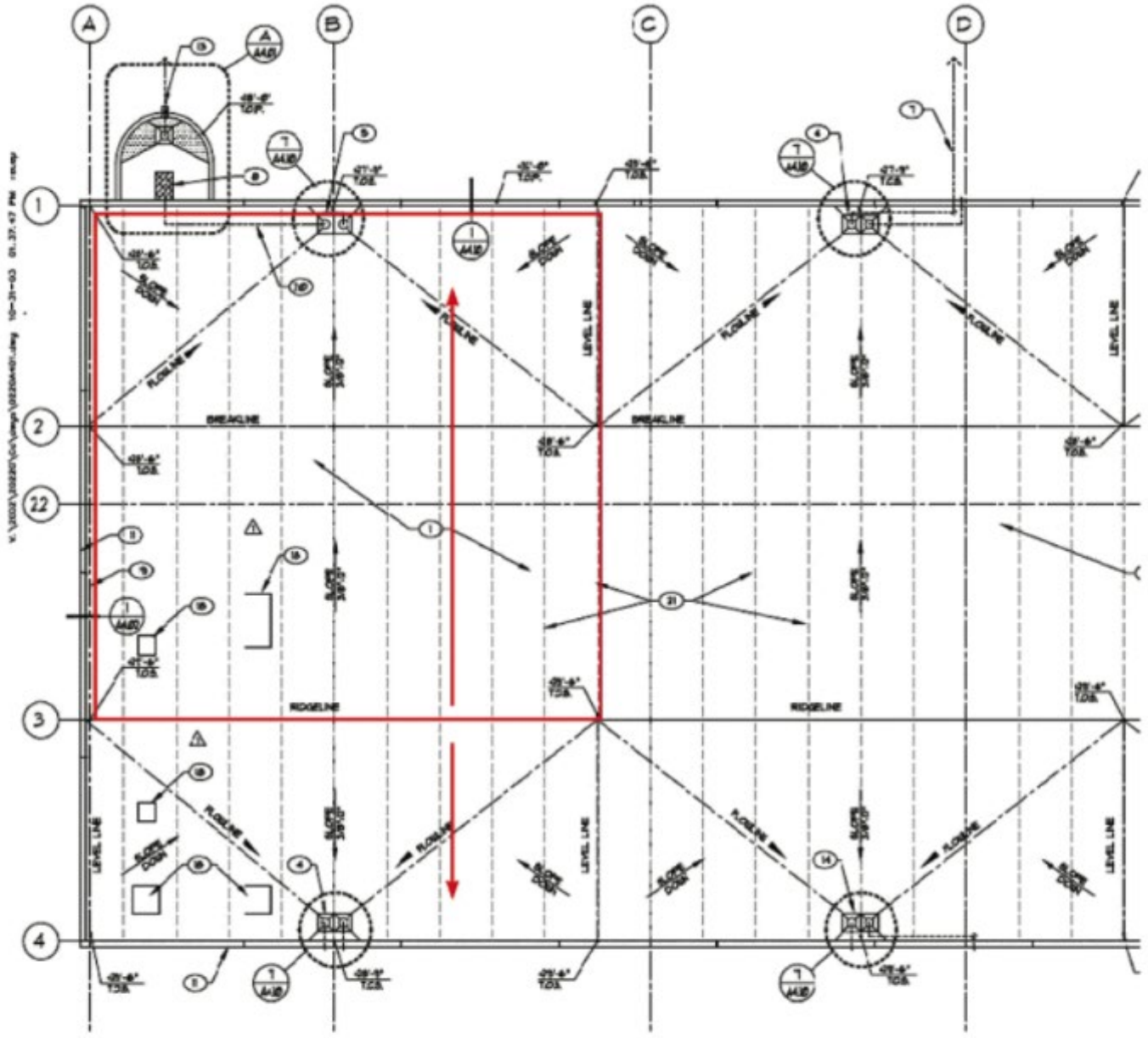
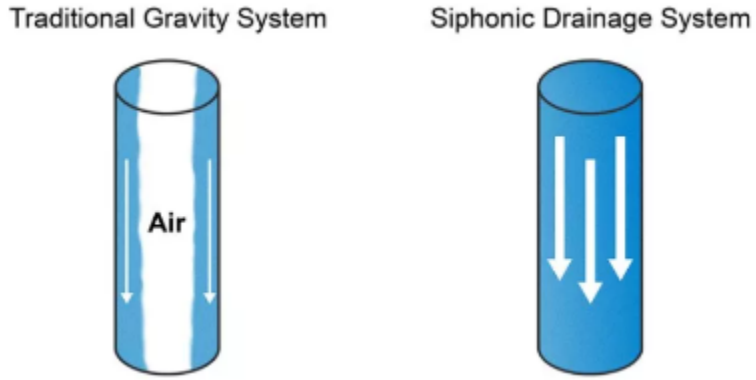


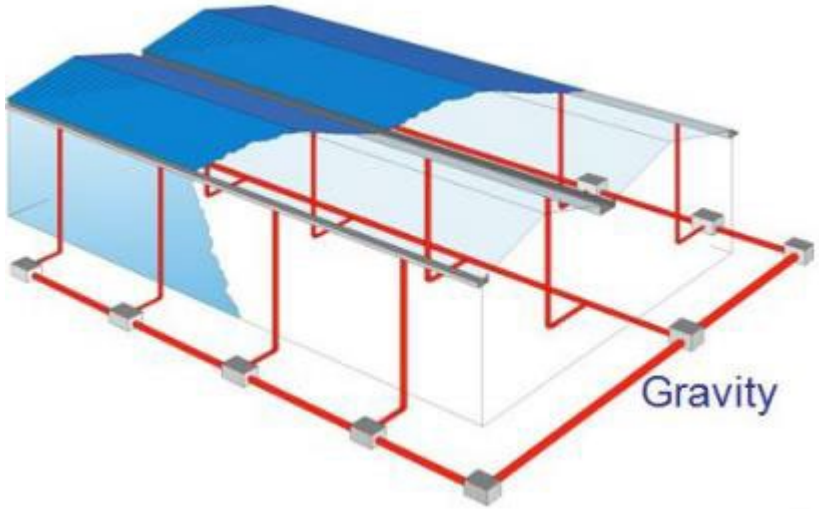
FIGURE 1103.3B
PARTIAL ROOF LAYOUT OF MULTIPLE ROOF DRAINS - RED BOX REPRESENTS THE PROJECTED ROOF AREA FOR ROOF DRAIN AT COLUMN LINE B-1

100 year 1 hour rainfall

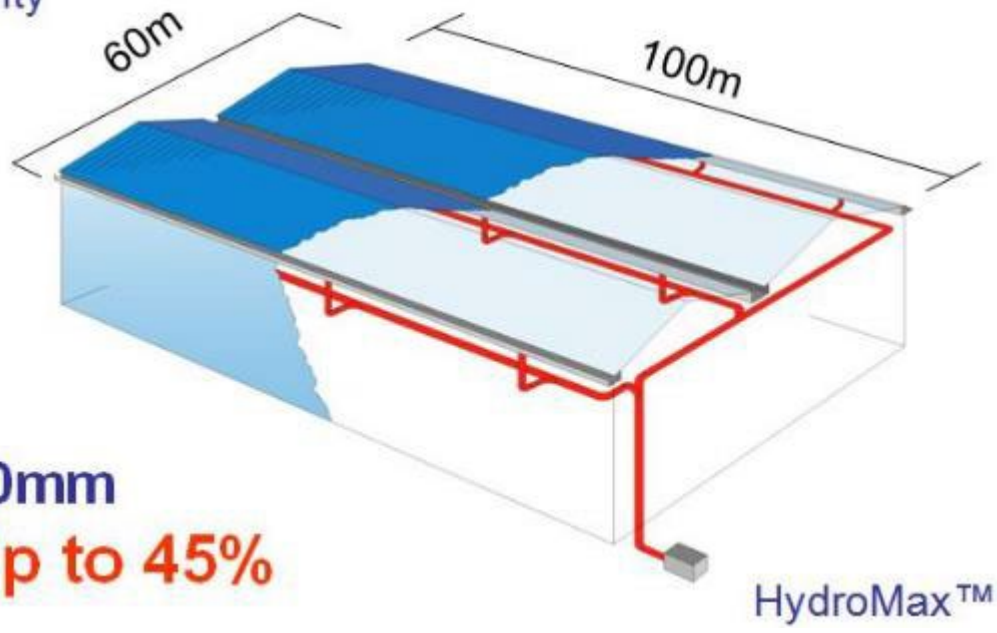
FIGURE 1106.1
100-YEAR, 1-HOUR RAINFALL (INCHES) EASTERN UNITED STATES

Gravity Drainage vs Siphonic Drainage





Traditional Gravity Solution
530 metres Pipework
Diameters 160mm to 450mm

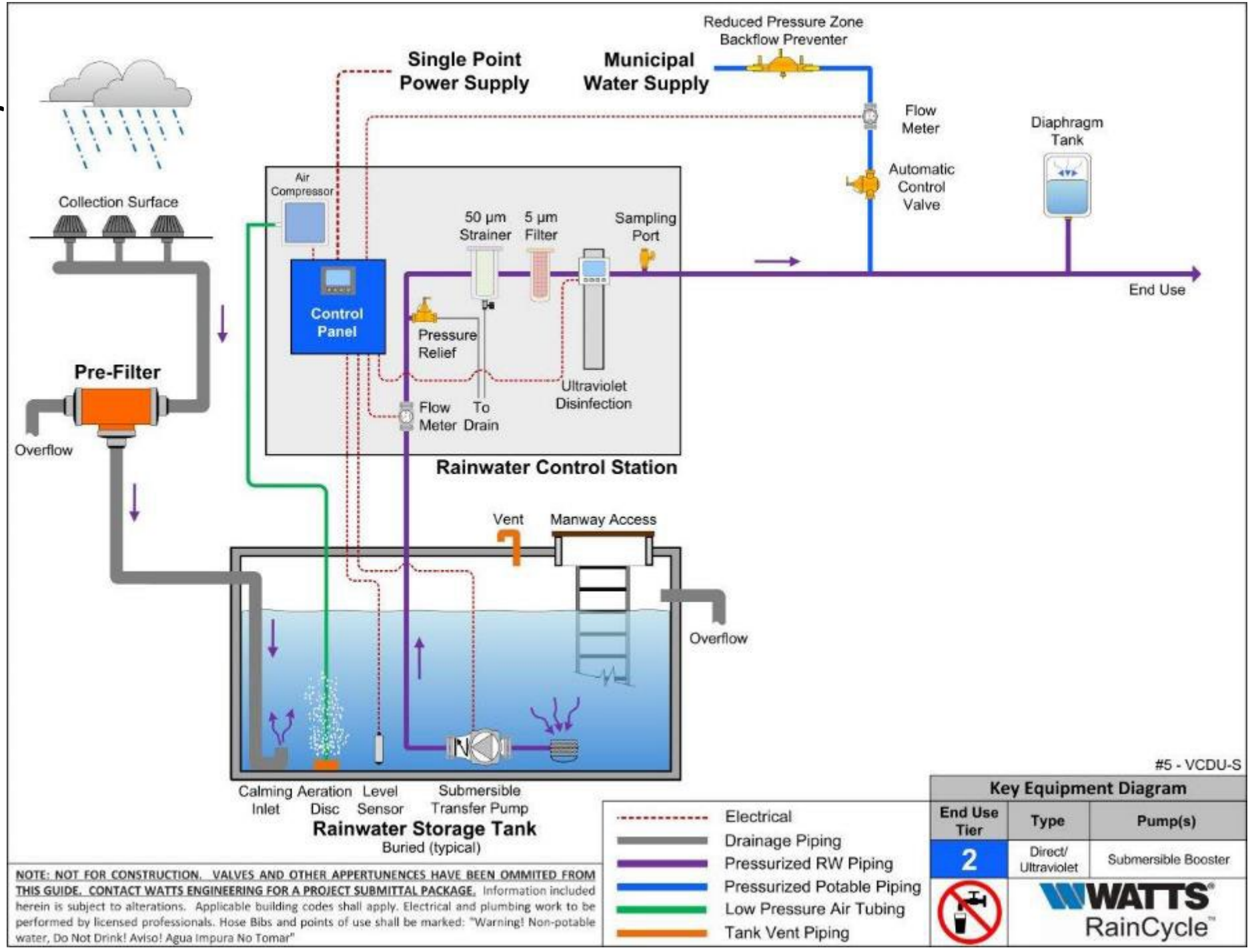


HydroMax™
Siphonic Scheme
360 metres Pipework
Diameters 56mm to 200mm
COST SAVINGS – Up to 45%

Siphonic drainage systems are usually installed on large industrial, storage, and retail buildings, where it is difficult to effectively drain the roof using a gravity drainage system.

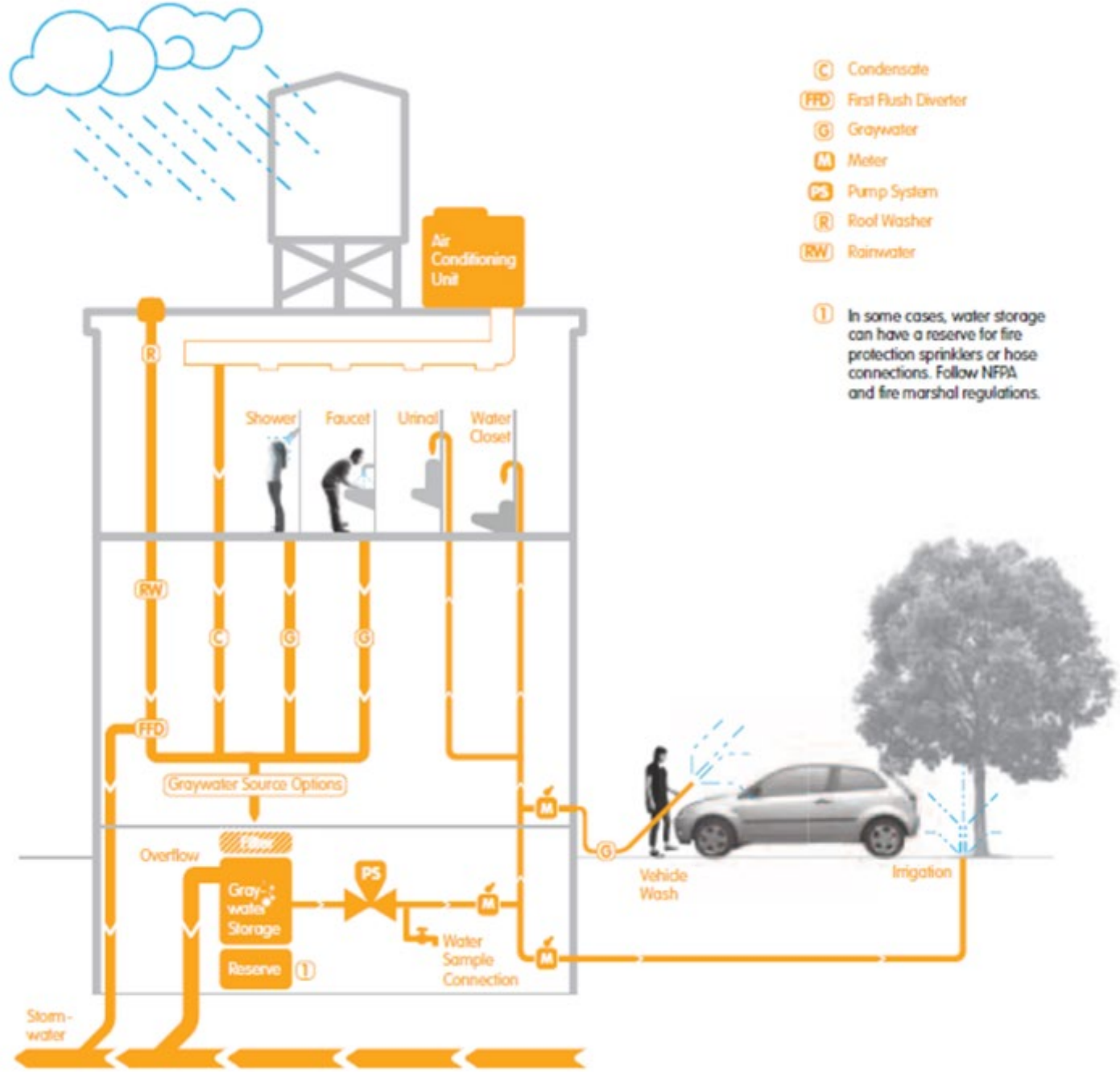
Reuse Water

Rainwater Harvesting System



Reuse Water

- **Greywater & Blackwater**



Medical Gas Systems

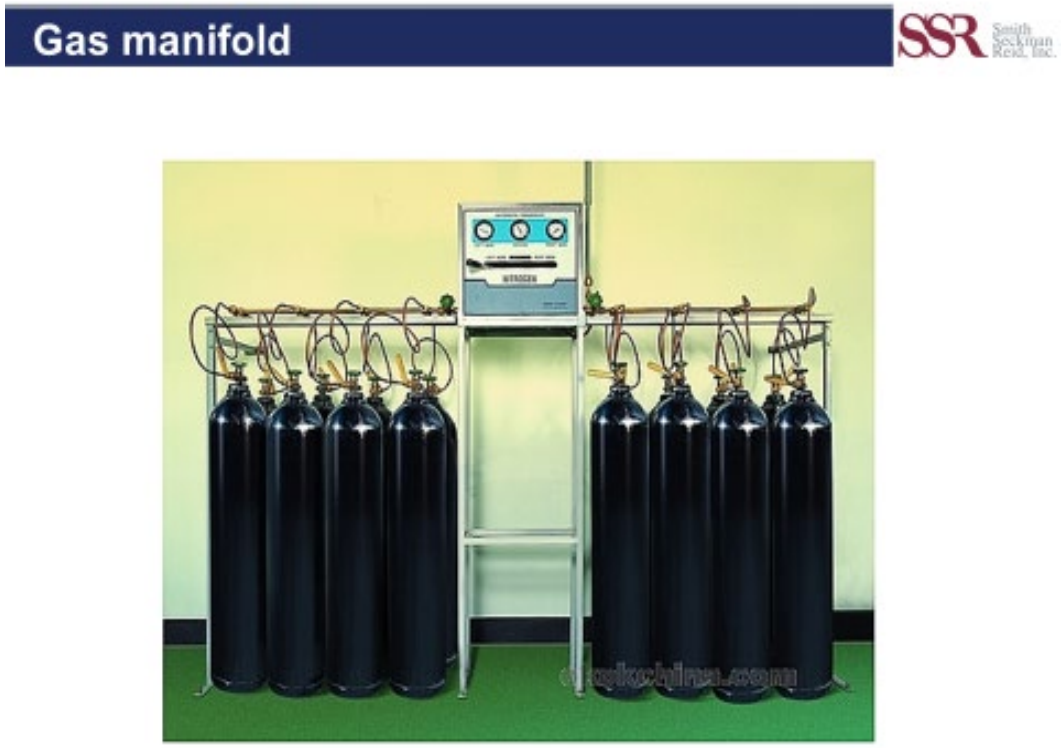
- Oxygen (O_2)
- Medical Air (MA)
- Medical Vacuum (VAC)
- Carbon Dioxide (CO_2)
- Nitrogen (N_2)
- Nitrous Oxide (N_2O)
- Waste Anesthesia Gas Disposal (WAGD)
- Used only for patient care (except Nitrogen)
- Master and area Alarms, zone valves, monitoring, service valves, backup sources, piping cleanliness, outlet types, and much more

- FGI - Facility Guidelines Institute – guidelines for designing and building hospitals and other health care facilities.
- NFPA 99 - Health Care Facilities Code – Medical Gas Requirements
- International Plumbing Code and Uniform Plumbing Code

4. Medical Gas Systems

- Med Gas Outlet – Wall Mounted or Console / headwalls
- Zone valves and Alarms
- Medical Air compressor
- Vacuum Pumps
- Med Gas Manifolds

Medical Gas Manifold



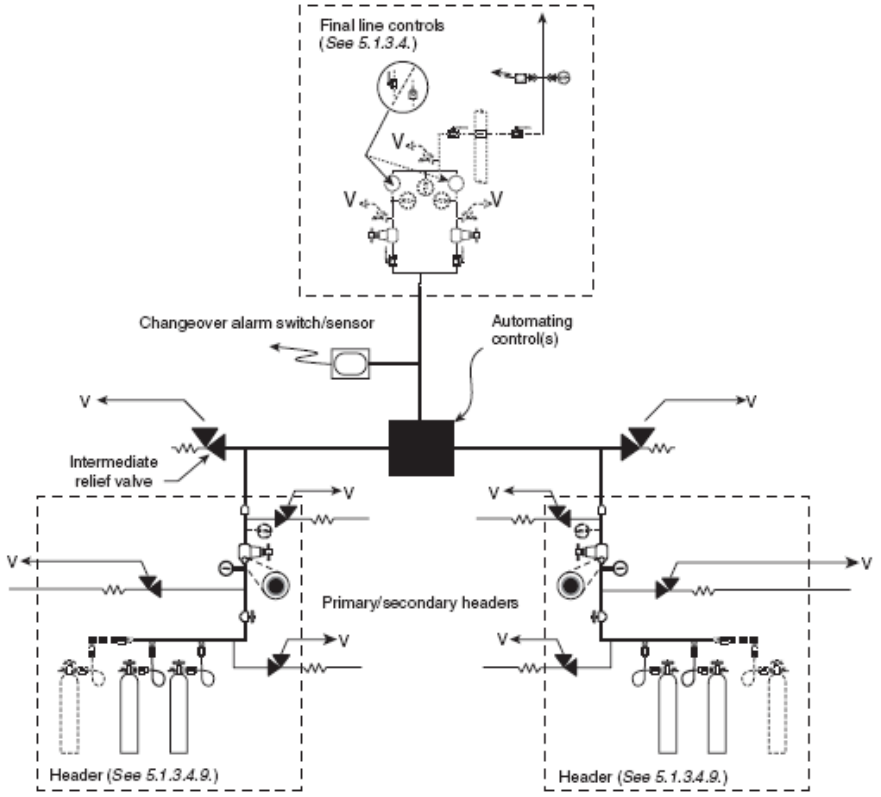
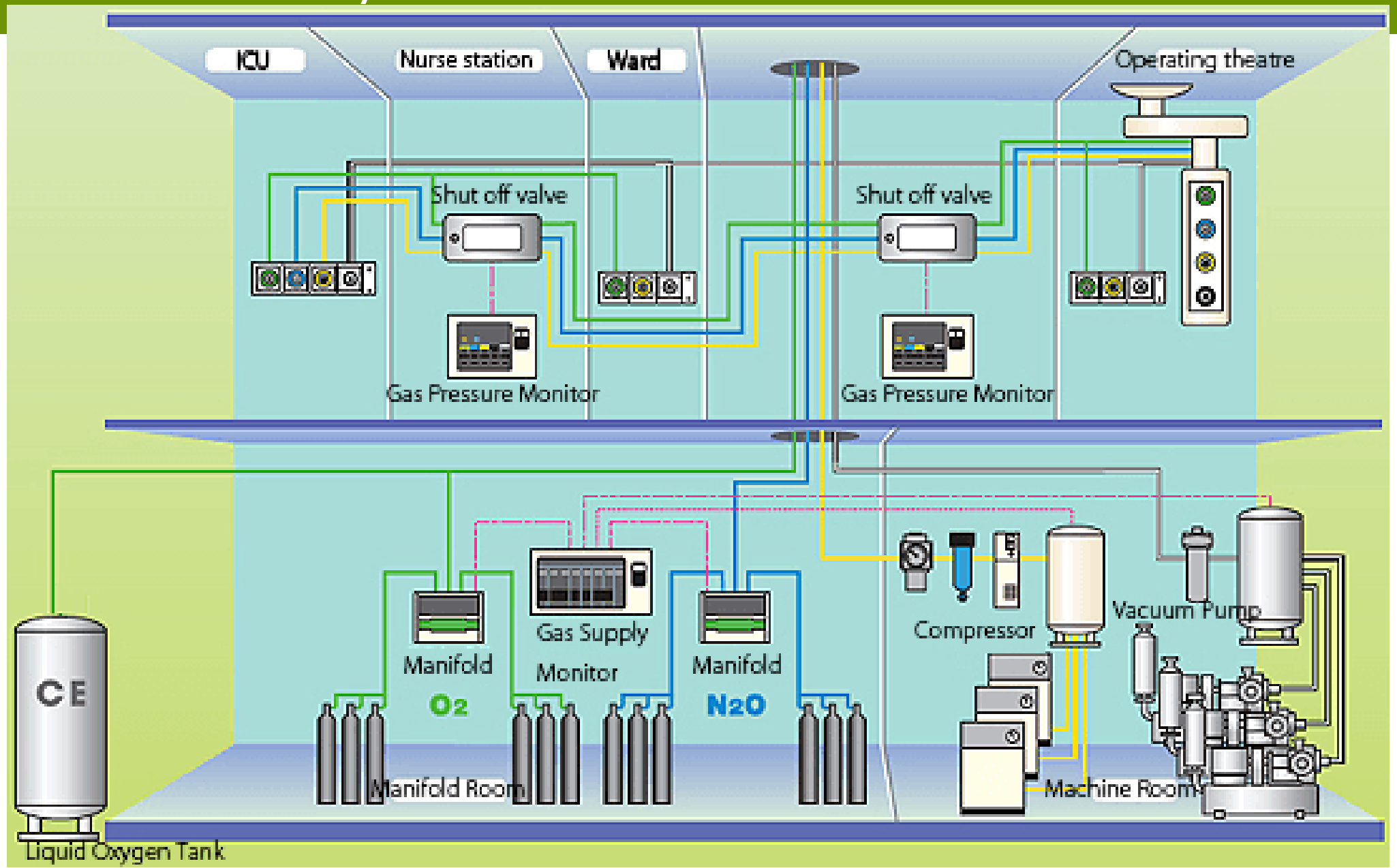
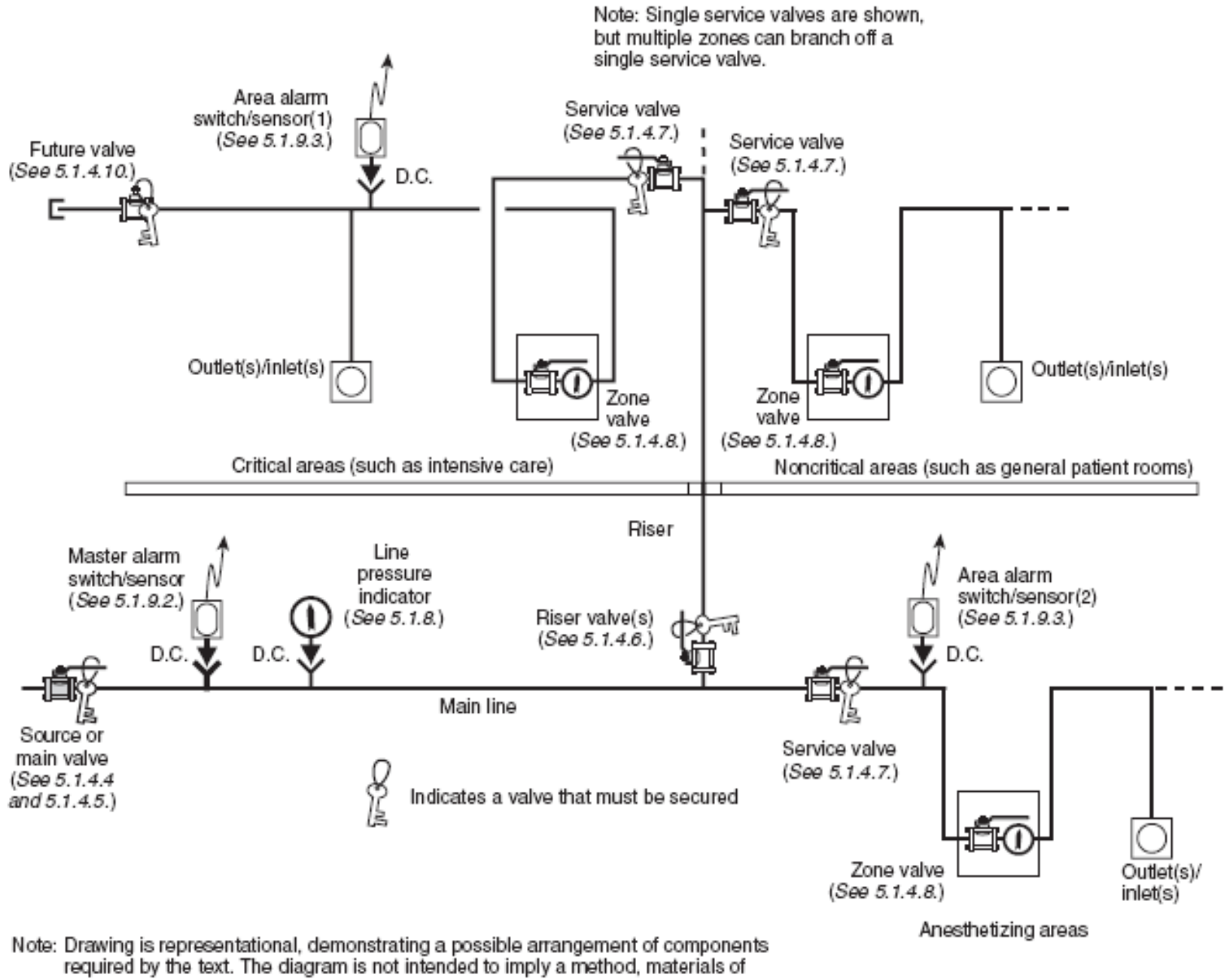


FIGURE A.5.1.3.4.10 Manifold for Gas Cylinders.

Medical Gas System



NFPA 99 Typical Med Gas Piping



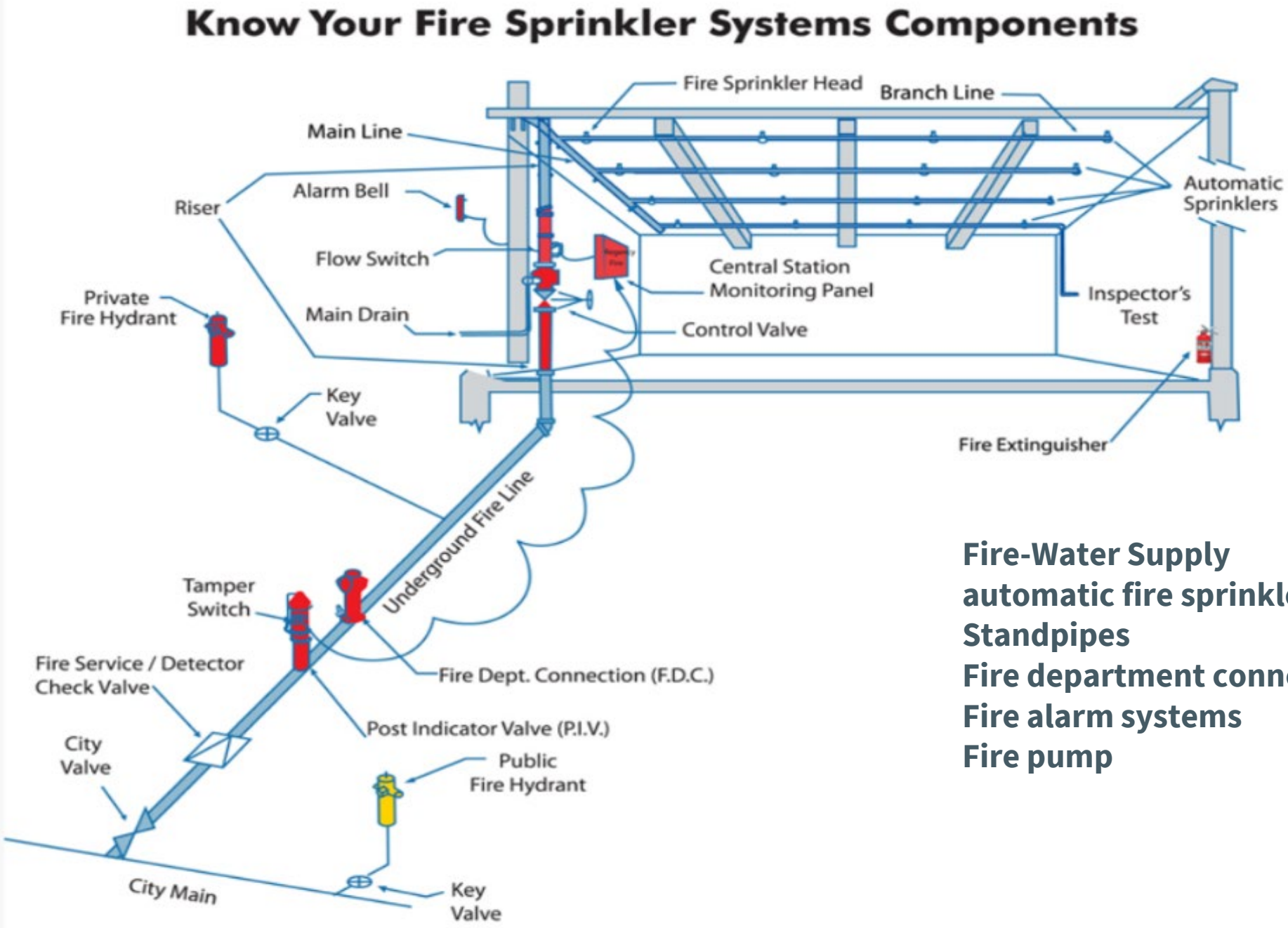
Fire Protection Systems

- Automatic Sprinkler systems
  - Wet Pipe system
  - Dry pipe system
  - Preaction system
- Standpipes
- Water mist fire suppression
- Gaseous fire suppression

2021 International Fire Code®

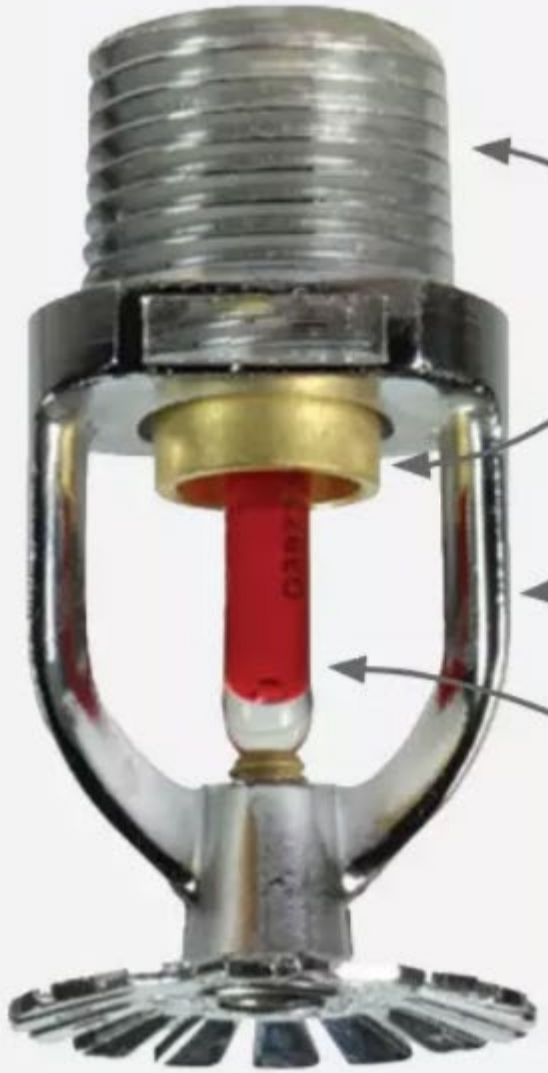
GOVERNING CODES

- NFPA 13 – Sprinkler Systems
- NFPA 14 – Standpipes and Hose Systems
- NFPA 20 – Fire Pumps
- NFPA 54 – Fuel Gas Code



Fire-Water Supply
automatic fire sprinklers
Standpipes
Fire department connections
Fire alarm systems
Fire pump

Fire Sprinkler Head Components



Orifice

6.4mm, 8.0mm, 10mm, 11mm, 12mm, 14mm, 16mm, 20mm

Thread

Plug

Frame

Glass Bulb

57°C	68°C	79°C	93°C	141°C	182°C
135°F	155°F	175°F	200°F	286°F	360°F

Deflector

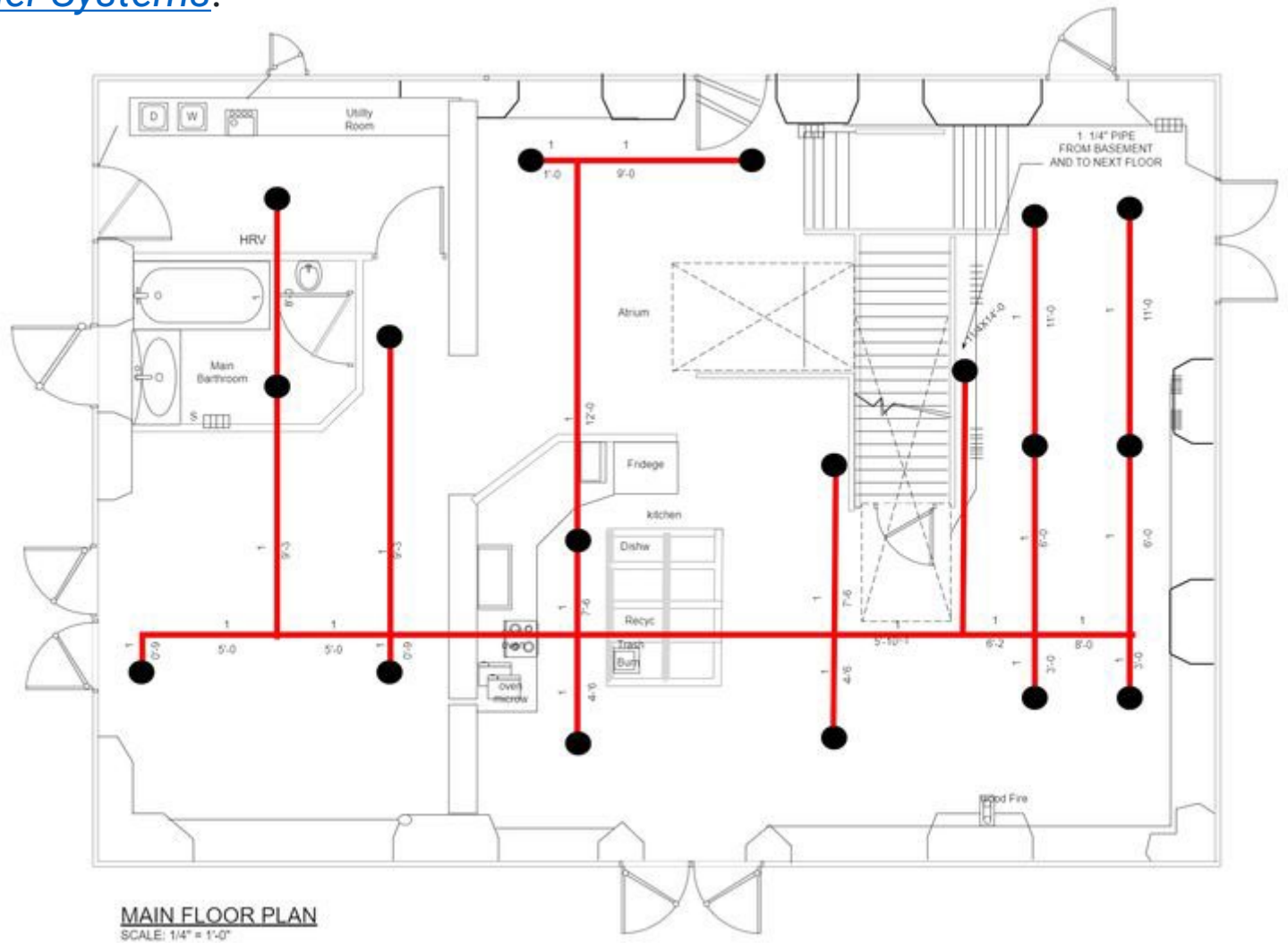
Pendent, Upright, Conventional, Sidewall, Concealed, EFSR, Foam-Water

Types of heads:

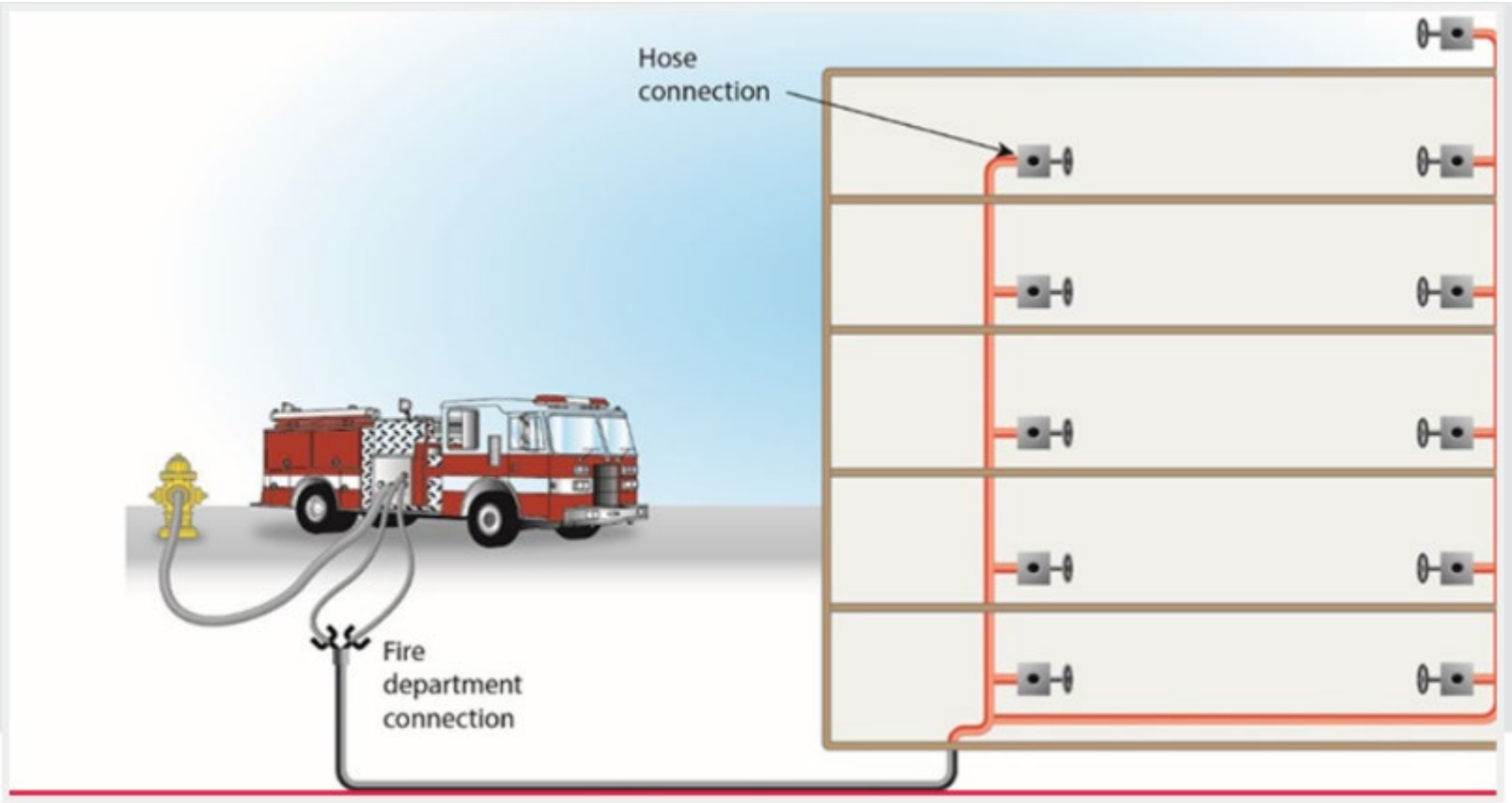
- Pendent
- Upright
- Sidewall
- Concealed
- Extended coverage
- Dry/freeze proof

Automatic Sprinkler Systems

NFPA 13, *Standard for the Installation of Sprinkler Systems*.



Standpipes and Hose Connections



A minimum residual pressure required for a Class I system is 100 psi at the hydraulically most remote 2 ½ in hose connection with a flow rate of 500 gpm, through the two most remote 2 ½ in hose connections.

Class I

Class I - used by the fire department in buildings that have more than three stories

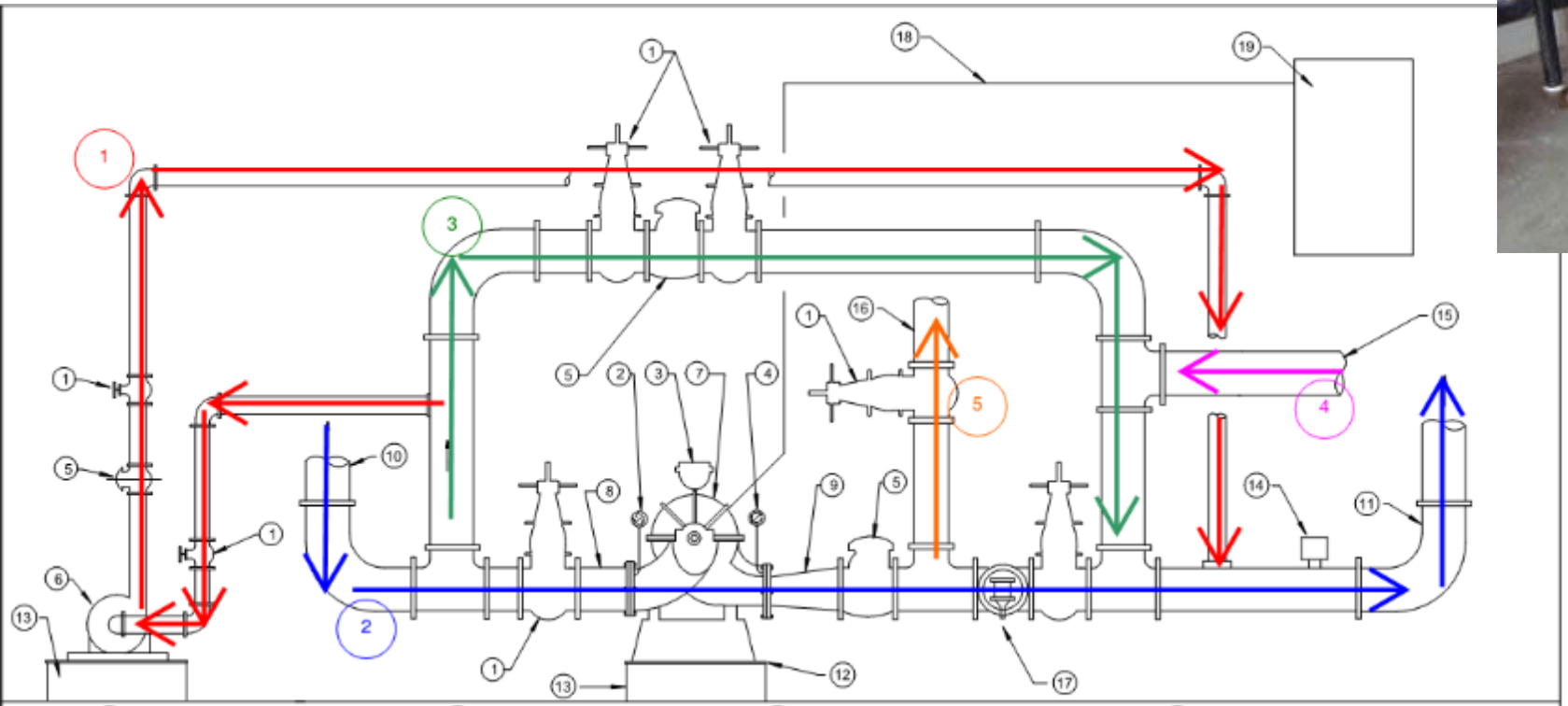
Class III

Class III

Class II

Class II

Fire Pump


1
2
3
4
5
1 O.S. & Y. GATE VALVE W/ ALARM POINTS.
2 SUCTION PRESSURE GAUGE
3 AUTOMATIC AIR VENT
4 DISCHARGE PRESSURE GAUGE
5 CHECK VALVE
6 JOCKEY PUMP
7 FIRE PUMP
8 ECCENTRIC DECREASER
9 CONCENTRIC INCREASER
10 SUPPLY LINE
11 DISCHARGE LINE
12 PUMP & MOTOR BASE
13 HOUSEKEEPING PAD
14 FLOW SWITCH W/ DELAY
15 TO FIRE DEPARTMENT FIRE HYDRANT
16 TO PUMP TEST HYDRANT
17 4" RELIEF VALVE
18 ¾" SENSING LINE TO CONTROLLER
19 FIRE PUMP CONTROLLER
07P102

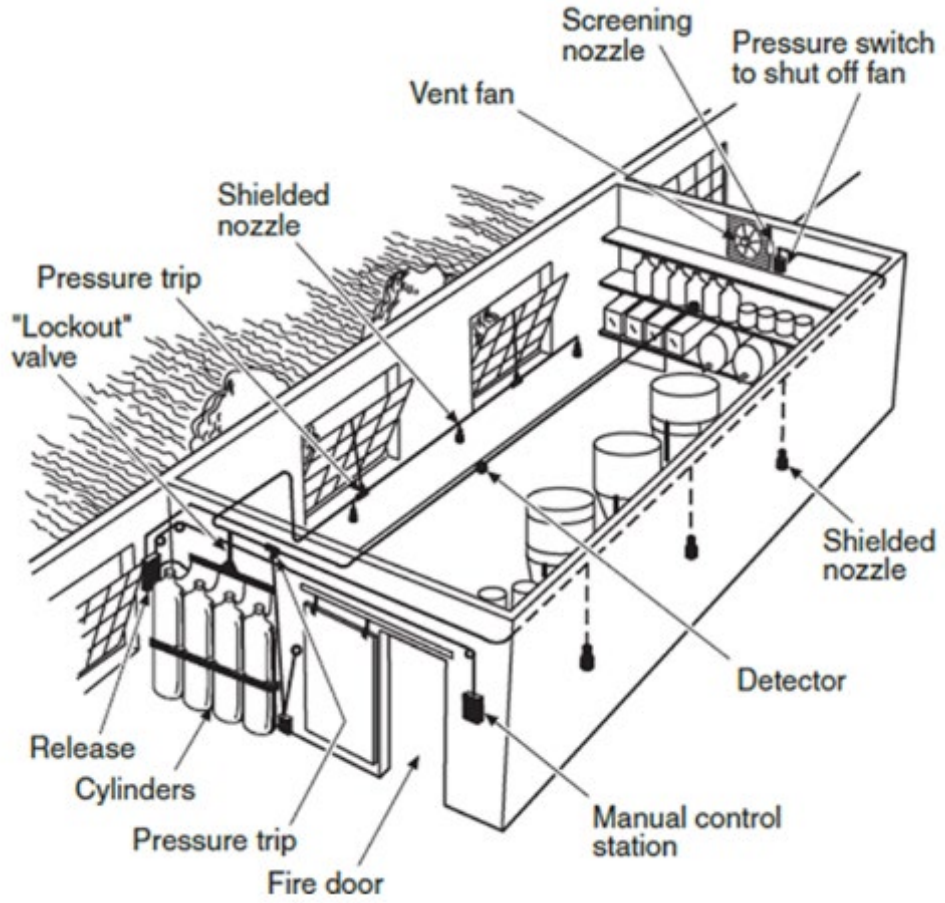
Water mist systems are fire suppression systems that use very small water droplets to extinguish or control fires.

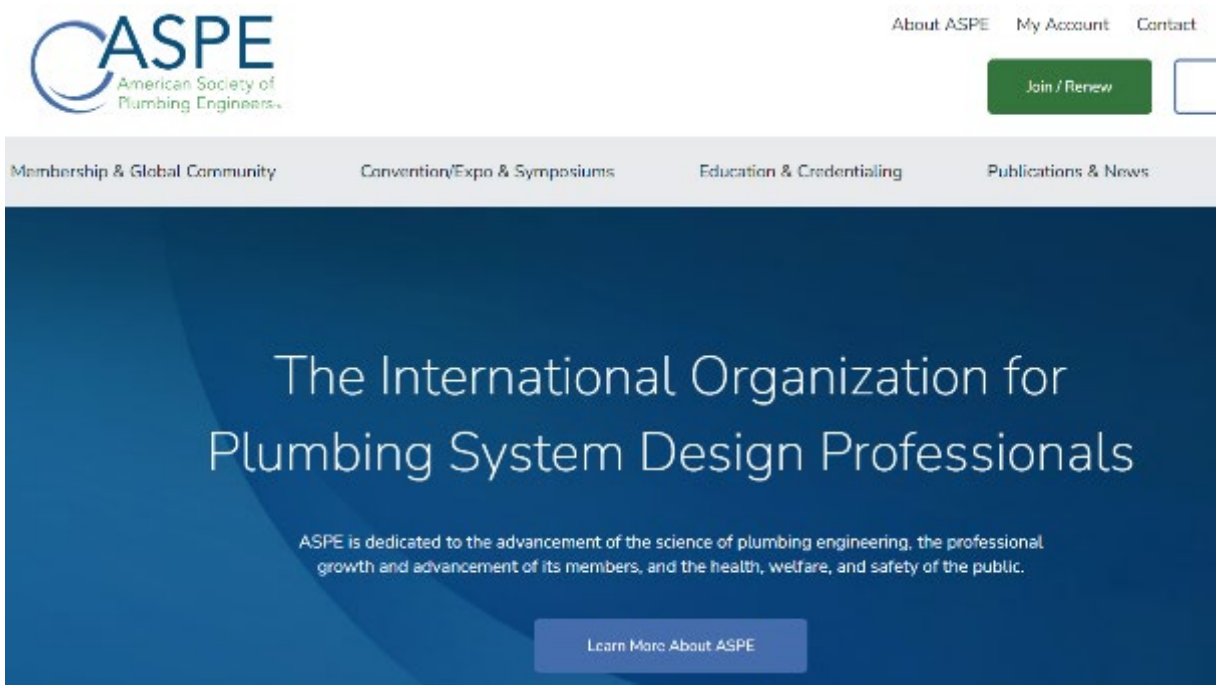
- Machinery spaces
- Combustion turbines
- Industrial oil cookers
- Computer room raised floors
- Data processing equipment rooms
- Chemical fume hoods
- Continuous wood board presses
- Shipboard passenger cabins and corridors
- Shipboard accommodation and public space areas
- Road tunnels
- Cable conduit tunnels

Gaseous fire suppression

most gaseous suppression systems suppress fire primarily by reducing the available oxygen for combustion with a secondary benefit of cooling and inhibiting the chemical chain reaction.

Carbon Dioxide
Halocarbon agent
Inert gas

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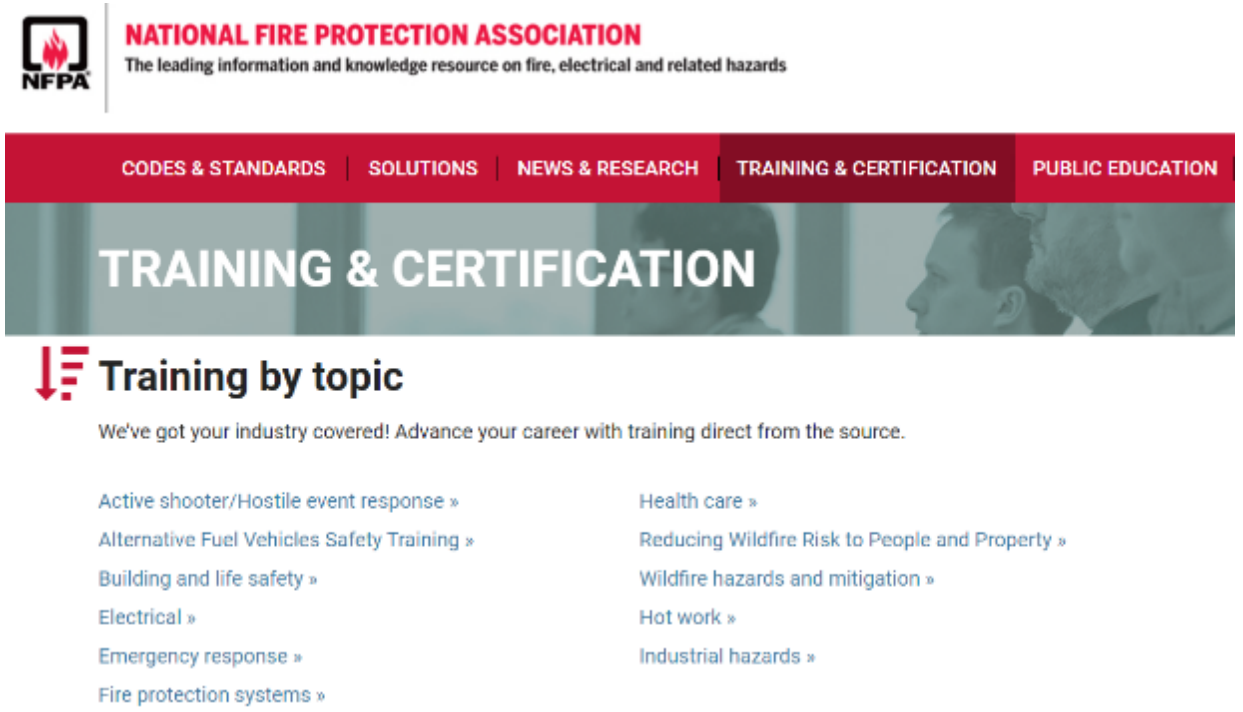
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TRAINING & CERTIFICATION
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Alternative Fuel Vehicles Safety Training »
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Electrical »
Emergency response »
Fire protection systems »
Health care »
Reducing Wildfire Risk to People and Property »
Wildfire hazards and mitigation »
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