

# ASPE Seminar

# Water Heater Piping

# Strategies

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# Presentation Overview

- Water Heater Piping Strategies
  - How to size a water heater?
  - How to size a storage tank?
  - Traditional System
    - Non-condensing water heater and storage tank
  - Condensing Water Heaters with storage
  - Condensing Water Heaters without storage
  - Utilizing the Boiler Plant
    - Water to Water Heater

# How to Size a Water Heater

- Fixture Count
  - ASHRAE Handbook – Service Water Heating
- Hunter Curve
- Occupancy Load
- Diversity



# ASHRAE - Service Water Heating

49.19

## Service Water Heating

**Table 10 Hot-Water Demand per Fixture for Various Types of Buildings**  
(Gallons of water per hour per fixture, calculated at a final temperature of 140°F)

	Apartment House	Club	Gymnasium	Hospital	Hotel	Industrial Plant	Office Building	Private Residence	School	YMCA
1. Basin, private lavatory	2	2	2	2	2	2	2	2	2	2
2. Basin, public lavatory	4	6	8	6	8	12	6	—	15	8
3. Bathtub <sup>c</sup>	20	20	30	20	20	—	—	20	—	30
4. Dishwasher <sup>d</sup>	15	50-150	—	50-150	50-200	20-100	—	15	20-100	20-100
5. Foot basin	3	3	12	3	3	12	—	3	3	12
6. Kitchen sink	10	20	—	20	30	20	20	10	20	20
7. Laundry, stationary tub	20	28	—	28	28	—	—	20	—	28
8. Pantry sink	5	10	—	10	10	—	10	5	10	10
9. Shower	30	150	225	75	75	225	30	30	225	225
10. Service sink	20	20	—	20	30	20	20	15	20	20
11. Hydrotherapeutic shower				400						
12. Hubbard bath				600						
13. Leg bath				100						
14. Arm bath				35						
15. Sitz bath				30						
16. Continuous-flow bath				165						
17. Circular wash sink				20	20	30	20		30	
18. Semicircular wash sink				10	10	15	10		15	
19. DEMAND FACTOR	0.30	0.30	0.40	0.25	0.25	0.40	0.30	0.30	0.40	0.40
20. STORAGE CAPACITY FACTOR <sup>b</sup>	1.25	0.90	1.00	0.60	0.80	1.00	2.00	0.70	1.00	1.00

Note: Data sources predate low-flow fixtures and appliances.

<sup>d</sup>Dishwasher requirements should be taken from this table or from manufacturers' data for model to be used, if known.

<sup>b</sup>Ratio of storage tank capacity to probable maximum demand/h. Storage capacity may be reduced where unlimited supply of steam is available from central street steam system or large boiler plant.

<sup>c</sup>Whirlpool baths require specific consideration based on capacity. They are not included in the bathtub category.

# ASHRAE - Hot Water Demands

49.14

2007 ASHRAE Handbook—HVAC Applications

**Table 7 Hot-Water Demands and Use for Various Types of Buildings\***

Type of Building	Maximum Hourly	Maximum Daily	Average Daily
Men's dormitories	3.8 gal/student	22.0 gal/student	13.1 gal/student
Women's dormitories	5.0 gal/student	26.5 gal/student	12.3 gal/student
Motels: Number of units <sup>a</sup>			
20 or less	6.0 gal/unit	35.0 gal/unit	20.0 gal/unit
60	5.0 gal/unit	25.0 gal/unit	14.0 gal/unit
100 or more	4.0 gal/unit	15.0 gal/unit	10.0 gal/unit
Nursing homes	4.5 gal/bed	30.0 gal/bed	18.4 gal/bed
Office buildings	0.4 gal/person	2.0 gal/person	1.0 gal/person
Food service establishments			
Type A: Full-meal restaurants and cafeterias	1.5 gal/max meals/h	11.0 gal/max meals/day	2.4 gal/average meals/day <sup>b</sup>
Type B: Drive-ins, grills, luncheonettes, sandwich, and snack shops	0.7 gal/max meals/h	6.0 gal/max meals/day	0.7 gal/average meals/day <sup>b</sup>
Apartment houses: Number of apartments			
20 or less	12.0 gal/apartment	80.0 gal/apartment	42.0 gal/apartment
50	10.0 gal/apartment	73.0 gal/apartment	40.0 gal/apartment
75	8.5 gal/apartment	66.0 gal/apartment	38.0 gal/apartment
100	7.0 gal/apartment	60.0 gal/apartment	37.0 gal/apartment
200 or more	5.0 gal/apartment	50.0 gal/apartment	35.0 gal/apartment
Elementary schools	0.6 gal/student	1.5 gal/student	0.6 gal/student <sup>b</sup>
Junior and senior high schools	1.0 gal/student	3.6 gal/student	1.8 gal/student <sup>b</sup>

\*Data predate modern low-flow fixtures and appliances.

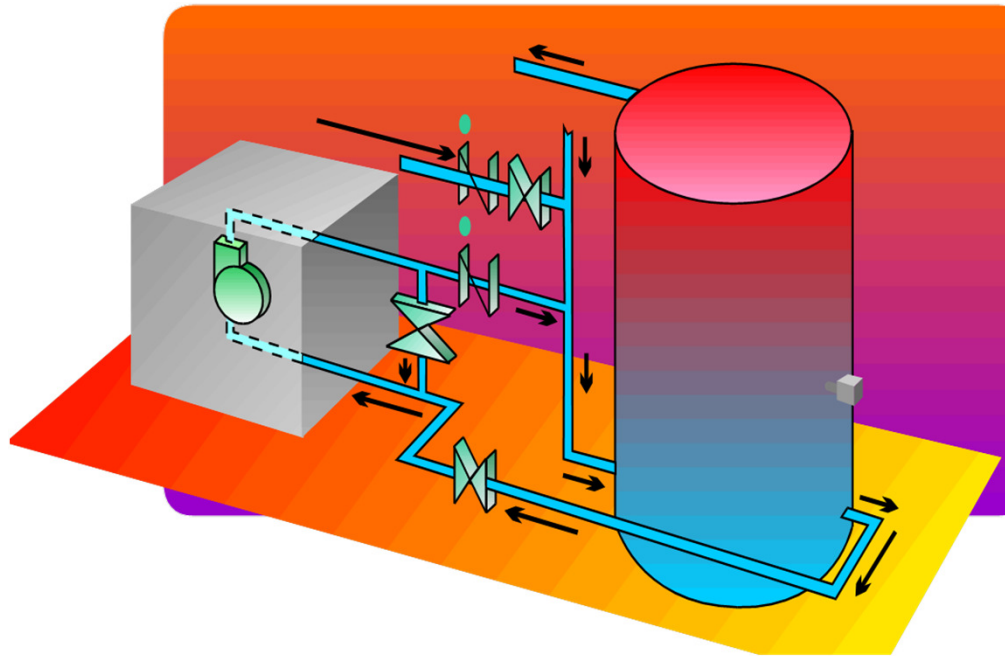
<sup>a</sup>Interpolate for intermediate values.

<sup>b</sup>Per day of operation.

# How to Size a Storage Tank

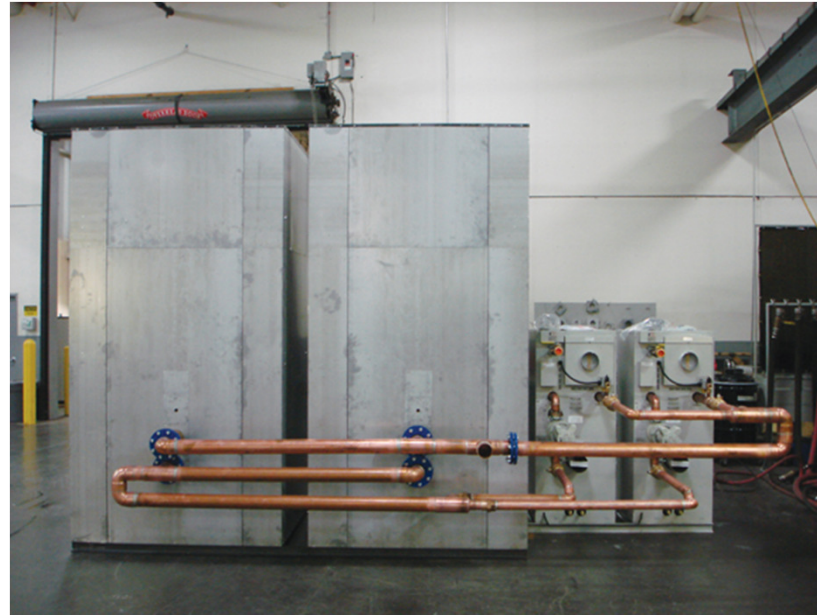
- Reason for Storage?
  - Protect system from poor temperature control
  - Protect water heater from condensing conditions
- How to Size a Storage Tank?
  - Typically depends on requirements set by water heater manufacturer
  - Common rule of thumb
    - 125 gallons storage/500 MBH

# “Traditional” System



- Non-condensing Water Heater
  - Requires a bypass or 3-way valve to maintain inlet water temperatures above 140°F
  - Requires Storage Tank & System Recirculation
    - Necessary to maintain accurate temperature control, due to lack of modulation capability
    - Storage tanks failure will shut down entire domestic water system

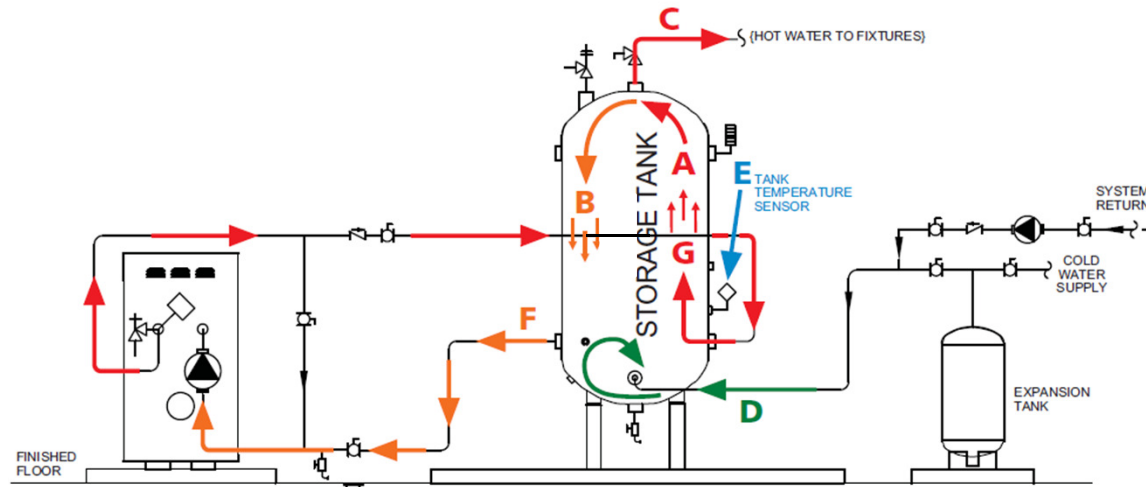
# “Traditional” System



- Wastes Energy
  - Non-condensing water heaters can only reach maximum efficiencies in the mid 80's
  - Must keep set point at a minimum of 140°F
  - Higher standby/radiant losses
  - Higher burner cycling losses
  - Additional electrical consumption of full flow circulators



# “Traditional” System

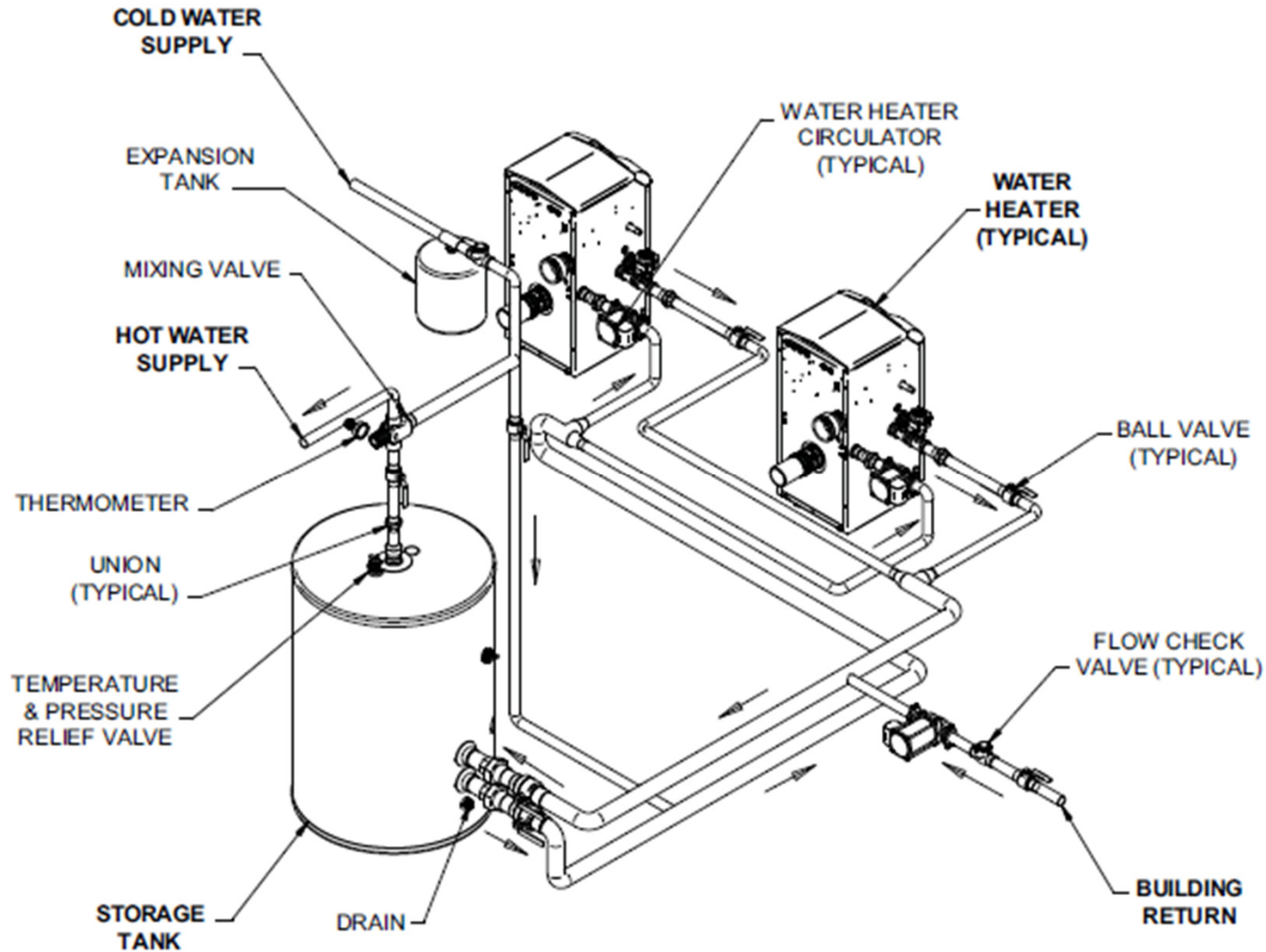


- Larger Installed Footprint
  - Water heater & tank
- Higher Risk of Legionella
  - Must keep tank at 140°F min.
- Extra Piping
  - Higher installation cost
- Added Maintenance
  - Additional components that need to be serviced and maintained

# Condensing Water Heaters With Storage

- Storage Heaters
  - Tank and integral heat exchanger
- Hot Water Supply Boiler with Separate Storage
  - ASME “H” Stamp
    - Classified as a boiler
    - Published efficiency is based on ANSI Z21.13
      - Tested at Full Fire: 80°F - 180°F
        - Does not take into account electrical consumption and radiant losses
  - Most Common Designs:
    - Copper Fin primary, Stainless Steel secondary HX
    - 300 series Stainless Steel Water tube HX

# Condensing Water Heaters with Storage



# Condensing Water Heaters With Storage

- Common Disadvantages:
  - Larger footprint
    - Typically require 125 gallons of storage per 500 MBH
  - Legionella Risk
    - 140°F set point required
    - Wastes energy & requires mixing station (added cost)
  - Higher standby/radiant losses
  - Limited Warranty
    - Typically 3-5 Year Warranty on Heat Exchanger

# Condensing Water Heaters With Storage

- Added Disadvantages of Separate Storage
  - High Flow Circulator
    - Higher energy consumption
  - Extra piping
  - Limits the effectiveness of condensing
  - Added Maintenance

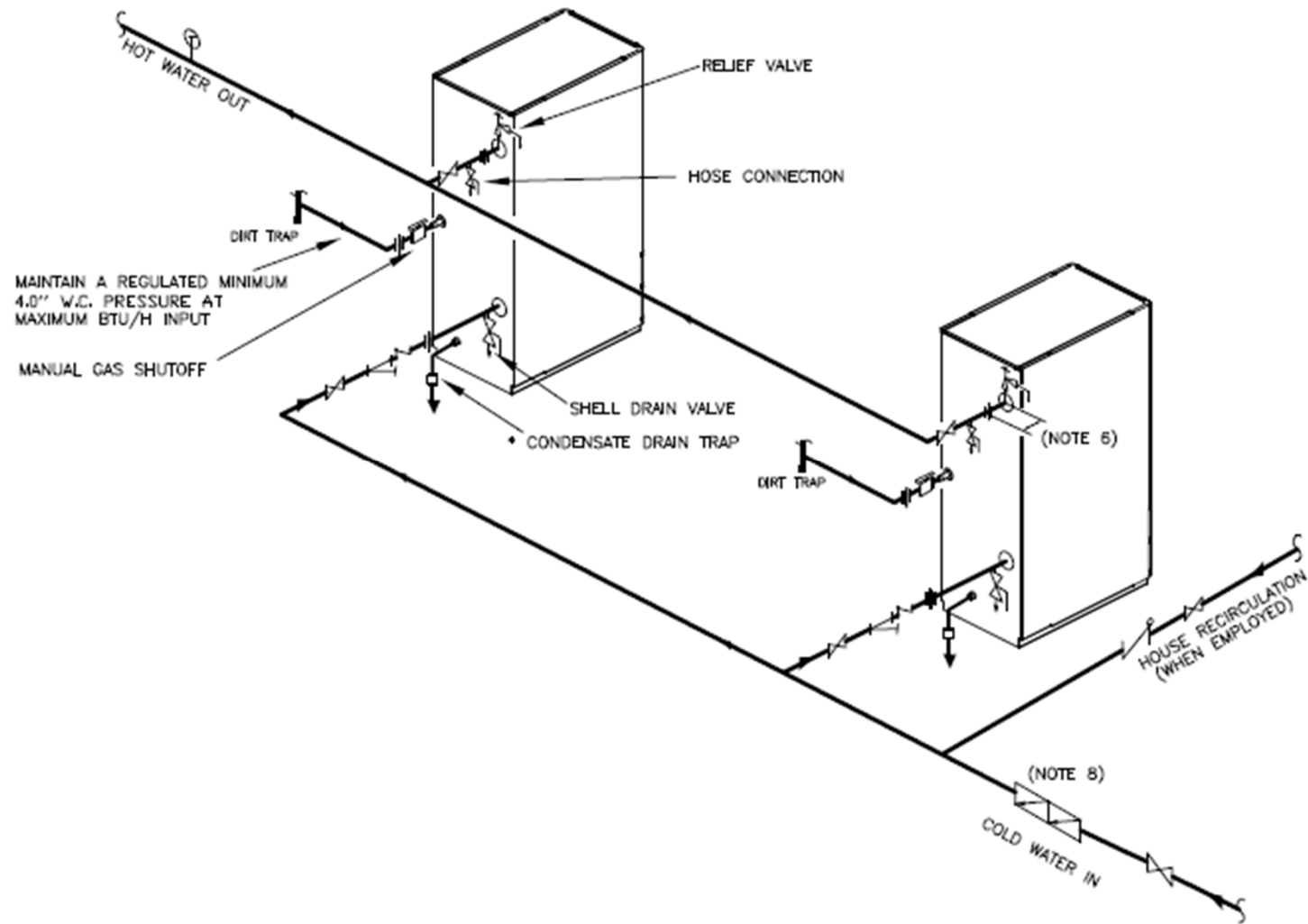
# Condensing Water Heaters without Storage

- “Tankless/Semi-Instantaneous” Water Heaters
  - ASHRAE defines a “semi-instantaneous” water heater as having an “Input to Storage Ratio” of 4,000 Btu/h per gallon or greater
- Heat Exchanger material of construction must be suitable for condensing application
  - Stainless Steel
- Fire Tube Heat Exchanger
  - Reduce risk of scale compared to water tube hx
  - Lower waterside pressure drop compared to water tube hx
  - Less pump electrical consumption compared to water tube hx

# Condensing Water Heaters without Storage

- Requires advanced controls with feed forward & feedback control system
- Requires high turndown/modulation
  - 14:1 or greater
    - Reduce cycling losses
    - Reduce “wear and tear” on equipment
    - Extends life of product

# Maximize Efficiency



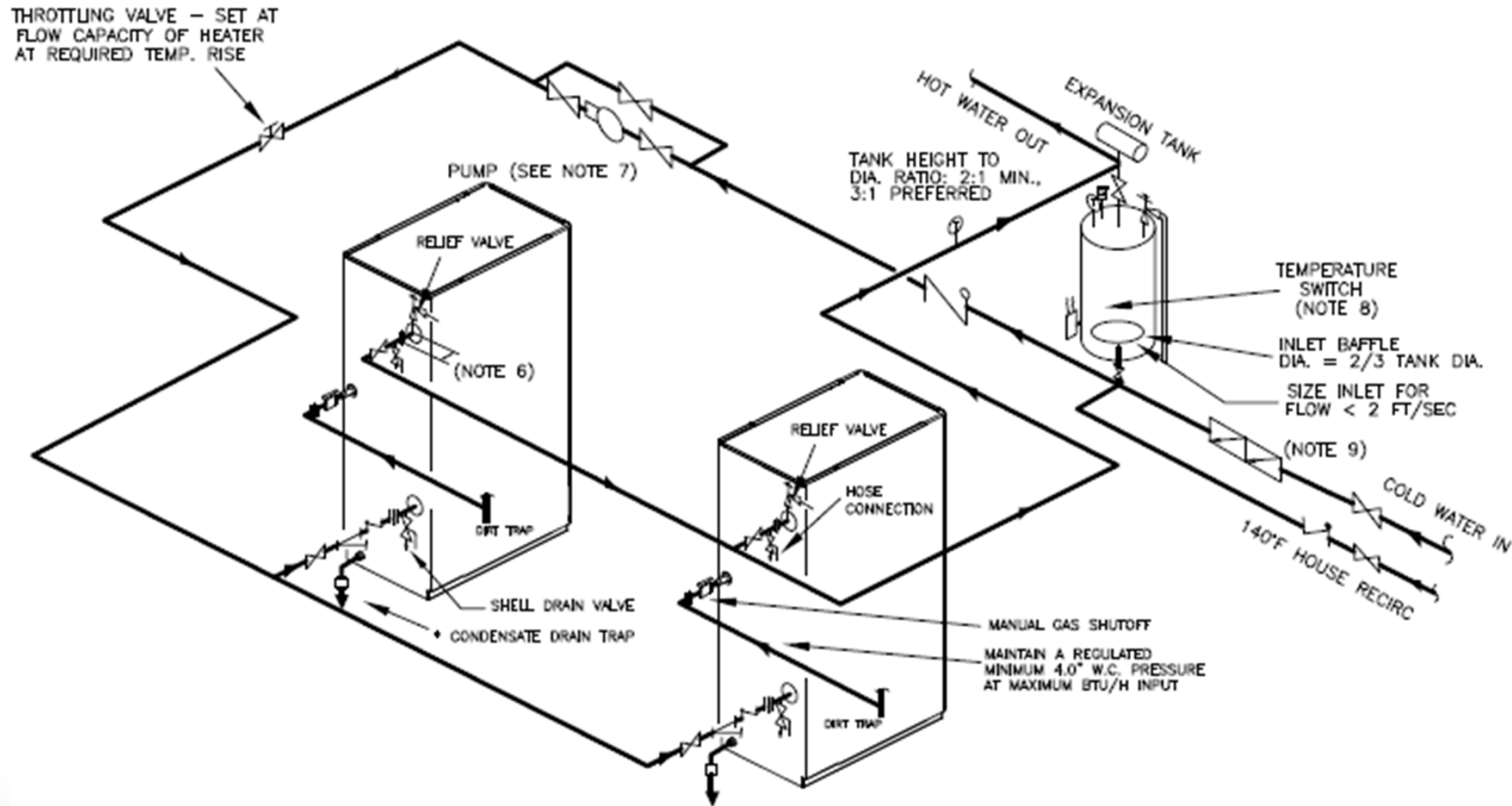


# When Storage Should Be Utilized

- “Dump Loads” – Peak Load for Short Time
  - Commercial Laundry
  - Gang Showers
  - Cage Washers



# Maximize Efficiency with Storage Tank



# Utilizing a Boiler Plant

- Water to Water Heater
  - Add indirect domestic load to oversized boiler plant
  - Utilize boiler water to heat domestic water
- Optimal Heat Exchanger – Braze Plate/Plate & Frame HX
  - Requires advanced controls for accurate temperature control
    - Feedback & Feed forward controls
  - Low boiler water supply and return temperatures
    - Eliminate waste associated with overheating
    - Reduce fuel consumption and maximizes boiler efficiency
    - Reduce radiant losses by up to 15%



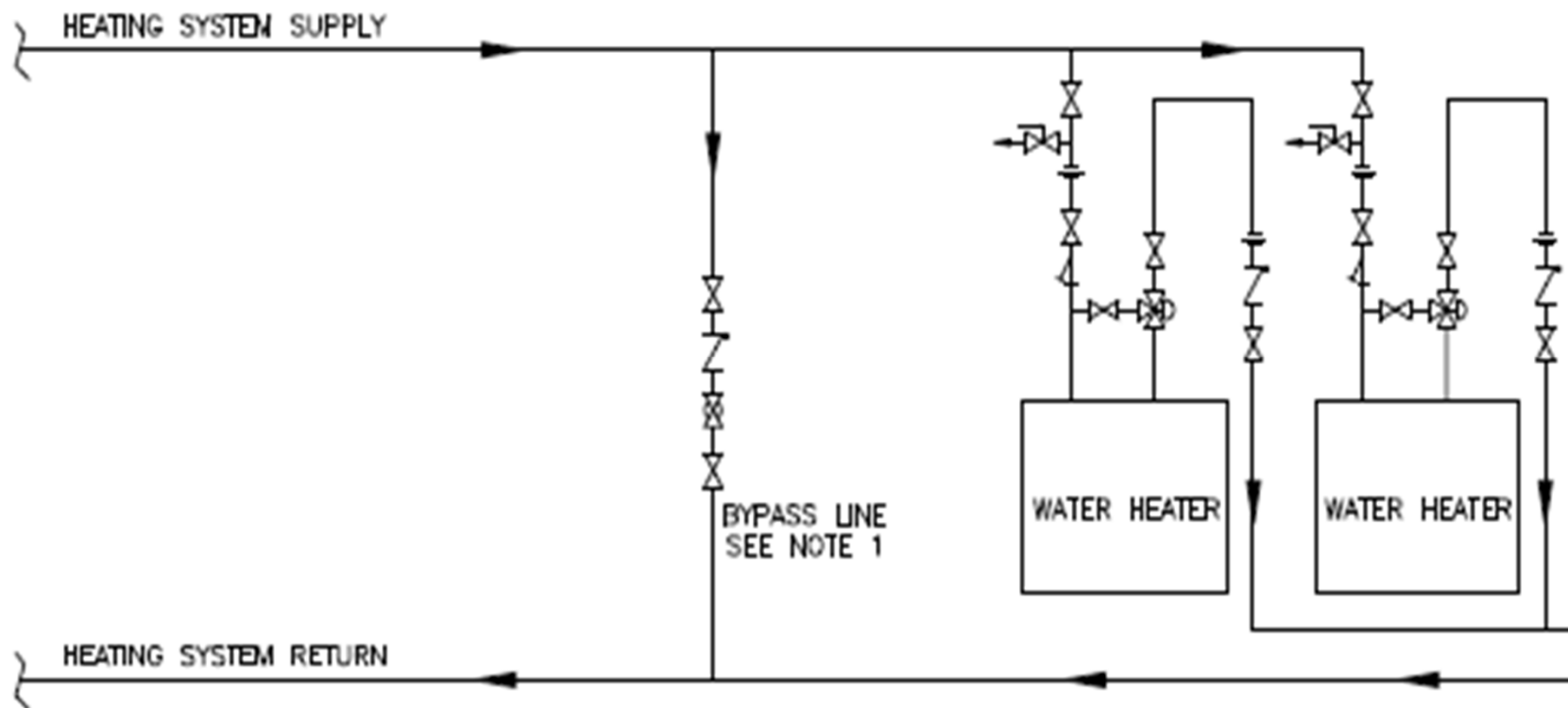
# System Integration

- Successful integration with hydronic boilers
  - Ensures acceptable temperature control
  - Minimizes boiler cycling
- Key Considerations
  - Thermal mass of overall system
  - Year-round load characteristics
  - Peaks and valleys in DHW demand
- With Low Mass and Fast, Diverse DHW Loads
  - Boiler-side buffer tank may be required (not DHW storage)
  - Should conform with boiler manufacturer recommendations

# High Mass System

- Sufficient water volume in boiler or system piping ensures minimal boiler cycling
- Can be either a condensing or non-condensing boiler
- If using a non-condensing boiler, must include bypass line with circuit-setter to ensure 140°F return water temperature

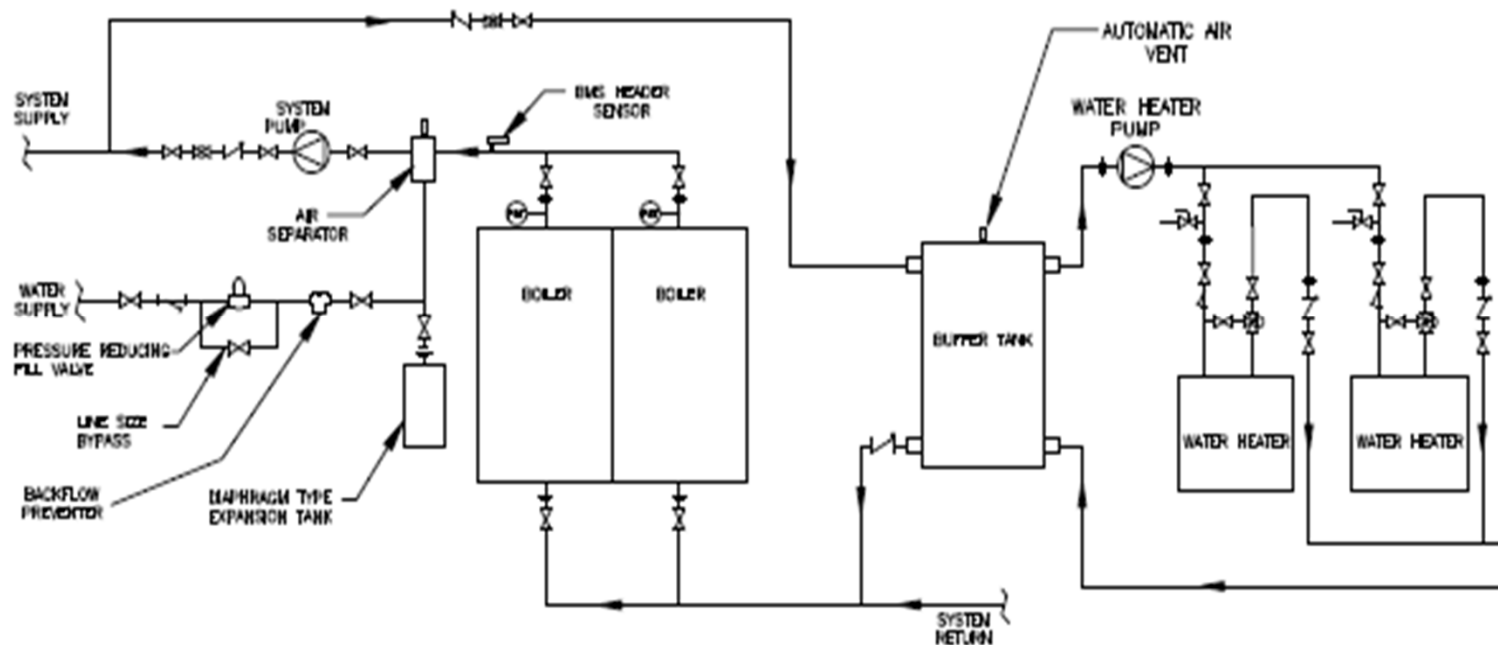
# High Mass System



Note: Size bypass line to ensure that RWT to non-condensing, high mass boilers always remains above 140°F

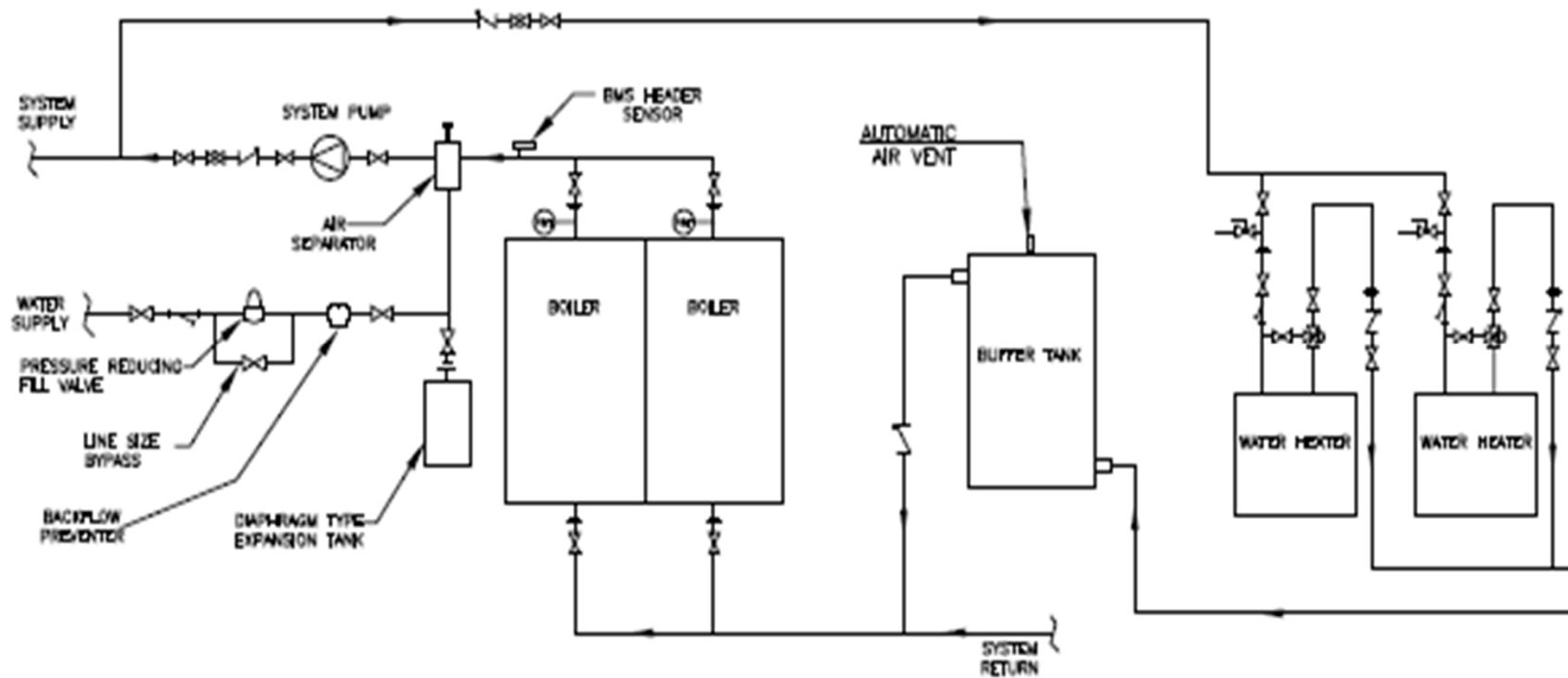
# Low Mass System

- Insufficient water volume in boiler or system piping between the boilers and the heaters to ensure minimal boiler cycling
- Can be either a condensing or non-condensing boiler with average to low turndown, 5:1 or less
- If using a non-condensing boiler, must ensure 140°F return



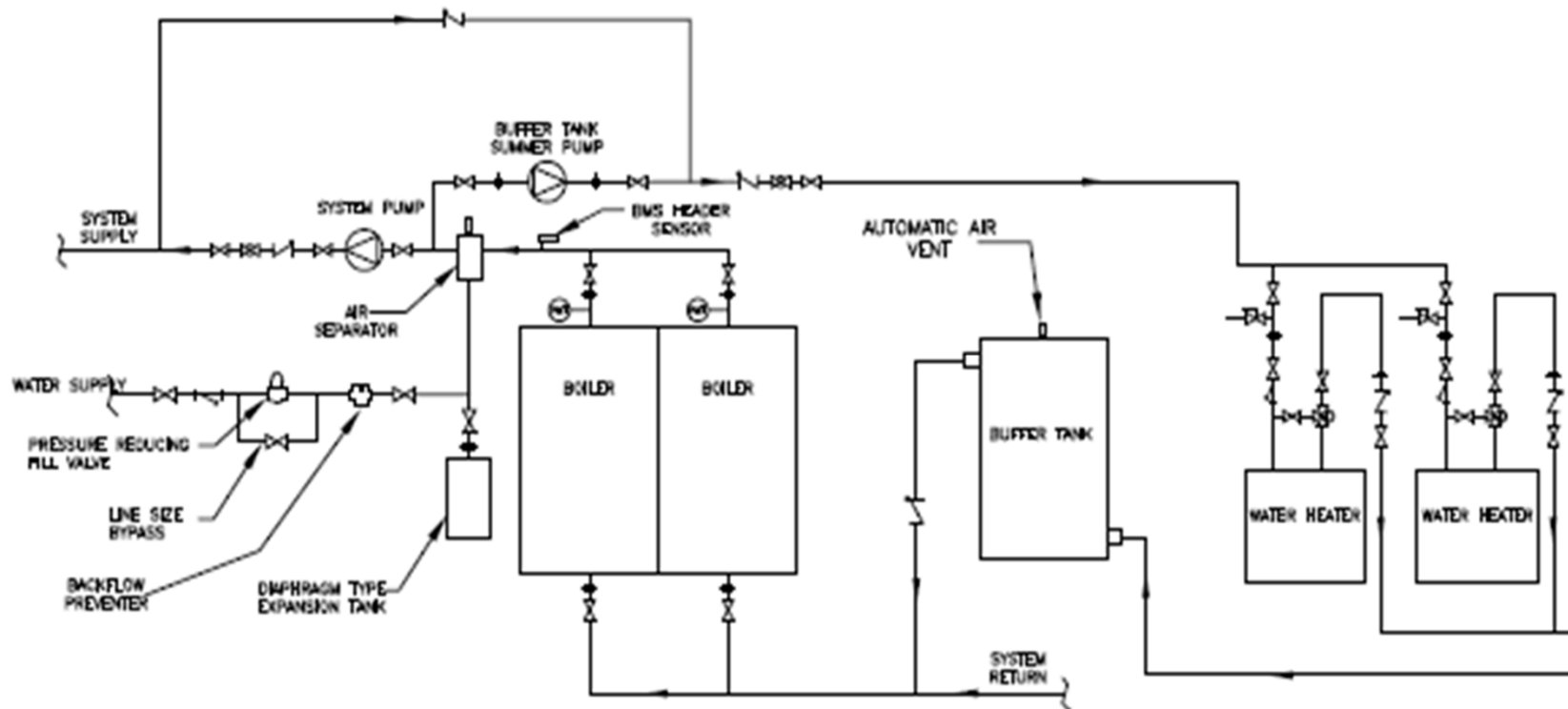
# Low Mass System

- Utilizing a Condensing Boiler with high turndown
  - Turndown greater than 15:1





# Low Mass System



For use when DHW is the only load on the system (spring/summer)  
Allows for main system pump shut down

# Low Mass System

- Hydronic buffer tank vs. domestic storage tank
  - In a closed system, corrosion failure is unlikely to occur as quickly as in an open loop
  - Operating temperatures are not limited to  $\geq 140$  °F
    - No fear of Legionella bacteria growth
  - Does not require glass or cement lining
    - Less expensive

# Optimum Instantaneous Heater

- Brazed plate and plate and frame are the most efficient water to water heat exchangers available
- Only requires a +5° F approach temperature vs. DHW set point
- Result: Lower boiler supply and return temperatures
  - Ideal with high-efficiency, condensing boilers in low temperature applications



# Optimum Instantaneous Heater

- Reduce maintenance costs
  - Plate HX's stand up better in DHW environment
    - 316 SS plate construction for high corrosion resistance
    - Maintain minimum flow velocity and reduce scale dropout
    - Easy to clean when required
- Reduce future replacement cost
  - Higher cost for domestic storage systems



# Optimum Instantaneous Heater

- Requires accurate temperature control for safe operation and to eliminate the need for storage
  - Should have PID Controls with feed-forward and feedback sensor inputs
  - Should have a fast-acting electronic control with failsafe actuator
  - Should include an integrated safety shutoff system



# Utilizing a Boiler Plant

- Low boiler water supply and return temperatures
  - Eliminate waste associated with overheating
  - Reduce fuel consumption and maximizes boiler efficiency
  - Reduce radiant losses by up to 15%
- Lower Boiler Water Flow Requirements
  - Less pumping HP
  - Smaller piping requirements
- Lower Domestic Set Point Temperature
  - Reduces scale
  - No storage tanks or mixing valves
  - Increased heater thermal efficiency
  - Reduced maintenance
  - Longer heater life

# Summary

- Purpose of Storage
  - Protect system from water heater with poor temperature control
  - Protect gas fired water heater from condensing conditions
- Most Efficient Design
  - Gas Fired Water Heater
    - Condensing, High Turndown, Semi-Instantaneous/Tankless Water Heater without Storage
  - Utilizing a Condensing Boiler Plant with a Water to Water Heater
    - Optimum Water Heater – Brazed Plate/Plate & Frame with feed-forward & feedback controls coupled with a fast acting electronic control valve
- Consider total system design when selecting products
- **DESIGN A SYSTEM WITH A LONG LIFE THAT WILL MAXIMIZE EFFICIENCY AND REDUCE ENERGY COSTS!**

# Questions

1. When should storage be utilized?
2. What is the optimum heat exchanger for water to water heat transfer?
3. Why is turndown important?
4. What is the minimum temperature that a storage tank must be kept at?
5. What type of tank is most likely to fail?  
Buffer Tank or Storage Tank
6. What material is best suited for gas fired condensing equipment?
7. What does a buffer tank reduce in boilers in Low Mass Systems?