How Much Energy is Used and Water Runs Down the Drain While Waiting for the Hot Water to Arrive?

What Determines how long you wait for hot water?

- Length of pipe between the fixture and the source of hot water
- Size of pipe between the fixture and the source of hot water
- How long it has been since hot water was last used at the fixture (pipe insulation).
- The flow rate of the fixture…newer fixtures with lower flow rates increase the wait time.
- Water pressure...lower pressures increase fixture wait times.

Historical Overview:
Or how we got where we are now

1940's Development of the *Plumbing Code*

- Based on "fixture units" @ 7.5 gpm
- Greater distance and more fixtures, fittings and appliances = bigger diameter pipe

1960's Beginning of large-scale development in the South and West

- What is different about houses in the South and the West from those in the North and the East?

1990's *Energy Codes* for water heaters and fixtures

- Fixture flow rates reduced to less than 2.5 gpm

Inadvertent Conflict Between the Plumbing and Energy Codes

1970 - Today

- Median US home increased from 1600 to 2400 square feet
- Distance to the furthest fixture increased from 30 to 80 feet
- Number of hot water fixtures increased from 6 to 12
- More baths with high flow rate requirements

Result - 18 times as long to get hot water

- Pipe area increased by 3, velocity reduced by 3
- Fixture flow rate reduced by 3, velocity reduced by 3
- Distance increased by at least 2, time increased by 2

Water, energy and time are wasted while waiting

Water Wastes

- Structural Waste
  - Determined by the plumbing in the house (pipe length and size, pressure, insulation, etc.)
- Behavioral Waste
  - Multi-tasking while waiting for hot water to arrive at the fixture.

Larger structural wastes (longer wait times) lead to more behavioral waste.

Annual Water and Energy Waste

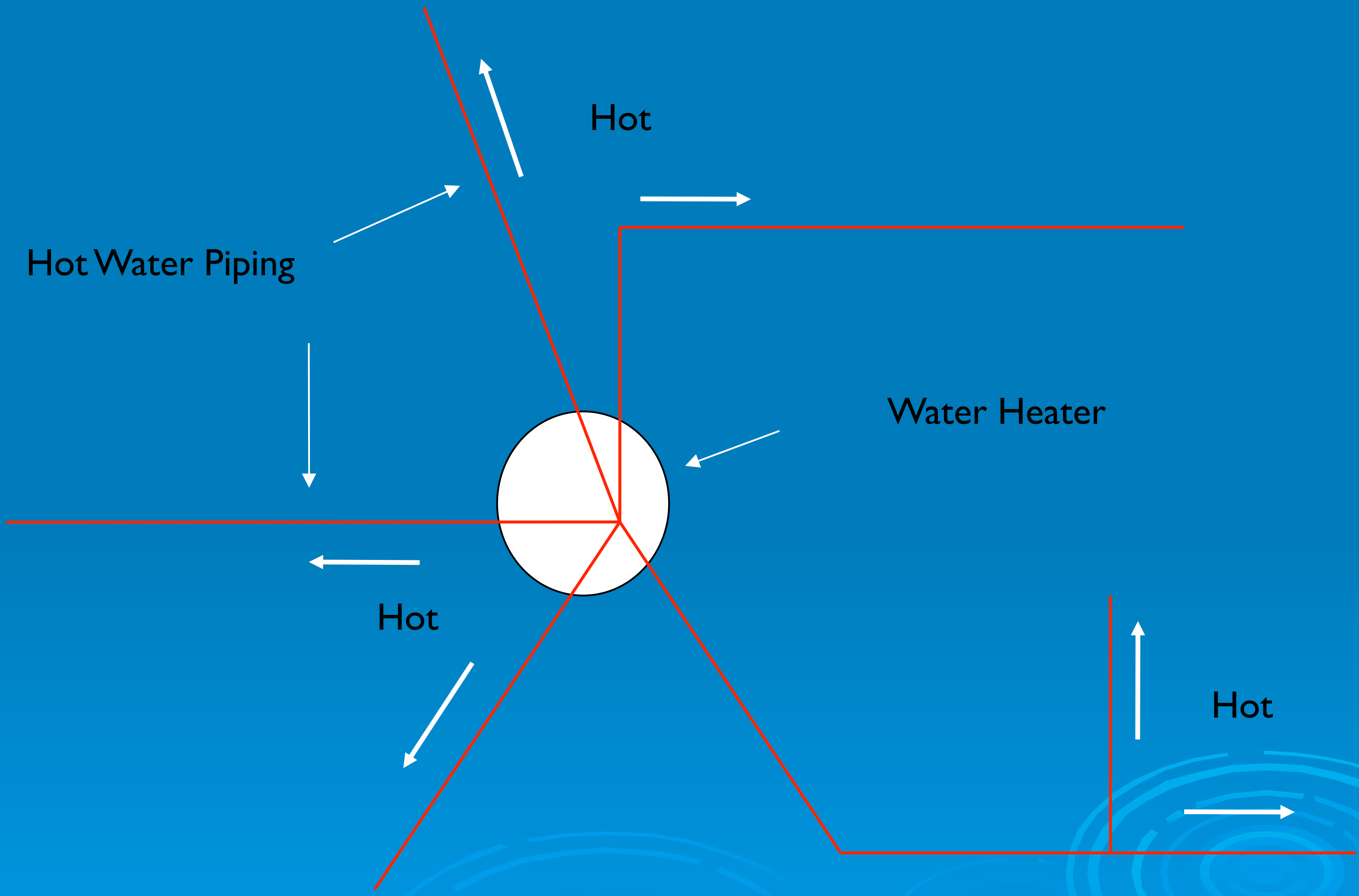
Annual Water Waste and Cost

(Combined water and sewer $0.005/gallon, rounded off, US prices, 2002)

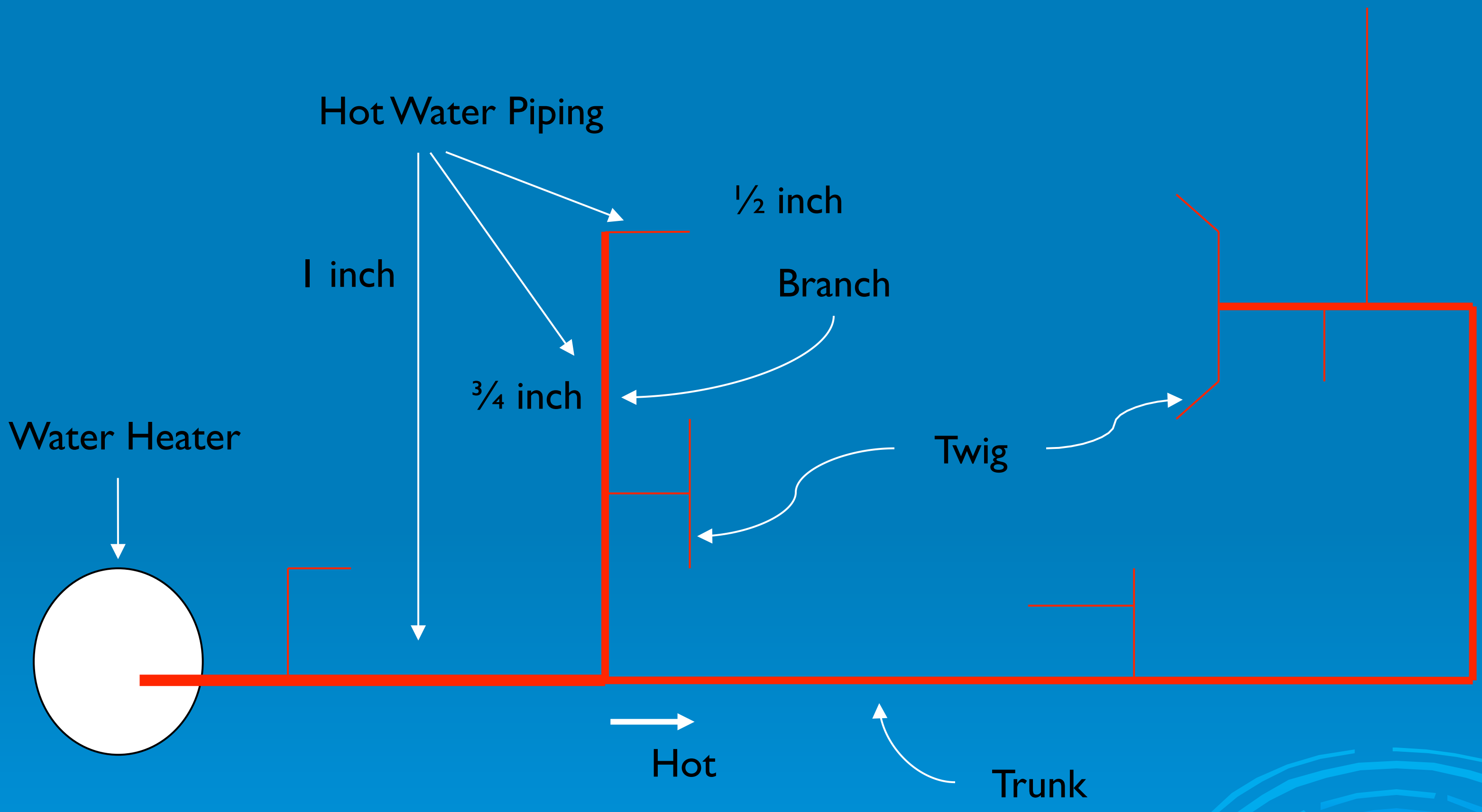
	Water Waste	Cost (Water and Sewer)
5 Gallons Per Day (8%)	1825 gallons	$9
10 Gallons Per Day (17%)	3650 gallons	$18
20 Gallons Per Day (33%)	7300 gallons	$36

Which distribution system is best?

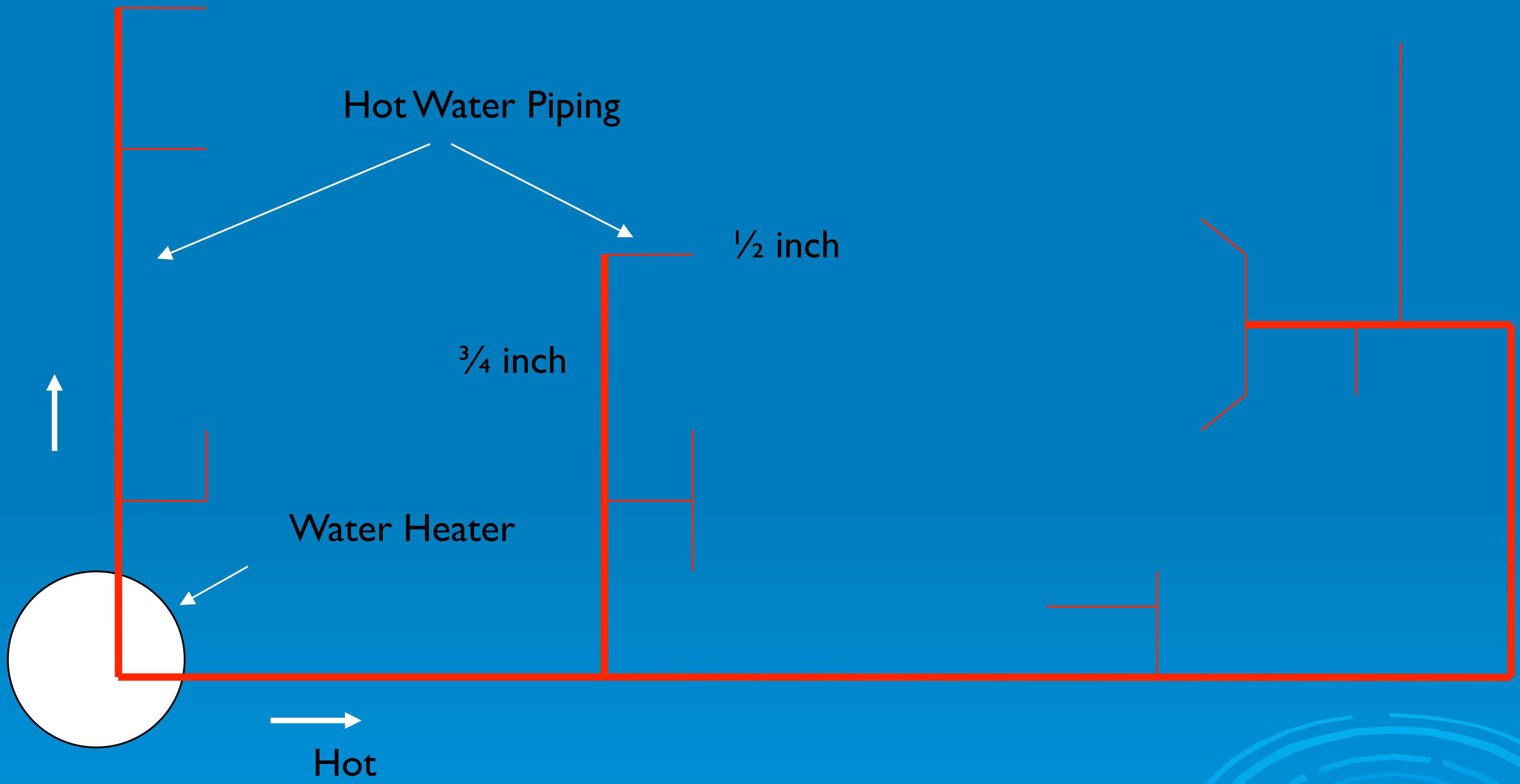
Radial, Manifold, Parallel Pipe-
Central Core



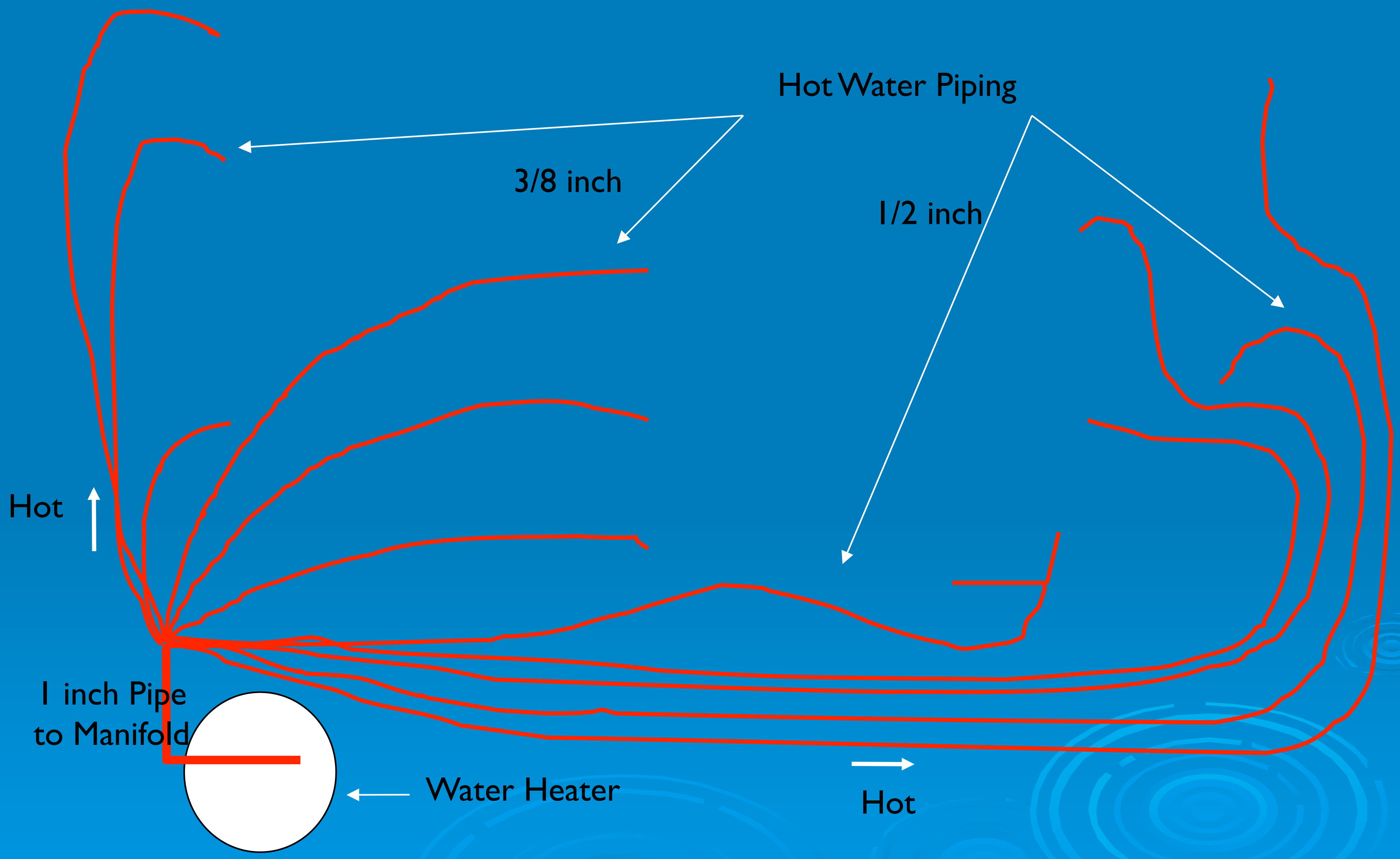
Single Trunk, Branch and Twig



Multiple Trunk, Branch and Twig



Radial, Manifold, Parallel Pipe- Distributed



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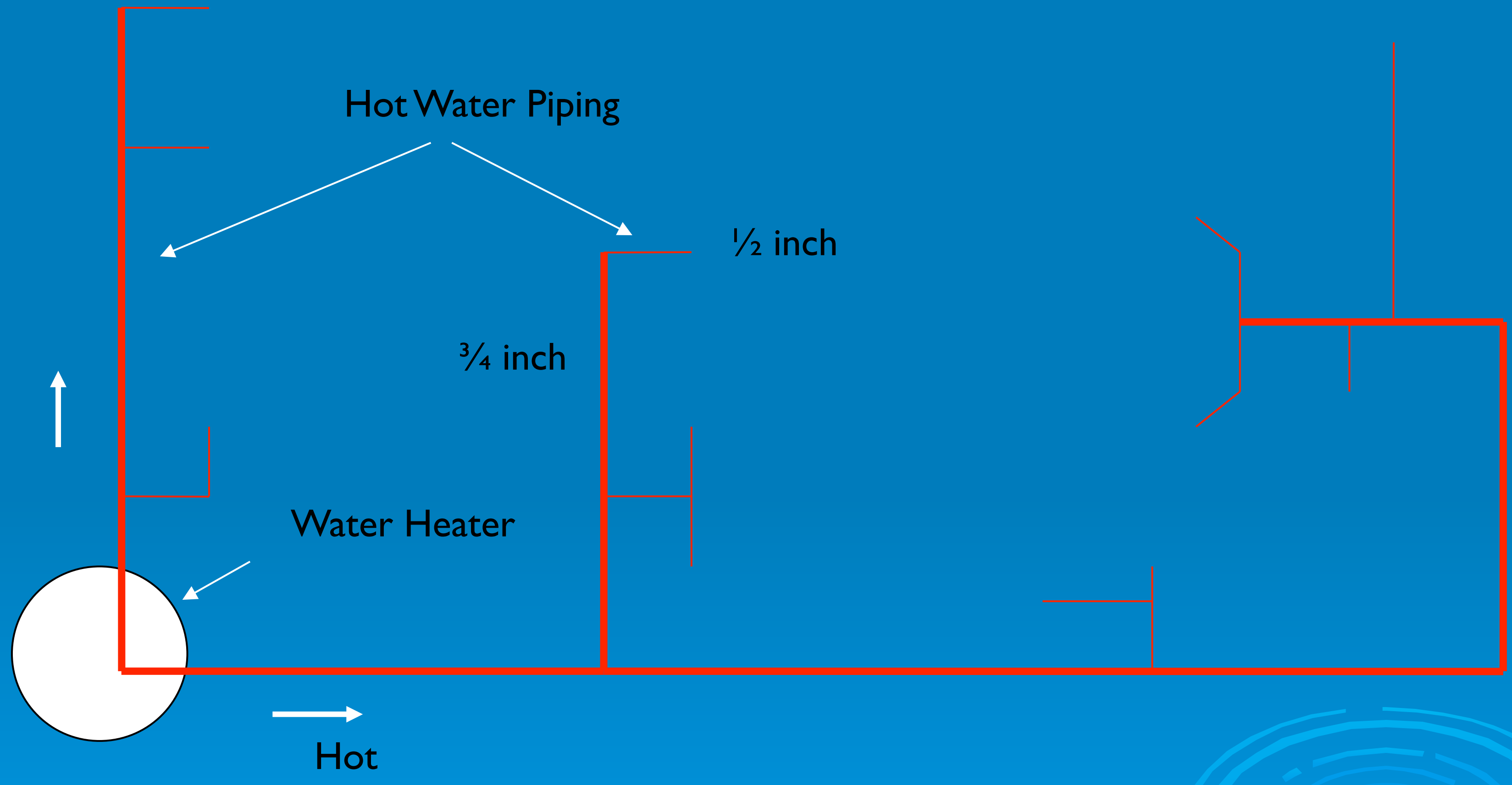
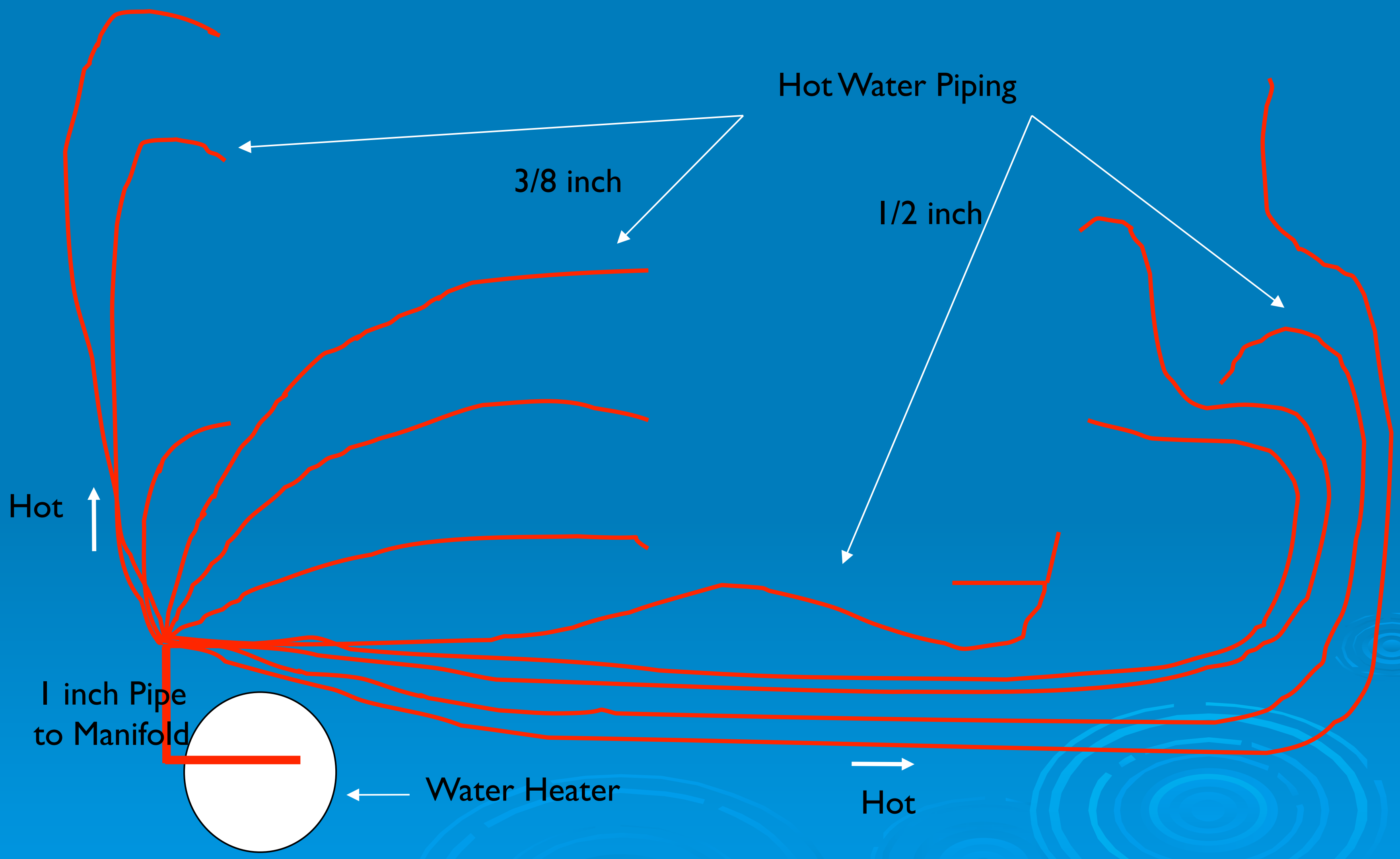
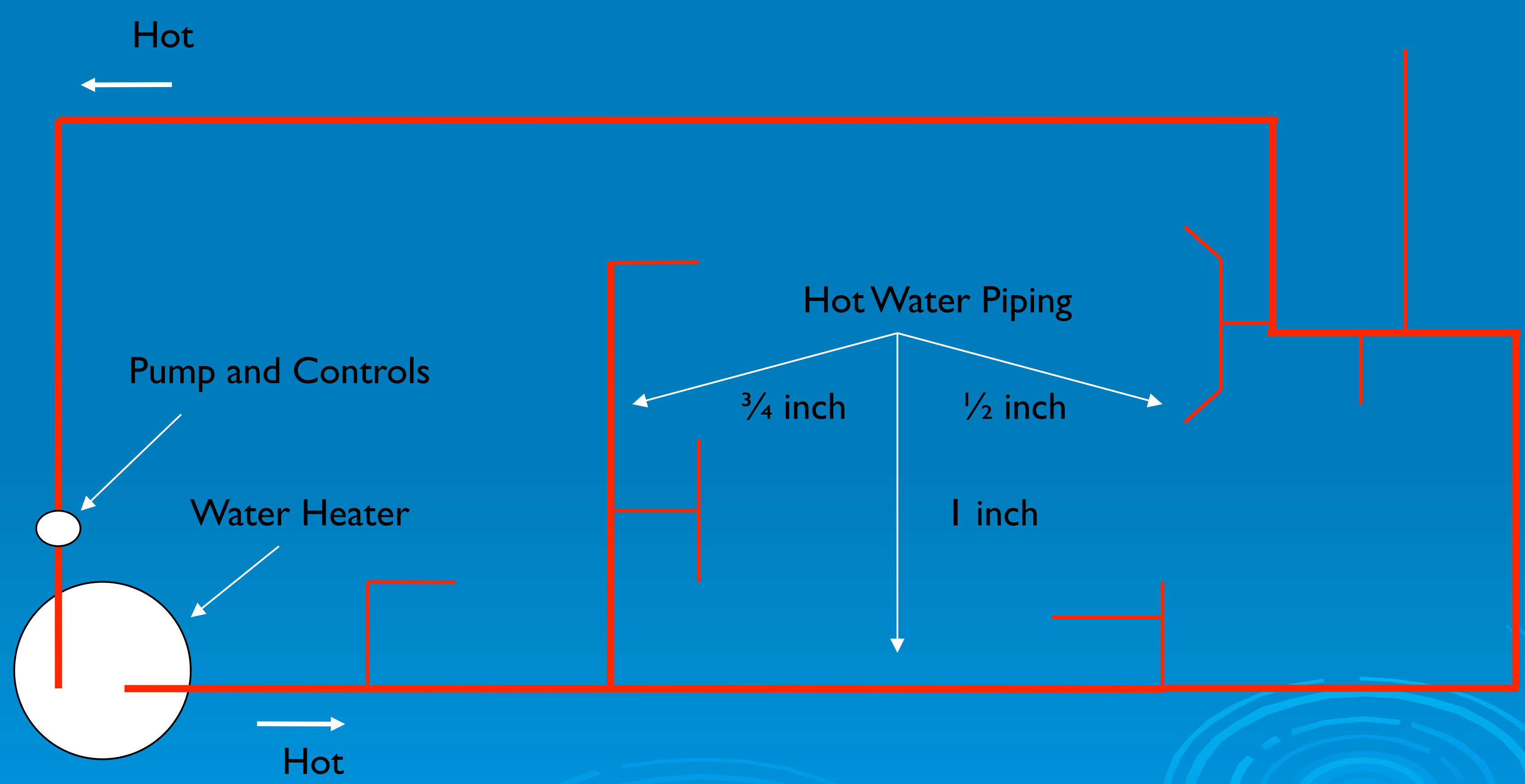


Radial, Manifold, Parallel Pipe- Distributed



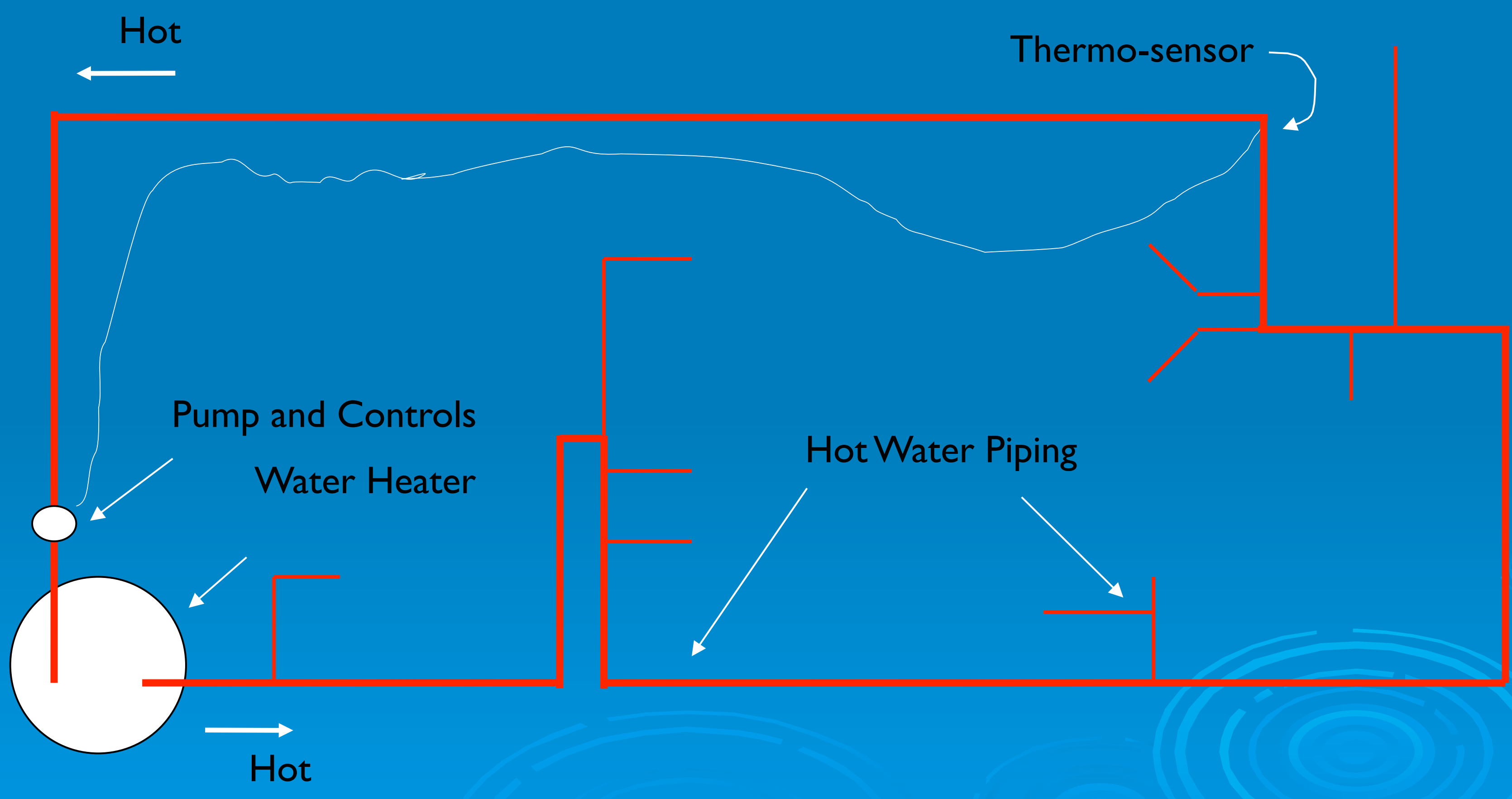
Standard Recirculation
Fully Heated Loop



Standard Recirculation

Half Heated Loop

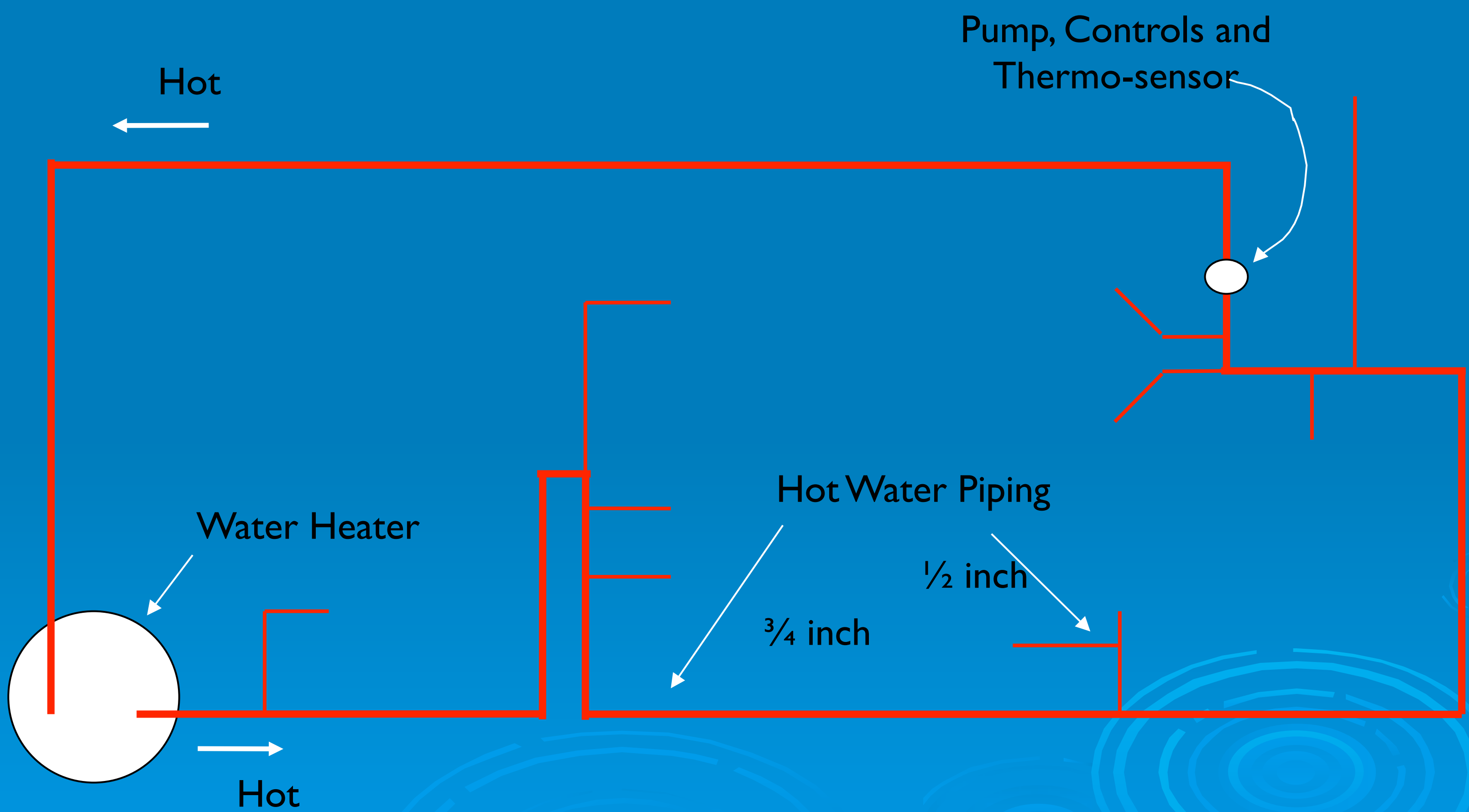
Pump Separated from Thermo-sensor



Standard Recirculation

Half Heated Loop

Pump Located with Thermo-sensor



Plumbing Layouts to Avoid:

Poorly conceived and installed:

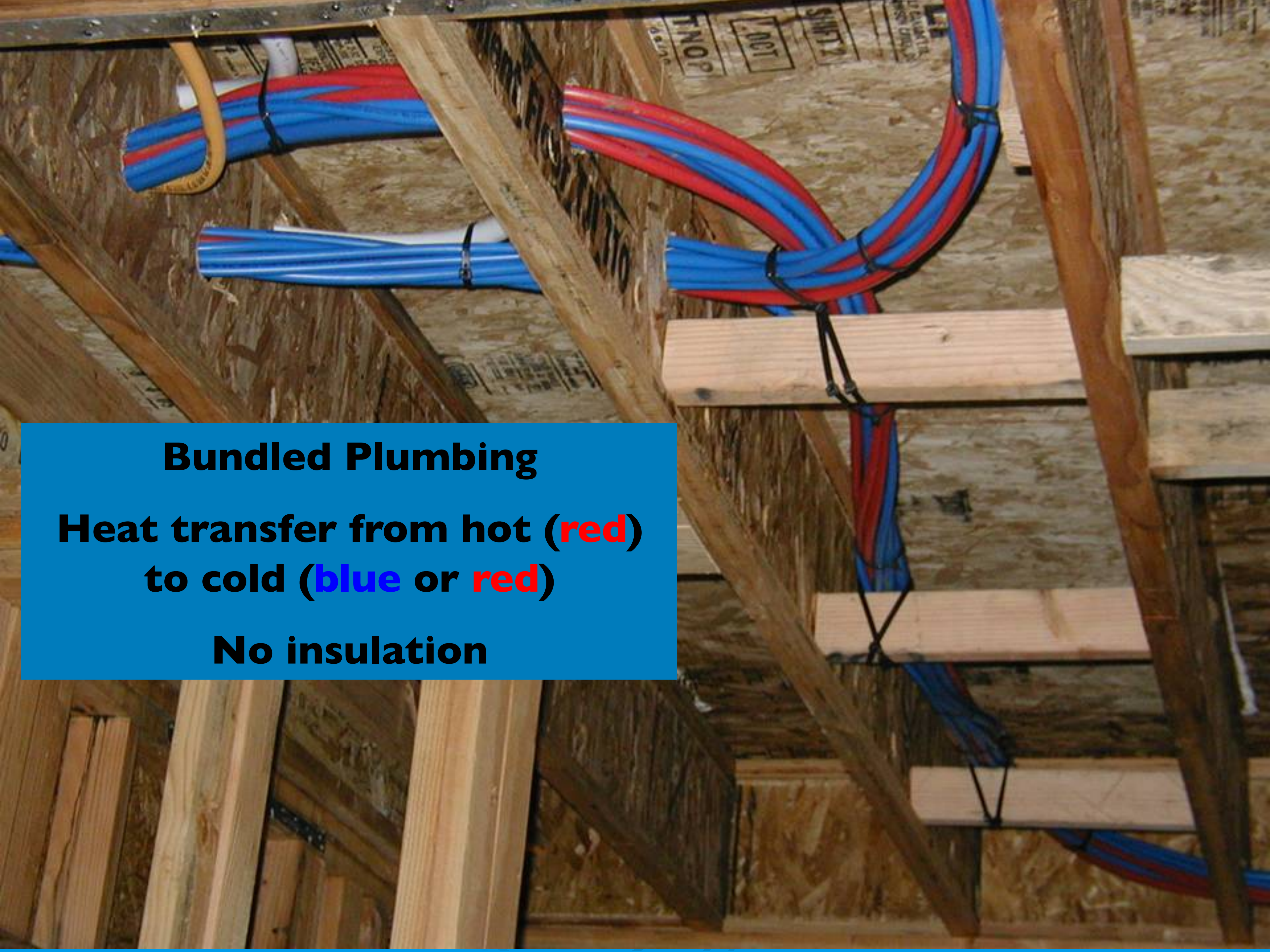
- Manifold, parallel pipe, or home-run plumbing layouts
- Under slab plumbing layouts

Distance from Water Heater to Manifold:

Actual Distance: 14 ft

Most Direct: 11 ft

Shortest: 5 ft



Bundled Plumbing

Heat transfer from hot (red) to cold (blue or red)

No insulation

Improving Hot Water Distribution Systems

Guiding Principle

Provide people what they want...

The Service of Hot Water

with what they expect…

Safety, Reliability and Convenience

as efficiently as possible

According to the research…

<u>Water</u> is wasted:

- Based on the volume of water between the source of hot water and the fixture.
- At low flow rates (really low face velocities), even *more* water that is wasted.
  - Low face velocities are caused by:
    - Large pipes
    - Flow restrictions in the plumbing
    - Low flow fixtures
    - Partially open fixtures

According to the research…

Energy is wasted:

- When water is wasted. This is true both in the building (pressurizing and heating) and in the water use cycle.
- When overcoming the heat losses in the piping.
  - Heat losses increase with:
    - Longer pipes
    - Larger diameter pipes
    - Slower face velocities
    - Less insulation
    - Worse ambient environment surround the pipes

The Ideal
Hot Water Distribution System

- Has the smallest volume (length and smallest "possible" diameter) of water in the pipe from the source of hot water to the fixture.
- Sometimes the source of hot water is the water heater, sometimes a trunk line.
- For a given layout (floor plan) of hot water locations the system will have:
  - The shortest buildable pipes
  - The fewest plumbing restrictions
  - Insulation on all hot water pipes, minimum R-4

The Challenge

Deliver hot water
to every fixture or appliance
wasting no more energy
than we currently waste and
wasting no more than 1 cup
waiting for the hot water to arrive.

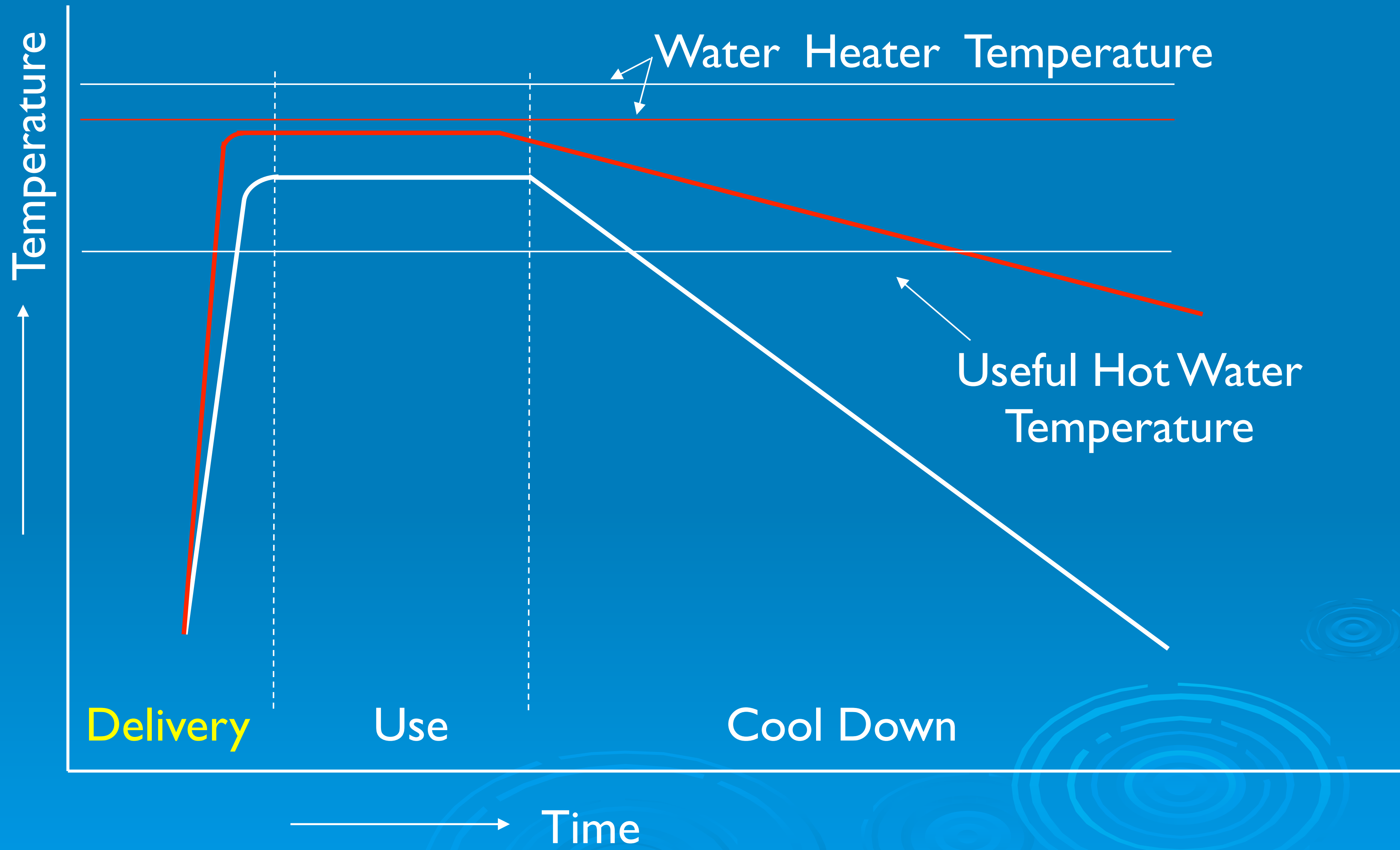
Question:

If you want to waste no more than 1 cup while waiting for hot water to arrive, what is the maximum amount of water that can be in the pipe that is not usefully hot?

Answer:

1 cup = 8 ounces = 1/16th gallon = 0.0625 gallon

Improved Hot Water Event



To Improve the Delivery Phase:

Get hotter water sooner by
minimizing the waste of water, energy & time

- Reduce the volume of water in the pipe (smaller diameter, shorter length)
- Reduce the number of restrictions to flow (decrease “effective length”)
- Increase the flow rate
- Insulate the pipe (becomes critical for very low flow rates and adverse environmental conditions)

Improved Hot Water Event