Design Considerations for Hot Water Plumbing

An Online Continuing Education Course for Engineers

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Design Considerations for Hot Water Plumbing

A. Bhatia, Mechanical Engineer

Introduction

Heating water is typically the second largest use of energy in residential and commercial buildings (after space heating and cooling). Despite its resource intensity, the hot water delivery system is seldom an area of significant focus when constructing a building. As a result, many buildings today are built with poor performing, inefficient hot water delivery systems that take minutes to deliver hot water to the point of use and waste large amounts of energy and water in the process.

The key to proper water heating system design is to correctly identify the quantity, temperature and time characteristics of the hot water requirement. The goal is to reduce hot water wait time to 10 seconds or less, which is considered acceptable for public lavatories. A wait time of 11 to 30 seconds is considered borderline, and a wait time of 30 seconds or more is unacceptable.

This course will outline the design strategies that will deliver hot water as efficiently as possible while meeting the increasingly challenging regulatory codes and user expectations.

The course is divided into nine sections:

- PART – 1: Estimating Hot Water Demand
- PART – 2: Hot Water Generation - Water Heaters
- PART - 3: Sizing Storage Water Heaters
- PART - 4: Hot Water System Design
- PART - 5: Hot Water Plumbing System Installation & Layouts
- PART - 6: Sizing Hot Water Circulator and Piping
- PART - 7: Hot Water Temperature Control
- PART - 8: Facts, Formulas and Good Engineering Practices
- PART - 9: Regulatory Standards and Codes

PART -1 ESTIMATING HOT WATER DEMAND

An adequate supply of hot water is a must for showers, kitchens, bathrooms, washing machines, dishwashers and other appliances in homes, motels, hotels or commercial buildings. Users expect hot water in adequate amounts, just as they expect lights at the flick of a switch. The improper sizing and design of hot water supply will invariably lead to dissatisfaction and/or wasteful energy expenses.

SIZING HOT WATER DEMANDS

The information on sizing potable water (cold and hot water) is defined in the American Society of Heating, Refrigeration and Air Conditioning Engineers ASHRAE Applications Handbook, the Uniform Plumbing Code (UPC), and the American Society of Plumbing Engineers (ASPE) handbooks. All of these criteria take into consideration people use factors: people socio-economic factors, facility types, fixture types, and a host of other factors.

Before we proceed, let's define a few important terms:

1. **Fixture -** A device for the distribution and use of water in a building. For example: shower, urinal, fountain, shower, sink, water faucet, tap, hose bibs, hydrant, etc.
2. **Maximum Possible Flow** –The flow that occurs when all fixtures are opened simultaneously. Since most plumbing fixtures are used intermittently and the time in operation is relatively small, it is not necessary to design for the maximum possible load.
3. **Maximum Probable Flow –**The flow that occurs under peak conditions for the fixtures that are expected to be in use simultaneously and NOT the total combined flow with all fixtures wide open at the same time. The probability that all fixtures will be used in a building at the same moment is quite remote. Generally, as the number of fixtures increases, the probability of their simultaneous use decreases. The plumbing system is normally designed on probability theory. If pipe sizes are calculated assuming that all taps are open simultaneously, the heater size and the pipe diameters will be prohibitively large, economically unviable and unnecessary. Maximum probable flow is also referred to as "peak demand" or "maximum expected flow".
4. **Intermittent Demand** – Plumbing fixtures that draw water for relatively short periods of time are considered an intermittent demand. Examples include bathroom fixtures, kitchen sinks, laundry trays and washing machines. Each fixture has its own singular loading effect on the system, which is determined by the rate of water supply required, the duration of each use, and the frequency of use.

METHOD – 1

Estimating Hot Water Demand on Fixture Units

The fixture unit concept is based on the theory of probability. The method is based on assigning fixture unit (w.s.f.u) value to each type of fixture based on its *rate of water consumption*, or the *length of time* it is normally in use and on the *average period between successive uses*. All of the factors together determine the maximum probable rate of flow. Table -1 lists the demand weights in "fixture units" as determined by the National Bureau of Standards.

TABLE 1

Demand weights of plumbing items in 'water supply fixture unit, w.s.f.u

Fixture or Group	Occupancy	Total Building Supply HW & CW	Cold Water (CW) only	Hot Water (HW) only
Water Closet (Flush Valve)	Public	10	10	--
Water Closet (Flush Tank)	Public	5	5	--
Pedestal Urinal (Flush Valve)	Public	10	10	--
Stall or Wall Urinal (Flush valve)	Public	5	5	--
Stall or Wall Urinal (Flush Tank)	Public	3	3	--
Lavatory (Faucet)	Public	2	1-1/2	1-1/2
Bathtub (Faucet)	Public	4	3	3
Shower Head (Mix valve)	Public	4	3	3
Service Sink (Faucet)	Office	3	2-1/4	2-1/4
Kitchen Sink (Faucet)	Hotel/ Restaurant	4	3	3
Water Closet (Flush valve)	Private	6	6	--
Water Closet (Flush tank)	Private	3	3	--
Lavatory (Faucet)	Private	1	¾	
Bathtub (Faucet)	Private	2	1-1/2	1-1/2
Shower Head (Mix valve)	Private	2	1-1/2	1-1/2
Shower (Mix valve)	Private	2	1-1/2	1-1/2
Kitchen Sink (Faucet)	Private	2	1-1/2	1-1/2
Laundry Trays (Faucet)	Private	3	2-1/4	2-1/4
Combination Fixture (Faucet)	Private	3	2-1/4	2-1/4
Washer	Private	4	3	3

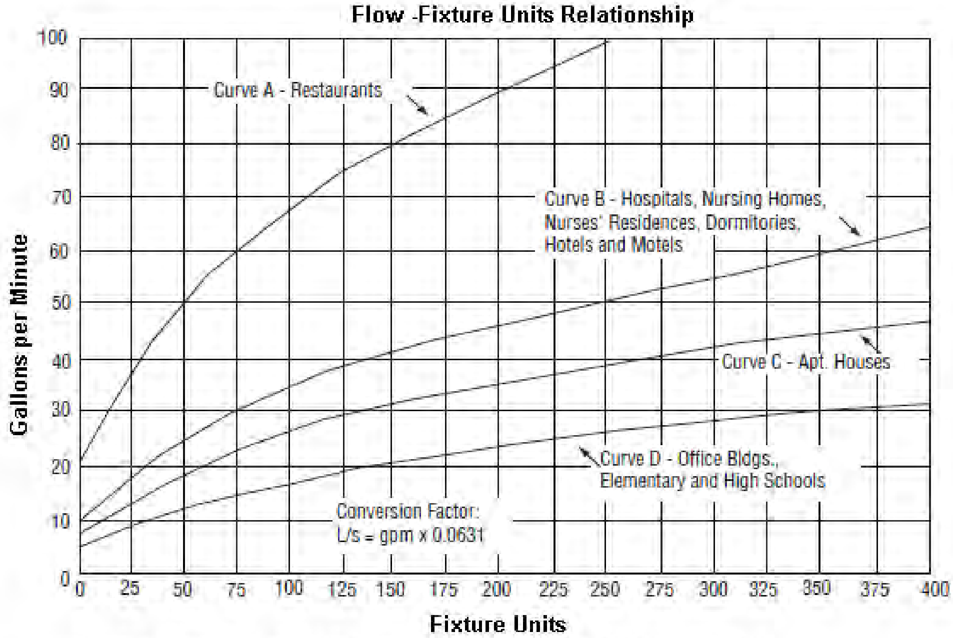
Source: National Bureau of Standard Reports: BMS 65 by Dr. R. B. Hunter

From the preceding table, the designer can assign fixture unit weights to the specific fixtures in the design. When these are added, their total provides a basis for determining the maximum probable flow that may be expected in a water pipe. As a rule, separate hot and cold water demand can be taken as ¾ the total portable water demand; for example, a lavatory faucet with a total demand of two w.s.f.u would be counted as 1½ fixture units on the cold water system, and 1½ fixture unit on the hot water. Supply piping would be calculated accordingly, while the total figure of two fixture units would be used to design the drainage piping.

Fixture Unit – Flow Relationship

Once the total fixture count is obtained, the next step is to correlate this to the probable flow. In buildings with normal usage, the probability of simultaneous flow is based on the statistical methods derived from the total number of draw-off points, the average times between draw-offs on each occasion and the time interval between occasion of use . There is a complex formula to get the probable water demand, but a simple chart and able are used to determine the probable water. The following figure shows the probability of flow as a function of fixture unit count.

Figure -1
Flow -Fixture Units Relationship



(Source: Figure:24, ASHRAE Applications Handbook,2003, Chapter 45)

Sum up the fixture units for your application. Enter from the bottom on the X-axis and then read up to the curve that best fits the application. Read to the left for the corresponding gallons per minute (gpm) requirement. Pipe size can then be calculated by referring to the pipe flowchart, which depicts the relationship between the flow in gpm to the pipe diameter in inches.

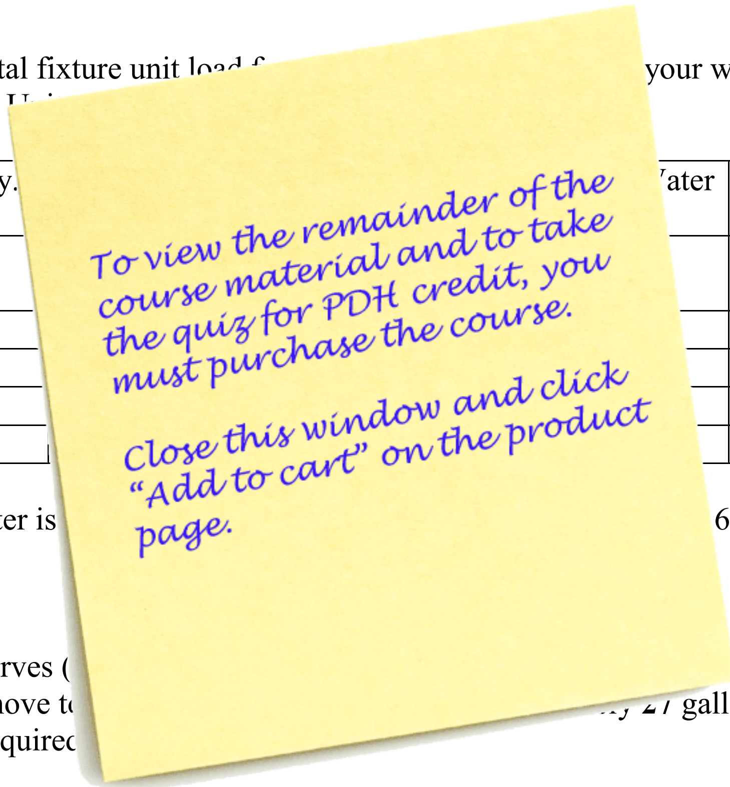
Example

Estimate the hot water flow rate for a small hotel building consisting of 52 flush valve water closets, 30 flush valve urinals, and 40 lavatories.

Solution

<u>Step 1</u>

Determine the total fixture unit load f... your water heater application using the Fixture U...



Fixture Type	Qty.		ater	Total (Hot & Cold)
WC (flush valve)	52			520
Urinals	30			150
Lavatories	40			80
Lavatories	40			
Total				750 f/u

Since the hot water is ... 60.

<u>Step 2</u>

Using Hunter Curves (... ture units and go up to curve C. Then, move t... 27 gallons per minute of hot water capacity required...

<u>**Caution**</u>

The fixture count method is based on the theory of probability. This method is considered accurate for large groups of fixtures, but for smaller applications, this may yield erroneous results. The reader is advised to use discretion and to refer to local codes and standards.

The flow probability as a function of fixture units will also vary with the type of facility, and it depends on the usage time duration and other specific requirements. A 100% simultaneous draw-off may occur in buildings such as factory wash-rooms, hostel toilets, showers in sports facilities, places of worship, etc. In these cases, all fixtures are likely to be open at the same time during entry, exit and recess.