UNITED STATES MARINE CORPS
Utilities Instruction Company
Marine Corps Engineer School
PSC Box 20069
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U-05C01
OCT 99

STUDENT HANDOUT

PLUMBING SYSTEM

TERMINAL LEARNING OBJECTIVE: Provided construction blueprint and the references, plan plumbing system. The plumbing system will be planned so that it will provide for the installation of all plumbing facilities specified in the construction blueprint per the reference. (1169.4.15)

ENABLING LEARNING OBJECTIVE:

(1) Given a construction print, with the aid of references, draw in the water supply lines needed for the plumbing system in accordance with FM 5-420. (1169.4.15a)

(2) Given a construction print, with the aid of references, draw in the drain lines needed for the plumbing system in accordance with FM 5-420. (1169.4.15b)

(3) Given a construction print, with the aid of references, draw in the vent lines needed for the plumbing system in accordance with FM 5-420. (1169.4.15c)

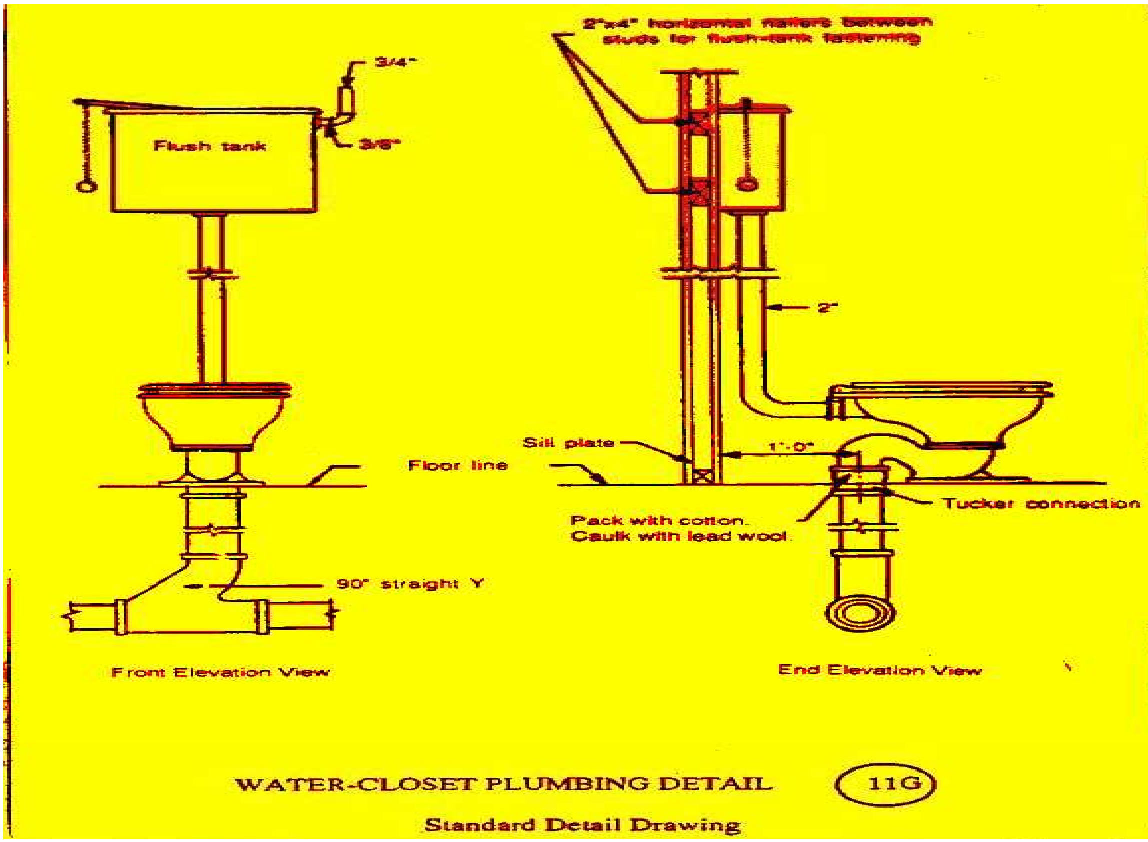
(4) Given a construction print, with the aid of references, draw in the plumbing fixtures needed for the plumbing system in accordance with FM 5-420. (1169.4.15d)

(5) Given a construction print, with the aid of references, list the material required to install the plumbing system in accordance with FM 5-420. (1169.4.15e)

1. PLUMBING SYSTEMS:

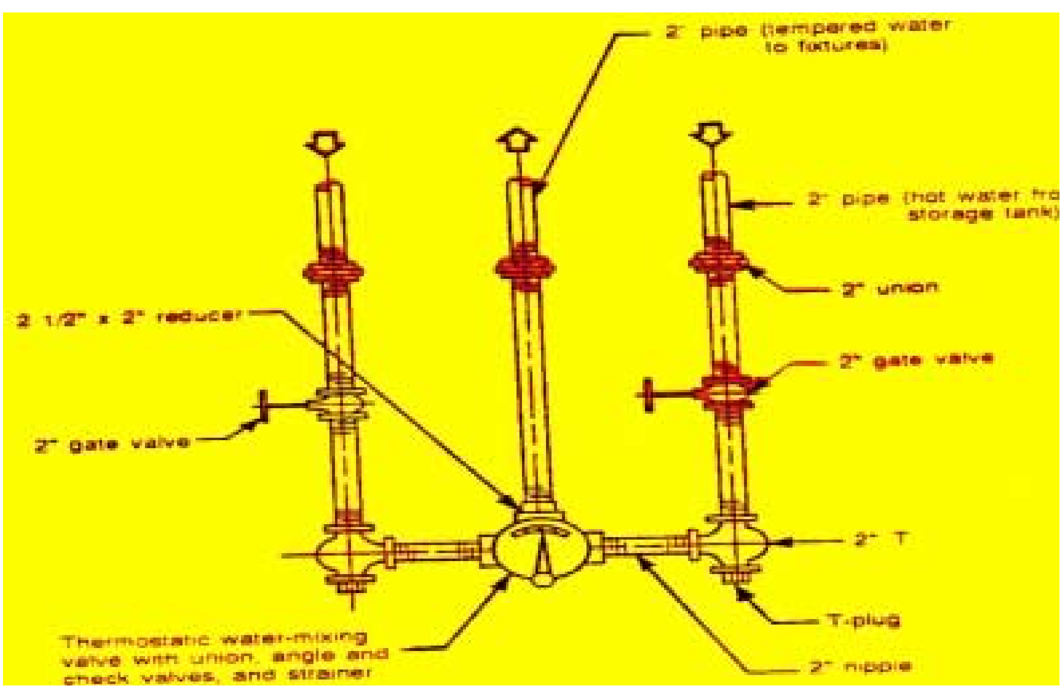
a. Plumbing is a system of piping, apparatus, and fixtures for water distribution and waste disposal within a building. When architects design a building, they prepare a set of blueprints drawn to scale, with actual dimensions annotated and specification sheets detailing the type and quality of materials to be used. Plumbers use these prints and specifications to layout and plan the project. The architect’s design list three sources of additional information such as: a standard detail drawing, a special detail drawing, a bill of materials, and sometimes plumbing symbols.

b. Standard Details Drawing: Indicated by a number and a letter in a circle.



ILLUSTRATIVE EXAMPLE: *11G - The standard details drawing shows the way to support the flush tank, how to join the water pipe to the flush tank, and all other necessary information not shown on the utility plan.*

c. Special Details Drawing: Indicated to call out a specific spot on a plan.



ILLUSTRATIVE EXAMPLE: *"DETAIL 6" - The special details drawing shows the shower head and control valve fitting requirements.*

2. Main water supply line:

a. The main water supply system provides drinkable cold water, at the main. The water service line for the plumbing installation taps into the street main. The supply water from the main can be under pressure up to 160 (PSI). Pressure into the buildings main usually ranges from 40 to 55 (PSI). If the pressure is over 60 PSI, a pressure reducing valve must be placed in the water service line where it enters the building. The factors that will effect the water supply line are; the size of the water supply line, rate of use, length of the line, the height of the outlet in the system control and the pressure available at the outlet.

b. Sizing the main water service line: Some of the factors which affect the size of the water supply line in a plumbing system are the types of flush devices on the fixtures, the pressure of the water supply in pounds per square inch, the length of the pipe in the building, the number and kind of fixtures installed, and the number of fixtures used at any given time. Pipe friction causes a drop in pressure of the water flowing through the pipe. In a small pipe this friction loss may be overcome by supplying water at a higher pressure than would normally be needed. Water normally enters into the building through a ¾ or 1 inch pipe. If higher water pressure is not available, increasing the pipe size will reduce friction loss. The plumbing system must provide enough water for normal use at each outlet after it leaves the water main. The maximum fixture demand and the factor of simultaneous use are calculated to determine the size of the pipes needed.

(1) Maximum fixture demand: The maximum fixture demand in gallons is the total amount of water, which would be needed to supply all fixtures if they were being used simultaneously for one minute. Since it is unlikely that all fixtures would be turned on at once, a probable percentage of the fixtures, which will be in use at any given time, must be found. This is called the factor of simultaneous use. To estimate the maximum fixture demand in gallons, the number and type of all fixtures in the complete plumbing system must be known.

MAXIMUM FIXTURE DEMAND	
Fixture	Gallons per Minute
Water Closet	45
Urinal	37.5
Slop Sink	22.5
Shower	15
Laundry Tub	15
Floor Drain	7.5
Lavatory	7.5

(2) Factors of simultaneous use: The more fixtures in a building, the smaller the possibility that all will be used at the same time. Simultaneous use factors decrease as the number of fixtures increase. The factor of simultaneous use is only an estimate.

FACTORS OF SIMULTANEOUS USE	
No. of Fixtures	Percent of Simultaneous Use
1-4 5-50 51 or more	50-100 25-50 10-25

(NOTE: IF A TABLE FOR THE FACTOR OF SIMULTANEOUS USE IS NOT AVAILABLE, ESTIMATE THE PROBABLE DEMAND BY COMPUTING 30% OF THE MAXIMUM FIXTURE DEMAND IN GALLONS.)

ILLUSTRATIVE EXAMPLE: *What is the maximum fixture demand for a plumbing system consisting of 14 fixtures as follows: two water closets, four lavatories, two showers, three urinals, one slop sink, one laundry tub, and one floor drain?*

Step 1: *Multiply the number of fixtures by the GPM of that type fixture.*

Step 2: *Total these figures.*

Result: *A maximum fixture demand of 307.5 gallons per minute.*

(NOTE: Use the maximum fixture demand (307.5 GPM)with the factors 0f simultaneous use to select the size pipe.)

ILLUSTRATIVE EXAMPLE: *The simultaneous use for the fourteen fixtures is about 35%. Since the fixture demand was 307.5 GPM, the water service line must have a capacity of 35% of 307.5 (107.6 gpm).What size pipe would you need for a 60-foot long pipeline with a pressure at the main of 45 psi?*

Step 1: *Read down the 60-foot column in Table to **1-1/2** inch diameter.*

Step 2: *Read across (left) to the psi column and establish the given **45** psi*
Step 3: *Read back to the 60-foot column. The table shows **155** GPM (the quantity that includes 107 GPM).*

Pipe Size: *Either 1-1/2 inch galvanized, copper, or plastic piping would be large enough for the water service line.*

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¾ INCH

Length of pipe in feet										
Pressure at source in pounds per square inch	**20**	**40**	**60**	**80**	**100**	**120**	**140**	**160**	**180**	**200**
10	**20**	**14**	**10**	**10**	**8**	**8**	**6**	**6**	**6**	**5**

20	30	20	16	14	12	10	10	10	8	8
30	36	26	20	17	15	14	13	11	10	8
40		30	24	20	18	16	15	14	13	12
50		34	28	24	20	18	16	16	14	14
60		36	30	24	22	20	18	18	16	16
70			32	28	24	22	20	18	18	16
80			36	30	26	24	22	20	18	18

1 INCH

Length of pipe in feet										
Pressure at source in pounds per square inch	20	40	60	80	100	120	140	160	180	200
10	50	30	24	20	18	16	14	14	12	12
20	70	45	36	30	26	24	22	20	18	18
30	80	55	45	38	34	30	28	26	24	22
40		65	55	45	40	36	32	30	28	26
50		75	60	50	45	40	36	34	32	30
60		80	65	55	50	45	40	38	36	34
70			70	60	55	50	45	40	38	36
80			80	65	60	50	50	45	40	40

1-1/2 INCH

Length of pipe in feet										
Pressure at source in pounds per square inch	20	40	**60**	80	100	120	140	160	180	200
10	130	90	**70**	60	50	45	40	40	35	35
20	170	130	**100**	90	75	70	65	60	55	50

30		170	**130**	110	100	90	80	75	70	65
40			***155***	130	115	105	95	88	80	77
50			170	150	130	120	108	100	90	88

b. Water service line: The water service line enters from the main water supply line into the basement or through the sub-floor of the building, the branches that are connected serve the fixture risers. It has the same diameter as the water service from the main and is centrally located to provide short takeoffs to fixture supply risers throughout the building. The main supply piping must be laid as straight as possible to reduce friction loss. It must not sag or trap water. The main supply pipe must be well supported to take its weight off the fittings and to prevent future leaks.

c. Fixtures supply riser: Fixture supply risers are pipes of a smaller diameter taken off the main supply to furnish water to the fixtures on each level of the plumbing system. They are connected to the main supply by reducing tees. Fixture supply risers are run through the interior walls of the building. All joints should be made up tight before the partitions are finished.

(1) All vertical fixture supply risers should be supported at each floor level by pipe rests or clamps and never depend upon the horizontal branches for support.

(2) Horizontal fixture branches should be well supported and graded upward toward the vertical fixture supply risers.

(3) Gate valves may be installed in each vertical supply riser so any given section can be repaired without shutting off the water to other sections. Small individual valves on the water supplies of each fixture allow shutting off the water for faucet repairs.

(4) Each individual fixture supply riser must have a diameter big enough to supply water to all the connected fixtures. Listed below are the pipe diameters for various plumbing fixtures.

Fixture	Pipe Diameter (inches)
Lavatory	½
Shower	½
Bathtub	½
Kitchen Sink	½
Slop Sink	½
Scullery Sink	¾
Laundry Tub	½
Drinking Fountain	½
Water Closet Tank	½
Urinal with Diaphragm type flushometer	½
Water Closet Tank Diaphragm type flushometer	½

Dishwasher	¾
Hot water heater (domestic)	¾

(NOTE: Cold water systems may be made of galvanized pipe, plastic pipe, or copper tubing. The material used in any given system depends upon the amount of water to be supplied, the amount of pressure under which the water is to be furnished, the corrosion factor which affects different types of pipe in different degrees and the cost of the various materials. Sometimes, cast-iron pipe is used in the water service from the main; however, galvanized, copper, or plastic pipe is used more widely. Copper resists corrosion better than galvanized pipe).

3. House drain lines:

a. A house or building sewer is that part of the sanitary sewer system beginning just outside the building foundation wall and ends at the main sewer in the street or at a septic tank. A house sewer carries liquid or waterborne wastes from the house drain to the main sewer lines.

b. Sizing the house sewer - The waste system is sized by drainage fixture unit value or (DFU). Each plumbing fixture is given a unit value, which helps determine the pipe size. To find the correct size of the pipe, plan the slope of the pipeline by counting the total number of DFU's emptying into a horizontal drain line. The DFU's for standard fixtures are shown below.

DRAINAGE FIXTURE UNIT VALUES	
Fixture	Unit Value (DFUs)
Lavatory or washbasin	1
Drinking fountain	1
Floor drain	2
Kitchen sink	2
Bathtub	2
Laundry tub	2
Shower	2
Slop sink	3
Urinal	5
Water closet, public	6
Water closet, private	4

(NOTE: The discharge of a plumbing fixture is figured in drainage fixture units (DFU's). One (DFU) represents approximately 7.5 gallons of water (1 cubic foot) discharged per minute.)

HORIZONTAL SANITARY DRAIN CAPACITY IN FIXTURE UNITS			
Size of Pipe (inches)	Slope (Fall per Foot in Inches)		
	1/8	¼	1/2
1 ¼	1	1	1
1 ½	2	2	3

2	5	6(**a**)	8(**a**)
3	15(**b**)	18(**b**)	21(**b**)
4	84	96	114
5	162	216	264
6	300	450	600
8	990	1,392	2,200
10	1,800	2,520	3,900
12	3,804	4,320	6,912
(**a**) No water closet will discharge into a pipe smaller than three inches (includes DWV type copper tubing). (**b**) No more than two water closets will discharge into any 3-inch horizontal branch, house drain, or house sewer.			

ILLUSTRATIVE EXAMPLE: *Assume that a plumbing installation consists of two water closets, four lavatories, two shower heads, three urinals, one slop sink, one laundry tub, and one floor drain. Determine the discharge in DFUs using the Tables shown above. Assume that the cast-iron house drain will have a slope of ¼ inch per foot.*

STEP 1: *Multiply the number of each fixture by its DFU value from the DFUs Table above, for a total of **42** DFU's.*

STEP 2: *Read down the ¼ inch column in the Horizontal sanitary drain capacity Table. The fixture unit capacity next higher than 42 is **96**.*

STEP 3: *Read horizontally across to the left to **4** inches.*

RESULTS: *The minimum pipe size required is **4** inches.*

(NOTE: The house drain must be large enough to carry off all the water and waste materials which maybe discharged into it at any one time. Using a size larger than required does not make the drain more efficient. When liquid and soil waste passes through a horizontal pipe, a natural scouring action results. The action is partially lost when the size of the drainpipe is increased. The water flow within the larger pipe is shallow and slow, and solids tend to settle to the bottom. A pipe flowing half full, under normal use has a natural scouring action and can carry peak loads if required. The minimum size house drain should be 4".)

c. Grading the house sewer: Whenever possible, house sewers are graded to a slope of ¼ inch per foot. Greater or lesser slopes are permitted when conditions require them. Trenches dug for house sewers may be graded with surveying instruments or by the batter board method.

d. House drains: The house drain is located between partition walls and is connected to the building drain and the house sewer. The house drain, also called the "collection line", receives the discharge of sanitary and domestic wastes from the building drain and carries it to the house sewer. It may be placed underground or suspended from the basement ceiling. The house drain is usually the same size as the house sewer.

(NOTE: A HOUSE DRAIN SIZE IS DETERMINED USING THE SAME METHOD AS WITH THE HOUSE SEWER.)

e. Stacks and branches: The term "stack" is used for the vertical main pipe in a plumbing system through which wastes are carried to the house drain. A soil stack carries waste from the water closets; a waste stack carries waste from all fixtures except water closets. Most buildings do not have separate soil and waste stacks, so a single stack known as the soil-and waste stack, or stack, carries both soil and waste. Branches are the pipes that carry the discharge from fixtures to the stack. All branches must have two factors to be effective, they must have a slope and a cleanout.

(1) Slope: a slope is a horizontal branches are run from takeoffs on the soil stack to the various fixtures. Branches should slope ¼ inch per foot from the fixture to the stack.

(2) Clean out: A cleanout is a opening in the waste line that is capped, to allow the waste line to be cleaned when clogged. The waste lines should have as many cleanouts as needed to clear stoppages or simplify repair. Install a cleanout for every change of direction and for each horizontal line 2 feet long or longer. The clean out should be the same diameter as the waste line.

f. Sizing the stack and branches: The stack is sized in the same way as the building and house drain. Determine the total DFUs, then apply this number to the table below to find the proper stack size. The minimum size for a solid-and-waste stack is 3". The size of the branch is determined by the number of drainage fixture units. No branch may be larger than the soil or waste stack to which it is connected.

DRAINAGE FIXTURE UNIT VALUES	
Fixture	Unit Value (DFUs)
Lavatory or washbasin	1
Floor drain	1
Kitchen sink	2
Bathtub	2
Laundry tub	2
Shower	2
Slop sink	3
Urinal	5
Water closet	6

MAXIMUM FIXTURE UNITS PER STACK	
Size of Pipe (inches)	Fixture Units per Stack
3	60
4	500
5	1,100

ILLUSTRATIVE EXAMPLE*: Assume that a plumbing installation consists of two water closets, four lavatories, two shower heads, three urinals, one slop sink, one laundry tub, and one floor drain. Determine the discharge in DFUs using the Tables shown above.*

STEP 1: *Multiply the number of each fixture by its DFU value from the DFUs Table above, for a total of* ***42*** *DFUs.*

STEP 2: *Read down the fixture units per stack column in the Maximum fixture units per stack Table. The fixture unit capacity for 42 is* ***60****.*

STEP 3: *Read horizontally across to the left to* ***3*** *inches.*

RESULTS: *The minimum pipe size required is* ***3*** *inches.*

g. Sizing individual waste:

(1) Water Closets : A water closet has no individual waste pipe. Usually, it is connected directly into the stack with a short branch attached to a closet bend. The closet bend is 3 or 4 inches in diameter.

(2) Lavatories: Because lavatories are used for washing, stoppage can occur in the waste pipe. Improve drainage by using a minimum number of fittings and no long horizontal runs. The minimum pipe size for lavatory waste is 1 ¼ inches. If other than copper pipe is used, 1-½ inches is more satisfactory.

(3) Urinals: Urinals present a particular problem because foreign matter is often thrown into them. Therefore, a urinal should be equipped with an effective strainer. The size of the waste pipe should be 2 inches if it is cast-iron, galvanized, or plastic and 1½ inches if copper.

(4) Showers: The diameter of the waste pipe for a single shower is 2 inches for cast-iron, galvanized, or plastic and 1 ½ inches for copper. To handle the flow during peak use, a shower room requires a waste pipe of 3 or 4 inch in diameter. Stoppage seldom occurs in shower waste pipes.

(5) Sinks:

(a) Kitchen Sink A kitchen sink needs a 1-½ inch waste pipe because of the food wastes flushed into the sink. The waste pipe must be as short and as free from offsets as possible.

(b) Slop Sink: The two styles of slop sinks are trap-to-floor and the trap-to-wall. Each is used for disposing of wash water, filling swab buckets, and washing out swabs. The trap-to-floor requires a 3-inch waste pipe. The trap-to-wall type requires a 2-inch waste pipe. In both types, copper pipe may be one size smaller.

(c) Scullery Sink: Scullery sinks are for general kitchen use. A 2-inch waste pipe should be used because a large amount of grease is passed into the pipe through the grease trap.

(6) Drinking Fountains - Since drinking fountains carry clear water wastes, a 1 ¼ inch pipe is ample.

4. Principles of ventilation:

a. A vent is a pipe that brings outside air into the plumbing systems and equalizes the pressure on both sides of a trap to prevent trap seal loss by siphonage. A trap provides a water seal that keeps dangerous sewer gases from entering a building through a waste outlet.

b. Installing the stack: The stack is first connected to the house drain using a ¼ bend, preferably a long sweep bend to keep back pressure at a minimum. A test Tee is then connected to the bend with a piece of pipe long enough to raise the test Tee side opening 12 inches above the finished floor. Add other pipe until the desired height for the first branch takeoff is reached. At this point a sanitary Tee or a combination Wye and 1/8 end is installed. These last two steps are repeated until the fitting for the highest branch line is installed. The extension of the stack above the top most branch fitting is called the stack vent if it is run through the roof without connecting it to the main vent. Usually it is connected to the main vent and called the main soil-and-waste vent.

c. Installing the main vent tee: The main vent Tee should be placed in the stack at least 6 inches above the flood level of the highest fixture in the plumbing installation. It joins the main vent to the main soil-and-waste vent. This keeps waste water from backing up above the drainage Tee and overflowing into the main vent when a stoppage occurs in the waste pipe. Any scale or rust in the vent pipe falls into the waste pipe and is washed away by the waste water.

d. Supporting the stack and branches: Stacks and branches are supported so that the weight of the pipe will not bear on joints, which are the weakest points in the line. The bend at the base of the stack should rest on a concrete or masonry pier. Vertical stacks may be supported on each floor with special hangers or by placing wood strips under two sides of the hub or by wrapping strap iron around the pipe at the hub and suspending it from a joist. Horizontal runs of piping must be supported by sturdy iron hangers placed about 5 feet apart. Threaded galvanized waste pipe and copper tubing drain and vent lines as well as PVC pipe should be supported every 8 to 10 feet.

e. Running the stack through the roof: After the main vent tee has been installed, the main soil-and-waste vent is run through the roof to form the vent terminal. The pipe must be as large as the stack or larger and should end at least 12 inches above the roof. It may be run straight up from the stack or offset. The opening in the roof is made water tight by roof flashing.

f. Types of vents: The following types listed below are examples of fixture vents.

(1) Single Fixture: The individual vent, also known as a back vent or continuous vent, is the most commonly used vent. It can be adapted to all types of fixtures and prevents both direct and indirect siphonage.

(2) Batteries of Fixtures: Batteries of two or more fixtures can be individually vented. Each vent ties into a vent pipeline (branch) connected to the main vent.

(3) Common Vent: Fixture mounted side by side or back to back on a wall are common vented. In the common vent, both fixtures discharge into a double sanitary Tee with deflectors.

(4) Circuit Vent: The circuit vent extends from the main vent to connections on the horizontal soil or waste branch pipe between the fixture connections. This is sometimes used in buildings have a battery of two or more fixtures, such as lavatories. A maximum of eight fixtures are permitted on any one circuit.

(5) Wet vent: The wet vent is part of the vent line through which liquid waste flow from another fixture that has an individual vent. It is used most commonly on a small group of head fixtures.

(NOTE: *Before we can vent any fixture we have to remember that we must know the correct distance between the fixture trap and the stack or vent. Below are the correct distances with the drain sizes).*

Distance from Fixture Trap to Vent	Size of Fixture Drain (in inches)
2 feet 6 inches	1 ¼
3 feet 6 inches	1 ½
5 feet	2
6 feet	3
10 feet	4 and larger

g. Sizing the vent:

(1) Main Vent - The main vent must be at least one-half the size of the stack, and the main soil-and-waste vent must be at least as large as the stack. To determine the correct size for the vent, use the table below along with the number of DFUs, the length of the vent and the diameter of the soil-and-waste stack.

SIZE AND LENGTH OF MAIN VENTS							
Diameter of Soil-and-Waste Stack (in inches)	Number of DFUs to be Connected	Maximum Permissible Developed Length of Vent (in feet)					
		Diameter of Vent (in inches)					
		1 ½	2	2 ½	3	4	5
1 ½	8	150	--------	--------	--------	--------	--------
2	12	75	---	--------	--------	--------	--------
2	24	70	310	--------	--------	--------	--------
2 ½	42	35	300	--------	--------	--------	--------
3	30	20	140	-	--------	--------	--------
3	60	18	80	450	----	--------	--------
4	100	-------	75	260	650	--------	--------
4	250	-------	35	240	600	--------	--------
4	500	-------	30	100	260	--	--------
5	550	-------	22	95	240	1,100	--------
5	1,100	-------	-------	70	180	1,000	--------
		-------	-------	28	70	750	--------
		------	-----	20	50	320	---
						240	1,000
							750

ILLUSTRATIVE EXAMPLE: *What size main vent (diameter) would you need for the following: soil-and-waste stack diameter 3 inches, DFUs of 59, and a 200 ft vent length? Using the Table shown above, follow these steps:*

STEP 1: *Read down the first column to* ***3****.*

STEP 2: *Find the* ***30*** *in the second column.*

STEP 3: *Go to the next higher number,* ***60*** *(since there are 59 DFUs).*

STEP 4: *Read across to the figure that is closest to 200, and select* ***450****.*

STEP 5: *Read up from* ***450****.*

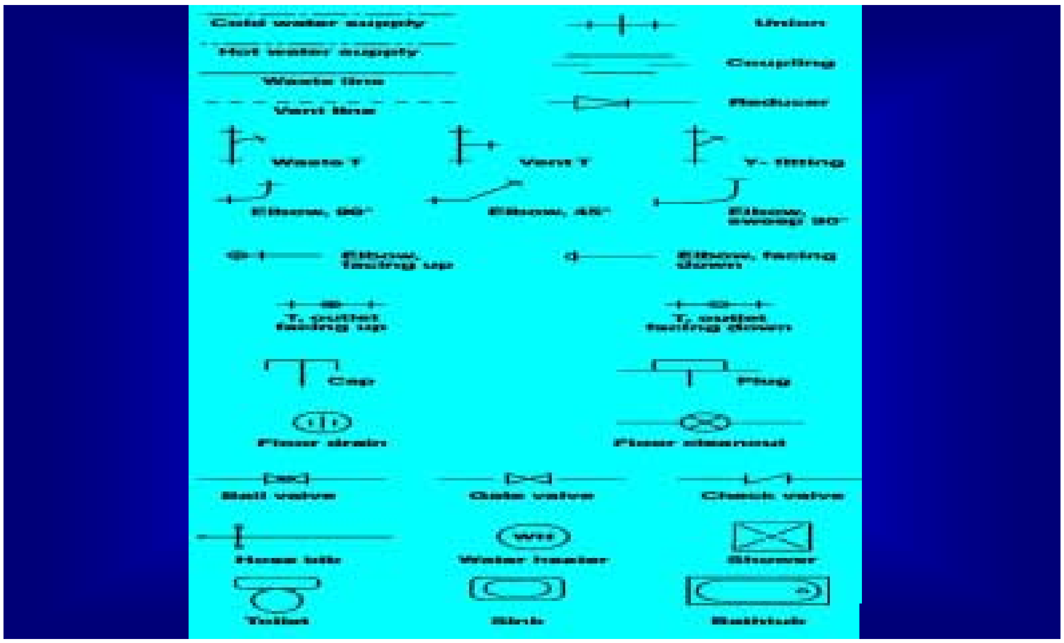
RESULTS: *The main vent would be* ***2*** *½ inches in diameter.*

(2) Individual Fixture Vent Size: A pipe less than 1 ¼ inches in diameter should not be used for ventilation because waste materials may cause stoppages where they flow past it. The list below shows recommended sizes for individual, branch, circuit, and stack vents.

SIZE OF INDIVIDUAL, BRANCH, CIRCUIT, and STACK VENTS	
Fixture	Minimum Size of Vent (in inches)
Lavatory	1 ¼
Drinking Fountain	1 ¼
Sink	1 ½
Shower	1 ½
Bathtub	1 ½
Laundry tub	1 ½
Slop sink	1 ½
Water Closet	2

5. <u>Symbols</u>:

a. Plumbing symbols on construction drawings show the general location of pipes, valves, pumps, water tanks, and other items. The four types of symbols are listed below:



b. Piping Symbols - used to indicate piping.

(1) Type and location of piping will be indicated on the plan by a solid or dashed line.

(2) Size of piping is indicated alongside each leg on the plan.

(3) Piping up to 12 inches in diameter is referred to by its normal size, inside diameter, or determined by the grade of pipe.

(4) Piping 12 inches or greater in diameter is referred to by it's outside diameter.

c. Pipe Fitting Symbols - used to indicate unions, couplings, and fittings used in combination with line (piping) symbols. The size of pipe and method of branching must be determined.

d. Valve Symbols - indicate required control points in the system.

(1) There are different designs and types of valves used in water supply systems.

(2) Drawings normally do not give the kind of materials and sizes of valves.

(3) Size and type of valve must be determined by it's use and from the size and material of the connected pipe.

(4) Valves must be listed on the bill of materials as type, size, material and working pressure.

(*EXAMPLE*: *Two (2) inch, check valve, brass, 175 lb. working pressure)*.

e. Fixture Symbols - Shown on plans by pictorial or block symbols indicating various type of fixtures such as; drains, sinks, water closets and shower stalls.

6. Bill of material:

a. A specification sheets detailing the types and quantity of materials to be used. Is a list or estimate of all materials needed to finish structure. Sometimes known as the materials "takeoff sheet" or "materials estimate sheet".

ITEM #	NATIONAL STOCK NUMBER	ITEM NAME	UNIT OF ISSUE	QUANTITY
1	4410-00-999-5886	Heater, water, oil fired, 600-GPH	each	1
2	4510-00-132-6376	Faucet, single, 3/4-NPT/M brass w/bib	each	1

ILLUSTRATIVE EXAMPLE: *A Bill of Materials list: Item Numbers (parts and materials), Government stock size and number (if called for), Item name and description, Unit of Issue, Quantity, and Weight as applicable.*

b. Preparing a bill of material:

(1) Usually made by the draftsman when the original drawings are prepared.

(2) In most cases the plumber must make the bill of materials.

(3) Take off and estimate.

(a) Takeoff is usually an actual count and check-off of the items shown or specified on the drawings and specifications.

(b) Estimate is quantities of materials known to be needed but which have not been placed on the drawings. This would include: nail, cement, concrete-form lumber, temporary bracing or scaffold lumber, tie wire, and so on.

c. Plans

(1) Provide ways to list names of the various items, which make up the bills of materials.

(2) Each item on the plan is checked, listed by name, and recorded by its stock number and size.

d.   Quantities - Usually determined by taking off and listing one type of material at a time.

e.   Tabulation - The tabulation should include column headings for each item as follows:

(a) Item number.

(b) Item name.

(c) Unit of measure.

(d) Quantity.

(e) Stock number