

# Drainage System



# Pipes used in Drainage

TABLE 702.2  
UNDERGROUND BUILDING DRAINAGE AND VENT PIPE

| MATERIAL  | STANDARD   |
|---|--|
| Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters, including schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core, or composite wall | ASTM D 2661; ASTM F 628; ASTM F 1488; CSA B181.1 |
| Asbestos-cement pipe  | ASTM C 428                                       |
| Cast-iron pipe  | ASTM A 74; ASTM A 888; CISPI301                  |
| Copper or copper-alloy tubing (Type K, L, M or DWV)   | ASTM B 75; ASTM B 88; ASTM B 251; ASTM B 306     |
| Polyolefin pipe   | ASTM F 1412; CAN/CSA B181.3                      |
| Polyvinyl chloride (PVC) plastic pipe in IPS diameters, including schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core, or composite wall              | ASTM D 2665; ASTM F 891; ASTM F 1488; CSA B181.2 |
| Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch A.D. and a solid, cellular core, or composite wall   | ASTM D 2949, ASTM F 1488                         |
| Polyvinylidene fluoride (PVDF) plastic pipe   | ASTM F 1673; CAN/CSA B181.3                      |
| Stainless steel drainage systems, Type 316L   | ASME A 112.3.1                                   |

TABLE 702.4  
PIPE FITTINGS

| MATERIAL  | STANDARD   |
|---|--|
| Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters             | ASTM D 2661; ASTM F 628; CSA B181.1  |
| Acrylonitrile butadiene styrene (ABS) plastic pipe in sewer and drain diameters | ASTM D 2751  |
| Asbestos cement   | ASTM C 428   |
| Cast iron   | ASME B 16.4; ASME B 16.12; ASTM A 74; ASTM A 888; CISPI301                         |
| Copper or copper alloy  | ASME B 16.15; ASME B 16.18; ASME B 16.22; ASME B 16.23; ASME B 16.26; ASME B 16.29 |
| Glass   | ASTM C 1053  |
| Gray iron and ductile iron  | AWWAC 110  |
| Malleable iron  | ASME B 16.3  |
| Polyolefin  | ASTM F 1412; CAN/CSA B181.3  |
| Polyvinyl chloride (PVC) plastic in IPS diameters                               | ASTM D 2665; ASTM F 1866   |
| Polyvinyl chloride (PVC) plastic pipe in sewer and drain diameters              | ASTM D 3034  |
| Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch G.D.                     | ASTM D 2949  |
| Polyvinylidene fluoride (PVDF) plastic pipe                                     | ASTM F 1673; CAN/CSA B181.3  |
| Stainless steel drainage systems, Types 304 and 316L                            | ASME A 112.3.1   |
| Steel   | ASME B 16.9; ASME B 16.11; ASME B 16.28  |
| Vitrified clay  | ASTM C 700   |



**TABLE 702.3  
BUILDING SEWER PIPE**

| <b>MATERIAL</b>  | <b>STANDARD</b>                                      |
|--|--|
| Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters, including schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall   | ASTM D 2661; ASTM F 628; ASTM F 1488; CSA B181.1     |
| Acrylonitrile butadiene styrene (ABS) plastic pipe in sewer and drain diameters, including SDR 42 (PS 20), PS 35, SDR 35 (PS 45), PS 50, PS 100, PS 140, SDR 23.5 (PS 150) and PS 200; with a solid, cellular core or composite wall | ASTM F 1488; ASTM D 2751                             |
| Asbestos-cement pipe   | ASTM C 428   |
| Cast-iron pipe   | ASTM A 74; ASTM A 888; CISPI301                      |
| Concrete pipe  | ASTM C14; ASTM C76; CAN/CSA A257.1M; CAN/CSA A257.2M |
| Copper or copper-alloy tubing (Type K or L)  | ASTM B 75; ASTM B 88; ASTM B 251                     |
| Polyethylene (PE) plastic pipe (SDR-PR)  | ASTM F 714   |
| Polyvinyl chloride (PVC) plastic pipe in IPS diameters, including schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall  | ASTM D 2665; ASTM F 891; ASTM F 1488                 |

|  |  |
|--|--|
| Polyvinyl chloride (PVC) plastic pipe in sewer and drain diameters, including PS 25, SDR 41 (PS 28), PS 35, SDR 35 (PS 46), PS 50, PS 100, SDR 26 (PS 115), PS 140 and PS 200; with a solid, cellular core or composite wall | ASTM F 891; ASTM F 1488; ASTM D 3034; CSA B182.2; CSA B182.4 |
| Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch I.D. and a solid, cellular core or composite wall.  | ASTM D 2949, ASTM F 1488                                     |
| Polyvinylidene fluoride (PVDF) plastic pipe  | ASTM F 1673; CAN/CSA B181.3                                  |
| Stainless steel drainage systems, Type 304 and 316L  | ASME A112.3.1  |
| Vitrified clay pipe  | ASTM C 4; ASTM C 700   |

TABLE 702.1  
ABOVE-GROUND DRAINAGE AND VENT PIPE

| MATERIAL   | STANDARD   |
|--|--|
| Acrylonitrile butadiene styrene (ABS) plastic pipe in IPS diameters, including Schedule 40, DR 22 (PS 200) and DR 24 (PS 140); with a solid, cellular core or composite wall | ASTM D 2661; ASTM F 628; ASTM F 1488; CSA B181.1 |
| Brass pipe   | ASTM B 43  |
| Cast-iron pipe   | ASTM A 74; ASTM A 888; CISPI301                  |
| Copper or copper-alloy pipe  | ASTM B 42; ASTM B 302                            |
| Copper or copper-alloy tubing (Type K, L, M or DWV)  | ASTM B 75; ASTM B 88; ASTM B 251; ASTM B 306     |
| Galvanized steel pipe  | ASTM A 53  |
| Glass pipe   | ASTM C 1053                                      |
| Polyolefin pipe  | ASTM F 1412; CAN/CSA B181.3                      |
| Polyvinyl chloride (PVC) plastic pipe in IPS diameters, including schedule 40, DR 22 (PS 200), and DR 24 (PS 140); with a solid, cellular core or composite wall             | ASTM D 2665; ASTM F 891; ASTM F 1488; CSA B181.2 |
| Polyvinyl chloride (PVC) plastic pipe with a 3.25-inch a.D. and a solid, cellular core or composite wall   | ASTM D 2949, ASTM F 1488                         |
| Polyvinylidene fluoride (PVDF) plastic pipe  | ASTM F 1673; CAN/CSA B181.3                      |
| Stainless steel drainage systems, Types 304 and 316L   | ASME A112.3.1                                    |

**TABLE 6-4**  
**Materials for Building Supply and Water Distribution Piping and Fittings**

| <b>Material</b>  | <b>Building Supply Pipe and Fittings</b> | <b>Water Distribution Pipe and Fittings</b> | <b>Referenced Standard(s) Pipe</b>                            | <b>Referenced Standard(s) Fittings</b>  |
|------------------|--|---|---|---|
| Asbestos-Cement  | X <sup>1</sup>                           |   | ASTM C296, AWWA C400  |   |
| Brass            | X  | X   | ASTM B43, ASTM B135   |   |
| Copper           | X  | X   | ASTM B42, ASTM B75, ASTM B88, ASTM B251, ASTM B302, ASTM B447 | ASME B16.15, ASME B16.18, ASME B16.22, ASME B16.26                                |
| CPVC             | X  | X   | ASTM D2846, ASTM F441, ASTM F442                              | ASTM D2846, ASTM F437, ASTM F438, ASTM F439, ASTM F1970                           |
| Ductile-Iron     | X  | X   | AWWA C151   | ASME B16.4, AWWA C110, AWWA C153  |
| Galvanized Steel | X  | X   | ASTM A53  |   |
| Malleable Iron   | X  | X   |   | ASME B16.3  |
| PE               | X <sup>1</sup>                           |   | ASTM D2239, ASTM D2737, ASTM D3035, AWWA C901, CSA B137.1     | ASTM D2609, ASTM D2683, ASTM D3261, ASTM F1055, CSA B137.1                        |
| PE-AL-PE         | X  | X   | ASTM F1282, CSA B137.9  | ASTM F1282, ASTM F1974, CSA B137.9  |
| PEX              | X  | X   | ASTM F876, ASTM F877, CSA B137.5                              | ASTM F877, ASTM F1807, ASTM F1960, ASTM F1961, ASTM F2080, ASTM F2159, CSA B137.5 |
| PEX-AL-PEX       | X  | X   | ASTM F1281, CSA B137.10, ASTM F2262                           | ASTM F1281, ASTM F1974, ASTM F2434, CSA B137.10                                   |
| PVC              | X <sup>1</sup>                           |   | ASTM D1785, ASTM D2241, AWWA C900                             | ASTM D2464, ASTM D2466, ASTM D2467, ASTM F1970                                    |
| Stainless Steel  | X  | X   | ASTM A269, ASTM A312  |   |

<sup>1</sup> For Building Supply or cold-water applications.

**TABLE 7-1**  
**Materials for Drain, Waste, Vent Pipe and Fittings**

| <b>Material</b>                    | <b>Underground<br/>Drain, Waste,<br/>Vent Pipe and<br/>Fittings</b> | <b>Above ground<br/>Drain, Waste,<br/>Vent Pipe and<br/>Fittings</b> | <b>Building<br/>Sewer Pipe<br/>and Fittings</b> | <b>Referenced<br/>Standard(s)<br/>Pipe</b>                           | <b>Referenced<br/>Standard(s)<br/>Fittings</b>        |
|------------------------------------|---|--|---|--|---|
| ABS (Schedule 40)                  | X   | X  | X   | ASTM D1527,<br>ASTM D2661,<br>ASTM D2680 <sup>1</sup> ,<br>ASTM F628 | ASTM D2661,<br>ASTM D2680 <sup>1</sup>                |
| Asbestos-<br>Cement                |   |  | X   | ASTM C428 <sup>1</sup> ,<br>ASTM C14 <sup>1</sup>                    |   |
| Brass                              |   | X  |   | ASTM B43   |   |
| Cast-Iron                          | X   | X  | X   | ASTM A74,<br>ASTM A888,<br>CISPI 301                                 | ASME B16.12,<br>ASTM A74,<br>ASTM A888,<br>CISPI 301  |
| Co-Extruded<br>ABS (Schedule 40)   | X   | X  | X   | ASTM F1488   | ASTM, D2661,<br>ASTM D2680 <sup>1</sup>               |
| Co-Extruded<br>PVC (Schedule 40)   | X   | X  | X   | ASTM F1488,<br>ASTM F891   | ASTM D2665,<br>ASTM F794 <sup>1</sup> ,<br>ASTM F1866 |
| Copper (Type DWV)                  | X   | X  | X   | ASTM B75,<br>ASTM B251,<br>ASTM B302,<br>ASTM B306                   | ASME B16.23,<br>ASME B16.29                           |
| Galvanized<br>Malleable Iron       |   | X  |   |  | ASME B16.3  |
| Galvanized<br>Steel                |   | X  |   | ASTM A53   |   |
| PVC (Schedule 40)                  | X   | X  | X   | ASTM D1785,<br>ASTM D2665,<br>ASTM F794 <sup>1</sup>                 | ASTM D2665,<br>ASTM F794 <sup>1</sup> ,<br>ASTM F1866 |
| Stainless Steel 304                |   | X  |   | ASME A112.3.1  | ASME A112.3.1   |
| Stainless Steel 316L               | X   | X  | X   | ASME A112.3.1  | ASME A112.3.1   |
| Vitrified Clay<br>(Extra strength) |   |  | X   | ASTM C700  | ASTM C700   |

<sup>1</sup> For Building Sewer applications.

## Drainage System:

The purpose of the sanitary drainage system is to remove effluent discharged from plumbing fixtures and other equipment to an approved point of disposal. A sanitary drainage system generally consists of horizontal branches, vertical stacks, a building drain inside the building, and a building sewer from the building wall to the point of disposal.

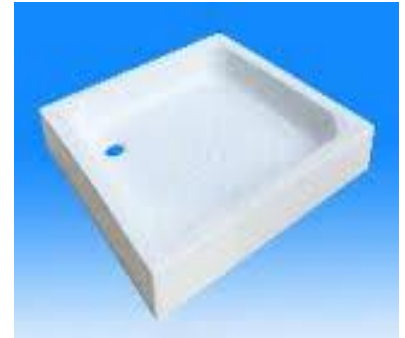
الغرض من نظام الصرف الصحي هو إزالة النفايات السائلة المصروفة من الأدوات الصحية وغيرها من المعدات إلى نقطة معتمدة للتخلص منها. ويتألف نظام الصرف الصحي عموماً من فروع أفقية، صواعد عمودية، وصرف المبني داخل المبني، والصرف الصحي خارج المبني حتي اقرب نقطه للتخلص منها.

## FLOW IN STACKS:

**Soil Stack.** A stack is the main vertical pipe that carries away discharge from water closets and urinals.

**Waste Stack.** A stack is the main vertical pipe that carries away other clear water waste from equipment and non-sanitary fixtures.

**عمود العمل.** هو أنبوب عمودي الرئيسي الذي يحمل بعيداً إفرازات الناتجة عن دورات مياه والمباول.  
**عمود الصرف.** هو أنبوب عمودي الرئيسي الذي يحمل المياه الناتجة عن من المعدات والأجهزة الصحية

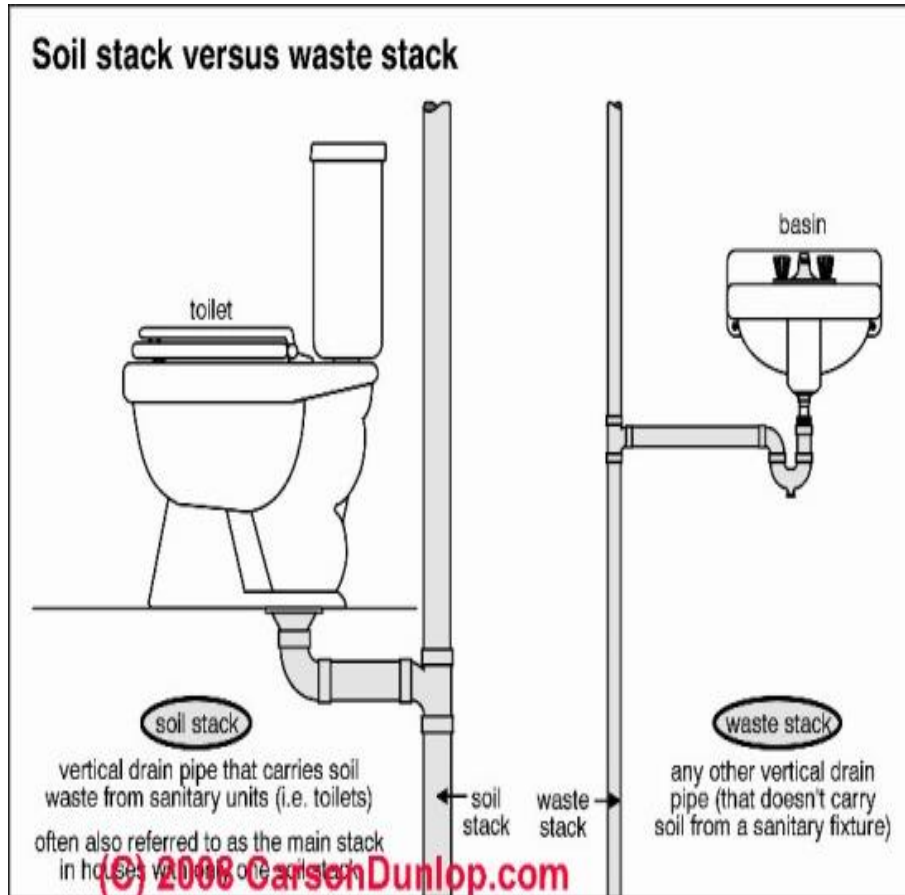


Soil

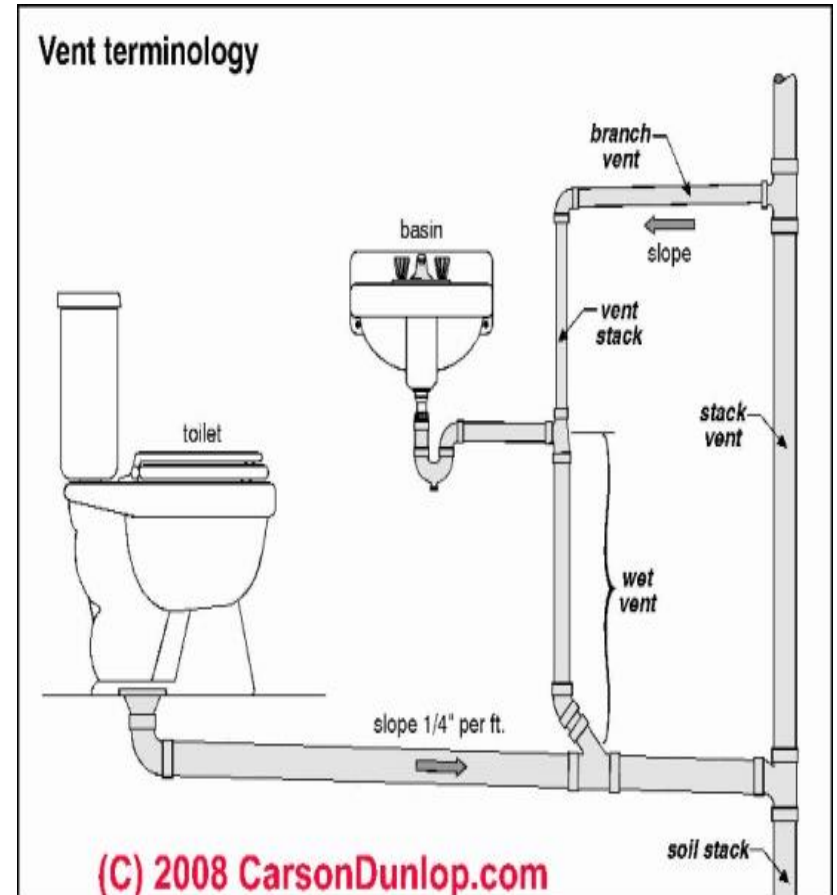
Waste

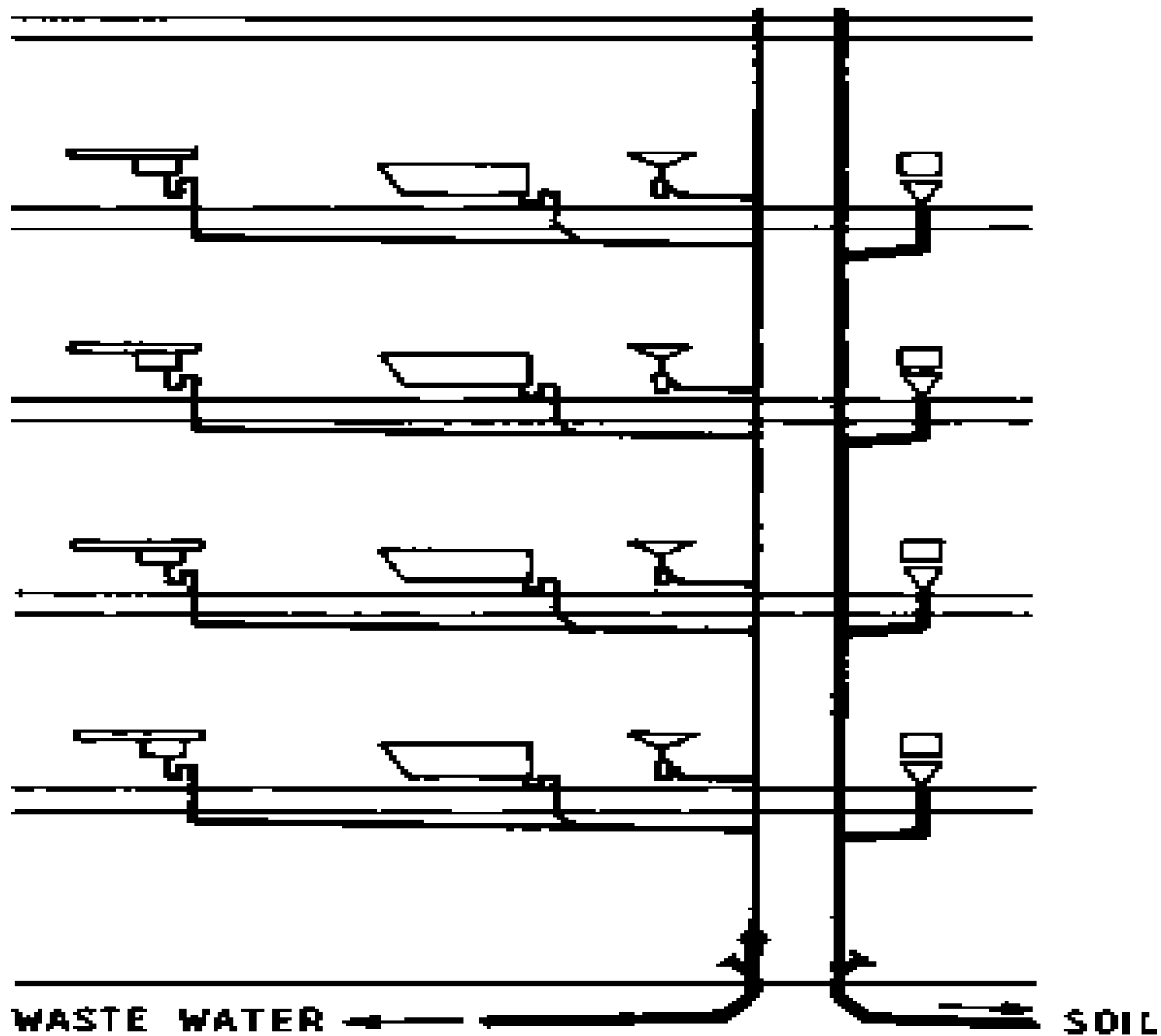


## One pipe system



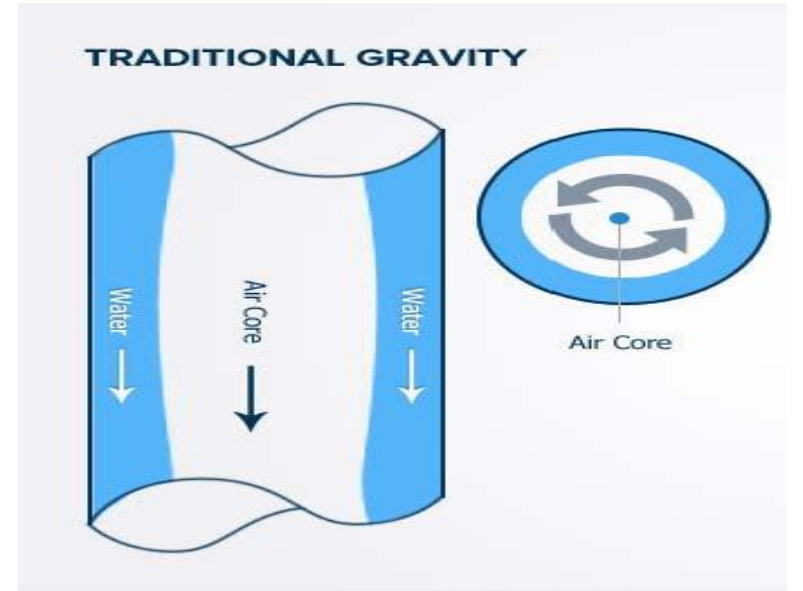
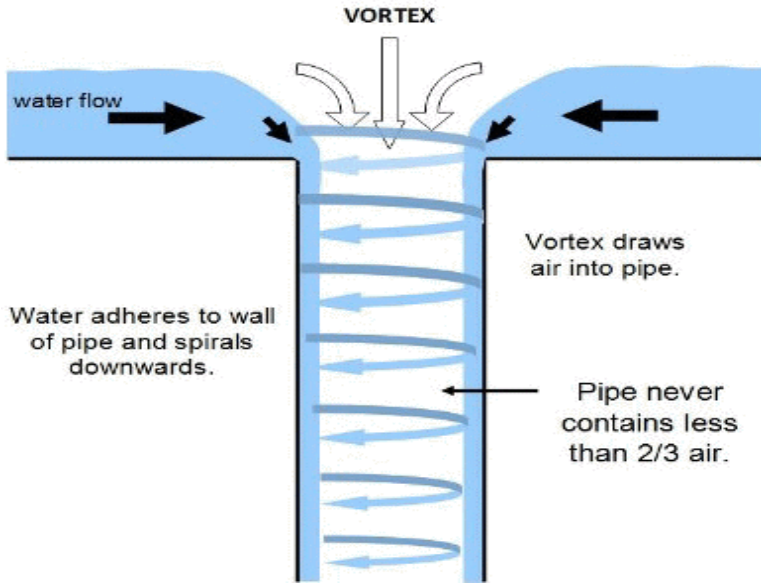
## Two pipe system

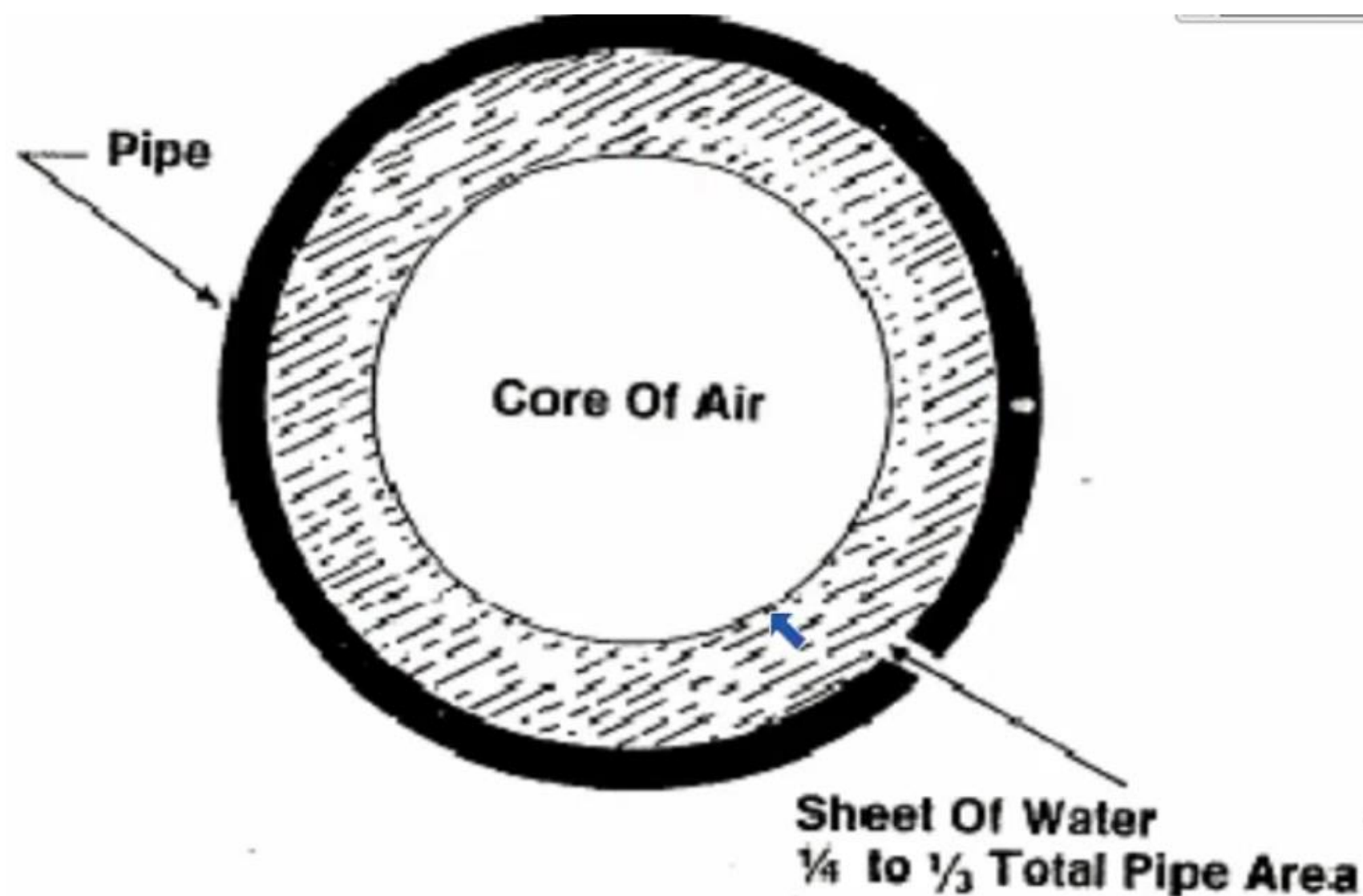




The discharge from the fixture drain may or may not fill the cross-section of the stack at the level of entry. In any event, as soon as the water enters the stack, the force of gravity rapidly accelerates it downward, and before it falls very far, it assumes the form of a sheet around the wall of the stack, leaving the center of the pipe open for the flow of air

الصرف الذي يخرج من الاجهزه الصحيه قد أو قد لا يملء المقطع العرضي من عامود الصرف في مستوى الدخول. وعلى أية حال، حالما يدخل الماء عامود الصرف، قوة الجاذبية تجعل مياه الصرف تتسارع بسرعة نحو الأسفل، وقبل أن تصل الي نقطه بعيدة عن نقطه الدخول، فإنه يفترض ان الصرف يتكون حول الجدار عامود الصرف، وتترك وسط الأنابيب مفتوحة لتدفق الهواء.

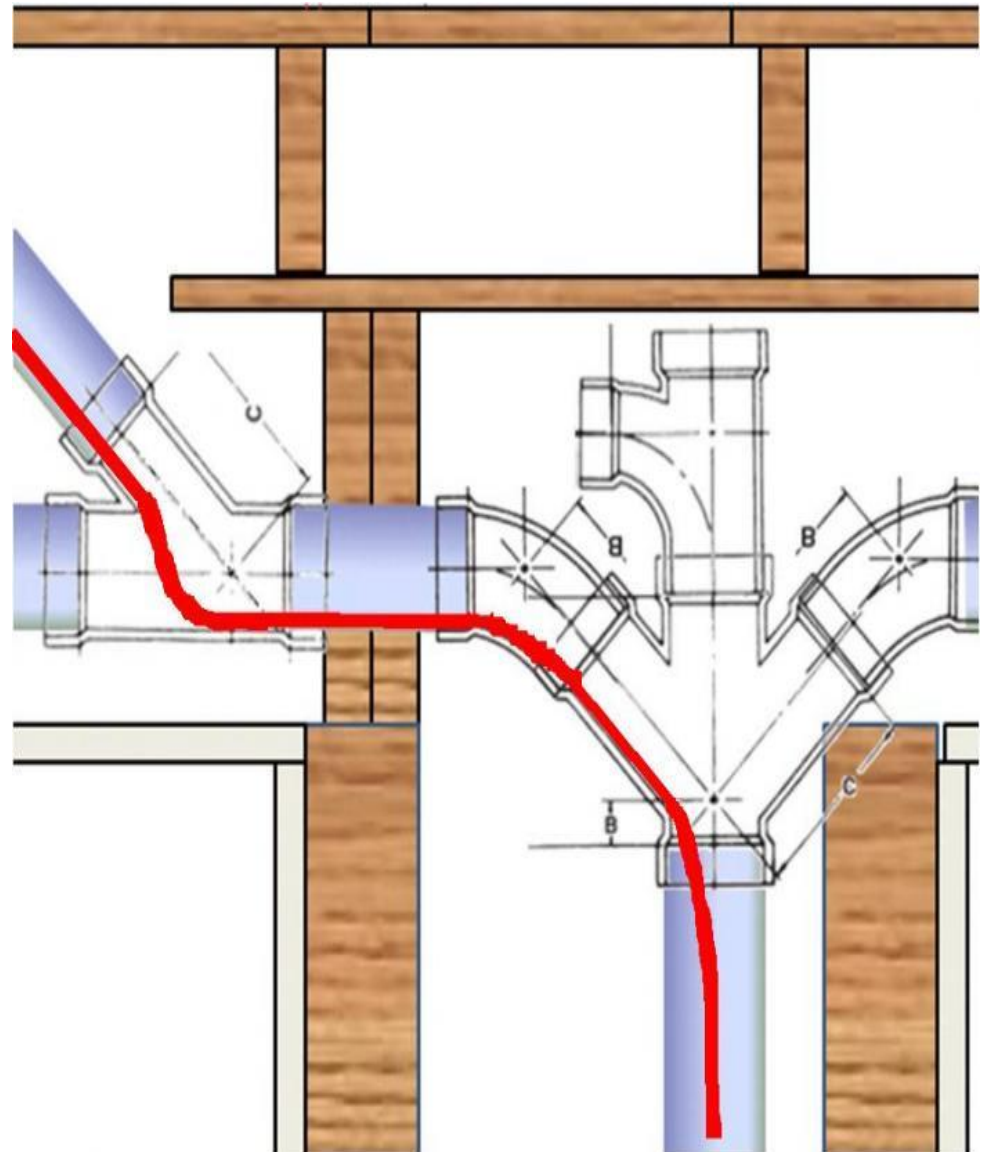




**FIGURE 4-1**  
**Cross-section of stack flowing at design capacity**

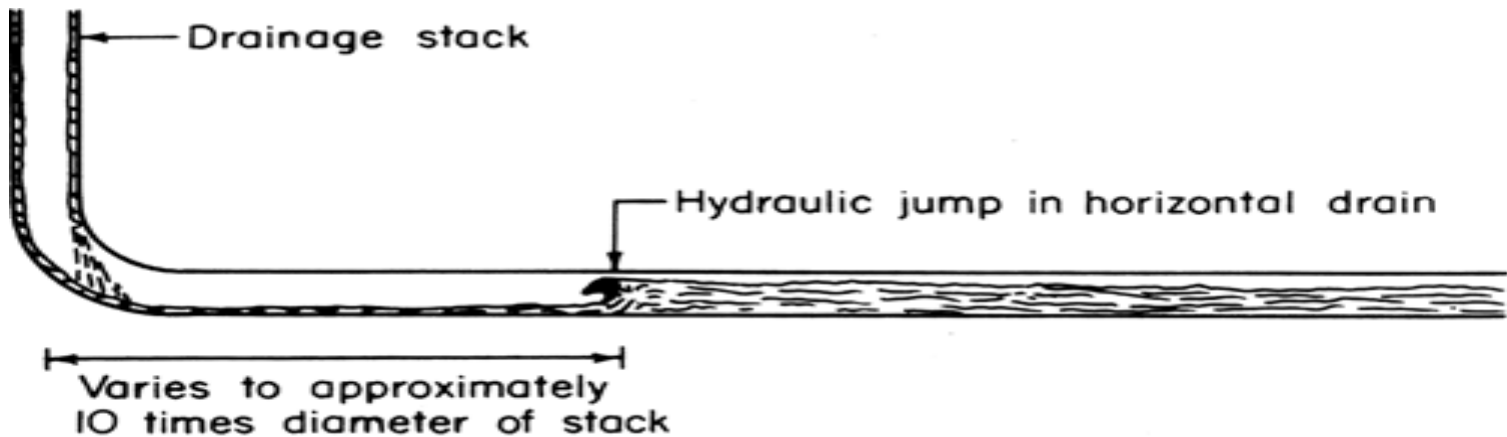


## Fitting used in drainage:



## **Connection between horizontal & vertical Flow of Building Drain Steps**

## Hydraulic Jump



**704.3 Connections to offsets and bases of stacks.** Horizontal branches shall connect to the bases of stacks at a point located not less than 10 times the diameter of the drainage *stack* downstream from the *stack*. Horizontal branches shall connect to horizontal *stack* offsets at a point located not less than 10 times the diameter of the drainage *stack* downstream from the upper *stack*.

## Drainage Load and Drainage Fixture Unit (DFU):

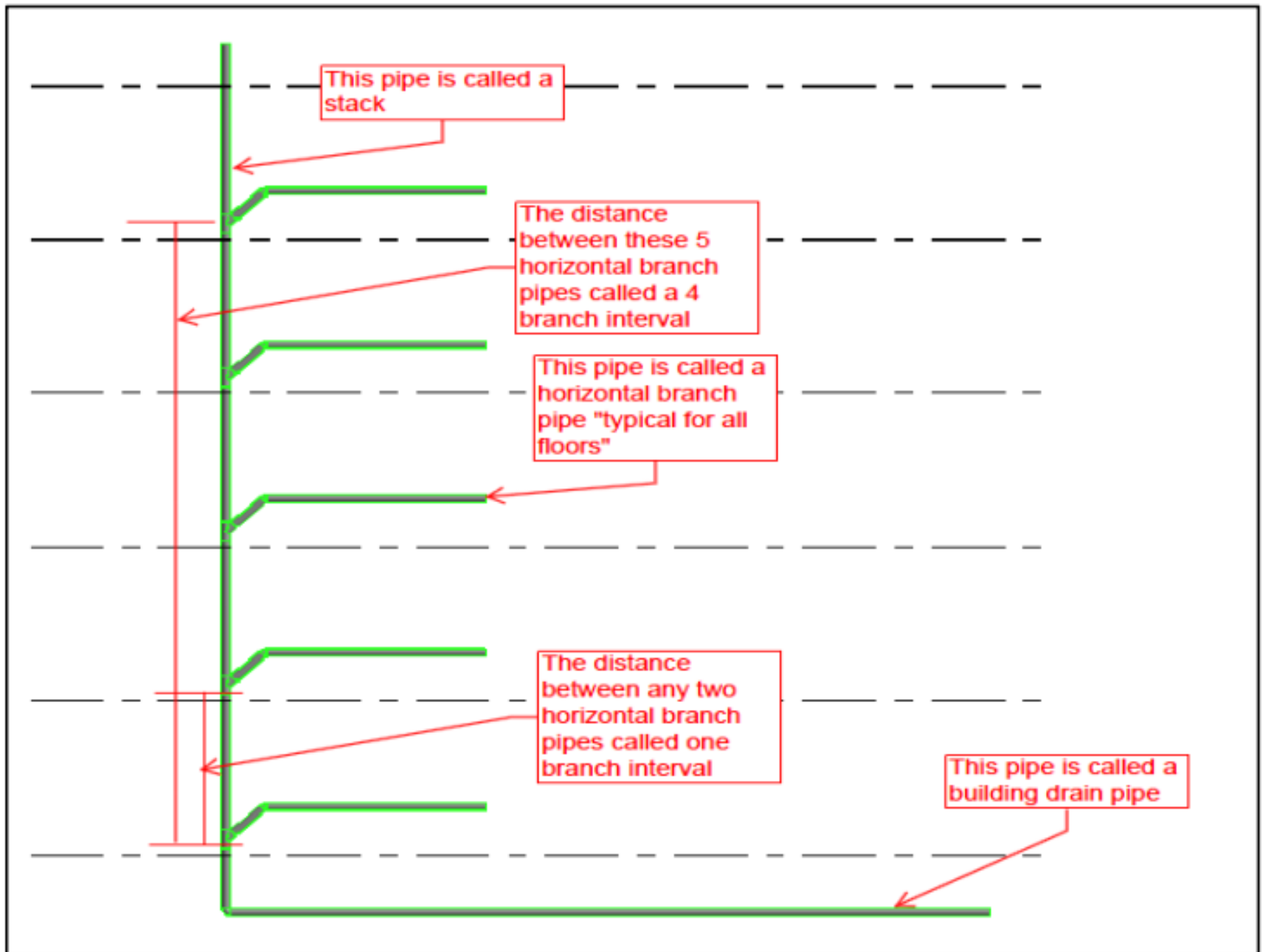
The fixture unit values were designed for application in conjunction with the probability of simultaneous use of fixtures to establish the maximum permissible drainage loads expressed in fixture units rather than in gpm of drainage flow

وحده الصرف القياسي قد صممت هذه القيم اساسيا لتطبيق احتماليه الاستخدام المتزامن للاجهزه الصحيه من تركيبات لإقامة الحد الأقصى لحمولة الصرف المسموح بدلا من حسابات السريان من تدفق الصرف

### Steps of design

- 1- get the total **DFU** for each Branch
- 2- Size all Branches
- 3- Size all Stacks





**TABLE 7-3**  
**Drainage Fixture Unit Values (DFU)**

| Inch  | mm |
|-------|----|
| 1-1/4 | 32 |
| 1-1/2 | 40 |
| 2     | 51 |
| 2-1/2 | 65 |
| 3     | 80 |

| Plumbing Appliance, Appurtenance, or Fixture                            | Min. Size<br>Trap and<br>Trap Arm <sup>7</sup> | Private | Public                      | Assembly <sup>8</sup> |
|---|--|---------|-----------------------------|-----------------------|
| Bathtub or Combination Bath/Shower.....                                 | 1-1/2"   | 2.0     | 2.0                         |                       |
| Bidet.....  | 1-1/4"   | 1.0     |                             |                       |
| Bidet.....  | 1-1/2"   | 2.0     |                             |                       |
| Clothes Washer, domestic, standpipe <sup>5</sup> .....                  | 2"   | 3.0     | 3.0                         | 3.0                   |
| Dental Unit, cuspidor.....  | 1-1/4"   |         | 1.0                         | 1.0                   |
| Dishwasher, domestic, with independent drain <sup>2</sup> .....         | 1-1/2"   | 2.0     | 2.0                         | 2.0                   |
| ■ Drinking Fountain or Water Cooler.....                                | 1-1/4"   | 0.5     | 0.5                         | 1.0                   |
| Food-Waste-Grinder, commercial.....                                     | 2"   |         | 3.0                         | 3.0                   |
| Floor Drain, emergency.....   | 2"   |         | 0.0                         | 0.0                   |
| Floor Drain (for additional sizes see Section 702).....                 | 2"   | 2.0     | 2.0                         | 2.0                   |
| Shower, single-head trap.....   | 2"   | 2.0     | 2.0                         | 2.0                   |
| Multi-head, each additional.....  | 2"   | 1.0     | 1.0                         | 1.0                   |
| Lavatory, single.....   | 1-1/4"   | 1.0     | 1.0                         | 1.0                   |
| Lavatory, in sets of two or three.....                                  | 1-1/2"   | 2.0     | 2.0                         | 2.0                   |
| Washfountain.....   | 1-1/2"   |         | 2.0                         | 2.0                   |
| Washfountain.....   | 2"   |         | 3.0                         | 3.0                   |
| Mobile Home, trap.....  | 3"   | 12.0    |                             |                       |
| Receptor, indirect waste <sup>1,3</sup> .....                           | 1-1/2"   |         | See footnote <sup>1,3</sup> |                       |
| Receptor, indirect waste <sup>1,4</sup> .....                           | 2"   |         | See footnote <sup>1,4</sup> |                       |
| Receptor, indirect waste <sup>1</sup> .....                             | 3"   |         | See footnote <sup>1</sup>   |                       |
| <b>Sinks</b>  |  |         |                             |                       |
| Bar.....  | 1-1/2"   | 1.0     |                             |                       |
| Bar <sup>2</sup> .....  | 1-1/2"   |         | 2.0                         | 2.0                   |
| Clinical.....   | 3"   |         | 6.0                         | 6.0                   |
| Commercial with food waste <sup>2</sup> .....                           | 1-1/2"   |         | 3.0                         | 3.0                   |
| ■ Special Purpose <sup>2</sup> .....                                    | 1-1/2"   | 2.0     | 3.0                         | 3.0                   |
| Special Purpose.....  | 2"   | 3.0     | 4.0                         | 4.0                   |
| Special Purpose.....  | 3"   |         | 6.0                         | 6.0                   |
| Kitchen, domestic <sup>2</sup> .....                                    | 1-1/2"   | 2.0     | 2.0                         |                       |
| (with or without food-waste grinder and/or dishwasher)                  |  |         |                             |                       |
| ■ Laundry <sup>2</sup> .....  | 1-1/2"   | 2.0     | 2.0                         | 2.0                   |
| (with or without discharge from a clothes washer)                       |  |         |                             |                       |
| Service or Mop Basin.....   | 2"   |         | 3.0                         | 3.0                   |
| Service or Mop Basin.....   | 3"   |         | 3.0                         | 3.0                   |
| Service, flushing rim.....  | 3"   |         | 6.0                         | 6.0                   |
| Wash, each set of faucets.....  |  |         | 2.0                         | 2.0                   |
| Urinal, integral trap 1.0 GPF <sup>2</sup> .....                        | 2"   | 2.0     | 2.0                         | 5.0                   |
| Urinal, integral trap greater than 1.0 GPF.....                         | 2"   | 2.0     | 2.0                         | 6.0                   |
| Urinal, exposed trap <sup>2</sup> .....                                 | 1-1/2"   | 2.0     | 2.0                         | 5.0                   |
| Water Closet, 1.6 GPF Gravity Tank <sup>6</sup> .....                   | 3"   | 3.0     | 4.0                         | 6.0                   |
| Water Closet, 1.6 GPF Flushometer Tank <sup>6</sup> .....               | 3"   | 3.0     | 4.0                         | 6.0                   |
| Water Closet, 1.6 GPF Flushometer Valve <sup>6</sup> .....              | 3"   | 3.0     | 4.0                         | 6.0                   |
| Water Closet, greater than 1.6 GPF Gravity Tank <sup>6</sup> .....      | 3"   | 4.0     | 6.0                         | 8.0                   |
| Water Closet, greater than 1.6 GPF Flushometer Valve <sup>6</sup> ..... | 3"   | 4.0     | 6.0                         | 8.0                   |

**Uniform  
Plumbing  
Code (UPC)**

**TABLE 709.1  
DRAINAGE FIXTURE UNITS FOR FIXTURES AND GROUPS**

| FIXTURE TYPE  | DRAINAGE FIXTURE UNIT<br>VALUE AS LOAD FACTORS | MINIMUM SIZE OF TRAP<br>(inches) |
|---|--|----------------------------------|
| Automatic clothes washers, commercial <sup>a,g</sup>  | 3  | 2                                |
| Automatic clothes washers, residential <sup>g</sup>   | 2  | 2                                |
| Bathroom group as defined in Section 202<br>(1.6 gpf water closet) <sup>f</sup>                       | 5  | —                                |
| Bathroom group as defined in Section 202<br>(water closet flushing greater than 1.6 gpf) <sup>f</sup> | 6  | —                                |
| Bathtub <sup>b</sup> (with or without overhead shower or whirlpool 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 <sup>c</sup> , domestic   | 2  | 1 1/2                            |
| Drinking fountain   | 1/2  | 1 1/4                            |
| Emergency floor drain   | 0  | 2                                |
| Floor drains <sup>h</sup>   | 2 <sup>h</sup>                                 | 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 <sup>e</sup>                                 | 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 <sup>e</sup>                                 | Note d                           |
| Water closet, private (1.6 gpf)   | 3 <sup>e</sup>                                 | Note d                           |
| Water closet, private (flushing greater than 1.6 gpf)   | 4 <sup>e</sup>                                 | Note d                           |
| Water closet, public (1.6 gpf)  | 4 <sup>e</sup>                                 | Note d                           |
| Water closet, public (flushing greater than 1.6 gpf)  | 6 <sup>e</sup>                                 | Note d                           |

## International Plumbing Code (IPC)

### Minimum Drainage Pipe Size for plumbing fixtures:

WC = 4" (100 mm)

LAV. = 2" (50 mm)

Sink = 2" (50 mm)

KITCHEN SINK = 2" (50 mm)

Shower = 2" (50 mm)

Bathtub = 2" (50 mm)

## Drainage Pipe Size (DFU):

TABLE 710.1(2)  
HORIZONTAL FIXTURE BRANCHES AND STACKS<sup>a</sup>

| DIAMETER OF PIPE<br>(inches) | MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS (dfu) |   |  |  |
|------------------------------|--|---|--|--|
|                              | Total for horizontal branch                    | Stacks <sup>b</sup>                         |  |  |
|                              |  | Total discharge into one<br>branch interval | Total for stack of three<br>branch Intervals or less | Total for stack greater than<br>three branch intervals |
| 1½                           | 3  | 2   | 4  | 8  |
| 2                            | 6  | 6   | 10   | 24   |
| 2½                           | 12   | 9   | 20   | 42   |
| 3                            | 20   | 20  | 48   | 72   |
| 4                            | 160  | 90  | 240  | 500  |
| 5                            | 360  | 200   | 540  | 1,100  |
| 6                            | 620  | 350   | 960  | 1,900  |
| 8                            | 1,400  | 600   | 2,200  | 3,600  |
| 10                           | 2,500  | 1,000                                       | 3,800  | 5,600  |
| 12                           | 3,900  | 1,500                                       | 6,000  | 8,400  |
| 15                           | 7,000  | Note c                                      | Note c   | Note c   |

For SI: 1 inch = 25.4 mm.

a. Does not include branches of the building drain. Refer to Table 710.1(1).

b. Stacks shall be sized based on the total accumulated connected load at each story or branch interval. As the total accumulated connected load decreases, stacks are permitted to be reduced in size. Stack diameters shall not be reduced to less than one-half of the diameter of the largest stack size required.

c. Sizing load based on design criteria.



TABLE 704.1  
SLOPE OF HORIZONTAL DRAINAGE PIPE

| SIZE<br>(inches)       | MINIMUM SLOPE<br>(inch per foot) |
|------------------------|----------------------------------|
| $2\frac{1}{2}$ or less | $\frac{1}{4}$                    |
| 3 to 6                 | $\frac{1}{8}$                    |
| 8 or larger            | $\frac{1}{16}$                   |

For SI: 1 inch = 25.4 mm, 1 inch per foot = 83.3 *mm/m*.

TABLE 710.1 (1)  
BUILDING DRAINS AND SEWERS

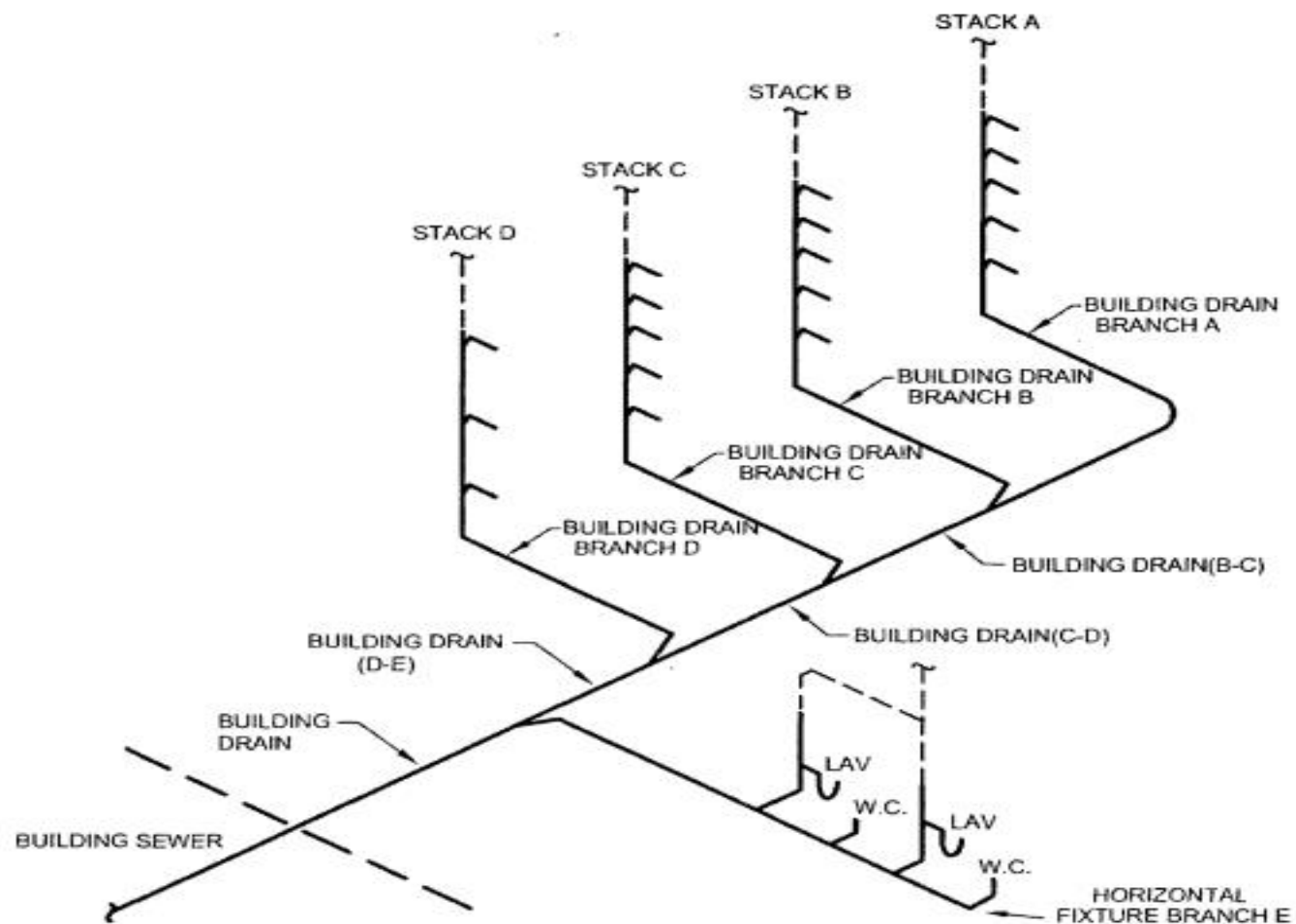
| DIAMETER OF PIPE<br>(inches) | MAXIMUM NUMBER OF DRAINAGE FIXTURE UNITS CONNECTED TO ANY PORTION OF THE BUILDING<br>DRAIN OR THE BUILDING SEWER, INCLUDING BRANCHES OF THE BUILDING DRAIN <sup>a</sup> |          |                |          |       |
|------------------------------|---|----------|----------------|----------|-------|
|                              | 0.5:100   | 1:100    | Slope per foot | 2:100    | 4:100 |
|                              | 1/16 inch   | 1/8 inch | 1/4 inch       | 1/2 inch |       |
| 1 1/4                        | —   | —        | 1              | 1        |       |
| 1 1/2                        | —   | —        | 3              | 3        |       |
| 2                            | —   | —        | 21             | 26       |       |
| 2 1/2                        | —   | —        | 24             | 31       |       |
| 3                            | —   | 36       | 42             | 50       |       |
| 4                            | —   | 180      | 216            | 250      |       |
| 5                            | —   | 390      | 480            | 575      |       |
| 6                            | —   | 700      | 840            | 1,000    |       |
| 8                            | 1,400   | 1,600    | 1,920          | 2,300    |       |
| 10                           | 2,500   | 2,900    | 3,500          | 4,200    |       |
| 12                           | 3,900   | 4,600    | 5,600          | 6,700    |       |
| 15                           | 7,000   | 8,300    | 10,000         | 12,000   |       |

For SI: 1 inch = 25.4 mm, 1 inch per foot = 83.3 mm/m.

a. The minimum size of any building drain serving a water closet shall be 3 inches.

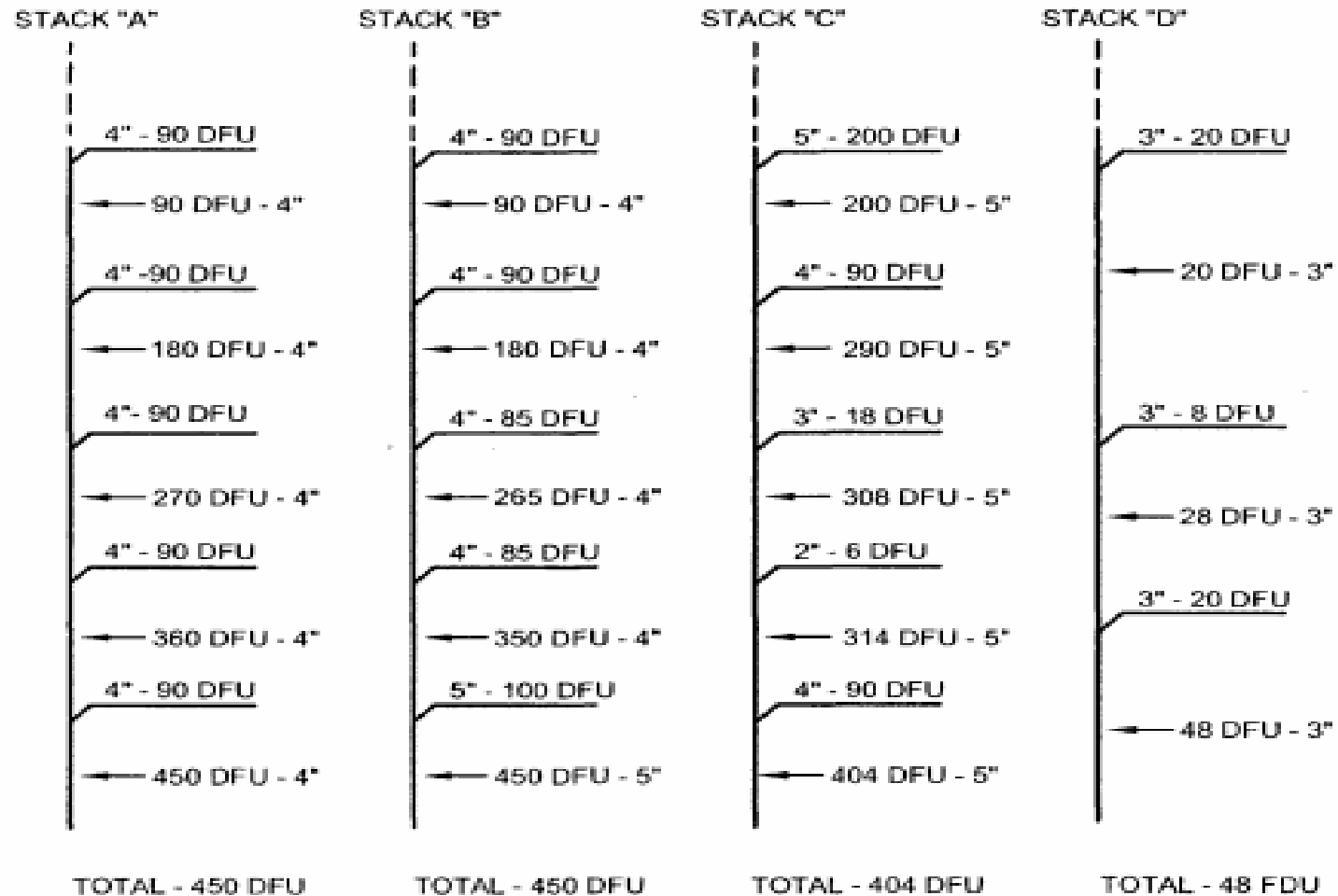
**EXAMPLE OF SIZING DRAINAGE PIPING**  
(Refer to Figures 11.5.1-A and -B)

1. To size the drainage system, start at the top floor and work down to the building drain.
2. Draw a diagram of the system showing the various fixtures.
3. Assign a drainage fixture unit (DFU) value to each fixture or fixture group using Table 11.4.1. Where a specific fixture type is not listed, use the "Sink" or "Trap Size" values.
4. Size the horizontal fixture branches on each floor using the pipe sizes in Table 11.5.1.B for the number of DFUs listed in the second column.
5. Size the stacks using the pipe size in Table 11.5.1.B for the number of DFUs listed in columns 3, 4, or 5, depending on the number of branch intervals. Check the limits on DFUs in any one branch interval and the total for the stack. Size the stack accordingly.
6. For Stack A in Figure 11.5.1-B, each horizontal branch drain has 90 DFU and is 4" size. The stack is 4" size from top to bottom.
7. For Stack B in Figure 11.5.1-B, the horizontal branch drains are all 4" size. Although the total number of DFUs is the same as Stack A (450 DFU), the lowest branch interval has more than 90 DFU and must be 5" size. The stack cannot be smaller than any of its branches and thus must be 5" size at the base. The upper portions of the stack can be 4" size.
8. For Stack C in Figure 11.5.1-B, although the total number of DFUs is less than Stack A and Stack B, the top horizontal branch drain must be 5" size because it has 200 DFUs. The entire stack must 5" size, even though 4" would have been adequate for the total number of DFUs.
9. Stack D in Figure 11.5.1-B only has three branch intervals and can be sized using column 3 in Table 11.5.1.B. Each of the 3" horizontal fixture branches is limited to four 1.6 GPF water closets per Section 11.5.6.b. Each branch interval of the 3" stack is limited to four 1.6 GPF water closets and the entire 3" stack is limited to twelve 1.6 GPF water closets per Section 11.5.6.c. If the number of water closets on any branch or the stack exceed the limits for 3" pipe, the branch and downstream stack must be increased to 4" size.
10. In Figure 11.5.1-A, Stack A is 4" size with 450 DFUs. In Table 11.5.1.A, Branch A of the building drain must be 5" size sloped 1/4" per foot. If 1/4" slope cannot be maintained, the branch must be increased to 6" size sloped 1/8" per foot.
11. In Figure 11.5.1-A, Stack B is 5" size with 450 DFUs. In Table 11.5.1.A, Branch B of the building drain can remain 5" size if sloped 1/4" per foot. Otherwise, the size must be increased if run at less slope.
12. In Figure 11.5.1-A, Section B-C of the building drain is  $450 + 450 = 900$  DFUs. In Table 11.5.1.A, it needs to be 8" size, but the slope can be reduced to 1/8" per foot.
13. In Figure 11.5.1-A, Stack C is 5" size with 404 DFUs. In Table 11.5.1.A, Branch C can remain 5" size, but must be sloped at 1/4" per foot. Otherwise, the size must be increased if run at less slope.
14. In Figure 11.5.1-A, Section C-D of the building drain is  $900 + 404 = 1304$  DFUs. Section C-D of the building drain must be at least 8" size because Section B-C is 8" size. In Table 11.5.1.A, 8" size is adequate at 1/8" or 1/16" per foot slope. Section 11.3.1 requires 1/8" slope for pipe 4" and larger. However, Table K-1 indicates that the velocity in Section C-D when flowing 1/2 full at 1/16" slope is not less than the 2 feet per second minimum and the reduced slope might be approved by the Authority Having Jurisdiction.
15. In Figure 11.5.1-A, Stack D is 3" size with 48 DFUs. In Table 11.5.1.A, branch D of the building drain could remain 3" if sloped 1/2" per foot. However, Section 11.5.6a limits it to four 1.6 GPF water closets. Otherwise, it would have to be increased to 4" size.
16. In Figure 11.5.1-A, Section D-E of the building drain is  $1304 + 48 = 1352$  DFUs. Section D-E must be at least 8" size because Section C-D is 8" size. In Table 11.5.1.A, 8" size is still adequate for 1352 DFUs.
17. In Figure 11.5.1-A, horizontal fixture branch E is  $4 + 1 + 4 + 1 = 10$  DFUs. In Table 11.5.1.B, the branch needs to be 3" size. It has less than the allowable number of water closets in Section 11.5.6.b.
18. In Figure 11.5.1-A, the load on the last section of the building drain and the building sewer is  $1352 + 10 = 1362$  DFUs. The 8" size of Section D-E is still adequate for the final section of the building drain and for the building sewer.



**Figure 11.5.1 - A**  
**SIZING BUILDING DRAINS AND SEWERS**





**Figure 11.5.1 - B**  
**SIZING DRAINAGE STACKS**

## Sump Pit Design

- 1- calculate all **Discharge Units** in sump pit by **DFU**
- 2- Convert all DFU to GPM as (**2 DFU = 1 GPM**)
- 3- Calculate the time of evacuate the sump pit by the pump and that is depends on the number of switching the pump on and off

Generally

The pump works **6 times/HR**

So it's works **5 minutes and stop for 5 minutes**

- 4- according to previous step we need a pump with **flow rate** double the discharge units flow
- 5- we need a sump pit with a **volume** equals the discharge units flow multiplying the working time of the pump

## Example

A sump pit receives a drainage of 200 DFU

Solution

$$2 \text{ DFU} = 1 \text{ GPM} \quad \text{so} \quad 200 \text{ DFU} = 100 \text{ GPM}$$

Assuming a pump works 6 times/HR

so the pump flow rate = 200 GPM

$$\begin{aligned} \text{sump pit volume} &= \text{discharge units flow} * \text{working time of the pump} \\ &= 100 \text{ GPM} * 5 \text{ minutes} = 500 \text{ Gallon} \end{aligned}$$

لدينا حفرة تستقبل في أسوأ الحالات 2.4 لتر/ثانية ، إحسب تدفق المضخة المطلوب و حجم الحفرة اللازمة ؟

**الجواب:**

بما أن تدفق التغذية يساوي 2.4 ل/ث ، فإننا سنحتاج لمضخة تدفقها يساوي ضعف التدفق السابق ، أي 2.4 مضروبة ب 2 ، ويساوي 4.8 ل/ث.

حجم الحفرة يساوي 2.4 مضروبا ب 300 ثانية ، و يساوي 720 لتر أو 0.72 متر مكعب.

## Sump pit types

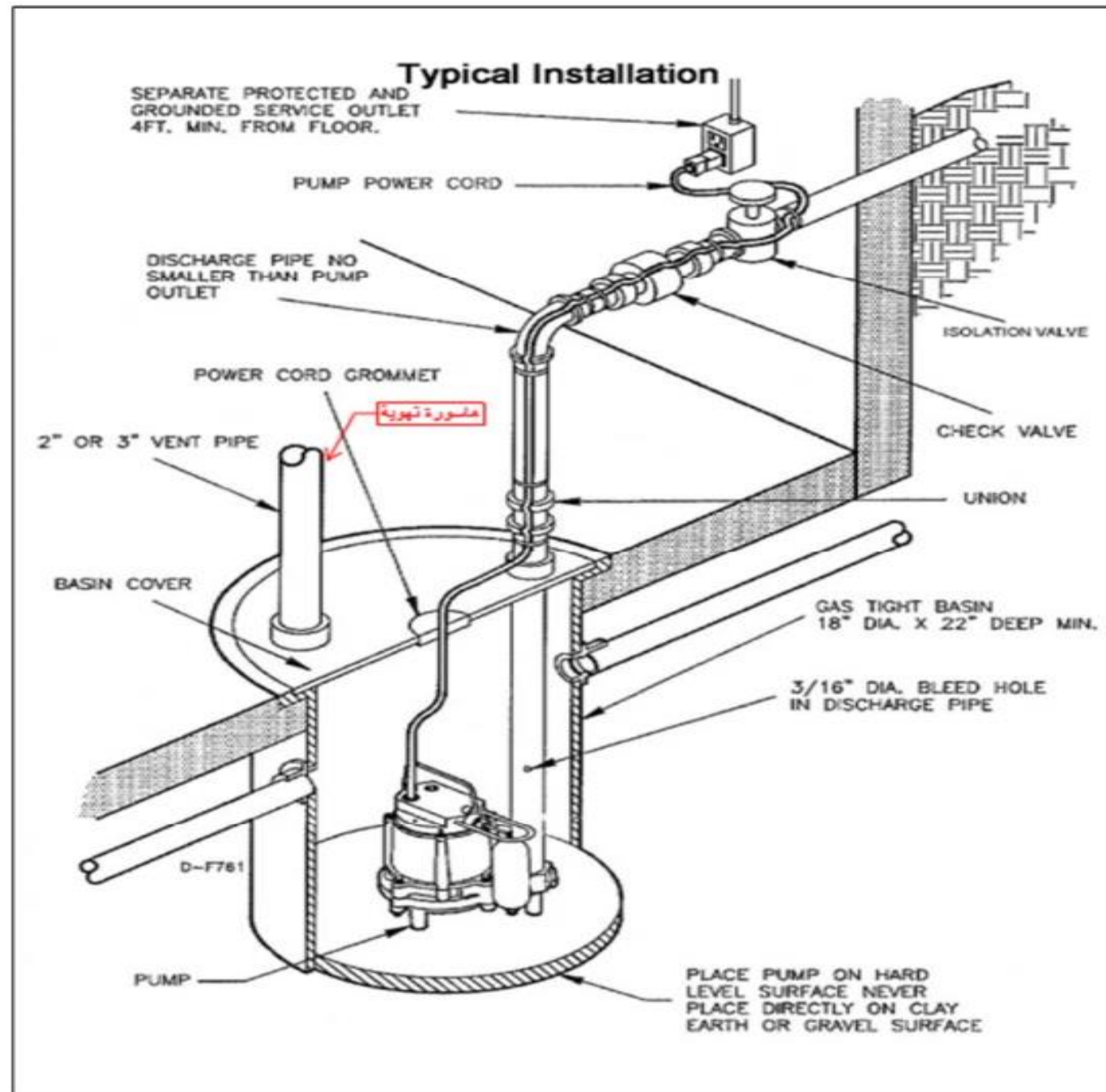
pneumatic sump ejector



Sewer sump pump

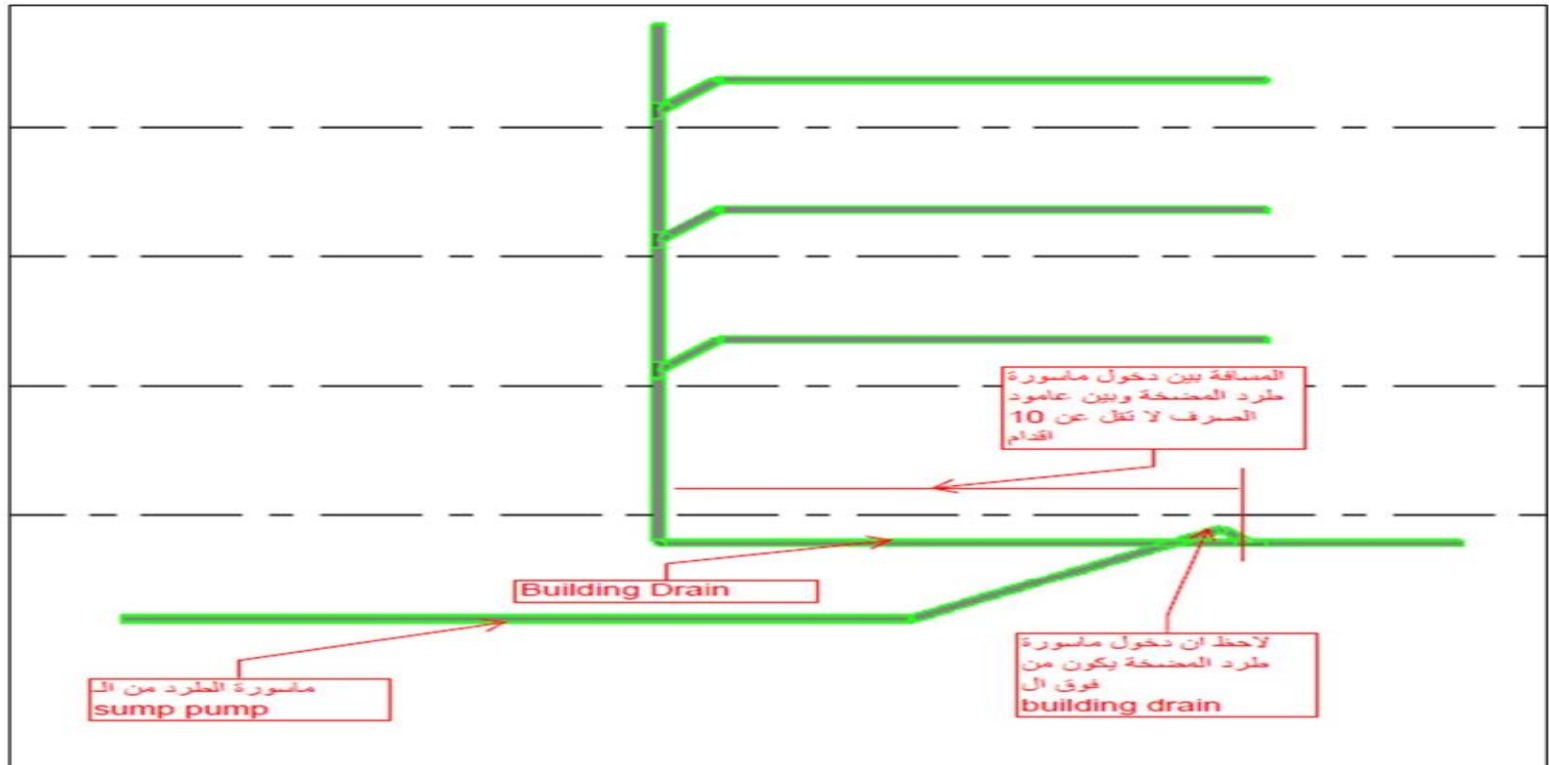


Typical installation



- 1- Discharge pipe must have **check valve** and **gate valve**
- 2- minimum **diameter** of sump pit is 18 " (50 cm)
- 3- minimum **Depth** of sump pit is 24 " (61 cm)
- 4- sump pit must be vented
- 5- sump pit pump must be fixed in hard surface
- 6- sump pit should be connected with the building sewer
- 7- sump pit pipe can be connect to the **building drain** but with **10 FT** from any stack

## Notes



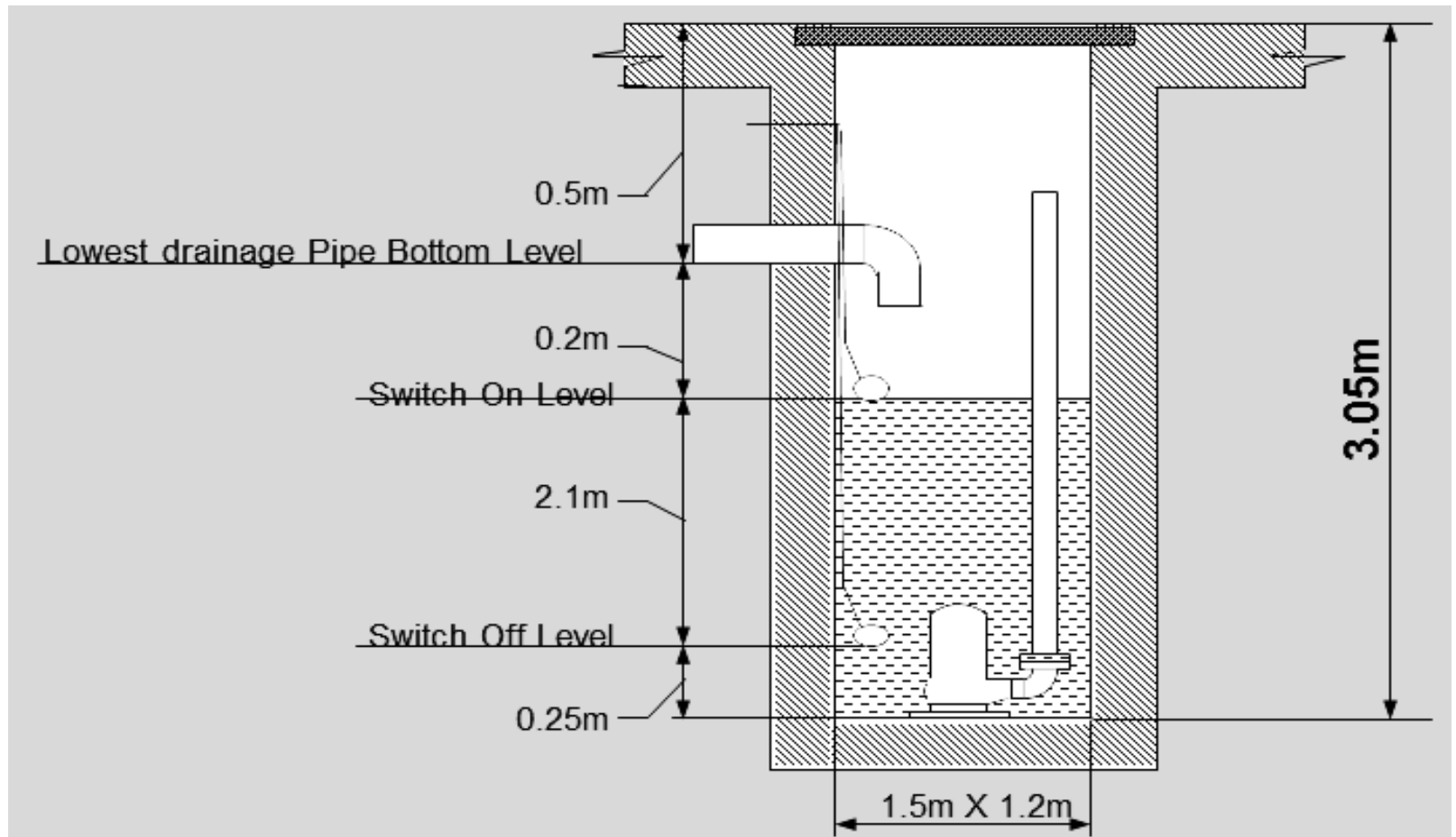


## Notes

Switch off and on for the sump pit locations

Alarm system for sump pit

The total volume of the sump pit

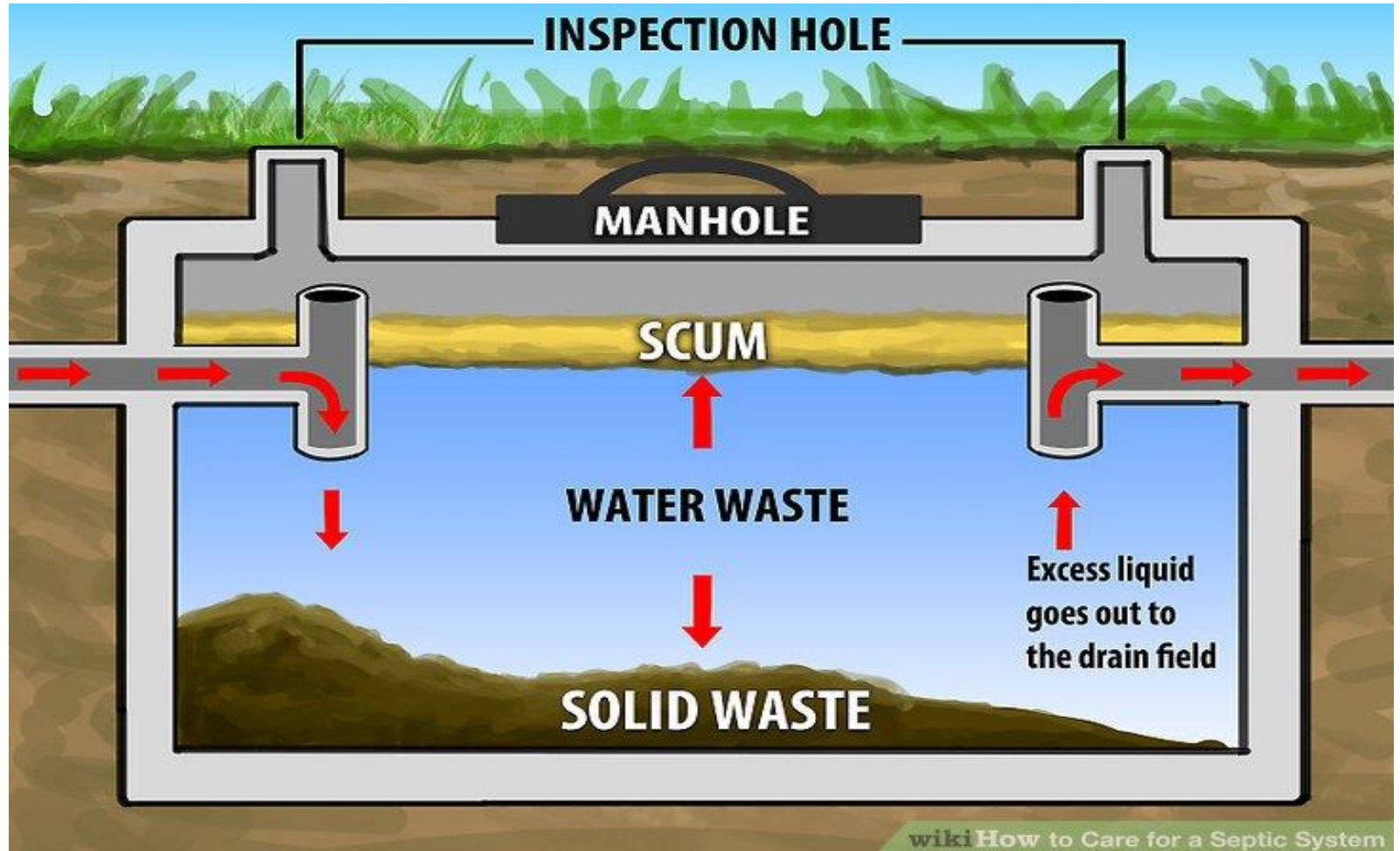


# Sump pit Video

# Septic tank & Holding tank

3. Septic tank & Holding tank :

ووظيفة هذا التانك هي تخزين الصرف لفترة زمنية معينة لحين كسحها بعربات كسح الصرف وذلك في حالة عدم توافر شبكة صرف صحي حكومية في هذا المكان.



## Difference between Septic and Holding tank

الـ holding tank يخزن الصرف لعدد من الايام وتأتى عربة الكسح بعد ذلك لتفريغه بالكامل بما يحتويه من soil & waste, وهنا الـ soil يسمى بالـ sludge.

اما الـ septic tank فيتم تخزين الصرف فيه ولا تأتى عربة كسح لتفريغه, ويتم تفريغ هذا التانك كالتالى :

التانك يحتوى على sludge & waste , الـ sludge يترسب فى قاع التانك لفترة زمنية كبيرة جدا ويكون التانك تام الاغلاق, وفى هذه الحالة تنشأ بكتيريا تتغذى على هذا الـ sludge وبذلك يفرغ التانك من الـ sludge,

اما بالنسبة للـ waste فإن مستواه فى التانك يرتفع الى مستوى معين حتى يصل الى ماسورة خروج من التانك وهذه الماسورة تذهب بعد ذلك تصرف الى ما يسمى بالـ percolating well or cesspool اى البالوعة, وهذه البالوعة تمتص صرف الـ waste من التانك ثم تنتشعه فى التربة المحيطة للـ percolating well.

ويتكون التانك سواء كان holding or septic من غرفتين او اكثر والغرفة الواحدة تسمى "compartment"

## **SEPTIC TANK CALCULATION AND RECOMMENDATIONS:-**

1. The retention time for sewage at septic tank must be between 24hr to 72hr.
2. The volume of septic tank shall be not less than  $2\text{m}^3$  and another one will be requested if its volume exceed  $36\text{m}^3$ .
3. The depth of septic tank shall be not less than 1.2m and not exceed 1.85m with slope towards inlet 1/10%.
4. It is better to construct septic tank with rectangular shape and with two compartments, satisfying the following conditions:-
  - a. The capacity of the inlet compartment shall have a capacity not less than  $1/3$  the total tank capacity
  - b. The ratio between its length and width shall be 2 or 3.
5. The distance between septic tank and distribution box of percolating pit shall be not less than 1.5m.
6. The level of outlet pipe shall be less than inlet pipe by 5cm.

## **PERCOLATING PIT CALCULATION AND RECOMMENDATIONS:-**

1. You have to identify the absorption rate of soil as it is vary according to its type (is it clay, sand, porous, rock...etc?).
2. The diameter of percolating pit shall not be less than 1m.
3. The distance between pit and distribution box shall be not less than 1.5m.
4. The distance between two percolating pit shall be not less than 3 times its diameter.
5. The distance between percolating pit and any beneath building shall be not less than 6m.
6. The percolating pit shall be vented with pipe not less than 10cm.
7. The bottom level of percolating pit shall be above level underground water reservoir by min. 2m.



## Steps of Design

1- calculate the Total avg. drainage /day

Total avg. drainage /day = (0.8 – 0.9 % from water consumption )

2- Design the septic tank according to the total retention time

بفرص لدينا ٩٠٠٠ جالون

نقسمه الى خزانين بنسبة ٣/١ و ٣/٢ طبقا للكود

اي الجزء الاكبر يكون ٦٠٠٠ (٢٧ متر مكعب) جالون

الجزء الاصغر يكون ٣٠٠٠ (١٤ متر مكعب) جالون

ناخذ الجزء الاكبر وهو ٢٧ ونقسمه على ١,٥ وهو متوسط ارتفاع الماء في خزان الصرف فيمكن الناتج ١٨ متر مربع

ثم نقوم بتوزيع الاجزاء الباقية بين طول وعرض الخزان متقيدا بشروط الكود اي ٣ x ٦ متر

ثم نأخذ الجزء الاصغر وهو ١٤ ونقسمه على ١,٥ ايضا فيكون الناتج ١٠ متر مربع

نقوم بتثبيت عرض الخزان وهو ٣ متر

نقسم الناتج ١٠ على عرض الخزان لنحصل على طول الجزء الاخر وهو ٣,٥ تقريبا

## Example

| الجزء الاكبر | الجزء الاصغر | طول   | عرض   | عمق     |
|--------------|--------------|-------|-------|---------|
| ٦ متر        | ٣,٥ متر      | ٣ متر | ٣ متر | ١,٥ متر |
| ٣,٥ متر      | ٣ متر        | ٣ متر | ٣ متر | ١,٥ متر |

TABLE 802.8  
MINIMUM HORIZONTAL SEPARATION DISTANCES  
FOR TREATMENT TANKS

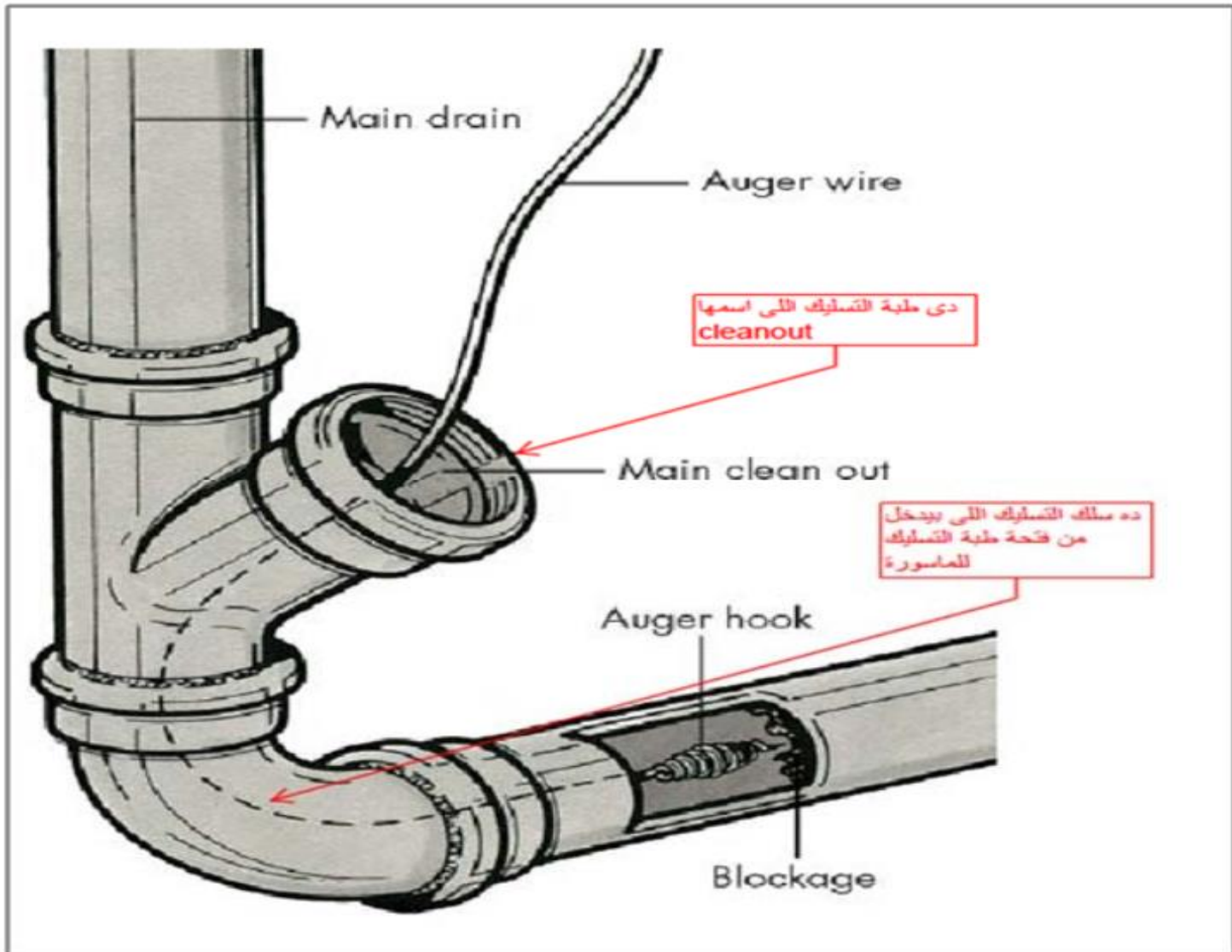
| ELEMENT               | DISTANCE (feet) |
|-----------------------|-----------------|
| Building              | 5               |
| Cistern               | 25              |
| Foundation wall       | 5               |
| Lake, high water mark | 25              |
| Lot line              | 2               |
| Pond                  | 25              |
| Reservoir             | 25              |
| Spring                | 50              |
| Stream or watercourse | 25              |
| Swimming pool         | 15              |
| Water service         | 5               |
| Well                  | 25              |

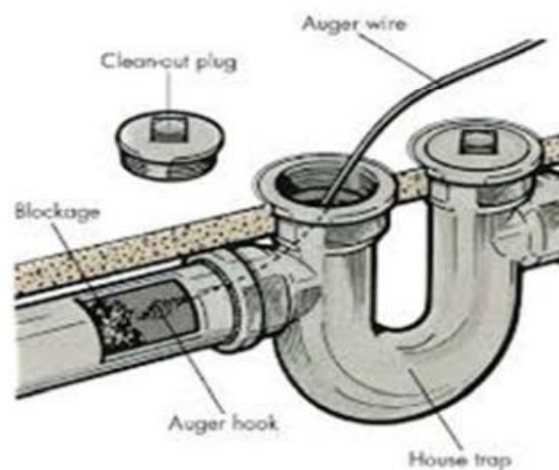
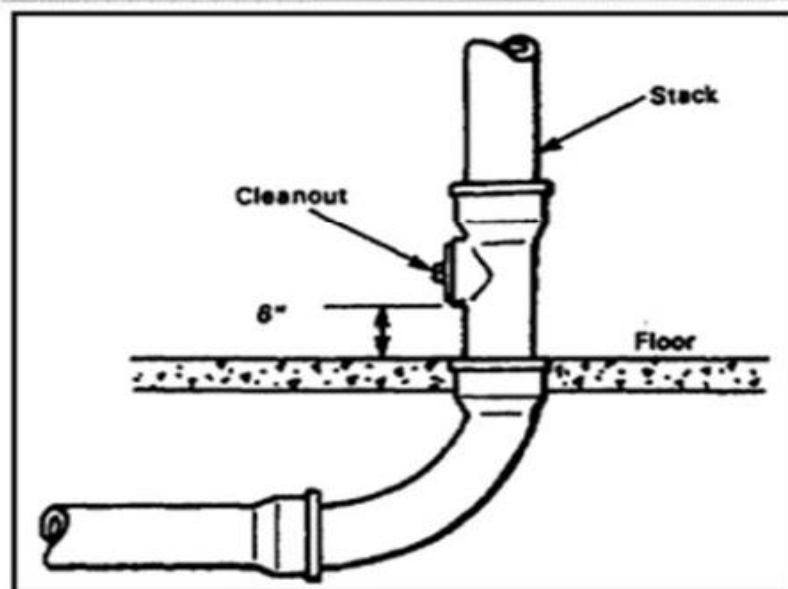
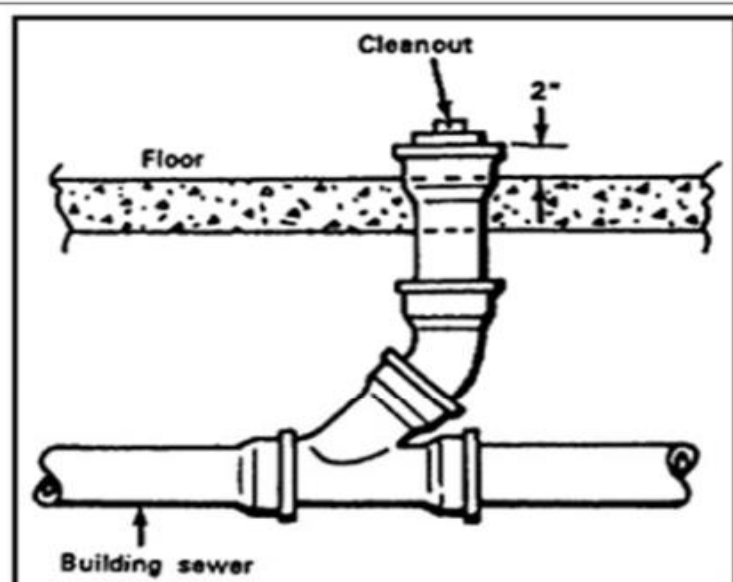
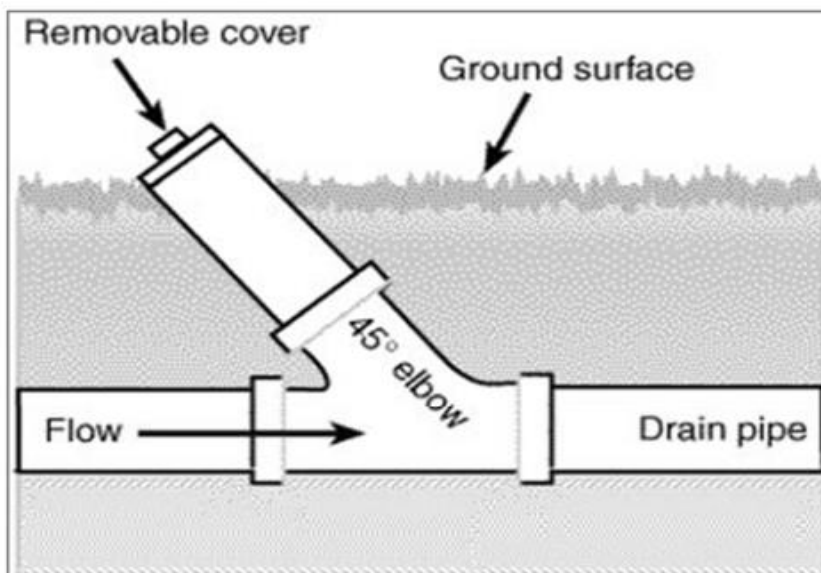
For 51: 1 foot = 304.8 mm.

Distance from Septic  
and Holding tank

Septic tank videos and Egyptian code example

## Clean outs





## Locations

- 1- at the base of all stacks
- 2- at any changing in direction with angle more than 45
- 3- at the horizontal pipes if it's length more than 75 - 100 FT
- 4- connection between building drain and building sewers

## Clean Out Code Installation

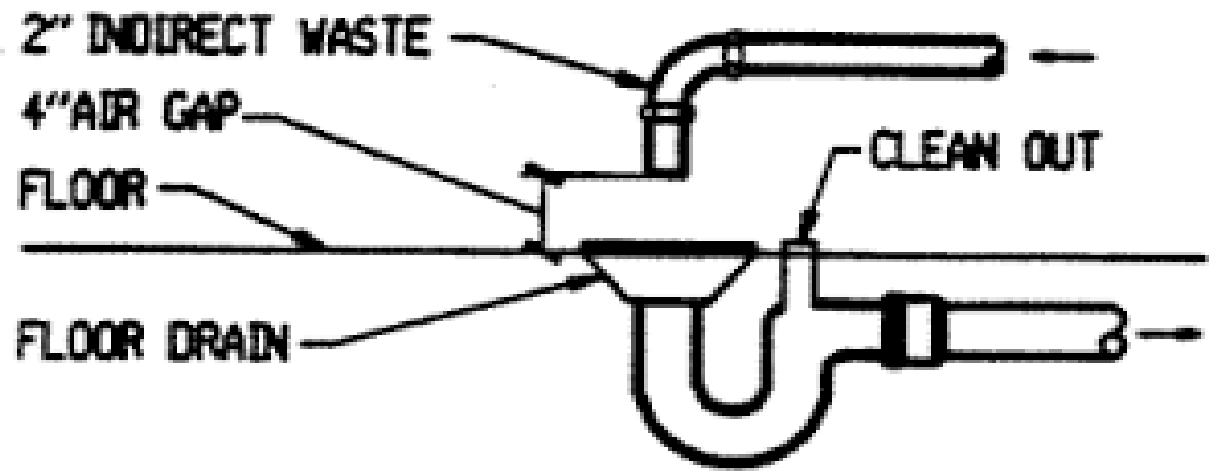


# Manholes

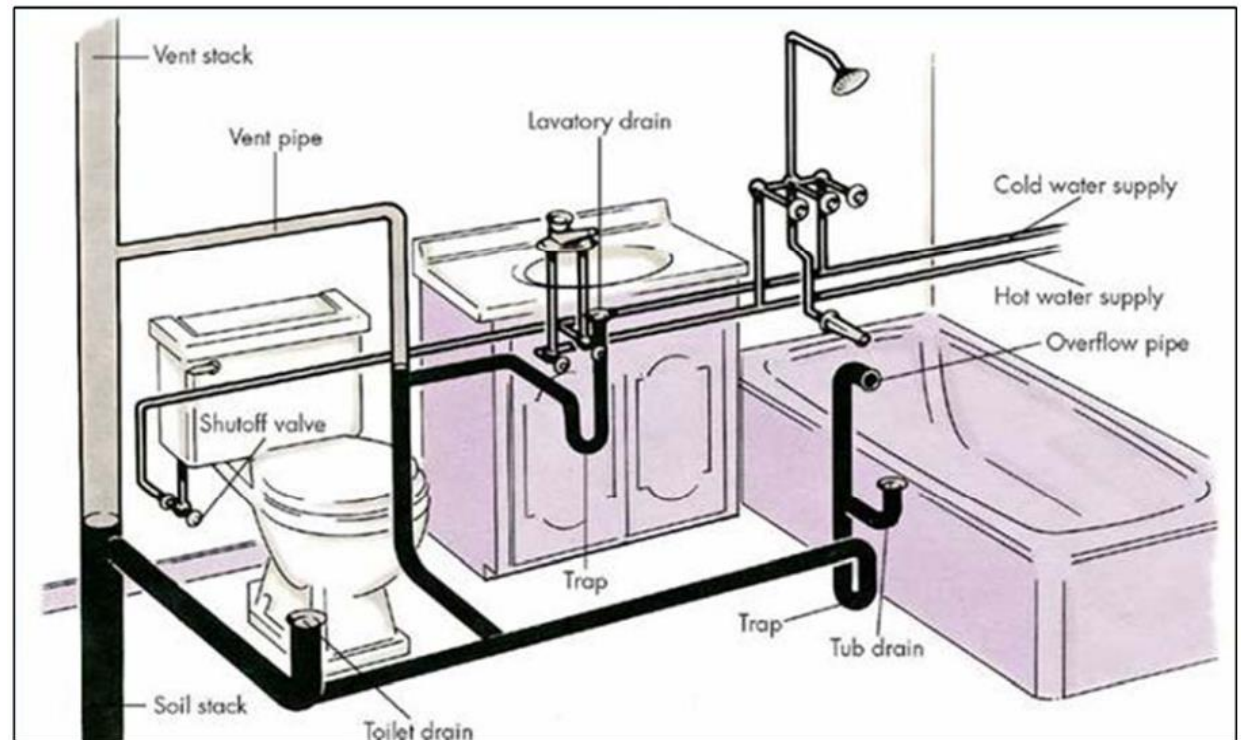


## Gully Traps





Different between  
Direct and Indirect  
waste









## Food handling Equipment





# Sterilizer



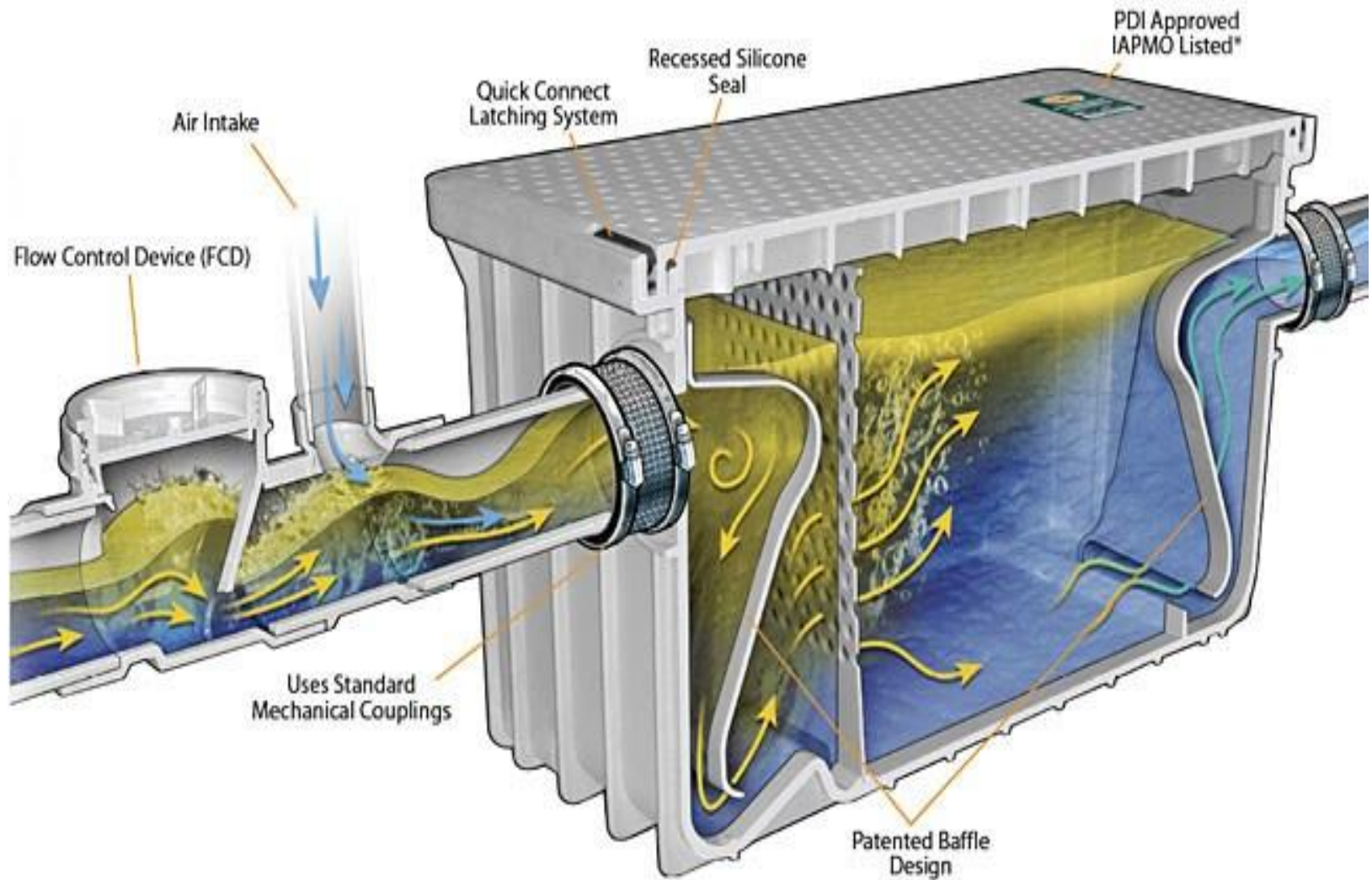
Process Tank



## Commercial and Domestic Dishwasher



# Grease Interceptor



Grease Interceptor Design





## waste food grinder



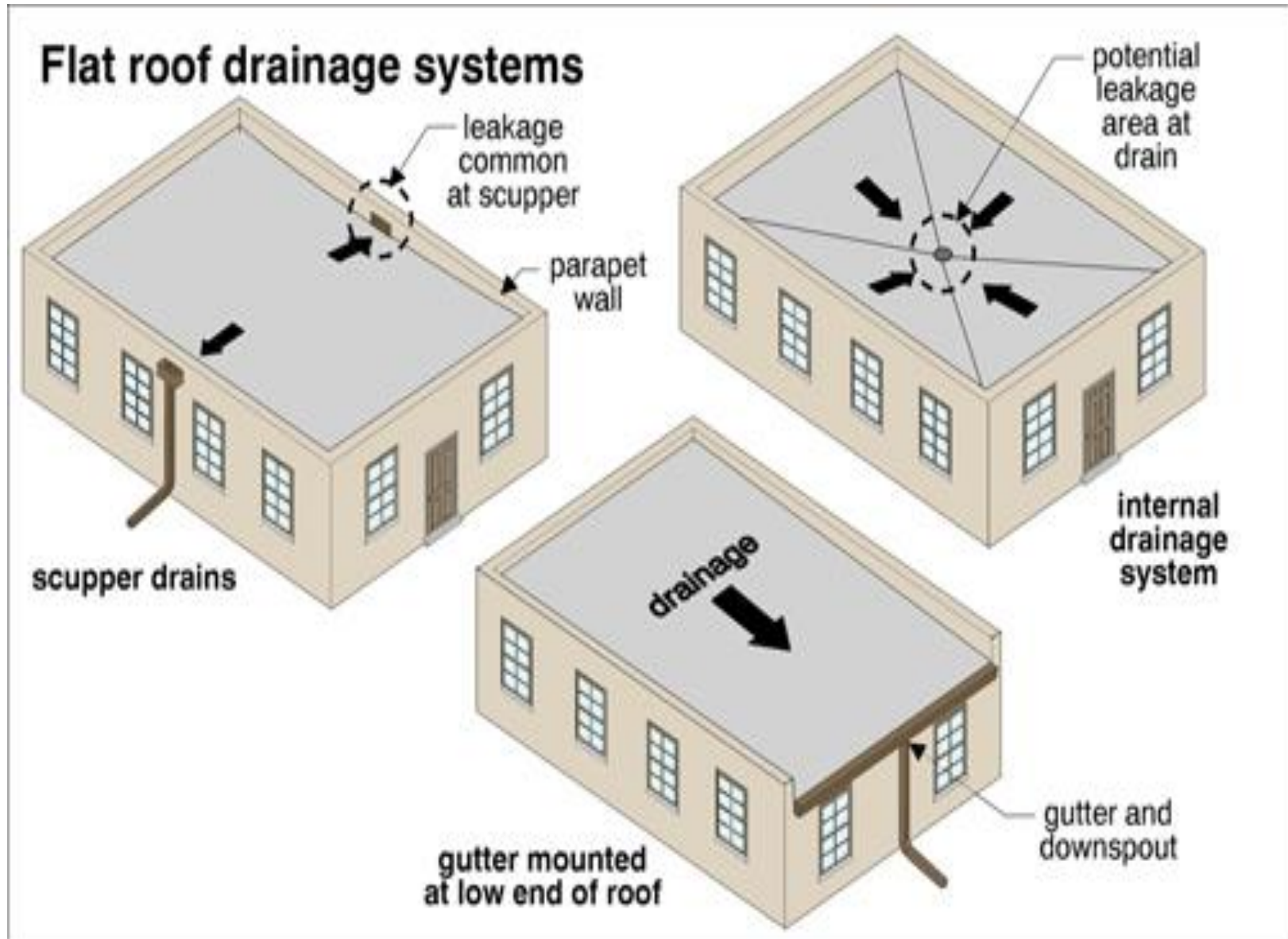
# Storm Drainage System

Gutters





## Semicircular gutter and downspout







**TABLE D-1**  
Maximum Rates of Rainfall for Various Cities

The rainfall rates in this table are based on U.S. Weather Bureau  
Technical Paper No. 40, Chart 14: 100-Year 60-Minute Rainfall (inches).

| States and Cities | Storm Drainage<br>60-Minute Duration, 100-Year Return |                 |
|-------------------|---|-----------------|
|                   | Inches/Hour   | GPM/Square Foot |
| <b>ALABAMA</b>    |   |                 |
| Birmingham        | 3.7   | 0.038           |
| Huntsville        | 3.3   | 0.034           |
| Mobile            | 4.5   | 0.047           |
| Montgomery        | 3.8   | 0.039           |
| <b>ALASKA</b>     |   |                 |
| Aleutian Islands  | 1.0   | 0.010           |
| Anchorage         | 0.6   | 0.006           |
| Bethel            | 0.8   | 0.008           |
| Fairbanks         | 1.0   | 0.010           |
| Juneau            | 0.6   | 0.006           |
| <b>ARIZONA</b>    |   |                 |
| Flagstaff         | 2.3   | 0.024           |
| Phoenix           | 2.2   | 0.023           |
| Tucson            | 3.0   | 0.031           |
| <b>ARKANSAS</b>   |   |                 |
| Eudora            | 3.8   | 0.039           |
| Ft. Smith         | 3.9   | 0.041           |
| Jonesboro         | 3.5   | 0.036           |
| Little Rock       | 3.7   | 0.038           |
| <b>CALIFORNIA</b> |   |                 |
| Eureka            | 1.5   | 0.016           |
| Lake Tahoe        | 1.3   | 0.014           |
| Los Angeles       | 2.0   | 0.021           |
| Lucerne Valley    | 2.5   | 0.026           |
| Needles           | 1.5   | 0.016           |
| Palmdale          | 3.0   | 0.031           |
| Redding           | 1.5   | 0.016           |
| San Diego         | 1.5   | 0.016           |
| San Francisco     | 1.5   | 0.016           |
| San Luis Obispo   | 1.5   | 0.016           |

Rain Fall



وتصميم قطر مواسير صرف المطر يعتمد فى المقام الاول على معدل او كثافة نزول المطر الذى يسمى بالـ rain fall intensity, ووحدها بالـ in/hr, فإذا قلنا ان كثافة نزول المطر فى مدينة ما 4 in/hr, فهذا معناه انه بعد ساعة واحدة من نزول المطر سترتفع مستوى مياه المطر فى هذا المكان لمسافة 4 بوصة.



## Size The Vertical pipes

**TABLE 1106.2**  
**SIZE OF VERTICAL CONDUCTORS AND LEADERS**

| DIAMETER OF OF<br>LEADER<br>(Inches) <sup>a</sup> | HORIZONTALLY PROJECTED ROOF AREA (square feet) |        |        |        |        |        |        |        |        |        |        |       |
|---|--|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
|   | Rainfall rate (inches per hour)                |        |        |        |        |        |        |        |        |        |        |       |
|   | 1  | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9      | 10     | 11     | 12    |
| 2   | 2,880  | 1,440  | 960    | 720    | 575    | 480    | 410    | 360    | 320    | 290    | 260    | 240   |
| 3   | 8,800  | 4,400  | 2,930  | 2,200  | 1,760  | 1,470  | 1,260  | 1,100  | 980    | 880    | 800    | 730   |
| 4   | 18,400   | 9,200  | 6,130  | 4,600  | 3,680  | 3,070  | 2,630  | 2,300  | 2,045  | 1,840  | 1,675  | 1,530 |
| 5   | 34,600   | 17,300 | 11,530 | 8,650  | 6,920  | 5,765  | 4,945  | 4,325  | 3,845  | 3,460  | 3,145  | 2,880 |
| 6   | 54,000   | 27,000 | 17,995 | 13,500 | 10,800 | 9,000  | 7,715  | 6,750  | 6,000  | 5,400  | 4,910  | 4,500 |
| 8   | 116,000  | 58,000 | 38,660 | 29,000 | 23,200 | 19,315 | 16,570 | 14,500 | 12,890 | 11,600 | 10,545 | 9,600 |

For SI: 1 inch = 25.4 mm, 1 square foot = 0.0929 m<sup>2</sup>.

- a. Sizes indicated are the diameter of circular piping. This table is applicable to piping of other shapes provided the cross-sectional shape fully encloses a circle of the diameter indicated in this table.

**TABLE 1106.3**  
**SIZE OF HORIZONTAL STORM DRAINAGE PIPING**

| SIZE OF<br>HORIZONTAL<br>PIPING<br>(inches)                          | HORIZONTALLY PROJECTED ROOF AREA (square feet) |         |         |         |        |        |
|--|--|---------|---------|---------|--------|--------|
|  | Rainfall rate (inches per hour)                |         |         |         |        |        |
|  | 1  | 2       | 3       | 4       | 5      | 6      |
| $\frac{1}{8}$ unit vertical in 12 units horizontal (1-percent slope) |  |         |         |         |        |        |
| 3  | 3,288  | 1,644   | 1,096   | 822     | 657    | 548    |
| 4  | 7,520  | 3,760   | 2,506   | 1,800   | 1,504  | 1,253  |
| 5  | 13,360   | 6,680   | 4,453   | 3,340   | 2,672  | 2,227  |
| 6  | 21,400   | 10,700  | 7,133   | 5,350   | 4,280  | 3,566  |
| 8  | 46,000   | 23,000  | 15,330  | 11,500  | 9,200  | 7,600  |
| 10   | 82,800   | 41,400  | 27,600  | 20,700  | 16,580 | 13,800 |
| 12   | 133,200  | 66,600  | 44,400  | 33,300  | 26,650 | 22,200 |
| 15   | 218,000  | 109,000 | 72,800  | 59,500  | 47,600 | 39,650 |
| $\frac{1}{4}$ unit vertical in 12 units horizontal (2-percent slope) |  |         |         |         |        |        |
| 3  | 4,640  | 2,320   | 1,546   | 1,160   | 928    | 773    |
| 4  | 10,600   | 5,300   | 3,533   | 2,650   | 2,120  | 1,766  |
| 5  | 18,880   | 9,440   | 6,293   | 4,720   | 3,776  | 3,146  |
| 6  | 30,200   | 15,100  | 10,066  | 7,550   | 6,040  | 5,033  |
| 8  | 65,200   | 32,600  | 21,733  | 16,300  | 13,040 | 10,866 |
| 10   | 116,800  | 58,400  | 38,950  | 29,200  | 23,350 | 19,450 |
| 12   | 188,000  | 94,000  | 62,600  | 47,000  | 37,600 | 31,350 |
| 15   | 336,000  | 168,000 | 112,000 | 84,000  | 67,250 | 56,000 |
| $\frac{1}{2}$ unit vertical in 12 units horizontal (4-percent slope) |  |         |         |         |        |        |
| 3  | 6,576  | 3,288   | 2,295   | 1,644   | 1,310  | 1,096  |
| 4  | 15,040   | 7,520   | 5,010   | 3,760   | 3,010  | 2,500  |
| 5  | 26,720   | 13,360  | 8,900   | 6,680   | 5,320  | 4,450  |
| 6  | 42,800   | 21,400  | 13,700  | 10,700  | 8,580  | 7,140  |
| 8  | 92,000   | 46,000  | 30,650  | 23,000  | 18,400 | 15,320 |
| 10   | 171,600  | 85,800  | 55,200  | 41,400  | 33,150 | 27,600 |
| 12   | 266,400  | 133,200 | 88,800  | 66,600  | 53,200 | 44,400 |
| 15   | 476,000  | 238,000 | 158,800 | 119,000 | 95,300 | 79,250 |

For SI: 1 inch = 25.4 mm, 1 square foot = 0.0929 m<sup>2</sup>.

**TABLE 1106.6  
SIZE OF SEMICIRCULAR ROOF GUTTERS**

| DIAMETER OF<br>GUTTERS<br>(inches)                                      | HORIZONTALLY PROJECTED ROOF AREA (square feet) |        |        |        |       |       |
|---|--|--------|--------|--------|-------|-------|
|   | Rainfall rate (inches per hour)                |        |        |        |       |       |
|   | 1  | 2      | 3      | 4      | 5     | 6     |
| $\frac{1}{16}$ unit vertical in 12 units horizontal (0.5-percent slope) |  |        |        |        |       |       |
| 3   | 680  | 340    | 226    | 170    | 136   | 113   |
| 4   | 1,440  | 720    | 480    | 360    | 288   | 240   |
| 5   | 2,500  | 1,250  | 834    | 625    | 500   | 416   |
| 6   | 3,840  | 1,920  | 1,280  | 960    | 768   | 640   |
| 7   | 5,520  | 2,760  | 1,840  | 1,380  | 1,100 | 918   |
| 8   | 7,960  | 3,980  | 2,655  | 1,990  | 1,590 | 1,325 |
| 10  | 14,400   | 7,200  | 4,800  | 3,600  | 2,880 | 2,400 |
| $\frac{1}{8}$ unit vertical 12 units horizontal (1-percent slope)       |  |        |        |        |       |       |
| 3   | 960  | 480    | 320    | 240    | 192   | 160   |
| 4   | 2,040  | 1,020  | 681    | 510    | 408   | 340   |
| 5   | 3,520  | 1,760  | 1,172  | 880    | 704   | 587   |
| 6   | 5,440  | 2,720  | 1,815  | 1,360  | 1,085 | 905   |
| 7   | 7,800  | 3,900  | 2,600  | 1,950  | 1,560 | 1,300 |
| 8   | 11,200   | 5,600  | 3,740  | 2,800  | 2,240 | 1,870 |
| 10  | 20,400   | 10,200 | 6,800  | 5,100  | 4,080 | 3,400 |
| $\frac{1}{4}$ unit vertical in 12 units horizontal (2-percent slope)    |  |        |        |        |       |       |
| 3   | 1,360  | 680    | 454    | 340    | 272   | 226   |
| 4   | 2,880  | 1,440  | 960    | 720    | 576   | 480   |
| 5   | 5,000  | 2,500  | 1,668  | 1,250  | 1,000 | 834   |
| 6   | 7,680  | 3,840  | 2,560  | 1,920  | 1,536 | 1,280 |
| 7   | 11,040   | 5,520  | 3,860  | 2,760  | 2,205 | 1,840 |
| 8   | 15,920   | 7,960  | 5,310  | 3,980  | 3,180 | 2,655 |
| 10  | 28,800   | 14,400 | 9,600  | 7,200  | 5,750 | 4,800 |
| $\frac{1}{2}$ unit vertical in 12 units horizontal (4-percent slope)    |  |        |        |        |       |       |
| 3   | 1,920  | 960    | 640    | 480    | 384   | 320   |
| 4   | 4,080  | 2,040  | 1,360  | 1,020  | 816   | 680   |
| 5   | 7,080  | 3,540  | 2,360  | 1,770  | 1,415 | 1,180 |
| 6   | 11,080   | 5,540  | 3,695  | 2,770  | 2,220 | 1,850 |
| 7   | 15,600   | 7,800  | 5,200  | 3,900  | 3,120 | 2,600 |
| 8   | 22,400   | 11,200 | 7,460  | 5,600  | 4,480 | 3,730 |
| 10  | 40,000   | 20,000 | 13,330 | 10,000 | 8,000 | 6,660 |

For SI: 1 inch = 25.4 mm, 1 square foot = 0.0929 m<sup>2</sup>.



## Roof Ground Slope

The different elevation between Top  
and Gutter is 15 cm