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PANDUAN TEKNIK MEKANIKAL

GUIDELINES ON THE DESIGN OF INTERNAL COLD WATER SYSTEM

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Cawangan Kejuruteraan Mekanikal

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PREFACE

Cawangan Kejuruteraan Mekanikal (CKM) is desirous that GUIDELINES ON THE DESIGN OF INTERNAL COLD WATER SYSTEM be prepared to streamline the planning and design of internal plumbing system. The intention being to standardize the planning and design by all units in CKM and to realign with the design of water reticulation system and sanitary fittings standards.

The standardization of design guideline shall promote expedient completion of tender drawings and to provide reference for new engineers.

The standards and design parameters quoted in this document are meant to guide designers to prepare the drawings. The standards, criteria and parameters specified in this document are subject to change or revision as deemed fit by the Committees.

GLOSSARY OF TERMS

Actual pipe length	:	The actual pipe length measured or obtained from the architectural drawing.
Anchor	:	A device used fasten or secure pipes to the building or structure.
Available head	:	The available head between two points is the pressure of water available at the initial point of flow considered in relation to the second point.
Backflow	:	The flow of water or other liquids, mixtures or substances into the distributing pipes of a potable supply from any sources or the sources other then its intended use.
Back siphonage	:	The flowing back of water from a plumbing fixture or vessel in to a water supply pipe due to negative pressure.
Balancing pipe	:	The pipe connecting two or more storage cisterns to balance the flow from each cistern.
Burst pressure	:	That pressure which can be slowly applied to a valve at the room temperature for 30sec without causing rupture.
Bushing	:	A pipe fitting for connecting a pipe with a female fitting of larger size. It is hollow plug with internal and external threads.
Butt weld joint	:	A welded pipe joint made with ends of two pipes butting each other, the weld being around the periphery.
Cavitation	:	A localised gaseous condition that is found within a liquid stream.
Communication pipe	:	Part of the service pipe between the water main and meter, or if there is no meter, it is the part of the service pipe between the main and the point where, in the opinion of The State Water Authority, the meter will be placed.

Companion flange	:	A pipe flange to connect with another flange or with a flanged valve or the fitting. It is attached to the pipes by threads welding or other method and differs from flange which is an integral part of a pipe or fitting.
Compression fitting	:	A fitting designed to a pipe or tube by means of pressure or friction.
Compression joint	:	A multi piece joint with cup shaped threads nuts which, when tightened, compress tapered sleeves so that they form a tight joint on the periphery of the tubing they connect.
Coupling	:	A pipe fitting with the female threads only which is used to connect two pipes in straight line.
Distribution pipe	:	Any consumers' pipe conveying water from a storage or feed cistern or hot water apparatus supplied from the feed cistern and under pressure only from such cistern.
Effective pipe length	:	The sum of the actual pipe length and the equivalent pipe lengths.
Elbow	:	A fitting that makes an angle between the adjacent pipes. The angle is 90 degree.
Erosion	:	The gradual destruction of metal or other materials by the abrasion action of liquids, gasses solids or mixtures of these materials.
Equivalent pipe length	:	The head loss of an equivalent length of straight pipe of the same diameter for the frictional loss caused by pipe fittings such as elbows, tees, etc.
Expansion joint	:	A joint whose primary purpose is to absorb longitudinal thermal expansion in the pipe line due to heat.
Feed cistern	:	Any storage cisterns used for supplying cold water to a hot water apparatus, or to the flushing cistern, or to any part of an air-conditioning system, or to any other plant or machinery.
Fitting	:	The connector or closure for the fluid lines and passages.
Flushing cistern	:	Cistern with discharge arrangements for flushing a water closet or urinal.

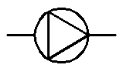
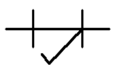
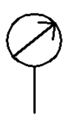
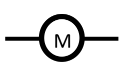
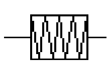
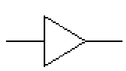
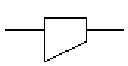
Flow pressure	:	The pressure in the water supply pipe near the water outlet while the faucet or water outlet is fully open and flowing.
High rise building	:	A multi-storey structure between 35-100 meters tall or if it had fewer than 40 floors and the height is unknown, it is also classified automatically as a high-rise. (ESN18727).
Loading unit	:	A measure of the probable hydraulic demand on the water supply by various types of plumbing fixtures. The supply fixture unit value for particular fixture depends on its volume rate of supply, on the time duration a single supply operation and on the average time between successive operation. A value assigned to a fitting which takes into account both the flow rate of the fitting and its probable usage.
Lux	:	A unit of illumination equal to the direct illumination on a surface that is everywhere one meter from a uniform point source of one candle intensity or equal to one lumen per square meter.
Nominal capacity	:	The volume calculated from the overall dimensions of the cistern.
Pipework	:	The term ‘pipework’ in this Guideline incorporates all pipes, fittings, fixtures and cisterns but excludes pumps, motors and switchboards whereupon mentioned.
Potable water	:	Water which is satisfactory for drinking, culinary and domestic purposes and meets the requirements of the health authority having jurisdiction.
Service pipe	:	The pipe linking the water main to the storage cistern.
Special	:	Any connecting length of pipe other than a straight pipe of uniform line.
Storage cistern	:	Cistern for storage of water which supplies cold water to fittings and feed cisterns and is connected to the water main by service pipe.
Storage capacity	:	The actual volume of water contained in the cistern when the water is at its top operating level.
UTG 2014	:	Uniform Technical Guideline 2014 as specified in Water Services Industry (Water Reticulation and Plumbing) Rules 2014

Water hammer	:	The forces, a pounding noise and vibration which develop in a piping system when a column of non-compressible liquid flowing in the pipe line at a given pressure and velocity is stopped abruptly.
Water main	:	A water supply pipeline intended for general public use.
Water supply plumbing	:	A general term indicating the practice, materials and fixture used in the installation or maintenance of all piping, fixtures, appliances and other appurtenance used in connection with both public or private water supply systems.

NOMENCLATURE

ABS	Acrylonitrile Butadiene Styrene
AWC	Asian Water Closet
B	Basin
BS	British Standard
BT	Bath Tub
BWL	Bottom Water Level
CIBSE	Chartered Institution of Building Services Engineers
DC	Direct Current
DOL	Direct on line
FRP	Fibre Reinforced Plastic
FV	Flush Valve
GALLONS (IGPM)	Imperial gallons per minutes
GALLONS (USGPM)	US gallons per minutes
G.I.	Galvanized Iron
GRP	Glass Reinforced Plastic
HDPE	High-Density Polyethylene Pipe
HGL	Hydraulic Grade Line
HL	Head Loss
HWC	High Water Closet
LB	Long Bath
MS	Malaysian Standards
NPSH	Net Positive Suction Head
PE	Polyethylene
PB	Polybutylene
PP-R	Polypropylene Random Copolymer
PRV	Pressure Reducing Valve
PVC	Polyvinylchloride
PWC	Pedestal Water Closet
RC	Reinforced Concrete
SDR	Standard Dimension Ratio
SH	Shower Head
SPAN	Suruhanjaya Perkhidmatan Air Negara
SS	Stainless Steel
T	Tap
UPVC	Unplasticized Polyvinyl Chloride
VAC	Volts Alternating Current
WB	Wash Basin
WCT	Water Closet Tap

LEGEND

Symbol	Name
	Pump
	Gate Valve / Stop Valve
	Normally Closed Gate Valve
	Flange Coupling
	Strainer
	PRV
	Check Valve
	Pressure Gauge
	Water Meter
	Flexible Connection
	Concentric Reducer
	Eccentric Reducer

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1 INTRODUCTION

This guideline is prepared for plumbing system design of a building consists of water storage and distribution system from the public main.

1.1 Objectives

The objective of this document is to provide guidelines for the design of internal cold water system that is safe, economical and compliant to current good engineering practices.

The objectives of the design of internal cold water system are to:

i. Prevent waste and contamination.
ii. Provide for the proper usage of waterworks fittings to ensure safety of the public.
iii. Optimise on the use of waterworks fittings with the requirement that fittings shall perform as specified.
iv. Ensure ease and accessibility for maintenance.
v. Avoid noise, airlock, vibration and water hammer.
vi. Comply with statutory requirements.
vii. Conform to what is considered as good engineering practice e.g. economic use of materials, neat arrangement of pipework, etc.

To ensure that the objective given above can be achieved, the following steps are recommended:-

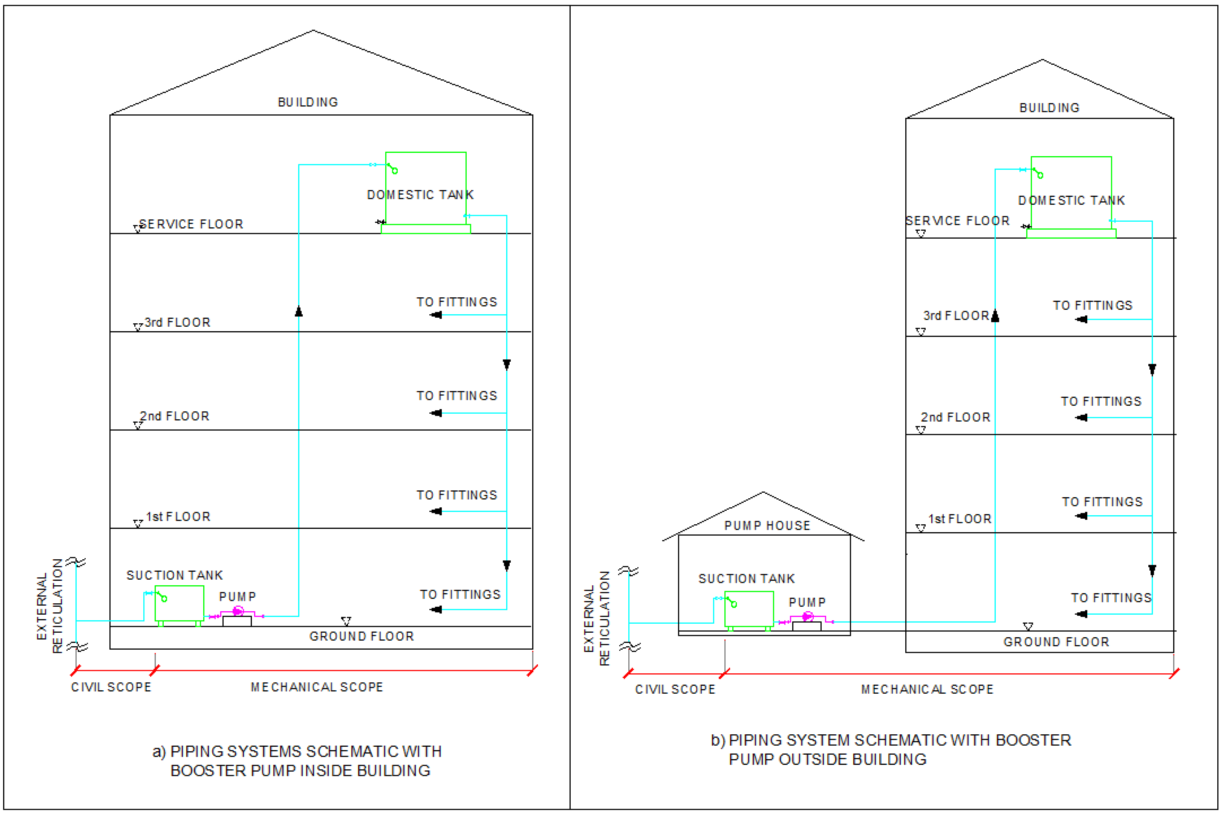
i. Obtain and study drawings and project brief.
ii. Investigate the availability of main water pipe and pressure in the vicinity.
iii. Decide on the location, type and size of the storage water tank, suction tank, main risers, droppers and pumping if required.
iv. Design distribution piping layout based on the architectural plans.
v. Select piping material.
vi. Carry out a detailed pipe sizing.

1.2 Limit Of Mechanical Scope Of Design(Civil and Mechanical)

Scopes of design for mechanical works include the following:

i. Design of pump and fittings.
ii. Design of water storage tank capacity.
iii. Design of internal cold water piping.

Details of the mechanical and civil scope are as shown in the FIGURES 1, 2, 3 and 4.



a) PIPING SYSTEMS SCHEMATIC WITH BOOSTER PUMP INSIDE BUILDING

b) PIPING SYSTEM SCHEMATIC WITH BOOSTER PUMP OUTSIDE BUILDING

FIGURE 1: INDIRECT FEED SYSTEM

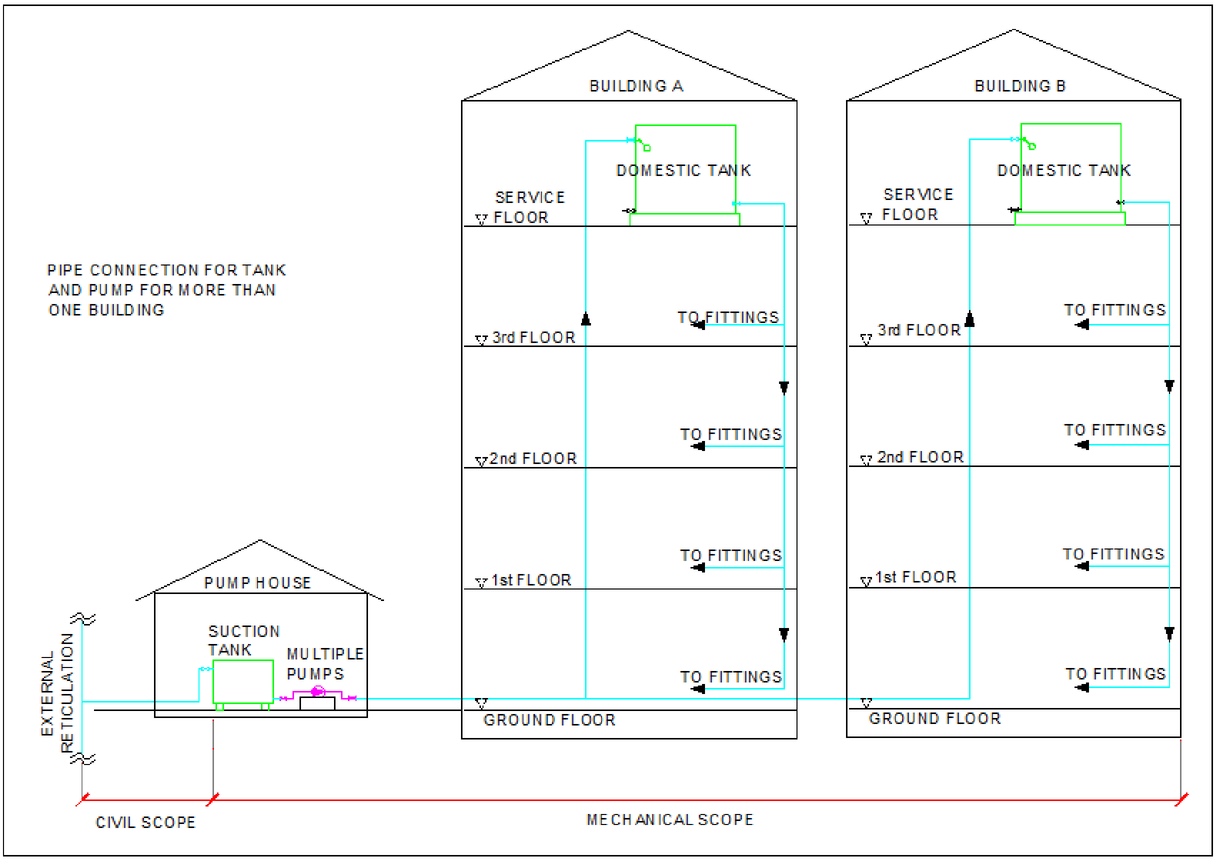


FIGURE 2 : PUMPING TO MULTIPLE BUILDING BLOCKS

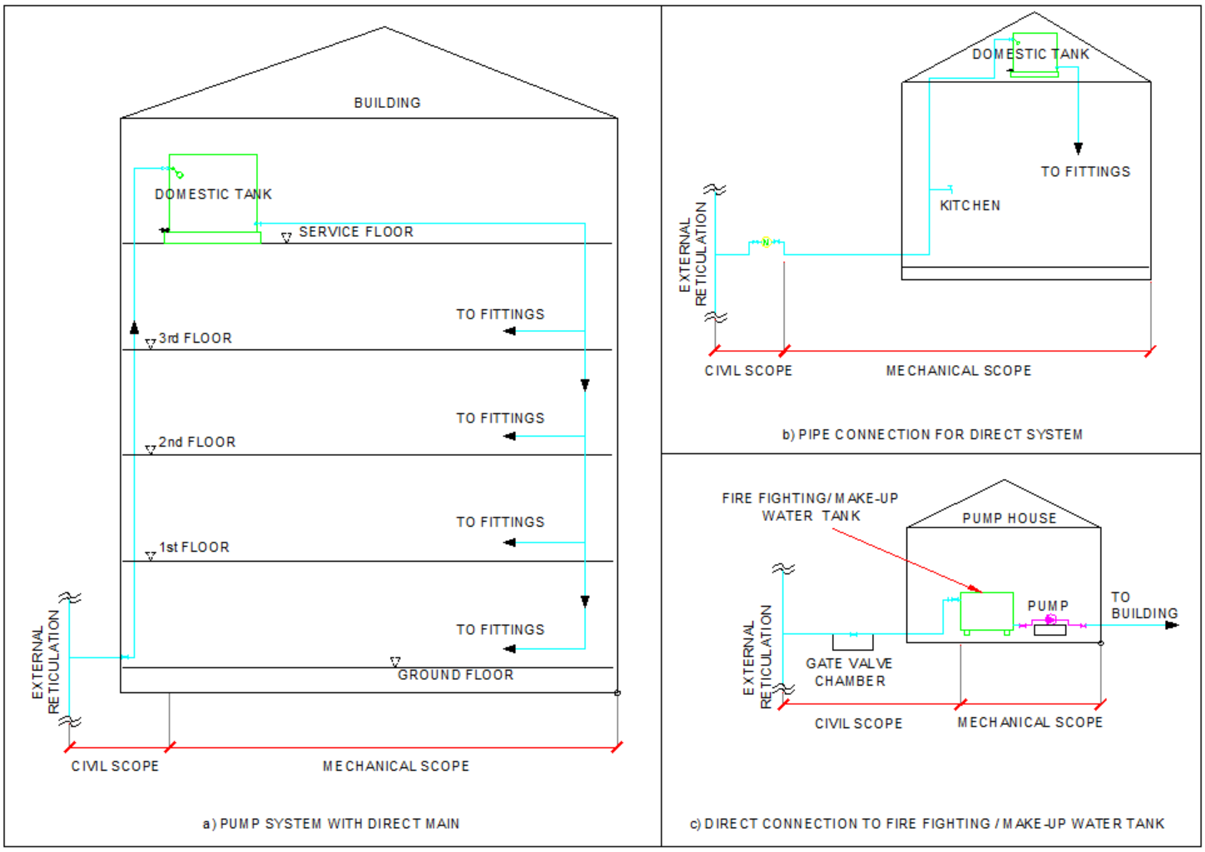


FIGURE 3 : DIRECT FEED FROM MAIN WATER PIPE

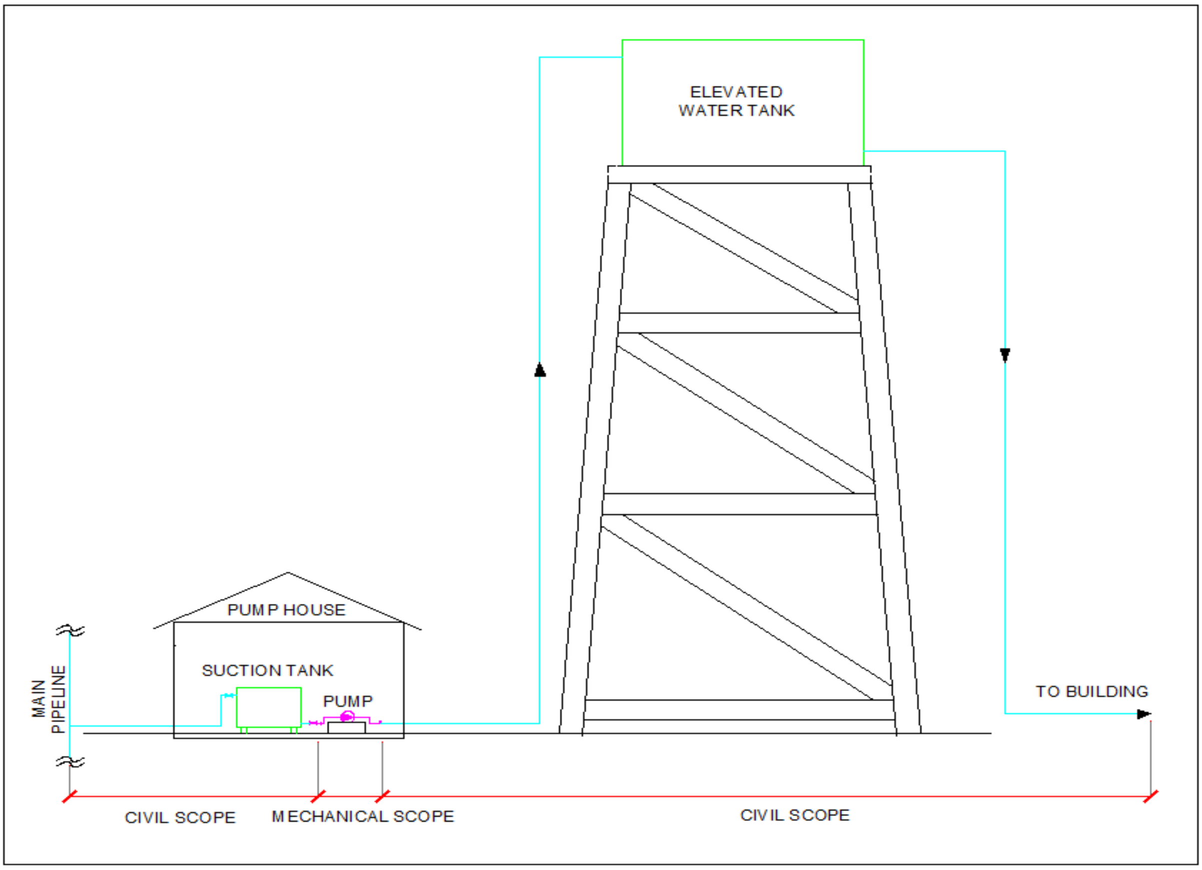


FIGURE 4 : PUMPING TO ELEVATED WATER TANK

2 WATER SUPPLY LEGISLATION

Beginning February 1, 2014, the Water Services Industry (Water Reticulation and Plumbing) Rules 2014 (Rules) and the Water Services Industry (Water Services Deposits, Fees and Charges) Regulations 2014 (Regulations) will be in effect throughout Peninsular Malaysia including Kuala Lumpur, Putrajaya and Labuan.

The purpose of the enforcement of these Rules and Regulations are to standardize the water services technical requirements as well as deposit rates, fees and charges throughout Peninsular Malaysia including Kuala Lumpur, Putrajaya and Labuan. It will replace the existing water supply rules and deposit rates, fees and charges (disconnection or reconnection) which vary according to the respective states.

The design shall comply with the latest edition of the following:

- Act 655- Water Services Industry Act 2006 (SPAN)
- Water Services Industry (Water Reticulation and Plumbing) Rules 2014 (SPAN)
- BS 8558:2011 – Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages – Complementary guidance to BS EN 806.

These Rules also contain instructions on **the proper installation, usage and maintenance** of plumbing appliances and fittings so as to achieve a high degree of reliability and efficiency of the water supply system.

The design of internal plumbing shall strictly follow the above rules with regard to:

i. layout
ii. use of materials and fittings
iii. protection of pipes and fittings
iv. provision of specials, valves and storage cistern (water tank)
v. other relevant practices, e.g: pumping requirements, etc.

3 PRELIMINARY REQUIREMENT

Before proceeding with the detail design, the following shall be taken into consideration.

3.1 External Water Pressure Requirement

It is necessary to check the external water pressure requirement for different type of buildings.

3.1.1 Landed Residential Premises

The residual pressure at any water fixture shall not be less than 2 meter Head.

Any section of the plumbing system shall not be subjected to a pressure of more than 30 meter Head, otherwise a pressure reducing valve shall be used to lower the water pressure.

3.1.2 Multi-Storey Buildings

The minimum pressure at point of use shall be as TABLE 1. All distribution pipes shall not be subjected to a pressure of more than 30 meter Head; otherwise a pressure reducing valve shall be employed to lower the water pressure.

TABLE 1 : MINIMUM PRESSURE AT POINT OF USE

Location	Minimum Pressure (meters Head)
Parcel meters of residential units	10
Water fixtures at commercial buildings (non-flush valves)	7
Flush valves	10.5

Source: *Uniform Technical Guidelines Water Reticulation And Plumbing* (1st ed.). (2014). SPAN.

3.1.3 Water For Non-Potable Purposes

The pressure of water supplied for non-potable use, e.g. for industrial process, cooling, washing, etc., shall conform to the equipment manufacturer specifications.

If the pressure of more than 30 meter Head is required, piping and fittings of a higher pressure rating to suit the specific requirement of a manufacturer shall be provided. If required, a separate localized pressure boosting pump set shall be employed to meet the required pressure level.

3.2 Space Requirement

It is important to provide space requirement for the following.

3.2.1 Pipe Riser (Service Shaft)

i. To provide pipe riser (service shaft) with opening at every floor for the riser pipe, complete with access doors adjacent to it and within the toilet area.

ii. To provide floor trap at the ground floor level of the shaft.

3.2.2 Storage Water Tank

i. For storage water tank in the ceiling space, the minimum clearance within roof top for the maintenance purposes. Refer to FIGURE 5.

ii. To provide a 600 mm x 600 mm service hatch in the ceiling. Refer to FIGURE 5.

iii. Staircase access shall be provided to the storage water tank located on the rooftop.

iv. To provide concrete plinth/support for the storage water tank.

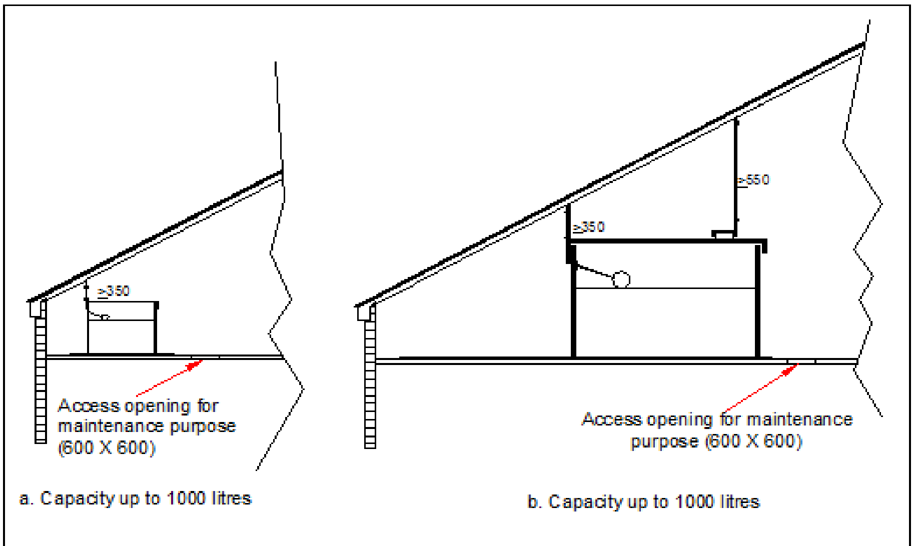
3.2.3 Break Tank

i. For buildings of height greater than 30 meters shall be provided with a break tank at every five storey intervals.

ii. The minimum clearance within roof top for maintenance purposes. Refer to FIGURE 5.

iii. To provide a 600 mm x 600 mm service hatch for break tank in the ceiling. Refer to FIGURE 5.

iv. To provide concrete plinths/support for the break tank.



NOTES:
1. Refer to the Mechanical Engineer to determine types and sizes of plinth for the water tank
2. Source BS6700:2006 (Design, installation, testing maintenance of services supplying water for domestic use within buildings and their curtilages Specification).
3. All dimensions are in millmeter (mm).

FIGURE 5: WATER TANK LAYOUT

Source: MECHANICAL SYSTEM DESIGN AND INSTALLATION GUIDELINES FOR ARCHITECTS AND ENGINEERS (JKR 20500-0008-10).

3.2.4 Pump (Flush Valve System)

i. To provide reinforced concrete (RC) plinth of 150 mm height.

3.2.5 Plant Room For Booster Pump

i. To provide plant room size dimension of 3 m x 3 m for water tank located outdoor.
ii. To determine the actual size of plant room by taking into consideration water tank dimension, booster pump size and spacing.
iii. To provide louvered double-leaf doors. Door shall open outwards.
iv. To provide high level louvered glass.
v. To provide concrete plinth 800 mm height for water tank.
vi. To provide concrete plinth of 150 mm height for pump.
vii. To provide floor trap according plant room size. Floor level shall slope gently towards drainage outlet.
viii. To provide non slip epoxy paint for floor / slope tile.
ix. To provide adequate lighting (150 Lux based on CIBSE code) and 13 amp socket outlet.

3.2.6 Water Meter

i. To provide water meter compartment.

3.3 Site Investigation

From water reticulation to the tapping off, the pressure requirement is to be determined by Civil Engineer.

From tapping off to the storage water tank, the pressure requirement is to be determined by Mechanical Engineer with calculation based on 1 psi = 2.31ft.
(If pressure is not enough then suction tank and pumping system is required).

3.4 Others

3.4.1 Structural Loading Requirement

Structural loading has to take into consideration of water tank size & capacity and the weight of pump. Mechanical Engineer is to give advice to the Structural Engineer. Rule of thumb, 1 litres of water equal to 1 kilogram.

3.4.2 Electrical Loading Requirement

Mechanical Engineer is to advise Electrical Engineer on the electrical loading if the design requires pumping system.

3.4.3 Aesthetic Requirement

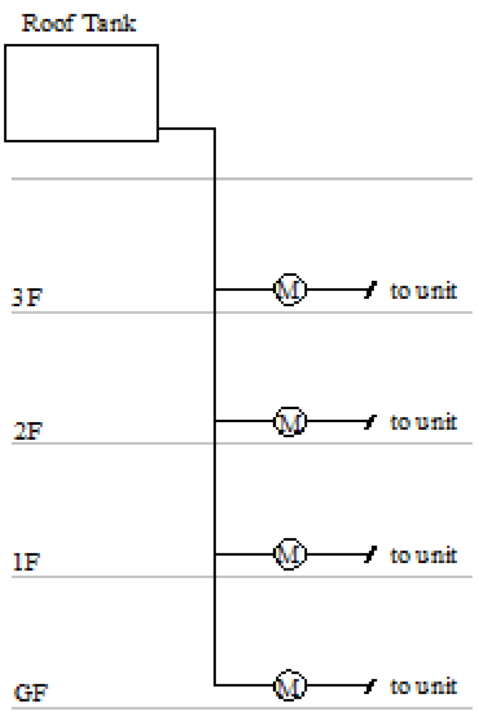
i. All equipment of the cold water system shall be properly located / enclosed and aesthetically acceptable with proper labels.
ii. Any exposed pipe shall be enclosed.
iii. For outside the building, to conserve aesthetic value, a proper pump house located at hidden location is preferable.

3.4.4 Water Metering Unit

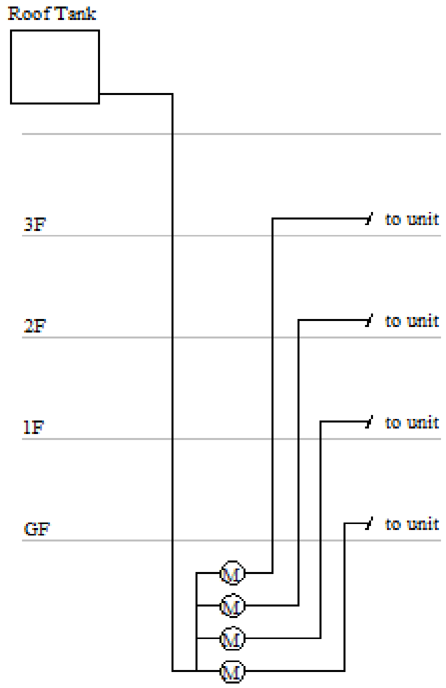
i. Scope of work for bulk meter shall be under Civil Contractor.
ii. Requirement and location of the sub-meter shall depend on the client/local water authority needs.
iii. The typical design of individual water metering unit for multi storey quarters is shown in FIGURE 6.

3.4.5 Water Supply To Kitchen

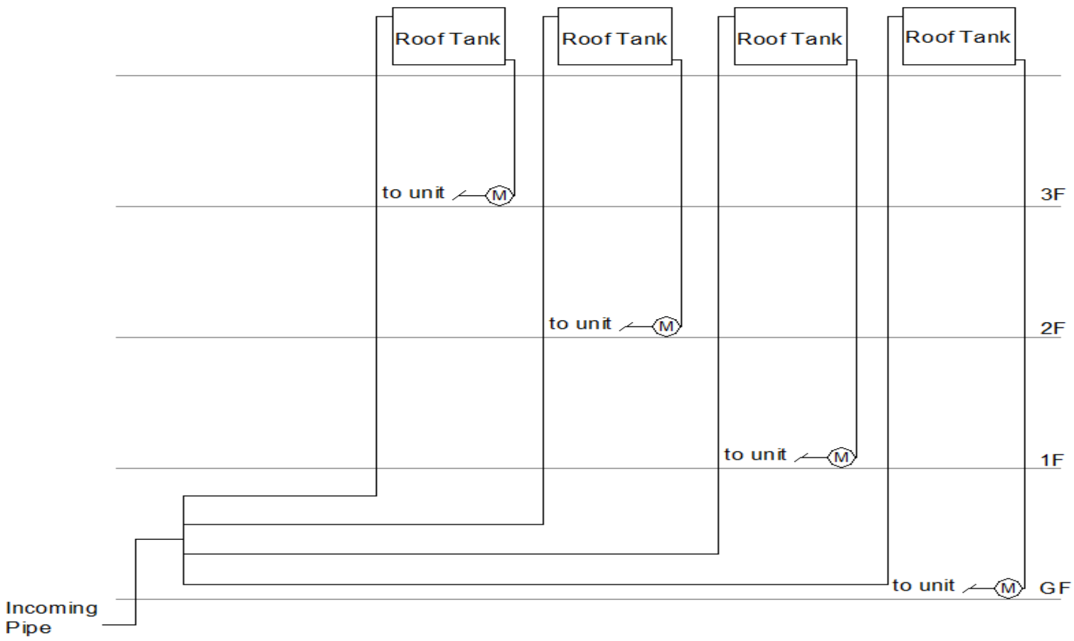
i. Tap off to kitchen sinks shall be drawn directly from a service pipe. (Not applicable for development with central storage cisterns).
ii. Draw off tap to kitchen sinks that draw water directly from service pipe shall be designed with an air gap to avoid contamination of the external water reticulation system. Such draw-off taps shall be fixed so that their outlets are at least 150 mm above the top edge of sink into which the water may be discharged.



Design A : Individual Meter Located At Every Floor For Each Unit



Design B: Individual Meter Located At Ground Floor For Each Unit.



Design C : Individual Meter Located At Every Floor For Each Unit And Individual Storage Water Tank

FIGURE 6: TYPICAL DESIGN OF INDIVIDUAL WATER METERING UNIT FOR MULTI STOREY QUARTER

4 WATER STORAGE REQUIREMENT

4.1 Design Standard

The daily consumption /storage requirement shall be based on the following:

i. Based on UTG 2014 by SPAN.
ii. Based on special functional needs or owners needs (car wash, hospital needs, factory etc.)

Generally, the effective capacity of a storage cistern (i.e. the maximum volume of water that can be drawn for use over a twenty four hour period) shall provide for one day's water consumption needs of different types of premises. The minimum storage capacities for different types of buildings are specified in TABLE 2, 3 and 4.

TABLE 2 : MINIMUM STORAGE CAPACITIES FOR HOSPITAL, AIRPORT AND PARTICULAR INDUSTRY

Building Type	Minimum Storage Capacity
Hospital	1500 Litres/bed
Airport	25 Litres/ passenger
Heavy Industry	65,000 Litres/ hectare
Medium Industry	50,000 Litres/ hectare
Light Industry	33,000 Litres/ hectare
Light Industrial Workshop	1,500 Litres/unit
Wet Market	1,500 Litres/stall
Dry Market	450 Litres/stall
Semi Detached / Bungalow / Workshops	1,500 Litres/unit

Source: *Uniform Technical Guidelines Water Reticulation And Plumbing* (1st ed.). (2014). SPAN.

TABLE 3 : MINIMUM STORAGE CAPACITIES FOR RESIDENTIAL / SHOP PREMISES

Building Type	Minimum Storage Capacity
Dwelling Houses (Rural)	800 Litres/unit
Dwelling Houses And Flats With Individual Storage Cistern(Urban)	1,300 Litres/unit
Flats With Shared Storage Cistern	1,000 Litres/unit
Low Cost Houses (Rural And Urban)	800 Litres/unit
Shop House (Single Storey) / Low Cost Shop	2,000 Litres/unit
Shop House (Double Storey)	3,000 Litres/unit

Building Type	Minimum Storage Capacity
Shop House (Three Storey)	4,100 Litres/unit
Shop House (Four Storey)	4,550 Litres/unit

Source: *Uniform Technical Guidelines Water Reticulation And Plumbing* (1st ed.). (2014). SPAN.

TABLE 4 : MINIMUM STORAGE CAPACITIES FOR OTHER TYPES OF BUILDINGS

Building Type	Minimum Storage Capacity
Hotels	270 Litres / Person
Hostels	180 Litres / Person
Day Schools / Kindergarden	30 Litres / Person
Boarding Schools	180 Litres / Person
Restaurants	14 Litres / Person
Mosque Or Other Place Or Worship	50 Litres / Person
Barrack (Amy And Police)	250 Litres / Person
Office / Complex / Commercial (Domestic Usage)	1000 Litres / 100 m^2
Community Centres Of Halls	1000 Litres / 100 m2
Education Institutions (Other Than School And Kindergarden)	100 Litres / Student
Institution Of Higher Learning With Hostel Facilities	250 Litres / Student
Prison	250 Litres / Person
Army Camp	100 Litres / Person
Bus Terminal	900 Litres / Sevice Bay
Petrol Kiosk (With Car Washing Bay)	50,000 Litres / Unit
Petrol Kiosk (Without Car Washing Bay)	10,000 Litres / Unit
Stadium	55 Litres / Person
Golf Course	1000 Litres / 100 m^2
Warehouse	1000 Litres / Unit
Other	As Person Estimated Water Demand By The Owner

Source: *Uniform Technical Guidelines Water Reticulation And Plumbing* (1st ed.). (2014). SPAN.

For premises where the population is transient and unknown the required storage cistern capacity may be estimated by the number of, and the types of, fittings installed as denoted in TABLE 5.

TABLE 5 : ESTIMATION OF WATER DEMAND BASED ON TYPES OF FITTINGS

Storage Capacity	Types of Fittings
450-900 liters	Per Shower
910 liters	Per Slipper Bath
180 liters	Per Water Closet
90 liters	Per Lavatory Basin
90 liters	Per Sink
180 liters	Per Urinal
180 liters	Per Bed Pan Washer
225 liters	Per Wash-Up Sink

Source: *Uniform Technical Guidelines Water Reticulation And Plumbing* (1st ed.). (2014). SPAN.

Storage cisterns for hospitals, airports and medium and heavy industries shall have a storage capacity of not less than two days water demand.

4.2 Estimation Of Water Requirement

Example 1 : Calculate the daily water demand for the building that have fittings given below:

Fittings	Ground floor	1st floor	2nd floor	3rd floor	Total
Water closet (wc)	14	14	14	14	56
Wash basin (wb)	18	14	14	14	60
Urinal	6	6	6	6	24
Tap	22	14	14	14	64
Sink	3	-	-	-	3

Solution: Since the number of fittings is known, TABLE 5 can be used.

Water closet (wc)	=	56	×	180	=	10,080	
Wash basin (wb)	=	60	×	90	=	5,400	
Urinal	=	24	×	180	=	4,320	
Tap	=	64	×	90	=	5,760	
Sink	=	3	×	90	=	270	
Total					=	225,830	litres/day

Example 2 : Calculate the daily water requirement for the full residential hostel block of 150 students.

Solution: Since the number of persons is known, TABLE 4 can be used.

Requirement = 150 persons × 180 litres/person/day

= 27,000 litres/day

Example 3 : Calculate the daily water requirement for the office block with the total net floor area is 19,400m^2.

Solution: Since the total floor area is known, TABLE 4 can be used.

Total Floor Area = 19,400m^2

For office, daily requirement is 1,000 liters / 100m^2

$\therefore$ 19,400m^2 × 1,000 liters / 100m^2 = 194,000 liters/day

4.3 Water Storage Tank

The storage tank shall be constructed of corrosion resistant material of approved quality or shall be coated internally with corrosion resisting material. Storage water tank for domestic purposes shall not impart taste, colour, odour or toxicity to the water.

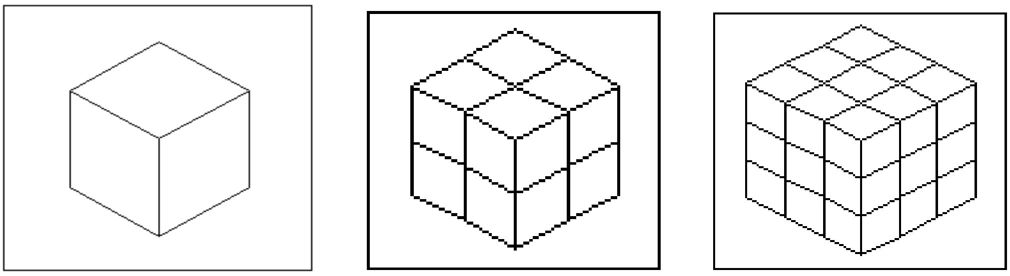
This section covers the sizing and selection methods of a storage tank system used in the typical building design process.

Tanks can be installed at ground level, on top of or inside buildings, or on towers.

Tanks can be coupled up with the balancing pipe to make up for the capacity required.

4.3.1 Glassfiber Reinforced Polyester (GRP) / Fiberglass Reinforced Polyester (FRP) Sectional Storage Tank

- GRP/FRP Panel Type Water Storage Tank system can cater for needs from **1 m^3 to 10,000 m^3.**
- Made from prefabricated GRP/FRP and can be easily assembled by bolting and brazing them together.
- All GRP/FRP panels should have a non-toxic compound moulded to ensure their original colour and appearance.
- The panel tank is a modular system, enabling a tank of any desired size to be constructed. Panel sizes are 1 m by 1 m and can be assembled up to 3 m in height as shown in FIGURE 7.



a) 1 panel in height b) 2 panels in height c) 3 panels in height

FIGURE 7 : WATER TANK CONFIGURATION

4.3.2 Polyethylene (PE) / High Density Polyethylene (HDPE) Tank

- PE/HDPE tank can cater for needs from 0.3 m^3 to 45 m^3.
- The tank shape to be constructed in cylindrical, taper, rectangular and square to suit with the space requirement.
- Available in various sizes and capacities to meet the requirements for various applications, multiple tank systems can be configured and installed to meet any storage capacity requirements.

4.3.3 Pressed Steel Tank

- Pressed Steel Water Storage Tank system can cater for needs from 1.2 m^3 to 10,000 m^3.
- Pressed steel sectional water tank constructed with hydraulically pressed flanged panels.
- Plates are galvanised with zinc coating as protection against corrosion. Upon assembly, they are further coated with approved bituminous paint or epoxy.
- The panel tank is a modular system, enabling a tank of any desired size and shape to be constructed. Panel sizes are 1 m × 1 m or 1.2 m x 1.2 m.
- Tanks can be installed at ground level, on top of or inside buildings.
- Typical applications include municipalities, industrial users, agriculture, aquaculture, reservoirs, hotels, hospitals, offices, private homes and other building complexes, as well as high volume long-term storage where regular piped supplies may not be available.

4.3.4 Stainless Steel Tank

- The sectional panel tank sizes are 1 m × 1 m and very according to manufacturer specification.
- The tank can be constructed in cylindrical or rectangular according to the type of applications.
- Tanks can be installed at ground level, on top of or inside buildings.
- Typical applications include municipalities, industrial users, agriculture, aquaculture, reservoirs, hotels, hospitals, offices, private homes and other building complexes, as well as high volume long-term storage where regular piped supplies may not be available.
- Made from 304 or/and 316 grade stainless steel and the tank fabrication can be any shape (sectional panel, cylindrical & etc.) and dimension.
- For cylindrical stainless steel water tank, the effective capacity is up to 15,000 litres (JKR 20200-0041-99 Stainless Steel Water Tanks with Effective Capacity Up to 15,000 L).

4.3.5 Composite Stainless Steel Tank

- The sectional panel tank sizes are 1 m × 1 m and vary according to manufacturer specification.
- Tanks are manufactured from 0.8 mm thick stainless steel grade 304/316 plate with a 5 mm thick welding bonded backing mild steel plate (BS 1564:1975 Specification for pressed steel sectional rectangular tanks).
- The internal surface shall be stainless steel combined with external surface of mild steel plate.

The list of SPAN'S standard for approved water tank can be referred at TABLE 6.

TABLE 6 : LIST OF SPAN'S STANDARD FOR APPROVED WATER TANK

Item	Standard Number	Standard Title
Glass Coated/ Glass Lined /Glass Fused /Epoxy Coated /Epoxy Lining	AWWA D103-97, ANSI/AWWA D103-09	Factory-Coated Bolted Steel Tanks For Water Storage
PE / HDPE Storage Tank	MS 1225-1:2014	Polyethylene (PE) tanks for cold water storage - Part 1: Capacity up to 600 gal (Third Revision)
	MS 1225-2:2006	Polyethylene (Pe) tanks for cold water storage -Part 2: Capacity More Than 600 gal (First Revision)
GRP/FRP Sectional Water Tank	MS 1390 : 2010	Specification for glass reinforced polyester panels & panel watertanks
FRP One-Piece Water Tank	BS EN 13280 : 2001	Specification for glass fibre reinforced cistern of one-piece and sectional construction for storage above ground of cold water
	MS 1241 : 1991	Specification for Fibreglass Water Tanks – Effective Capacity of Less Than 2000L
	BS 7491: Pt 2 : 1992	Glass Fibre Reinforced Plastic Cisterns for Cold Water Storage. Specification for one piece cisterns of nominal capacity for 500L to 25000L
Pressed Steel Sectional Rectangular Tank Pane	BS 1564 : 1975	Specification for Pressed Steel Sectional Rectangular Tanks
Stainless Steel Storage Tank	JKR 20200-0041-99	Stainless Steel Water Tanks (With Effective Capacity Up to 15,000L)
Stainless Steel Storage Tank (Rectangular / Panel Tank)	CNS 9443 : 2000	Stainless Steel Storage Tanks

Source: *Uniform Technical Guidelines Water Reticulation And Plumbing* (1st ed.). (2014). SPAN.

4.4 Tank Sizing Method

Example 4: Calculate the tank size required for an office building with 194,000 litres daily water demand. Assume booster pumping is required due to insufficient incoming water pressure.

Solution:

Water demand = 194,000 litres/day

Assume Demand Factor as 85%;

Therefore, **Net tank capacity** = 194,000 litres × 0.85 = 164,900 litres/day

Nominal tank capacity has to be bigger than net tank capacity, taking into consideration the non effective volume at the top portion and bottom portion of the water tank by **adding 20%(if using electrode control)** to the net capacity.

Therefore, **Nominal tank capacity** = 164,900 litres × 1.2

= **197,880 litres/day**

When booster pump is used, the capacity of suction tank should be from 30% to 70% of the total daily storage capacity required as per SPAN UTG 2014. In this example, ⅓ capacity is allowed for suction water tank and ⅔ for storage water tank.

Since panel **FRP tank** is selected, the **tank panel size of 1 m × 1 m** is used to assemble the required tank capacity.

Suction Tank

Nominal capacity = 197,880 litres/day

Capacity for suction tank = ⅓ × Total demand

= ⅓ × 197,880 litres

= **65,960 litres**

Conversion, 1 litre = 0.001 m^3

Therefore suction tank capacity = 65,960 × 0.001 m^3

= 65.96 m^3

Determine the **width (w)** and **height (h)** of the FRP tank; Say, **4 m (w)** × **2 m (h)** of the FRP tank;

$\therefore$ **Length (L)** of the suction tank is = 65.96 m^3 ÷ (4 m × 2 m)

= 65.96 m^3 ÷ (8 m^2)

= 8.245 m

≈ **10 m**

Therefore, the proposed size for the suction tank is **10 m x 4 m x 2 m.**

Storage Water Tank

Nominal capacity = 197,880 litres/day

Capacity for storage water tank = ⅔ × Total demand

= ⅔ × 197,880 litres

= **131,920 litres**

Therefore storage water tank capacity = 131,920 × 0.001 m^3

= 131.92 m^3

Determine the **width (w)** and **height (h)** of the FRP tank;

Say, **4 m (W)** × **2 m (H)** of the FRP tank;

Length (L) of the storage water tank is = 131.92 m^3 ÷ (4 m × 2 m)

= 131.92 m^3 ÷ (8 m^2)

= 16.49 m

≈ **18 m**

Therefore the propose size for the sorage water tank is 18 m(L) x 4 m(W) x 2 m (H).

In the above example, the height of the tank and tank configuration maybe limited by the room size and as such adequate room space to be provided. Also tank height of more than 3 meters is not allowed.

Example 5 : Calculate the tank size for the PE/HDPE tank required for a building with 41,000 litres daily water demand. Assume booster pumping is required due to insufficient incoming water pressure.

Solution:

Water demand = 41,000 litres/day

Assume Demand Factor as 85%;

Therefore, **Net tank capacity** = 41,000 litres × 0.85 = 34,850 litres/day

Nominal tank capacity has to be bigger than the net tank capacity, taking into consideration the non effective volume at the top the portion and bottom portion of the water tank by **adding 20%(if using electrode control)** to the net capacity.

Therefore, **Nominal tank capacity** = 34,850 litres × 1.2

= **41,820 litres/day**

When booster pump is used, the capacity of suction tank should be from 30% to 70% of the total daily storage capacity required as per SPAN UTG 2014. In this example, ⅓ capacity is allowed for suction water tank and ⅔ for storage water tank.

Suction Tank

Nominal capacity = 41,820 litres/day

Capacity for suction tank = ⅓ × Total demand

= ⅓ × 41,820 litres

= **13,940 litres**

Referring to the supplier's catalog, the tank **effective capacity is 15,000 litres and the size is 2,400 mm in diameter** × **3,900 mm in height.**

Therefore the number of tanks can be determined as follows:

= 13,940 litres ÷ (15,000 litres)

= 0.93

≈ **1 no.**

Storage Water Tank

Nominal capacity = 41,820 litres/day

Capacity for storage water tank	=	$\frac{2}{3}$ × Total demand
	=	$\frac{2}{3}$ × 41,820 litres
	=	**27,880 litres**

Since the capacity is large, the large-sized tank (cylindrical type) is used. Multiple tanks cank be used to cater for the storage capacity required.

Referring to the supplier's catalog, the selected tank **effective capacity is 7,200 litres and the size is 2,080 mm in diameter** × **2,920 mm in height.**

Therefore, the number of tanks can be determined as follows:

=	**27,880** litres ÷ (**7,200** litres)
=	3.87
≈	4 **no.**

5 PIPING SYSTEM DESIGN

5.1 Pipe Material

Designer must determine the pipe material to be used, with reference made to the relevant state water supply rules and to the approval of SPAN / the state water authority. The following standards in their latest edition shall apply as in TABLE 7. TABLE 8 shows its minimum wall thickness and pressure rating.

TABLE 7: PIPE MATERIAL AND STANDARDS

Item	Standard
ABS Pipes	MS 1419 : Part 1 :1997 – Pipes MS 1419 : Part 2 :1997 – Fittings MS 1419 : Part 3 :1997- Solvent
Stainless Steel	ASTM A312 / A312M or JIS G 3448 or BS EN 10312 : 2002
HDPE Pipe Class PN 15	MS 1058 : Part 2, 2002
Copper	BS EN 1057 : 2006 or ASTM B88

Source: *Spesifikasi Teknikal Piawai Sistem Bekalan Air Sejuk Dalaman dan Perpaipan Sanitari* (JKR 20500-0010-10).

TABLE 8: MINIMUM WALL THICKNESS & PRESSURE RATING FOR PIPES

Type of pipe	Minimum Wall Thickness & Pressure Rating
High Density Polyethylene (HDPE)	PN 12.5 at 20°C (equivalent to 10 bar derated working pressure at 30°C)
Acrylonitrile Butadiene Styrene (ABS)	Class 12-15 to MS 1419 : Part 1 : 1997
Polybutylene (PB)	PN 15 at 20°C (equivalent to 15 bar derated working pressure at 30°C)
Polypropylene Random Copdymer (PP-R)	More than 10 bar working pressure: PN 16 or SDR 7.4 at 20°C Less than 10 bar working pressure: PN 10 or SDR 11
Stainless Steel (SS)	BS EN 10312 (Welded): <Ø 12mm → Series 1 ≥Ø 12mm → Series 1 or Series 2 or ASTM A312/A312M: Ø ½'' – Ø 2'' → Schedule 40S (Threaded) Ø 2½'' – Ø 8'' → Schedule 10S (Welded)
Copper tubing	Type K

Source: *Spesifikasi Teknikal Piawai Sistem Bekalan Air Sejuk Dalaman dan Perpaipan Sanitari* (JKR 20500-0010-10).

5.2 Pipe Material Selection

TABLE 9 will give a quick-guide on the pipe material selection for different building.

TABLE 9 : PIPE MATERIAL SELECTION

Building Categories	Pipe Material
Office	ABS / PB / PP-R / Stainless steel
Hospital	Stainless Steel
Hostel	ABS / PB / PP-R / Stainless steel
School	ABS / PB / PP-R / Stainless steel

Note: For internal plumbing system which used pressurized system (flush valve, medical equipment, emergency shower, etc), the material of pipe shall be non-plastic material e.g stainless steel.

5.3 Category Of Cold Water Plumbing System

5.3.1 Low Rise Building (Gravity System)

For low rise building as in FIGURE 8, where the pressure in the main is sufficient to reach the storage tank, no pumping system is required.

From the storage tank, water shall be supplied by gravity to the various fittings within the building.

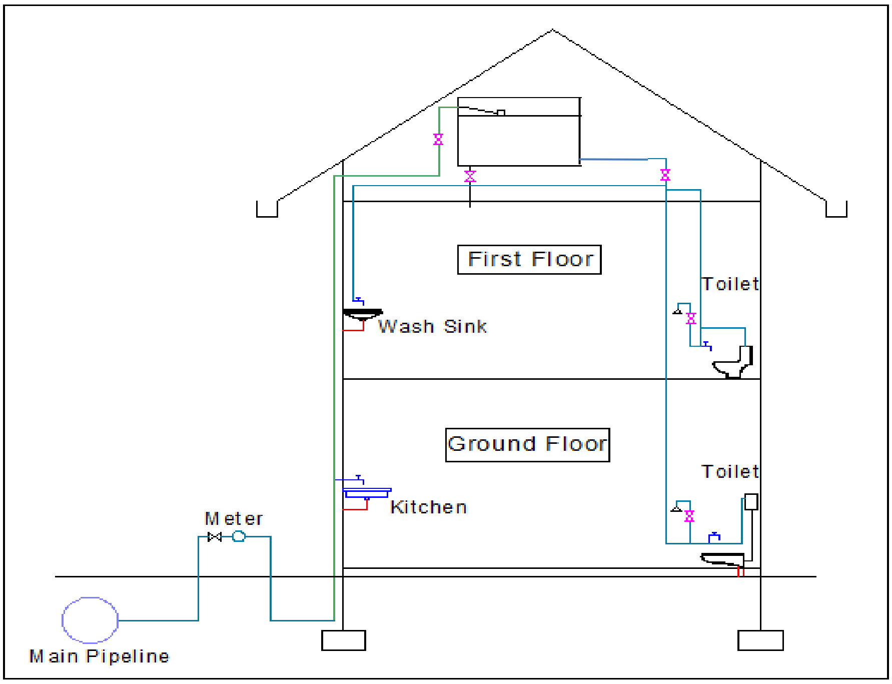


FIGURE 8: DOUBLE STOREY BUILDING

5.3.2 High-Rise Building

In FIGURE 9, when the pressure is inadequate for gravity flow at the required flow rate to the high level storage tank, then pumping system is necessary.

Water shall be distributed to the various fittings by gravity. Installation of break pressure tank is recommended to prevent excessive pressure. Pressure reducing valve shall be installed at 30 meters intervals along downpipes in order to restrict the pressure sustained by the fittings to prevent water hammer and other effect.

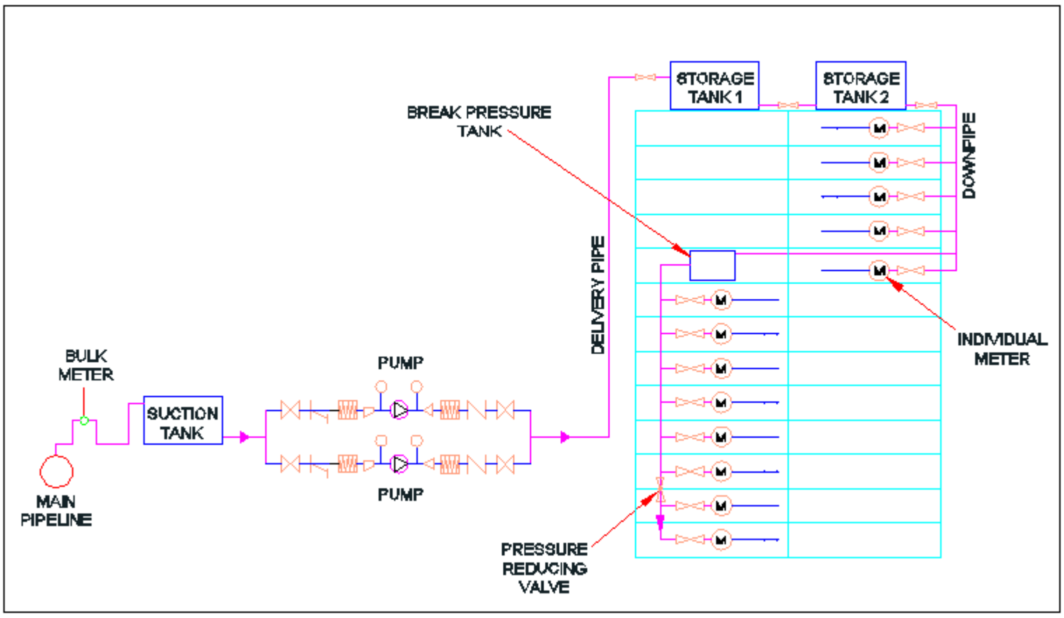


FIGURE 9: HIGH-RISE BUILDING

5.3.3 Flush Valve System

This system normally used for building having high frequency use such as public toilet, office etc. The system comprises of either hand-operated or foot-operated flush valve. The minimum residual head requirements for flush valve are shown in TABLE 10.

TABLE 10: MINIMUM RESIDUAL HEAD FOR FLUSH VALVE

Requirements	Low Pressure Flush Valve	High Pressure Flush Valve
Dynamic/operating head at the inlet of flush valve	3.25m	5.2m**
Flow rate	1.8 litres/sec	1.8 litres/sec

** Subject to manufacturer recommendation.

Source: *STANDARD SPECIFICATIONS FOR BUILDING WORKS 2005* (JKR 20800-132-23).

5.3.3.1 Gravity System (Low Pressure Flush Valve System)

A separate internal plumbing system (dedicated pipe) shall be provided for low pressure flush valves and fittings to have adequate dynamic pressure and flow, to ensure effective operation of each flush valve, i.e. for hydraulics of water closet to function properly, as shown in FIGURE 10. Minimum pipe size 100mm diameter to cater 3 numbers of flush valves for the top floor, as shown in FIGURE 11.

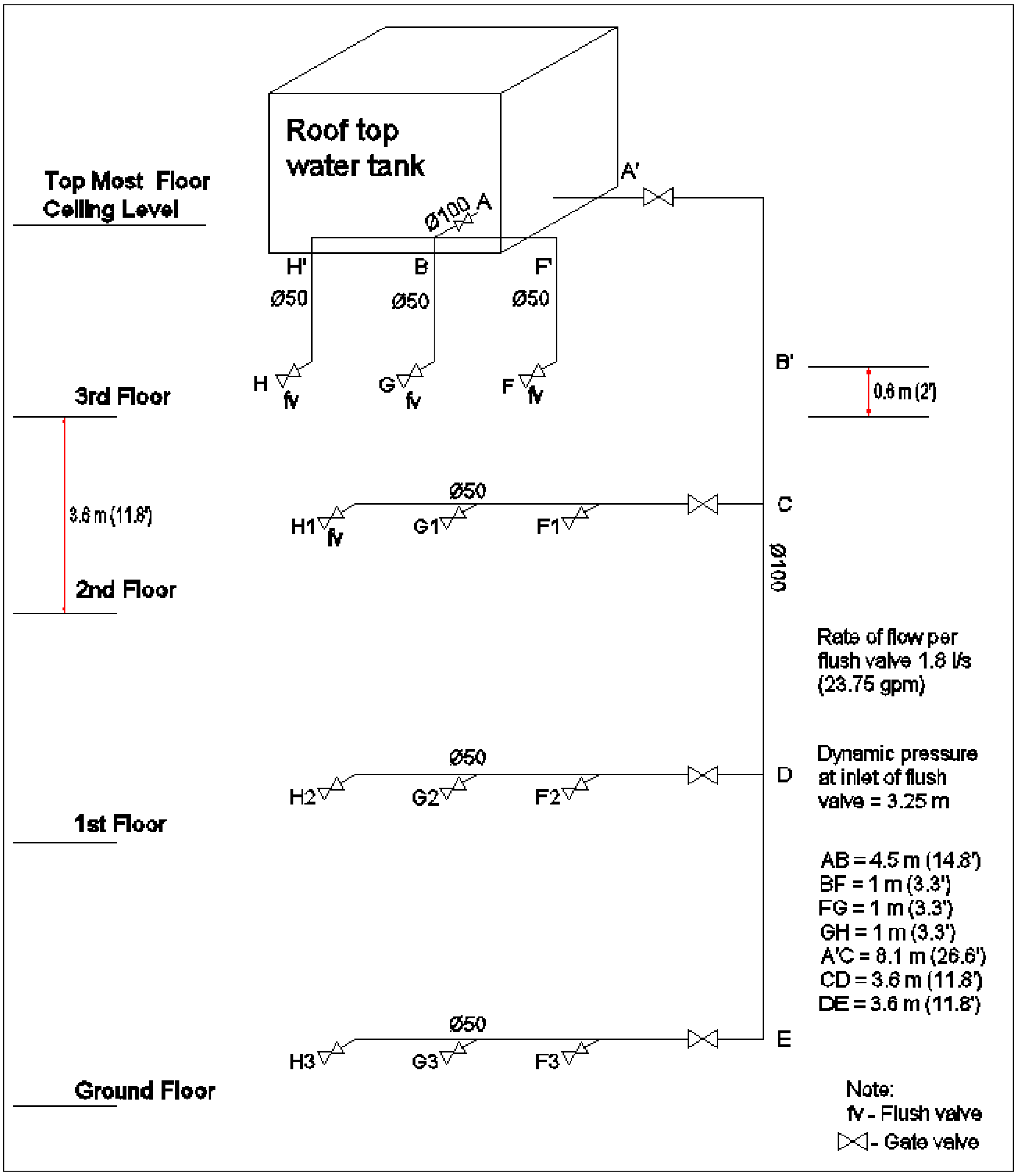


FIGURE 10: GRAVITY SYSTEM (LOW PRESSURE FLUSH VALVE)

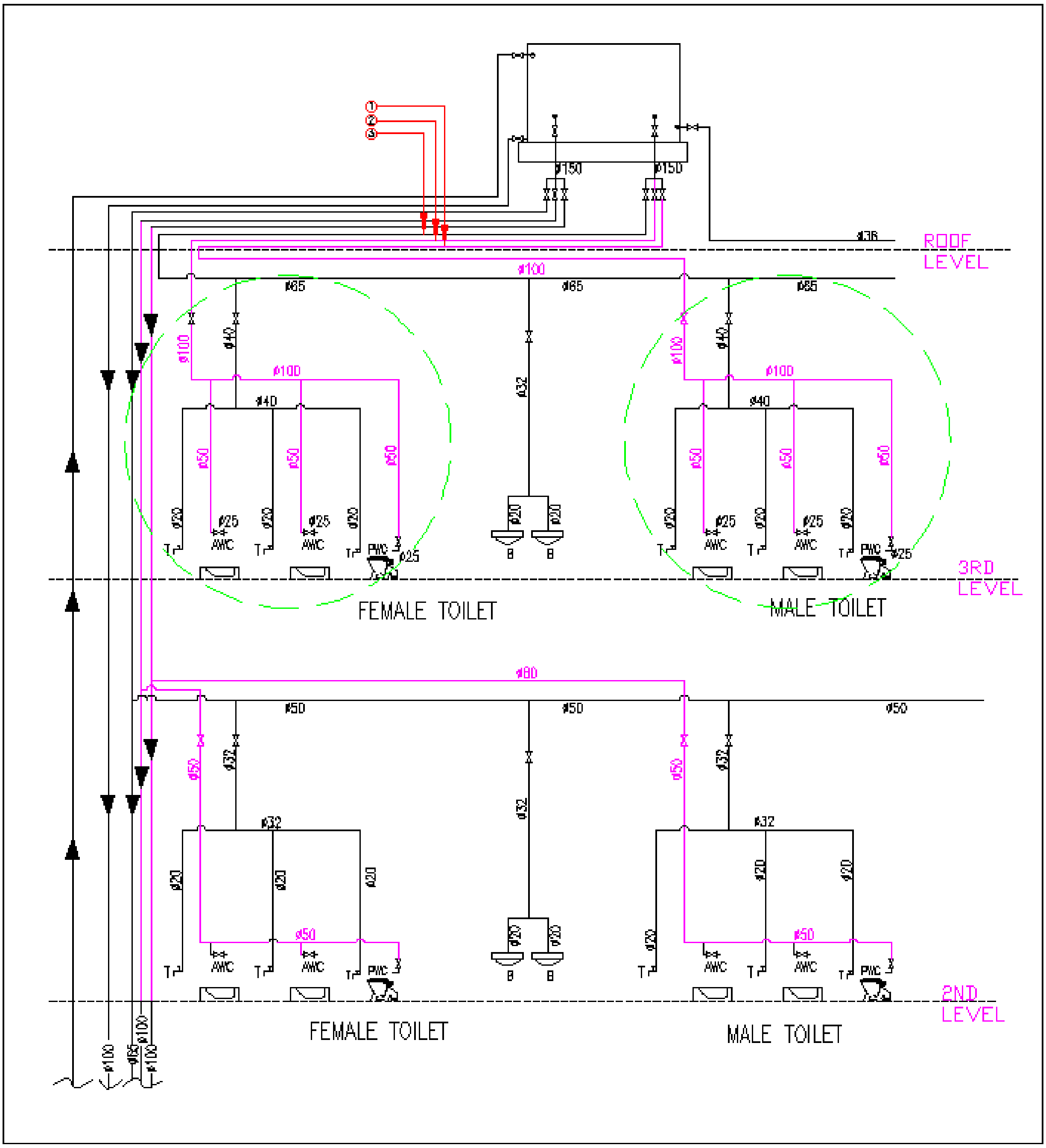


FIGURE 11: MINIMUM PIPE SIZE 100 MM DIAMETER TO CATER FOR 3 NUMBERS OF FLUSH VALVES

5.3.3.2 Gravity System (Low Water Closet Cistern)

Other than low pressure flush valve system in clause 5.3.3.1, an internal plumbing system shall be provided for low pressure water closet flushing cistern**,** water closet taps, taps for toilet wash hand basins as shown in FIGURE 12.

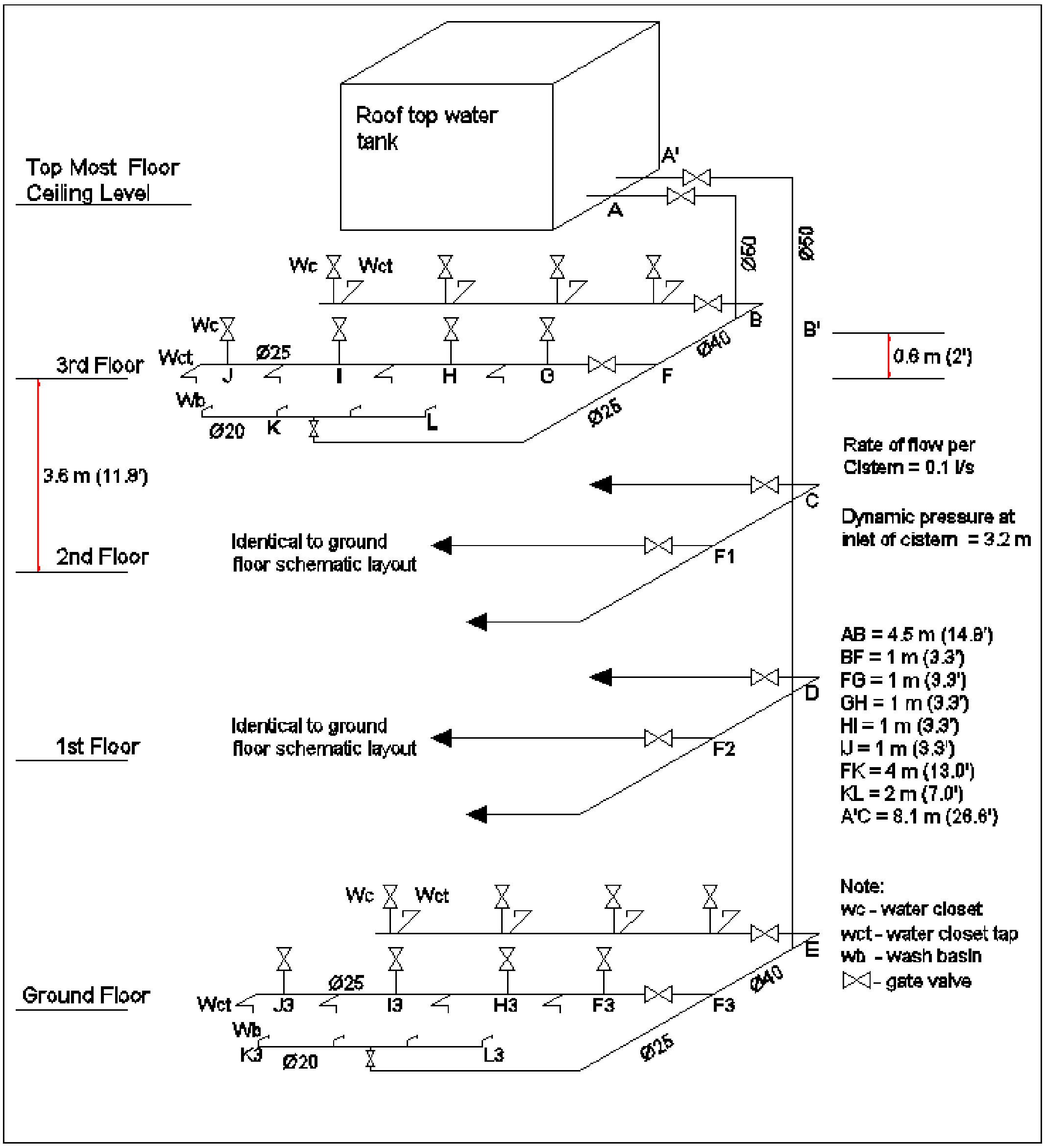


FIGURE 12: GRAVITY SYSTEM (LOW WATER CLOSET CISTERN)

5.3.3.3 High Pressure Flush Valve (Pumping System)

A separate internal plumbing system (dedicated pipe) shall be provided for flush valves and fittings to have adequate dynamic pressure and flow, to ensure effective operation of each flush valve, i.e. for hydraulics of water closet to function properly, as shown in FIGURE 13.

This design requires the installation of the pump as shown in FIGURE 13. The type of pump shall be hydropneumatic or variable speed.

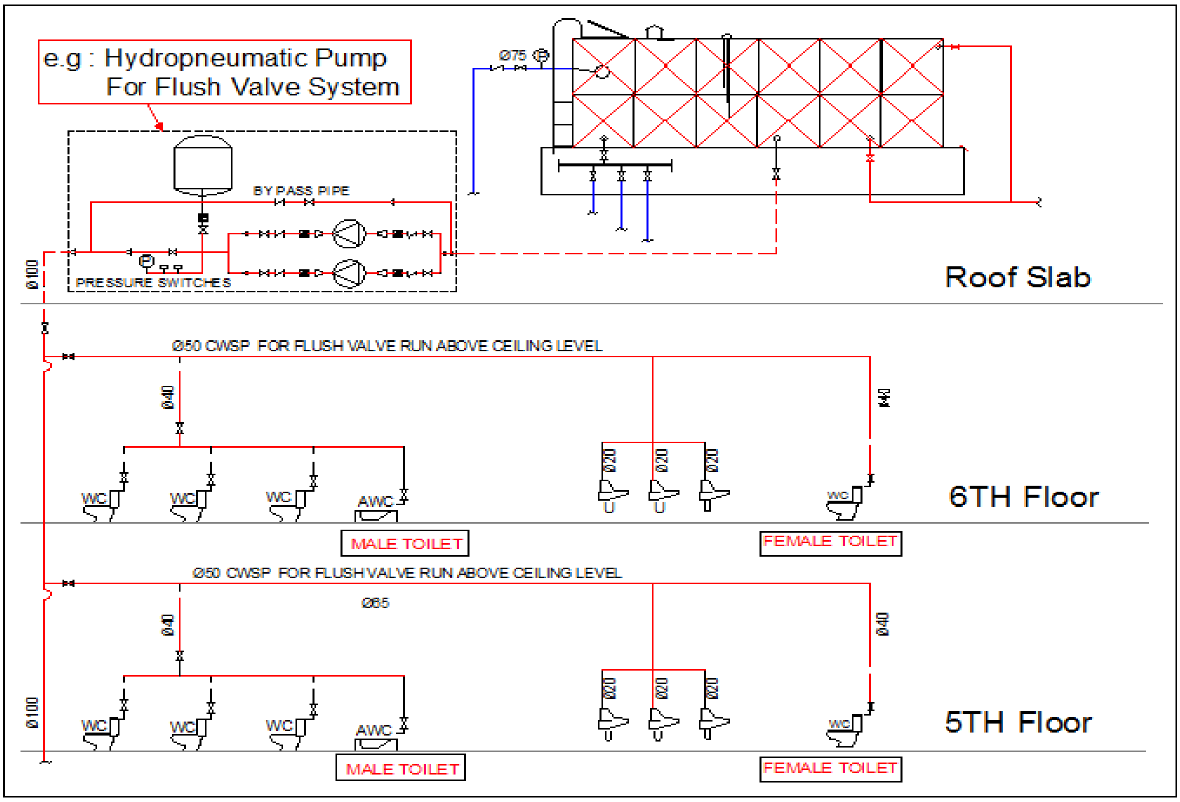


FIGURE 13 : SEPARATE PLUMBING SYSTEM AND PUMPING SYSTEM

5.3.4 Others (Medical Equipment And Emergency Shower etc)

A separate internal plumbing system (dedicated pipe) shall be provided for medical equipment and emergency shower to have adequate dynamic pressure and flow, to ensure effective operation of each shower to function properly.

5.4 Water Feed To Hot Water System

Hot water can be generated by one or more instantaneous heaters, a hot water storage system or a water-jacketed tube type heater. The selection will depend on the quantities of hot water required and the types of energy readily available.

Generally, there are two types of hot water system used in Malaysia which are direct non-circulating system and direct circulating system.

5.4.1 Direct Non-Circulating System

This system is normally used in small installations where an individual storage heater supplies hot water to a few fittings (2 or 3 fittings) in a building.

The hot water heating apparatus shall be supplied with cold water either from storage cistern or direct from service pipe. For instantaneous water heater, adequate dynamic pressure head and flow must be taken into consideration.

A typical arrangement of this system is as shown in FIGURE 14:

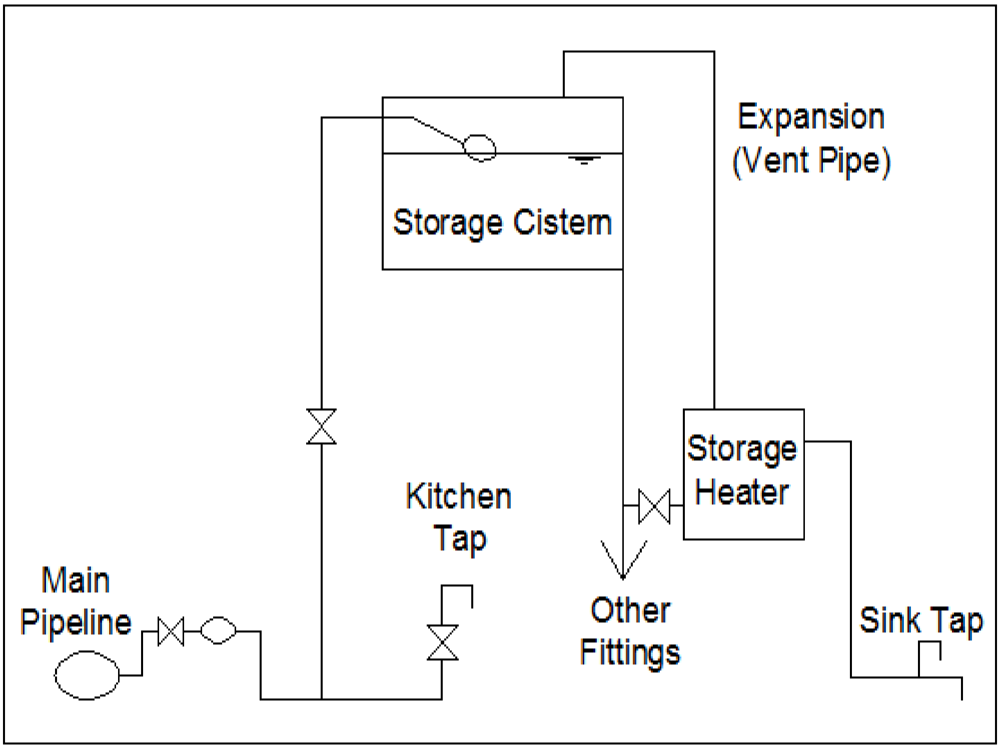


FIGURE 14: DIRECT NON-CIRCULATING SYSTEM

5.4.2 Direct Circulating System

This system is used in larger installations where fittings may be situated at some distance. The feed cistern shall be provided and the incoming water supply shall be from cold water storage tank.

A typical arrangement of this system is as shown in FIGURE 15:

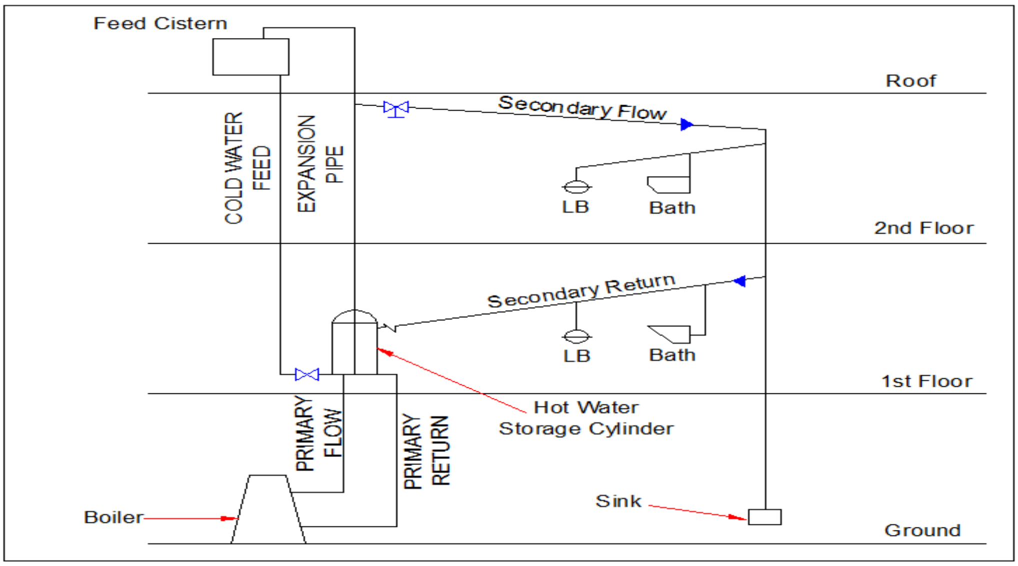


FIGURE 15: DIRECT CIRCULATING SYSTEM

5.5 Pipework Layout Design

In order to comply with the Water Supply Rules and the UTG by SPAN, it is a good practice for the designer to take note of the following:

5.5.1 Layout Of Pipework

The pipes should be as straight as possible and should not have sudden kinks or negative pressures in them which may give rise to air locks. The designer must avoid locating pipes in positions which cause contamination (e.g near drainage outlet) and there should not be any cross connection between the service pipe and the distribution pipe.

Service pipes and distribution pipes (run vertical / horizontal) except those buried underground level shall be concealed in walls, ceilings, boxed up or laid within the common trench, pipe riser etc.

Pipe to be concealed in the brick wall shall not be more than 35 mm in diameter size.
Minimum diameter for internal water plumbing system shall be 20 mm except for flush valve system where minimum diameter shall be 25 mm. Final branches to fittings shall be 20 mm in diameter size.

The sizes of feeders from which these branches are taken shall be as in the TABLE 11.

TABLE 11: NUMBERS OF FITTINGS VS SIZES OF FEEDERS

No of Fittings Served	Diameter of Feeders (mm)
1	20
2	20
3, 4	25
5, 6 ,7	32
8, 9, 10, 11, 12	40
13, 14, 15, 16, 17, 18	50

Source: *Spesifikasi Teknikal Piawai Sistem Bekalan Air Sejuk Dalaman dan Perpaipan Sanitari* (JKR 20500-0010-10).

The height of the pipe run horizontal in the concealed wall must be 600 mm (2 ft) above the floor level. It is a good practice to run the pipework above the ceiling level of the floor it serves.

5.5.2 Location Of Stop Valves

Stop valves shall be placed in such positions that they can be easily operated and maintain. It shall be positioned at each fittings. Installation of valves and fittings shall be grouped where this will not affect their operation.

If a branch pipeline serves more than 5 fittings, additional stop valves shall be installed for maintenance. The location of each valve shall be near to fitting or above ceiling level. Stop valves shall also be provided at the following positions:

- On the service pipe before it enters the building.
- On each branch of the service pipe.
- On the inlet to each storage or feed cistern.
- On the inlet to each flushing cistern.
- On the outlet of each storage tank or feeder cistern.

Example of schematic drawings for position of the stop valve and pipe routing as shown in FIGURE 16.

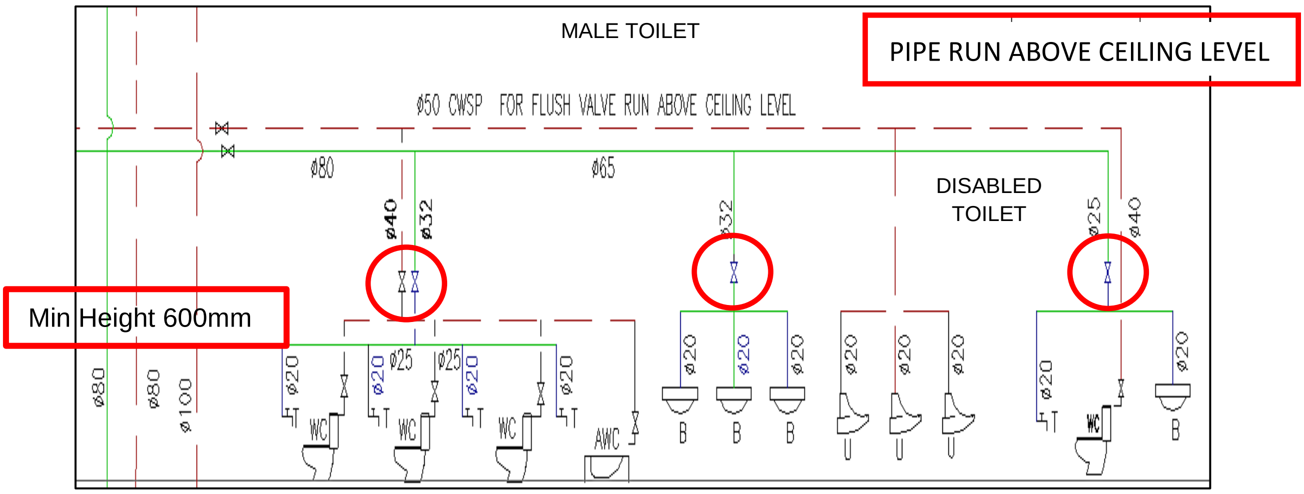
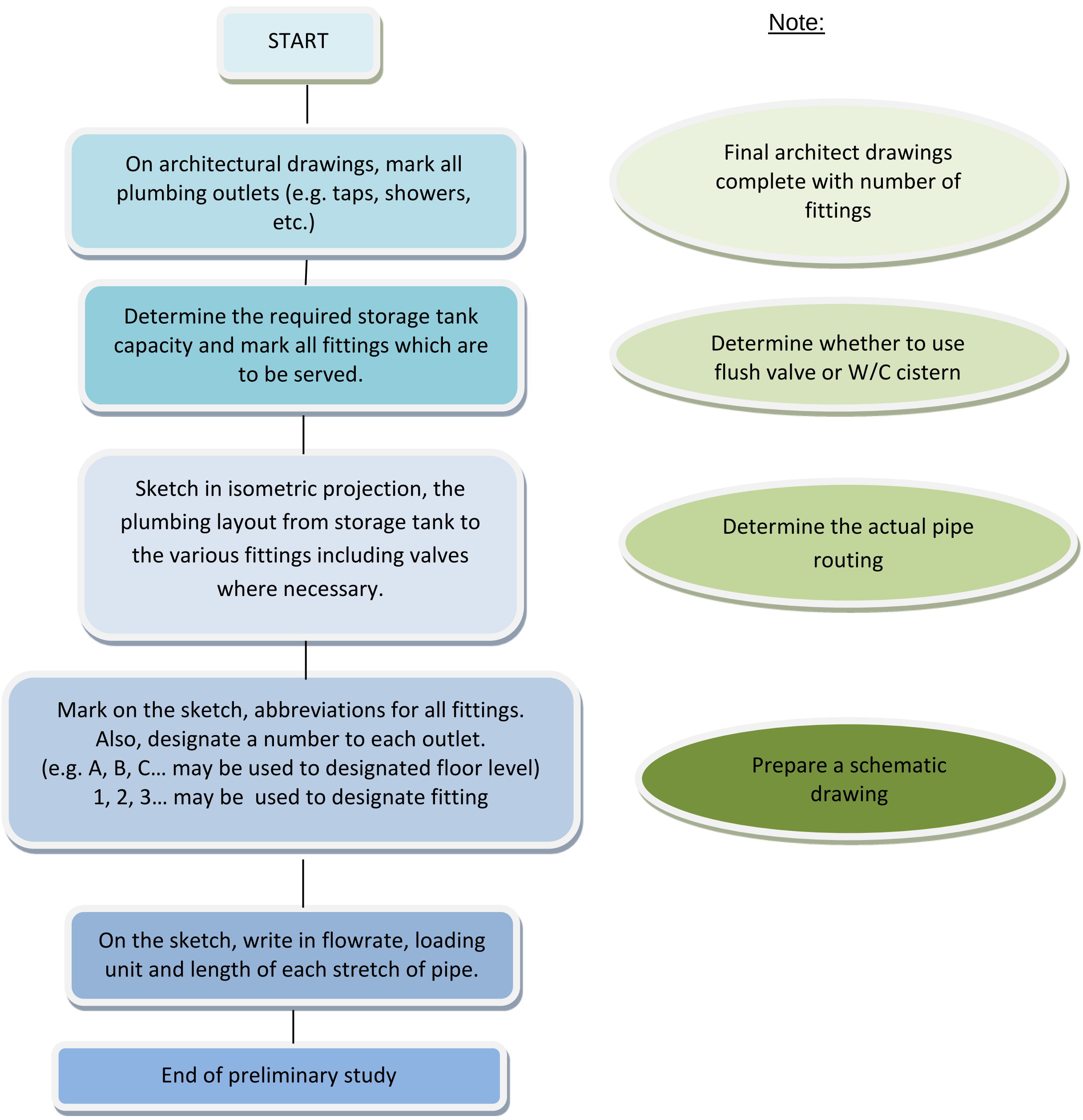
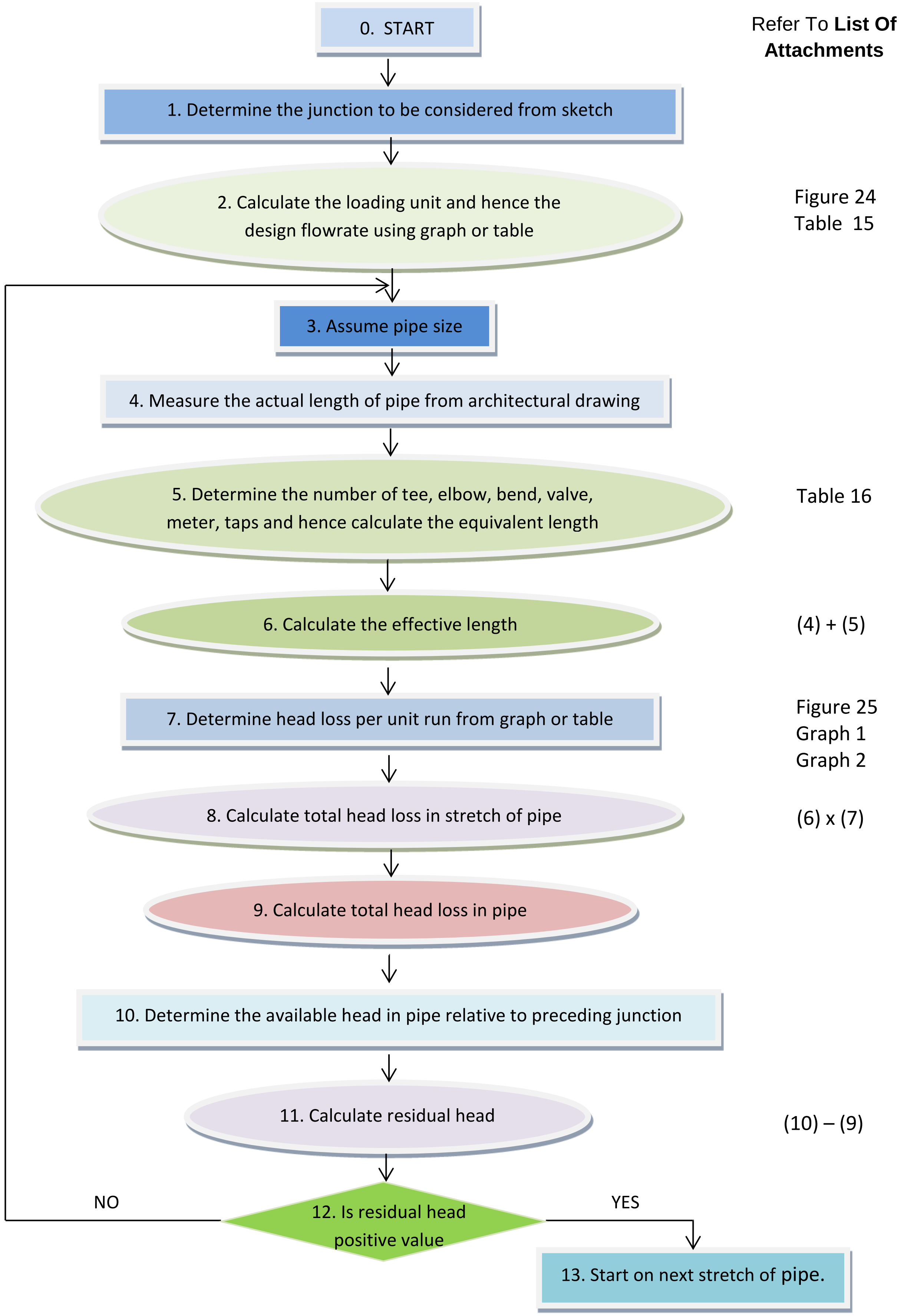


FIGURE 16 : 2D SCHEMATIC DRAWINGS FOR POSITION OF THE STOP VALVE AND PIPE ROUTING

5.6 Flow Chart Preliminary Study



5.7 Flow Chart For Pipe Sizing



5.8 Method For Pipe Sizing

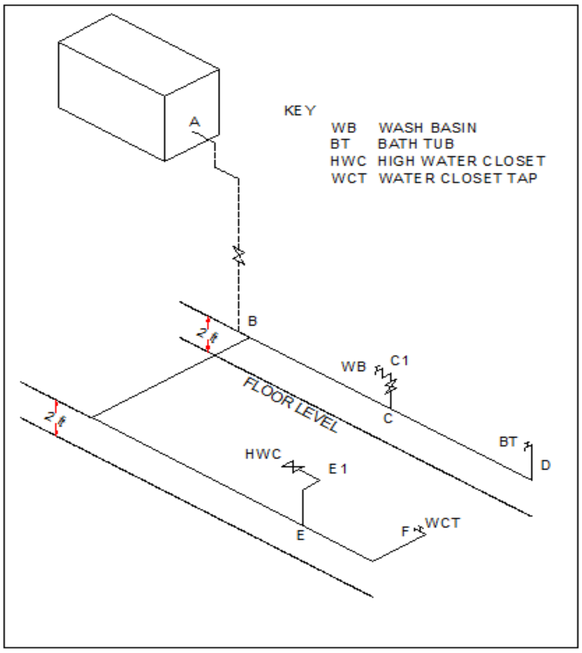
5.8.1 Pre-Calculated Method

The method for pipe sizing based on the number of fittings should only be used to give a quick check on whether a pipe is about the right size or not.

The number of branches of a given size that can be supplied by a distribution pipe may be obtained from TABLE 14 (List Of Attachments).

Example 6:

Estimate the pipe size for diagram below by using preliminaries selection of pipe sizes.



Solution:

The Pipe size for each fitting,

WB	=	20 mm	BT	=	20 mm
HWC	=	20 mm	WCT	=	20 mm

Point BC - There are 2 branch pipes (WB & BT) of 20 mm each.

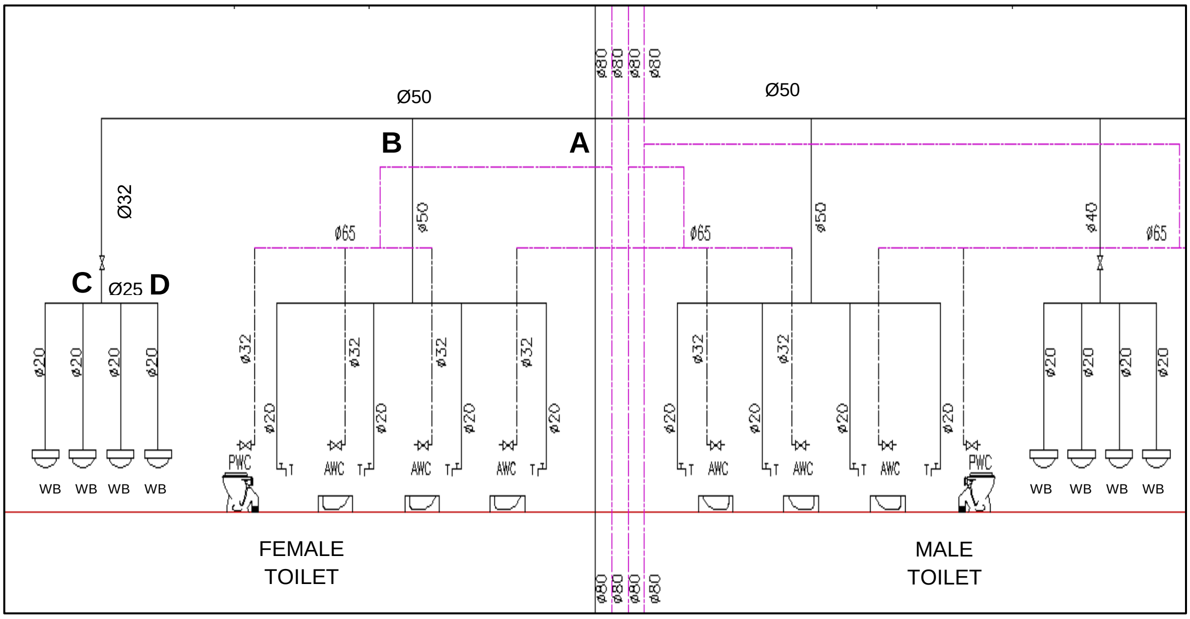
From TABLE 14: Number of branch pipes for 20mm (¾ inch) is 2, so the size of distribution pipe at point BC is 25 mm(1 inch).

Point AB - There are 4 branch pipes (1WB, 1 BT, 1 HWC & 1 WC) of 20 mm each.

From TABLE 14: Number of branch pipes for 20mm (¾ inch) is 4, so the size of distribution pipe at point AB is 32 mm (1 ¾ inch).

Example 7:

Estimate the pipe size for diagram below by using preliminaries selection of pipe sizes.



Point CD - There are 2 branch pipes (2 WB) of 20 mm each.

From TABLE 14: Number of branch pipes for 20 mm (¾ inch) is 2, so the size of distribution pipe at point CD is 25 mm(1 inch).

Point BC - There are 4 branch pipes (4WB) of 20 mm each.

From TABLE 14: Number of branch pipes for 20mm (¾ inch) is 4, so the size of distribution pipe at point BC is 32 mm(1 ¼ inch).

Point AB - There are 8 branch pipes (4WB & 4 WCT) of 20 mm each.

From TABLE 14: Number of branch pipes for 20mm (¾ inch) is 8, so the size of distribution pipe at point AB is 50mm (2 inch).

5.8.2 Hydraulic Calculation Method

Hydraulic calculation method is used to provide adequate pressure to all plumbing fittings and to optimize pipe sizing.

TABLE 12 can be used for the purpose of hydraulic calculation.

TABLE 12: HYDRAULIC CALCULATION DATA

1	2 (Table 15)	3 (Table 15)	4	5 (Dwg)	6 (Table 16)	7= (5+6)	8	9= (7x8)	10	11 = (9+10)	12	13= (12 - 11)
Point to point	No of Loading units	Design Flow rate (l/s)	Dia (in)	Actual length (ft)	Equiv. pipe length (ft)	Eff. length (ft)	Head loss per ft	Head loss in eff. length (ft)	Head loss in valves, taps, meter (ft)	Total Head Loss (ft)	Avail Head (ft)	Res. Head (ft)

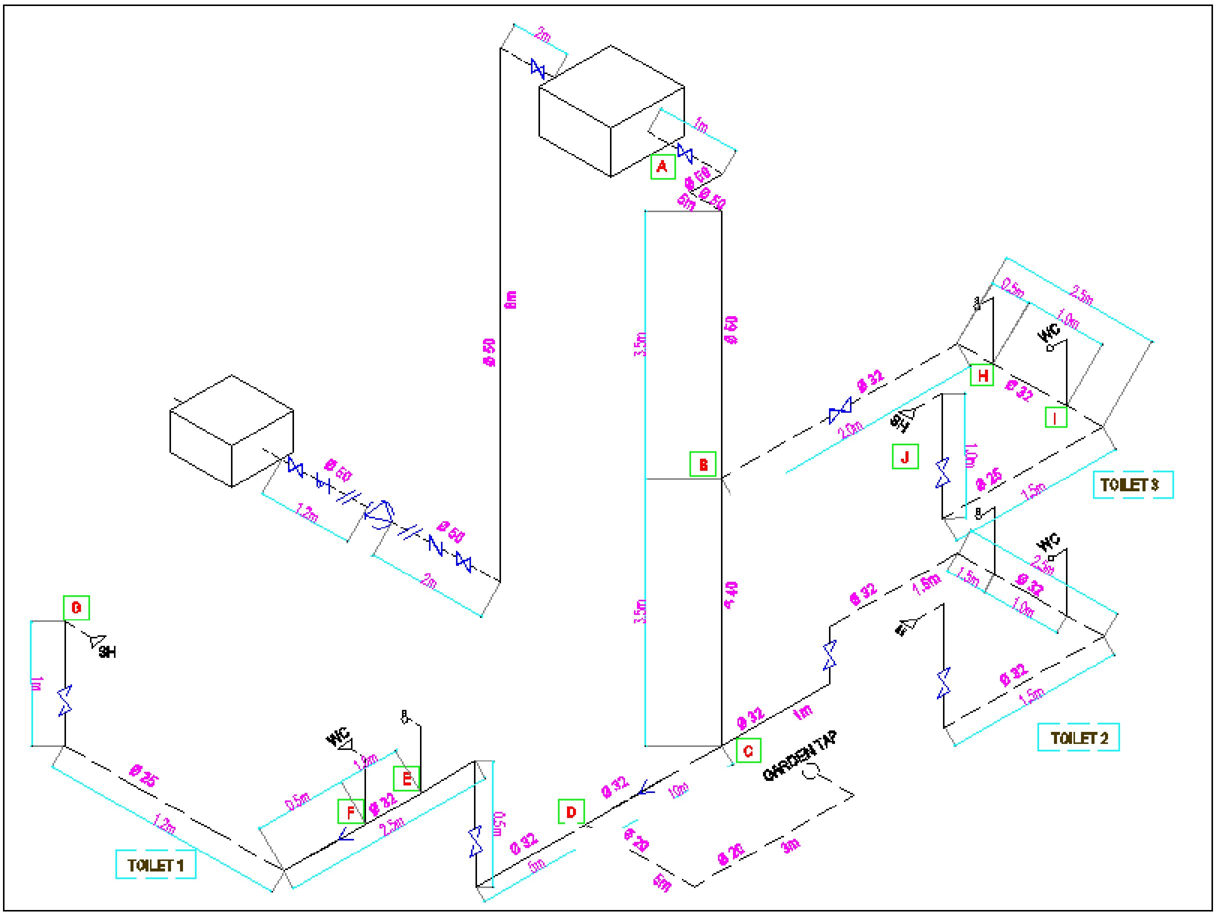
Example 8 shows the hydraulic calculation method for a typical pumping and gravity cold water plumbing system.

<u>Example 8</u>:

i) Prepare the schematic drawing.

ii) Determine the junction on the drawing.

Point AB	=	14.5 m	Point BC	=	3.5 m
Point CD	=	10 m	Point DE	=	6.5 m
Point EF	=	1.0 m	Point FG	=	2.7 m
Point BH	=	2.5 m	Point HI	=	1.0 m
Point IJ	=	3.0 m			



iii) Calculate the loading unit and flow rate.

Calculate the loading unit :

Point	Fitting	Qty	LU per Fitting (Table 15)	Sub Total
F-G	SH	1	2	2
E-F	SH	1	2	3
	WC	1	1	
D-E	SH	1	2	4
	WC	1	1	
	B	1	1	
C-D	SH	1	2	9
	WC	1	1	
	B	1	1	
	Tap	1	5	
B-C	SH	2	2	13
	WC	2	1	
	B	2	1	
	Tap	1	5	

I-J	SH	1	2	2
H-I	SH	1	2	3
	WC	1	1	
B-H	SH	1	2	4
	WC	1	1	
	B	1	1	
A-B	SH	3	2	17
	WC	3	1	
	B	3	1	
	Tap	1	5	

Calculate the flow rate:

Point	Fitting	Qty	Sub Total LU	Flow rate (l/s) (TABLE 15)		Flow rate (l/s) (FIGURE 24)
F-G	SH	1	2	0.2	0.2	
E-F	SH	1		0.2	0.3	
	WC	1	3	0.1		
D-E	SH	1	4	0.2		
	WC	1		0.1	0.4	
	B	1		0.1		
C-D	SH	1		0.2		
	WC	1		0.1	0.9	
	B	1	9	0.1		
	Tap	1		0.5		
B-C	SH	2		0.4		
	WC	2		0.2	1.3	0.35
	B	2	13	0.2		
	Tap	1		0.5		
I-J	SH	1	2	0.2	0.2	
H-I	SH	1	3	0.2	0.3	
	WC	1		0.1		
B-H	SH	1		0.2		
	WC	1	4	0.1	0.4	
	B	1		0.1		

A-B	SH WC B Tap	3 3 3 1	17	0.6 0.3 0.3 0.5	1.7	0.41

Point	Loading Unit	Flow rate (l/s)
F-G	2	0.2
E-F	3	0.3
D-E	4	0.4
C-D	9	0.9
B-C	13	0.35
I-J	2	0.2
H-I	3	0.3
B-H	4	0.4
A-B	17	0.41

iv) Assume the pipe size - Refer TABLE 14

Point	Fitting	Qty	Pipe Size
F-G	SH	1	25 mm
E-F	SH, WC	2	32 mm
D-E	SH,WC,B	3	32 mm
C-D	SH,WC,B,Tap	4	32 mm
B-C	SH,WC,B,Tap	7	40 mm
I-J	SH	1	25 mm
H-I	SH,WC	2	32 mm
B-H	SH,WC,B	3	32 mm
A-B	SH,WC,B,Tap	10	50 mm

v) Determine Actual Length

Point	Pipe Size	Actual Length (m)	Actual Length (ft)
F-G	25 mm	2.7	8.86
E-F	32 mm	1.0	3.28
D-E	32 mm	6.5	21.32
C-D	32 mm	10	32.80
B-C	40 mm	3.5	11.48
I-J	25 mm	3.0	9.84
H-I	32 mm	1.0	3.28
B-H	32 mm	2.5	8.20
A-B	50 mm	14.5	47.56

vi) Determine Equivalent Pipe Length

Point	Fitting	Diameter	Qty	EL (ft) (TABLE 16)	Sub Total
F-G	Elbow	25 mm	3	3.28	9.84
E-F	Tee	32 mm	1	6.56	6.56
D-E	Elbow	32 mm	2	4.6	9.2
	Tee	32 mm	1	6.56	6.56
C-D	Tee	32 mm	1	6.56	6.56
B-C	Tee	40 mm	1	8.2	8.2
I-J	Elbow	25 mm	3	3.28	9.84
H-I	Tee	32 mm	1	6.56	6.56
B-H	Elbow	32 mm	1	4.6	4.6
	Tee	32 mm	1	6.56	6.56
A-B	Elbow	50 mm	3	7.55	22.65
	Tee	50 mm	1	11.5	11.5

vii) Determine Effective Pipe Length

Effective Length = Actual Length + Equivalent Length

Point	Pipe Size (TABLE 14)	Actual Length (ft)	Equivalent Length (ft)	Effective Length (ft)
F-G	25 mm	8.86	9.84	18.7
E-F	32 mm	3.28	6.56	9.84

D-E	32 mm	21.32	15.76	37.1
C-D	32 mm	32.80	6.56	39.36
B-C	40 mm	11.48	8.2	19.68
I-J	25 mm	9.84	9.84	19.68
H-I	32 mm	3.28	6.56	9.84
B-H	32 mm	8.20	11.16	19.36
A-B	50 mm	47.56	34.15	81.71

viii) Determine Head Loss In Pipe

Method 1 - Refer FIGURE 25

Point	Pipe Size	Flow rate (l/s)	Head loss (kPa/m)	Head Loss (ft/ft)
F-G	25 mm	0.2	0.07	0.007
E-F	32 mm	0.3	0.035	0.004
D-E	32 mm	0.4	0.06	0.006
C-D	32 mm	0.9	0.4	0.042
B-C	40 mm	0.35	0.011	0.001
I-J	25 mm	0.2	0.07	0.007
H-I	32 mm	0.3	0.035	0.004
B-H	32 mm	0.4	0.06	0.006
A-B	50 mm	0.41	0.004	0.0004

Method 2 - Using Hazen-William Formula

Calculate friction loss using Hazen-William Formula

$$V = 1.318\ CD^{0.63}\ I^{0.54}\ \text{(Imperial Unit)}$$

$$V = 0.85\ CD^{0.63}\ I^{0.54}\ \text{(SI Unit)}$$

Where,

V = Velocity of water (m/s)

Q = Flow rate (m^3/s)

C = Coefficient for ABS pipe

D = Diameter of pipe (m)

I = Friction Loss

ix) Determine Head Loss In Effective Length

Head Loss In Effective Length = Head loss (ft/ft) x Effective length(ft)

Point	Pipe Size	Effective Length (ft)	Head Loss (ft/ft)	Head Loss In Effective Length (ft)
F-G	25 mm	18.7	0.007	0.131
E-F	32 mm	9.84	0.004	0.039
D-E	32 mm	37.1	0.006	0.223
C-D	32 mm	39.36	0.042	1.653
B-C	40 mm	19.68	0.001	0.020
I-J	25 mm	19.68	0.007	0.138
H-I	32 mm	9.84	0.004	0.039
B-H	32 mm	19.36	0.006	0.116
A-B	50 mm	81.71	0.0004	0.033

x) Determine Head Loss In Valve

According to BS 6700:2600+A1:2009, TABLE 16 (List of Attachments), the losses through fully open gate valves may be ignored.

xi) Determine Total Head loss

Total Head Loss = Head Loss In Effective Length + Head Loss In Valve

Point	Pipe Size	Head Loss In Effective Length (ft)	Head Loss In Valve (ft)	Total Head Loss (ft)
F-G	25 mm	0.131	Losses through fully open gate valves may be ignored.	0.131
E-F	32 mm	0.039		0.039
D-E	32 mm	0.223		0.223
C-D	32 mm	1.653		1.653
B-C	40 mm	0.020		0.020
I-J	25 mm	0.138		0.138
H-I	32 mm	0.039		0.039
B-H	32 mm	0.116		0.116
A-B	50 mm	0.033		0.033

xii) Determine Available Head

Static Head from A-B	=	3.5 m	=	11.48 ft
Static head from B-C	=	Residual Head at AB + Static Head at BC		
	=	11.45 ft + 11.48 ft		
	=	22.93 ft		

1	**2 (Table 15)**	**3 (Table 15)**	**4**	**5 (Dwg)**	**6 (Table 16)**	**7= (5+6)**	**8**	**9= (7x8)**	**10**	**11= (9+10)**	**12**	**13= 12-11**
Point to point	No of Loading units	Design Flow rate (l/s)	Dia (in)	Actual length (ft)	Equiv. pipe length (ft)	Eff. length (ft)	Head loss per ft	Head loss in eff. length (ft)	Head loss in valves, taps, meter (ft)	Total Head Loss (ft)	Avail Head (ft)	Res. Head (ft)
A-B	17	0.41	2	47.56	34.15	81.71	0.0004	0.033	-	0.033	11.48	11.45
B-H	4	0.4	1.25	8.20	11.16	19.36	0.006	0.116	-	0.116	11.45	11.33
H-I	3	0.3	1.25	3.28	6.56	9.84	0.004	0.039	-	0.039	11.33	11.29
I-J	2	0.2	1	9.84	9.84	19.68	0.007	0.138	-	0.138	8.01	7.87
A-B	17	0.41	2	47.56	34.15	81.71	0.0004	0.033	-	0.033	22.93	22.90
B-C	13	0.35	1.5	11.48	8.2	19.68	0.001	0.020	-	0.020	22.90	22.88
C-D	9	0.9	1.25	32.80	6.56	39.36	0.042	1.653	-	1.653	22.88	21.22
D-E	4	0.4	1.25	21.32	15.76	37.1	0.006	0.223	-	0.223	19.58	19.36
E-F	3	0.3	1.25	3.28	6.56	9.84	0.004	0.039	-	0.039	19.36	19.32
F-G	2	0.2	1	8.86	9.84	18.7	0.007	0.131	-	0.131	16.04	15.91

Available head at I-J	=	Residual head at H-I – Static head I-J
	=	11.29 ft – 3.28 ft (1 m)
	=	8.01 ft
Available head at D-E	=	Residual head at C-D – Static head D-E
	=	21.22 ft – 1.64 ft (0.5 m)
	=	19.58 ft
Available head at F-G	=	Residual head at E-F – Static head F-G
	=	19.32 ft – 3.28 ft (1.0 m)
	=	16.04 ft

5.8.3 Equal Friction Loss Method

In gravity downfeed system where the head available is a limiting factor, pipe velocities are generally low, often in the range of 0.4 m/s to 0.8 m/s.

Solution for Example 8, using Equal Friction Loss:

Refer GRAPH 2 (List Of Attachments);

Always take friction loss of 0.03 wg/m run to 0.05 wg/m run; for sizing take **0.03wg/m run.**

Branch pipe use fixed velocity.

<u>The pipe size note D-E</u>

Where:	Loading unit	=	4
	Flow rate	=	0.17 l/s
	Friction loss	=	0.03 wg/m run
	Velocity	=	0.63 m/s
	Pipe diameter	=	25 mm to 32 mm (always take the largest size)

Therefore, pipe diameter = 32 mm

<u>The pipe size note A-B</u>

Where:	Loading unit	=	17
	Flow rate	=	0.36 l/s
	Friction loss	=	0.03 wg/m run
	Velocity	=	0.7 m/s
	Pipe diameter	=	32 mm to 40 mm (always take the largest size)

Therefore, pipe diameter = 40 mm

By repeating the same calculation, we will get the pipe size at each point as shown in the table below.

Point	Loading Unit	Flow rate (l/s)	Friction loss (wg/m run)	Velocity (m/s)	Pipe diameter
F-G	2	0.13	0.03	0.55	25 mm
E-F	3	0.15	0.03	0.6	25 mm
D-E	4	0.17	0.03	0.63	32 mm
C-D	9	0.29	0.03	0.65	32 mm
B-C	13	0.35	0.03	0.7	40 mm
I-J	2	0.13	0.03	0.55	25 mm
H-I	3	0.15	0.03	0.6	25 mm
B-H	4	0.17	0.03	0.63	32 mm
A-B	17	0.36	0.03	0.7	40 mm

6 PUMPING SYSTEM DESIGN

6.1 Booster Pump

Booster pump is used to add pressure to the water at the lower position so that it has higher kinetic energy to overcome the gravity and subsequently move the water to the water tank at a higher position. This is normally done by adding pressure into the reticulation system by centrifugal force. FIGURE 17 shows a typical diagram for booster pump system.

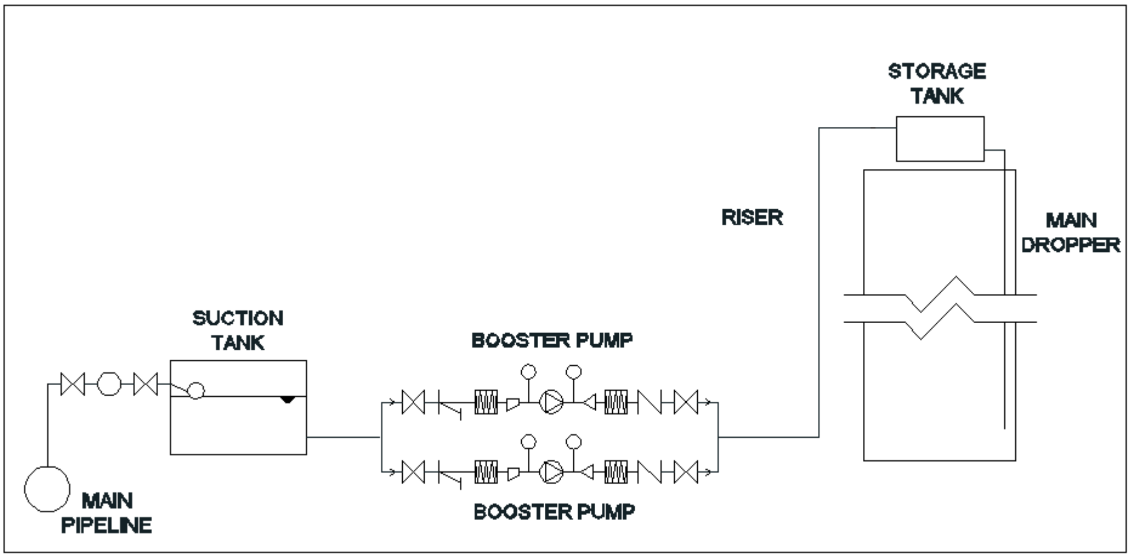


FIGURE 17: TYPICAL BOOSTER PUMP SYSTEM DIAGRAM (Not To Scale)

6.1.1 Centrifugal Pump Types

The following are different type of centrifugal pumps:

i) *End Suction Pump*

This pump is a single suction pump (single-stage) having its suction nozzle at the opposite side of its casing. Typically constructed with the low cost material such as:

a) Cast Iron Casing
b) Bronze Impeller
c) Brass Impeller

It has reasonable efficiency (55% to 65%), heavy-duty and suitable for general purpose booster pump application. This pump type is the most widely used in domestic water application and comes with horizontal and vertical configuration. Variations of end suction pumps are as follows:

a) Split casing - Pump and motor are detachable since they are connected by a coupling. Due to the coupling requirement, the pump is usually subjected to high vibration and as a result, has low bearing and mechanical seal life. This pump is usually used in high flow rate application. Another type of split casing is back pull-out. This type of pump has low durability. Pump has a spacer coupling fitted to a direct couple unit making it easy for maintenance. This pump is suitable for low head and low flow rate application.
b) Closed couple – The pump is directly driven by the motor. This pump has better bearing and mechanical seal life and is also more durable due to low vibration. This type of pump is suitable for medium flow rate application.

ii) *Multi-Stage Pump*

A centrifugal impeller has its limitation to create high different pressure between the suction and discharge. It is also costly and difficult to design single impeller pump for high pressure application. A more economical and practical approach to develop high pressures with a single centrifugal pump is to include multiple impellers on a common shaft within the same pump casing.

Most centrifugal pumps are single-stage pumps, containing only one impeller. A pump containing seven impellers within a single casing would be referred to as a seven-stage pump, or generally, as a multi-stage pump. Because of this, the design is more expensive since it has more technical issues in its design such as balancing and vibration compared to single-stage pump.

Generally, this type of pump is recommended for low flow rate, high pressure application. Variations of multi-stage pump are as follows:

a) Vertical Multi-Stage Pump - This type gives very high head with minimum use of installation space.
b) Horizontal Multi-Stage Pump – This type of pump has compact design but rarely used.

iii) *Submersible Pump*

This pump is closed-coupled pump and hermetically sealed. It is designed to be submerged into the water. This type of pump is especially suitable as a booster for rainwater harvesting application.

iv) *Self-Priming Pump*

Non self-priming pump require the volute casing to be fully filled with water for the pump to create pressure differential. If there is air inside the volute casing, the pump becomes air-locked and the impeller is not able to create the required pressure difference. Priming must be done before starting the pumping process.

A self-priming pump has a special process to release the air inside the volute casing into its reservoir located outside the casing. This process will create a situation just like the submersible pump, where the whole pump is submerged in the water. The process is called self-prime. This process allows the pump to start the pumping process even the water is not fully filled in the volute casing. This type of pump is rarely used in domestic water application except in situation where NPSH is negative.

6.2 Hydropneumatic Pump

Hydropneumatic pump system consists of a pressure vessel and a pressure pump. Both the vessel and the pumps are usually located at the rooftop of multi-storey building to boost pressure in the reticulation piping system with flush valve fittings, typically at the two top most levels.

This pump is normally used to build up and maintain a required amount of pressure in a vessel that subsequently pressurizes the whole piping system. With this approach, users of any flush valve will enjoy instantaneous volume of water supply even if the flush valve is activated repeatedly in a short time.

Hydropneumatic pump system usually comes with multi-stage pump in order to create high pressure in a very short time.

Hydropneumatic pump type are as follows:

a) Hydropneumatic Vertical Multi-Stage Pump
b) Hydropneumatic Horizontal Multi-Stage Pump

However, where the hydraulic calculation shows the static head is enough to provide the desired pressure, the use of Hydropneumatic pump is not required.

6.3 Booster Pump Design

6.3.1 Pump Characteristics

The impeller and the volute casing of centrifugal pump are the major components to centrifuge the water out of the pump thus imparting kinetic energy. This process generates certain pressure or Head (H) and flow rate (Q) which varies according to the pump speed. The relationship between Head (H) and flow rate (Q) is expressed as a characteristic curve in pump characteristic chart (H vs. Q). An example of typical characteristic centrifugal pump curves is illustrated in FIGURE 18.

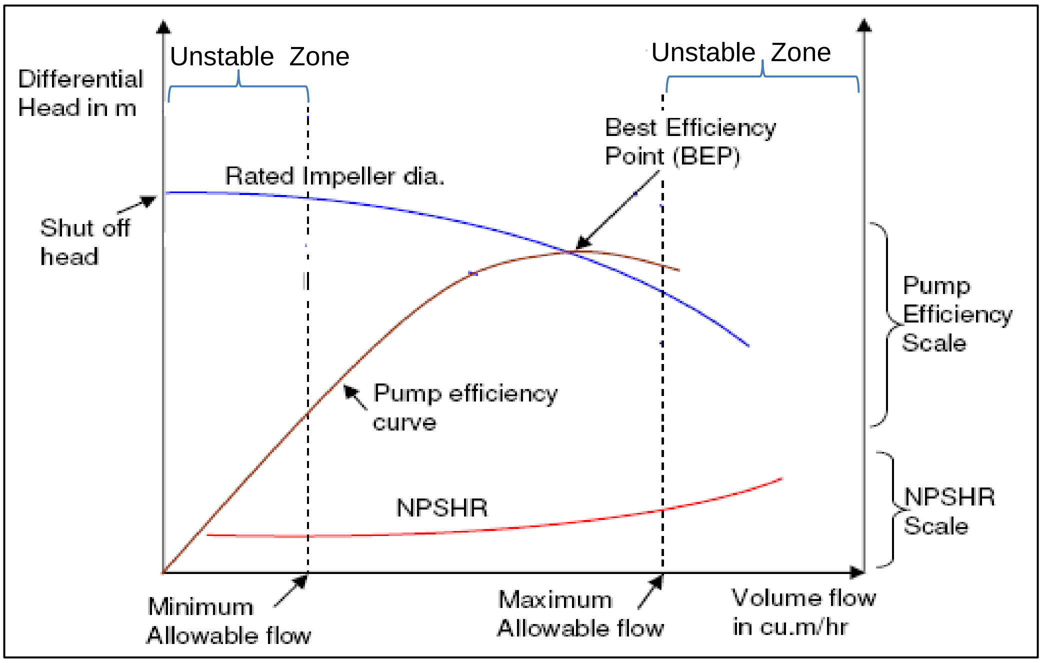


FIGURE 18: TYPICAL CHARACTERISTIC CENTRIFUGAL PUMP CURVES

Typically pump performance curve will carry information about the following points:

a) Variation Of Differential Head Vs Flow Rate

This is the primary information produced by the curves. The curve represents the differential Head (Δh) produced by the pump for a specific **Rated Impeller Diameter,** also known as the **pump Head.** Different impeller size and angle will give different pump head and flow rate.

Note that moving along the line will give various combinations of head (H) and flow rate (Q).

b) Pump Efficiency

Calculated pump efficiency, if plotted against the flow rate, will give the pump efficiency curve. This curve shows the various pump efficiencies when it operates at different head (H) and flow rate (Q).

Note that, the best efficiency of the pump occurs at the point where the pump curve intersects the pump efficiency curve.

c) NPSHR (Net Positive Suction Head Required)

Any pump operating at heads below the water vapour pressure, may result in cavitation. Centrifugal pumps are particularly vulnerable to cavitation especially when pumping high temperature liquid.

The pressure or head required to avoid the vaporization in water is plotted against the flow rate as shown in FIGURE 18. Note that the NPSHR line is the required head at the intake point of the pump to avoid the formation of bubble that subsequently damaging the impeller or widely known as cavitation.

FIGURE 19 shows two conditions of NPSH. Where possible, the designer shall avoid the installation of pump, where the intake to pump is lower than the pump. This condition is known as negative suction head condition.

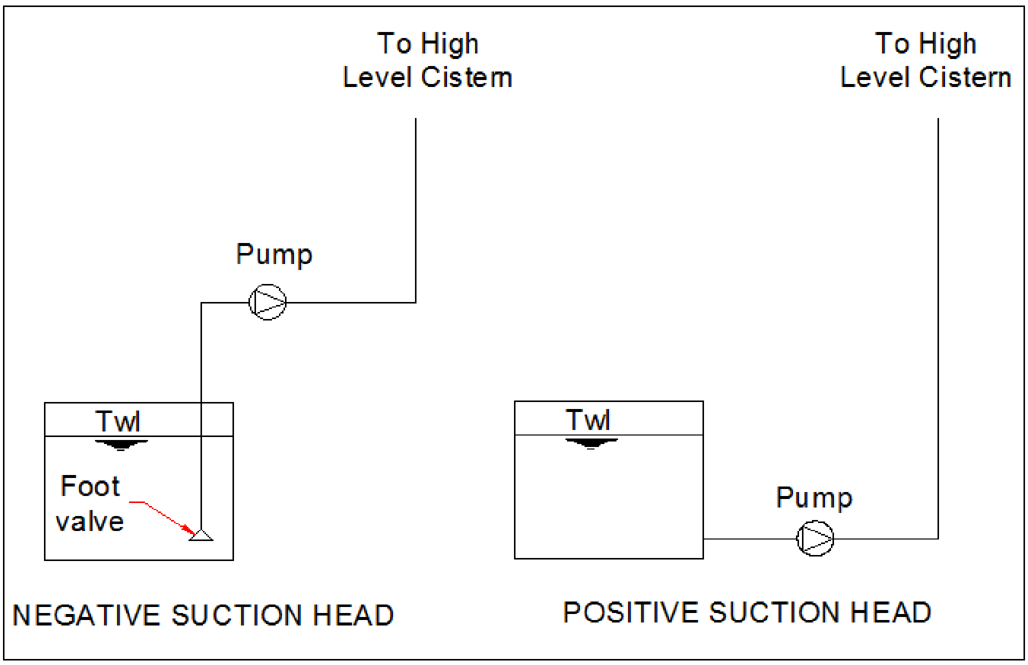


FIGURE 19: TWO CONDITIONS OF NPSH

6.3.2 Pump Capacity

The capacity is usually defined as flow rate measured in gallons/min (GPM) or cubic meter/hr (m^3/hr). The capacity is also define as the pumping head (H) which explain the pressure required by the pump to overcome the resistance of the flow, measured in feet (ft) or meter (m).

The flow rate (Q) of a booster pump depends on factors stated below:

a) Pumping Duration

Pumping duration is the time set by the designer for the operation of pump in one (1) day. Usually the pumping duration is set to 8 hours per day. This mean, the required capacity of the water storage shall be achieved after 8 hours continuous operation of the pump.

The designer may set the pumping duration per day as:

i) 8 - 12 hours for normal application such as offices, schools, mosque and etc.

ii) 6 – 8 hours for high usage application such as apartments, hostels, prisons and etc.

b) Storage Volume

The storage volume is the total volume of water required. This is including the storage tank capacity and together with the capacity in the suction tank.

The flow rate(Q) is determined as:

$$\text{Flow rate(Q)} = \frac{\text{Storage Volume (V)}}{\text{Pumping time (minutes)}}$$

<u>Example 9</u>:

A school building requires 20,000 Imperial gallon (IG) of water per day. Calculate the flow rate required for a pump in one day.

<u>Solution</u>:

The pumping duration set is to 8 hour or 480 minutes, therefore;

$$\text{Flow rate, Q} = \frac{\text{20,000 IG}}{\text{480 minutes}}$$

$$= \text{41.7 IGPM}$$

6.3.3 Pipe Sizing For Booster Pump

It is important to select the correct pipe size for the booster pump application in order to avoid the problem of water hammer and serious erosion in pipe.

Example 10:

How to determine the pipe size?

First, we have to determine the type of pipe. Take note that, the delivery pipe shall be non-plastic pipe for better durability. In this example, we shall use stainless steel pipe.

Then, set the velocity in the pipe. Note that, by selecting a higher velocity, the smaller pipe it will be. TABLE 13 shows the recommended velocity for domestic water application:

TABLE 13 : PIPEWORKS VELOCITY FOR DOMESTIC WATER

Location	Noise rating NR	Pipe material	
		Metal: Copper, stainless steel, galvanized (m/s)	Plastic: UPVC, ABS, CPV,Pb (m/s)
Service duct, riser, shaft, plant room	50	2.0	2.5
Service enclosure, ceiling void	40	1.5	1.5
Circulation area, entrance corridor	35	1.5	1.5
Seating area, lecture/meeting room	30	1.25	1.25
Bedroom	25	1.0	1.0
Theatre, cinema	20	0.75	0.75
Recording studio	<20	0.5	0.5

Source: *Plumbing Engineering Services Design Guide*. (2002). Essex: The Institute of Plumbing.

Referring to GRAPH 1 (List of Attachments), one may choose the diameter of the pipe based on:

Q = 41.7 IGPM or 3.15 l/s (the conversion is required as the table used is in l/s)

v = 1.7 m/s – the velocity is within the domestic water application for the 50 mm pipe. Friction loss m/m pipe = 0.06 m.

Note that, velocity of 1.5 m/s is considered as optimal and the maximum velocity in pipe shall be limited to 3 m/s only. Therefore, in this example, 50 mm pipe is selected.

6.3.4 Pump Head For Booster Pump

The pump head, H_{pump} of booster pump is determined as:

$H_{pump} = H_{static} + H_{pipe} + H_{equivalent} + H_{delivery}$

Where,

H_{pump} = Total head required for pumping

H_{static} = Head required due to the different elevation of the water

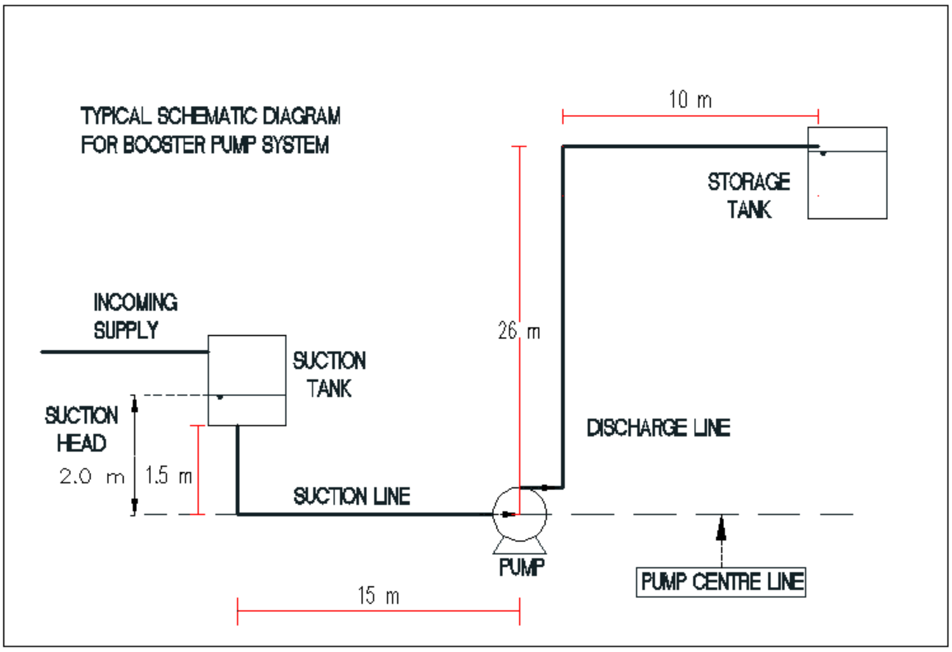
H_{pipe} = Head required due to friction along the physical length

$H_{equivalent}$ = Head required due to friction of fittings

$H_{delivery}$ = Desired head at the end of the piping.

<u>Example 11</u>:

A typical schematic diagram of booster pump system is as shown below. Assuming the pipe diameter is 50 mm, and the flow rate is 3.15 l/s, the total pump head required is as calculated below:



From the diagram, the data below shall be obtained,

H_{static} = 26 m – 2 m = 24 m

Actual pipe length = 1.5 m + 15 m + 26 m + 10 m = 52.5 m

From GRAPH 1, the friction loss / m for 50 mm pipe at 3.15 l/s is equal to (0.06 m/m);

therefore H_{pipe} = 52.5 x (0.06 m/m) = 3.15 m

$H_{equivalent}$ = Equivalent length for 3 elbows + 1 gate valve + 1 strainer for 50 mm pipe

Note 1: According to BS 6700:2600+A1:2009, TABLE 16 (List of Attachments), the losses through fully open gate valves may be ignored.

Note 2: Referring to TABLE 16 and provided by manufacturer that the equivalent length for a strainer is 0.2 m.

Total Equivalent length: (3 x 2.3 m) + (1 x 0 m) + (1 x 0.2 m) = 7.1 m

$H_{equivalent}$ = (0.06 m/m) x 7.1 m = 0.43 m

$H_{delivery}$ = 1.5 m

Therefore, the total pump head is, ;

H_{pump} = H_{static} + H_{pipe} + $H_{equivalent}$ + $H_{delivery}$

= 24.00 m + 3.15 m + 0.43 m + 1.50 m

= 29.08 m (take safety factor 10%)

= 32.00 m

6.3.5 Pump Capacity Calculation

Hydraulic Power is the power produced from the movement of fluid, either noted in metric (watt, W) or imperial units (horsepower, hp).

The formula to define a pump hydraulic power is shown below:

i)	Hydraulic Power (P_h)	$= \rho \times g \times Q \times H$
ii)	a) Pump Power (P_p) for water in Kilowatt	$= \dfrac{9810 \times Q\ (m^3/hr) \times H\ (m)}{\eta_p}$
	b) Pump Power (P_p) for water in Horsepower (US Units)	$= \dfrac{Q\ (GPM) \times H\ (feet)}{3960 \times \eta_p}$
	c) Pump Power (P_p) for water in Horsepower (Imperial Units)	$= \dfrac{Q\ (IGPM) \times H\ (feet)}{3300 \times \eta_p}$
iii)	Motor Power, P_m for pump	$= \dfrac{P_p}{\eta_m}$

P_h = Hydraulic power of the pump.

P_p = Pump power sometimes noted as shaft power. (The sum of hydraulic power and power loss due to inefficient of pump).

P_m = Pump power sometimes noted as shaft power. (The sum of hydraulic power, power loss due to inefficient of pump and electrical motor).

η_p = Pump efficiency shall be obtained from the pump characteristic chart.

η_m = Motor efficiency shall fall between 75% to 90%.

Example of pump capacity calculation is as shown in Example 12.

Example 12:

A centrifugal pump with Q = 41.7 IGPM @ (0.19m^3/hr), H_{pump} = 24.64 m or 80.85 ft is installed. If the pump efficiency is 75 % and electric motor efficiency is 85%, calculate the pump power.

Solution :

Pump Power(P_p) for water in Hp $= \dfrac{Q\ (IGPM) \times H\ (ft)}{3300 \times \eta_p}$

$$= \frac{41.7 \times 80.85}{3300 \times 0.75}$$

$$= 1.36 \text{ hp}$$

Motor Power, P_m for pump $= \dfrac{Pp}{\eta_m} = \dfrac{1.36}{0.85} = 1.6$

Therefore, the horsepower pump is 1.6 hp. (Refer to the catalogue, for the nearest actual pump horsepower available in the market)

6.3.6 Pump Selection

There are many factors to be considered prior to the pump selection as listed below:

a) Single-Stage Pump

A centrifugal pump with one impeller is called single-stage pump. This type of pump is cheaper and has low maintenance cost.

b) Multi-Stage Pump

A centrifugal pump with multiple impellers is called multi-stage pump. This type of pump produced higher output pressure and commonly used in high rise building.

c) Flow Type

For booster pump application where high head is much critical than the flow rate, radial flow pump shall be considered. Where the application needs to give the flow rate some priority, mixed flow pump shall be considered. Axial-flow pump is meant for high flow rate application only.

d) Pump Speed

The running hours of a booster pump is considered high if it needs to operate 8 hours per day. Therefore the designer may avoid the wear and tear problem by selecting low speed pump (1450 rpm). However, to reduce capital cost, pump speed of 2900 rpm can be considered, where the running hours are expected to be at minimum.

e) Impeller Type

The impeller shall always be corrosion free type. It is recommended to use stainless steel impeller in booster pump and hydropneumatic pump application.

6.3.7 Pump Configuration

Pump configuration shall be complying to UTG by SPAN, which specify the use of at least one standby pump as stated below.

For pumping designs using a pressurized system, and where all of the storage of water is provided at the ground level storage cistern, the following shall apply:-

i. The number of pumps on standby shall be 100% of the duty pumps.
ii. Pumping system shall be of variable speed drive type.

However, for a normal pumping system utilizing a suction and storage tank, a fixed-speed drive type pumping system shall be employed. Number of standby usually 100% but 50% are also used for large pumps.

1 duty and 1 standby:

This is the simplest form of operation. One pump will be set as duty while the other one will be set as run. A timer will set when the duty will be turned “off” and the standby pump will set to “on” as duty pump.

Lead / Lag Operation:

This configuration can be considered but is rarely used.

6.4 Hydropneumatic Pump Design

The hydraulic calculation as explained in previous section shall recommend the use of Hydropneumatic pump if the required head is not enough for the flush valve fittings. Some flush valve fittings require up to 15 psi of pressure equivalent head to 30 feet. The flushing volume may require up to 7.5 litres or 2 gallons per flushing.

However, the pressure and volume of water may vary from a product to another. To make sure the system will work regardless of any brand of product installed, the figure stated above is used to size up the pneumatic tanks.

6.4.1 Pipe Sizing For Flush Valve

Total number required for flush valve fitting shall be determined by the designer. The designer may take into consideration some percentage of this flush valve to be operated simultaneously. For example, if an office has 50 unit flush valve fittings, the design shall take only 20% of the fitting or 10 units may be operated simultaneously. This usage factor is important to make sure there is no over design. For high application, such as public amenities, higher percentage shall be considered.

Therefore, the loading unit shall be based on the number of fitting after the usage factor being considered. Example 13 is an example of a calculation of flush valve pipe sizing:

<u>Example 13</u>:

No. of flush valve units	:	10	
Loading Unit	:	10 X 15 = 150	(Refer TABLE 15)
Flow rate	:	1.65 l/s or 0.058 ft^3/s	(Refer FIGURE 24)
Velocity, v in pipe	:	1.5 m/s (5 ft/s), maximum v ≤ 3.0 m/s (10 ft/s).	

Base on Q = 1.65 l/s and v = 1.5 m/s, repeat procedure as specified in clause 6.3.3;

$$H_{pump} = H_{static} + H_{pipe} + H_{equivalent} + H_{delivery}$$

Where,

H_{static}	=	0 (since the pump is pumping down, there is no static head required)
H_{pipe}	=	shall be calculated as in clause 6.3.4, assume 20ft.
$H_{equivalent}$	=	shall be calculated as in clause 6.3.4, assume 10ft.
$H_{delivery}$	=	assume 30 ft

Therefore, H_{pump} = 60 feet.

Take safety factor of 10%, the pump head is now 66 feet.
Base on Q = 1.65 l/s and H = 66 feet, one may refer to GRAPH 1 and select the pipe size as 1.5 inch.

Another method to size the pipe is using the formula below:

$Q = v / A$, and take $v = 5$ ft/s;

Therefore, $A = Q / v = (0.058\ ft^3/s) / (5\ ft/s)$
$= 0.12$ ft
$= 1.44$ inches

Diameter selected is 1.5 inches.

6.4.2 Hydropneumatic Tank Sizing

It is important to make sure the tank is not too big that it will increase the initial cost of the installation or it is not too small until the start-stop of the pump is too frequent.

The sizing of the tank depends on the period during which the designer set the pump to be at “off”, at no flow condition. It is recommended to set the pump “off” at between 15 to 30 minutes (manufacturer’s recommendation) depending on the application or type of building. A building like hospital may require a bigger tank for the pump to remain “off” compared to an office.

Based on the Example 13:

The flow rate required is 18.1 GPM and the pressure Head required is H = 66 ft or (66 ft x 0.43 psi/ft = 28.4 psi). The designer shall also determine the differential pressure for the pump. In this example, take the differential pressure as 50%.

Therefore,	Cut in pressure(Design Pressure), P_f	:	28.4 psi
	Cut off pressure , P_o	:	42.6 psi

The required amount of water to be supplied during any given cycle is called drawdown. Drawdown is determined by the following equation:

$$D = (t \times Q) / 4 ;$$

Where,	D	= Drawdown (gallon)
	t	= cycle time (minutes)
	Q	= tank flow rate (GPM)

Therefore, $D = (15 \times 18.1) / 4 = 67.84$ gallon

The acceptance factor is determined by the following equation:

$$F = 1 – [(P_f + \text{atmospheric pressure}) / (P_o + \text{atmospheric pressure})]$$

Where:	F	=	Acceptance factor
	P_f	=	Minimum operating pressure (gauge pressure)
	P_o	=	Maximum operating pressure (gauge pressure)
	Atm	=	Atmospheric pressure = 14.5 psi

Therefore, $F = 1 – [(28.4 + 14.5) / (42.6 + 14.5)] = 0.12$

Alternatively, the tank size, V, may be determined by the following equation:

$$V = D / F ;$$

Therefore, $V = 67.84 / 0.12 = 565.3$ gallon

Finally, designer must refer to the catalogue, for the nearest actual tank size, V, available in the market.

Therefore, the drawdown obtained is adequate to cater for 10 numbers of flush valves in this example.

6.5 Pumping Control System

Any building which require pump to boost water from the suction tank to the storage tank will also require a control system. The most common way of doing this is by electrodes or pilot operated valve. FIGURE 20 shows the example of schematic control system by using electrodes.

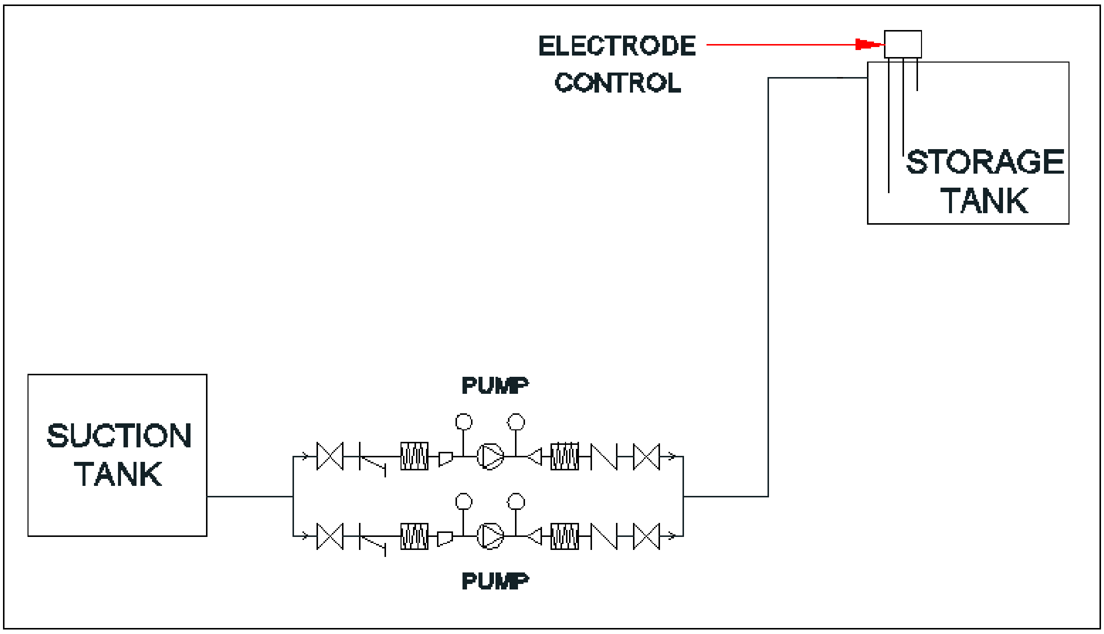


FIGURE 20 : SCHEMATIC PUMPING SYSTEM USING ELECTRODES

6.5.1 Electrode Controls - Operating Principle

When the water level in the elevated tank is below the Bottom Water Level (BWL), water is pumped from the suction tank. When the water level reaches Top Water Level (TWL), the pump stops operating. Elevated tanks are controlled in this manner to maintain the water level.

The two pole electrodes system is as shown in FIGURE 21:

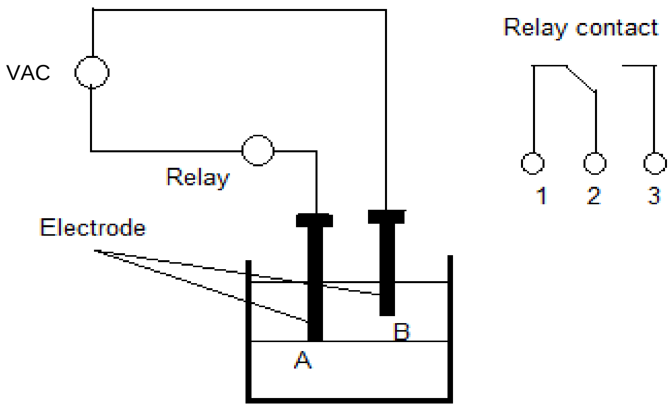


FIGURE 21: TWO POLE METHOD

Referring to FIGURE 21, when water is at low level position, electrode B is not in contact with the water as shown above, the electrical circuit is open, and no current flows between electrodes A and B. Consequently relay does not operate and the contact remains at the # 1 side. Thus, it triggers the pump to turn on.

When electrode B is in contact with the water, the relay circuit closes due to the water completing the circuit between A and B. Relay operates and switches to the # 3 side by mean of connecting the relay contacts to a contactor that triggers the pump to be off. Hence, the pump can be turned ON and OFF.

However in practice, with only two electrodes, any ripple on the surface of the water cause the relay to switch rapidly. This problem can be solved by using another pole of connector. The two pole connector configuration shown can be used as water level alarms.

Adding more poles will give the system better control. For example, three pole method. An extra electrode C is added, B and C are connected via contact # 2 as shown in FIGURE 22.

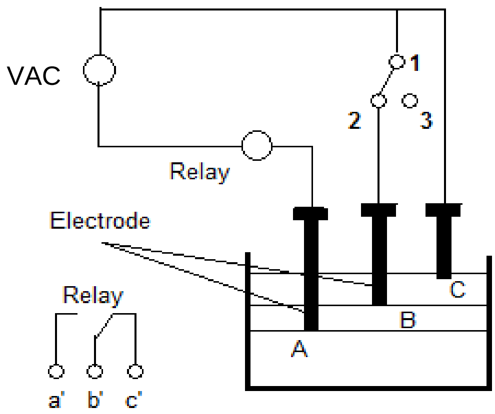


FIGURE 22: THREE POLE METHOD

When electrode C is in contact with water, relay operates through b'. Even if the liquid level falls below C, the electrical circuit made through the water by A and B, as long as contact is closed. This method will get rid of the ripple problem.

When the water level falls below B, the circuit made through the electrode circuit opens, which de-energizes relay.

There are a few more operating controls / level switch available that a designer can use such as float type controls. However, the principals are still the same. One may get the appropriate controls for the right cost and application in the market.

6.5.2 Multi Tank Controls – Pilot Operated Valves

It is advisable that the designer to plan the distribution of storage tank properly and avoid the condition where each separate building has its own storage tank. The designer shall minimize the use of pumping and appreciate the power of gravity from elevated water tank. However, where multi storage tank is required one may use pilot operated valve to control the level of water.

One method available is using pilot operated valve together with a float valve installed at the storage tank. FIGURE 23 shows the example of schematic pumping system using pilot operated valves.

The usage of this system shall be coupled with the hydropneumatic pump or variable speed pump designed to maintain a range of pressure. The calculation of the pneumatic tank shall be done carefully so that the pump has the correct stop/start period.

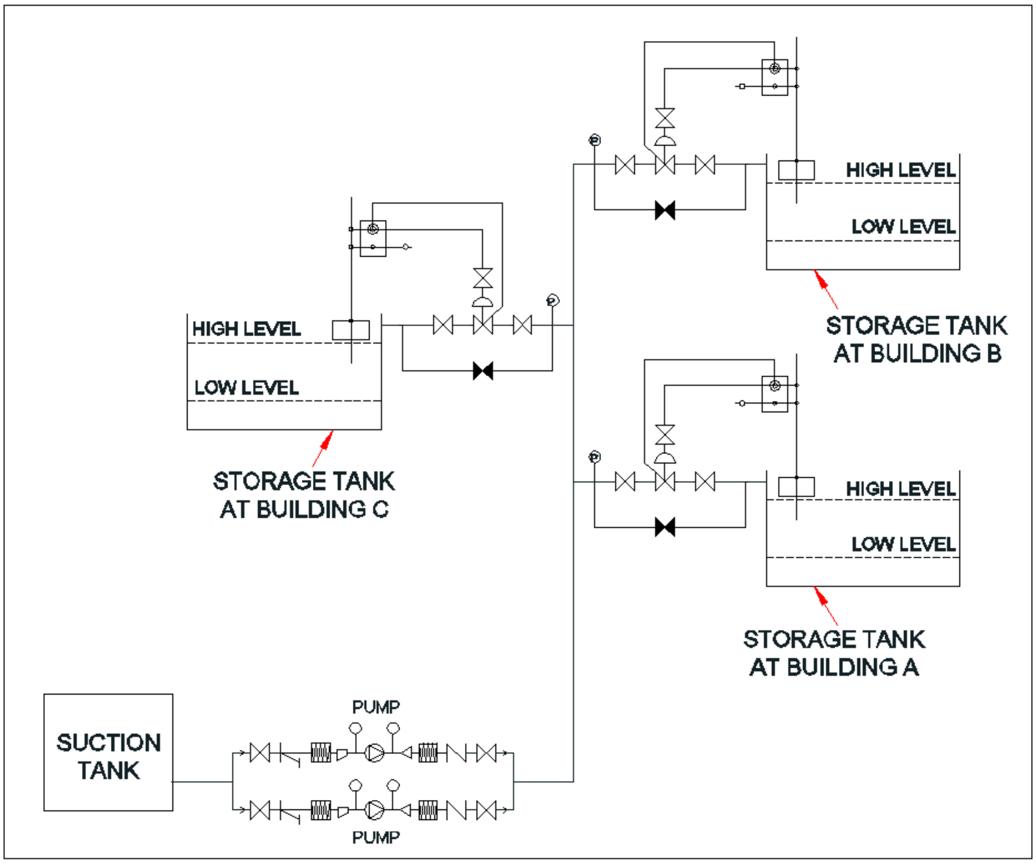


FIGURE 23 : SCHEMATIC PUMPING SYSTEM TO MULTIPLE BUILDINGS USING PILOT OPERATED VALVES

7 TENDER DRAWINGS

Tender drawing issued for tendering purposes must be able to convey the location , requirements and scope of work of the project. It shall form a uniform set , consistent in sheet size and general appearance.

Tender drawing shall consist of site plan, floor plan (layout), schematic and details. Example of the drawings can be referred in the **List Of Attachments** (**Drawing 1 to 5**).

The format of tender drawing shall be as follows :

- Wherever appropriate detail drawing must be shown and used as a reference to get a clear and complete requirement.
- All dimension shall be in SI unit.
- The scale for the whole drawing shall be appropriate and normally set to 1 : 100.

8 REFERENCES

- BS 6700:2006+A1:2009 - Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages –Specification, British Standards Institute, 2006 Amendment 2009 replaced by BS 8558:2011.
- Design Criteria And Standards For Water Supply System – Volume 3, JKR Cawangan Bekalan Air, 1989.
- Engineered Plumbing Design, Alfred Steele, Miramar Publishing Company, California, 1977.
- Guidelines On The Design Of Water Supply Plumbing System, JKR Cawangan Bekalan Air, 1987.
- International Plumbing Code, International Code Council, 2009.
- Plumbing Engineering Design Handbook Volume 2 : Plumbing System, American Society of Plumbing Engineers (ASPE), 2006.
- Plumbing Engineering Services Design Guide. (2002). Essex: The Institute of Plumbing.
- Standard Plumbing Engineering Design, Louis S. Nielsen, McGraw-Hill, 1982.
- STANDARD SPECIFICATIONS FOR BUILDING WORKS 2005 (JKR 20800-132-23).
- Spesifikasi Teknikal Piawai Sistem Bekalan Air Sejuk Dalaman dan Perpaipan Sanitari (JKR 20500-0010-10).
- 7th Edition Piping Handbook, Mohinder L. Nayyar, McGraw-Hill, 2000.

9 APPENDIX

Attached herewith is sample of calculation from Projek JPA3 Perlis (Blok Operasi 911 and Dormitori).

9.1 PROJECT : JPA3 NEGERI PERLIS (BLOK OPERASI 911)

Hydraulic Calculation For Pneumatic Pump System (Flush Valve)

1 **Static Head**

Static Head Loss — Take 0 ft.

2 **Residual Head at Outlet**

Head required for discharging — 30 ft.

3 **Friction Loss**

Through pipe 50mm diameter

i. Pipe Length — 80 ft.

ii. Fittings Equivalent Length
(From manufacturer catalogue)

Fitting Equipments	Qty	Fel/Unit(ft)	FEL (ft)
Gates Valve	1	1	1
Strainer	1	10	10
Check Valve	1	10	10
Elbows	7	7.5	52.5
Tee	3	11.5	34.5
TOTAL			108

Total Fitting Equivalent Length — 108 ft.

iii. Effective length of pipe — 188 ft.

iv. Friction through ABS pipe at a flow rate of 40 iGPM — 15ft/100 ft.

v. The total head loss — 28.2 ft.

4 **Pumping Capacity**

Minimum pump head required (Item 2 + 3 + 4v.) — 58.2 ft.

5 **Recommendation**

Take pump capacity as follow :

i.	Pumping head	58.2	ft.			
ii.	Pumping head (with 10% safety factor)	64.02	ft.			
	Selected pump head	65	ft.	Head	@	40 IGPM
		19.81	m.	Head	@	40 IGPM

9.2 PROJECT : JPA3 NEGERI PERLIS (DORMITORI)

Hydraulic Calculation For Pneumatic Pump System (Flush Valve)

1 **Static Head**

Static Head Loss Take 0 ft.

2 **Residual Head at Outlet**

Head required for discharging 30 ft.

3 **Friction Loss**

Through pipe 40mm diameter

i. Pipe Length 30 ft.

ii. Fittings Equivalent Length
(From manufacturer catalogue)

Fitting Equipments	Qty	Fel/Unit(ft)	FEL (ft)
Gates Valve	1	1	1
Strainer	1	10	10
Check Valve	1	10	10
Elbows	5	5.5	27.5
Tee	3	8	24
TOTAL			72.5

Total Fittings Equivalent Length 72.5 ft.

iii. Effective length of pipe 102.5 ft.

iv. Friction through ABS pipe at a flow rate of 20 IGPM 15ft/100 ft.

v. The total head loss 15.375 ft.

4 **Pumping Capacity**

Minimum pump head required (Item 2 + 3 + 4v.) 45.375 ft.

5 Recommendation

Take pump capacity as follow :

i.	Pumping head	45.375	ft.			
ii.	Pumping head (with 10% safety factor)	49.91	ft.			
	Selected pump head	50	ft.	Head	@	20 IGPM
		15.24	m.	Head	@	20 IGPM

CAWANGAN KEJURUTERAAN MEKANIKAL

UNIT KESELAMATAN

PROJECT: PUSAT PERTAHANAN AWAM NEGERI PERLIS **DATE: 06/10/08**

(PIPE MATERIAL : Galvanised Mild Steel, Stainless Steel, High Density Polythylene(HDPE))

Point to Point	No. of Loading Unit				Flow rate (GPM)		Dia. Inches	Actual Length (feet)	Equiv. Length (feet)				Eff. length (ft)	Hloss per ft	HL in Eff. Length feet	HL in Valves, Taps & Meters(ft)	Total HL (ft)	Avail Head (ft)	Resi dual Head (ft)
	Type	No.	Load	Sub-Total		Sub-Total			Type	No	EQ								
AB	WCL	0	5.0	0.0	1.5	0.0	2	33	GE	5	3.5	17.50	50.50	0.01212	0.61	1	1.61	10	8.39
	WCT	6	2.0	12.0	1.0	6.0			GT	0	8.75	0.00							
	SH	0	3.0	0.0	1.5	0.0			GB	0	2.75	0.00							
	AB	0	3.0	0.0	2.0	0.0													
	STQ	0	4.0	0.0	4.0	0.0													
	WB	5	3.0	15.0	2.0	10.0													
				27.0		**7.3**						**17.50**							
BC	WCL	0	5	0.0	1.5	0.0	1.5	20	GE	1	3.50	3.50	32.25	0.00718	0.23	0	0.23	8.39	8.16
	WCT	0	2	0.0	1.0	0.0			GT	1	8.75	8.75							
	SH	0	3	0.0	1.5	0.0			GB	0	2.75	0.00							
	AB	0	3	0.0	2.0	0.0													
	STQ	0	4	0.0	4.0	0.0													
	WB	5	3	15.0	2.0	10.0													
				15.0		**5.6**						**12.25**							
CD	WCL	0	5	0.0	1.5	0.0	1	9	GE	2	1.75	3.50	17.00	0.14	2.38	1	3.38	8.16	4.78

	WCT	0	2	0.0	1.0	0.0			GT	1	4.5	4.50							
	SH	0	3	0.0	1.5	0.0			GB	0	1.5	0.00							
	AB	0	3	0.0	2.0	0.0													
	STQ	0	4	0.0	4.0	0.0													
	WB	2	3	6.0	2.0	4.0													
				6.0		**4.0**						**8.00**							
DE	WCL	0	5	0.0	1.5	0.0	0.75	7	GT	1	4.5	4.50	13.25	0.036	0.48	1	1.48	4.78	3.30
	WCT	0	2	0.0	1.0	0.0			GE	1	1.75	1.75							
	SH	0	3	0.0	1.5	0.0			GB	0	1.5	0.00							
	AB	0	3	0.0	2.0	0.0													
	STQ	0	4	0.0	4.0	0.0													
	WB	1	3	3.0	2.0	2.0													
				3.0		**2.0**						**6.25**							
				51.00		**11.5**													

9.3 PROJEK : JPA3 NEGERI PERLIS (BLOK OPERASI 911)

FLUSH VALVE CALCULATION

No. of valve (W.C) = 24

From manufacturer catalogue (Loading Unit),
Office Flush Valve

L.U = 10

Therefore total loading unit = 240

From FIGURE 24 (Design Flow rate vs Loading Unit)

Total Loading Unit,	L.U	=	240					
Design Flow rate,	Q	=	33	IGPM				
add 15% safety factor								
Therefore, design flow rate,	Q	=	37.95	IGPM				
	Q	=	Av					
	take v	=	2.0	m/s	(for pumping velocity)			
Calculated design flow rate,	Q	=	37.95	IGPM				
	Q	=	0.002875	m^3/s		A	=	0.001438 m^2
Pipe diameter,	d	=	0.042774	m				
Therefore	d	=	42.77358	mm				
Take diameter,	d	=	43	mm				
Pipe Size,	d	=	50	mm				

9.4 PROJEK : JPA3 NEGERI PERLIS (DORMITORI)

FLUSH VALVE CALCULATION

No. of valve (W.C) = 6

From manufacturer catalogue (Loading Unit),
Office Flush Valve

L.U = 10

Therefore, total loading unit = 60

From FIGURE 24 (Design Flow rate vs Loading Unit)

Total Loading Unit, L.U = 60

Design Flow rate,	Q	=	13	IGPM				
add 15% safety factor								
Therefore, design flow rate,	Q	=	14.95	IGPM				
	Q	=	Av					
take	v	=	2.0	m/s	(for pumping velocity)			
Calculated design flow rate,	Q	=	14.95	IGPM				
	Q	=	0.001133	m^3/s		A	=	0.000566 m^2
Pipe diameter,	d	=	0.026847	m				
therefore	d	=	26.84666	mm				
Take diameter,	d	=	27	mm				
Pipe Size,	d	=	40	mm				

LIST OF ATTACHMENTS

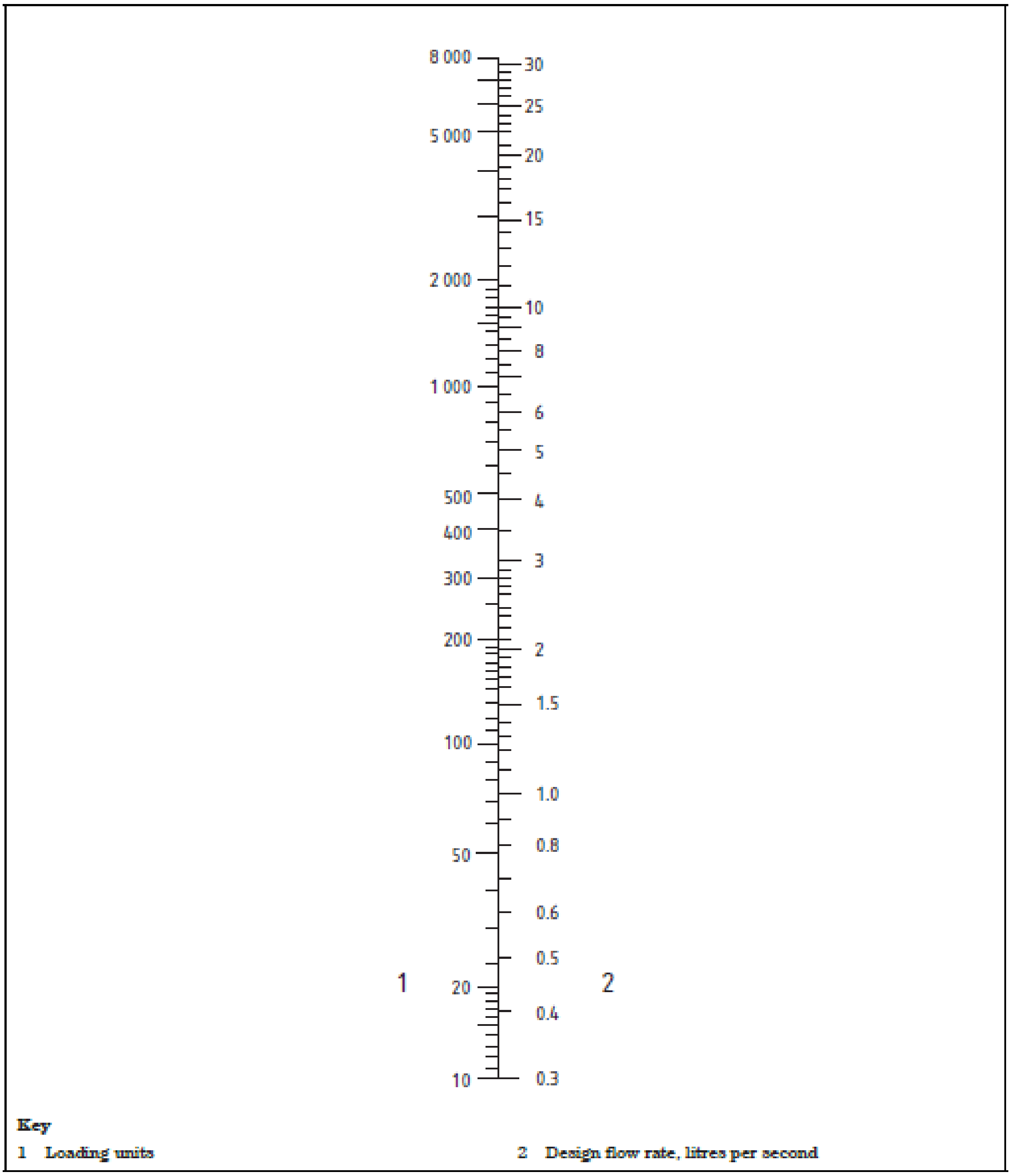
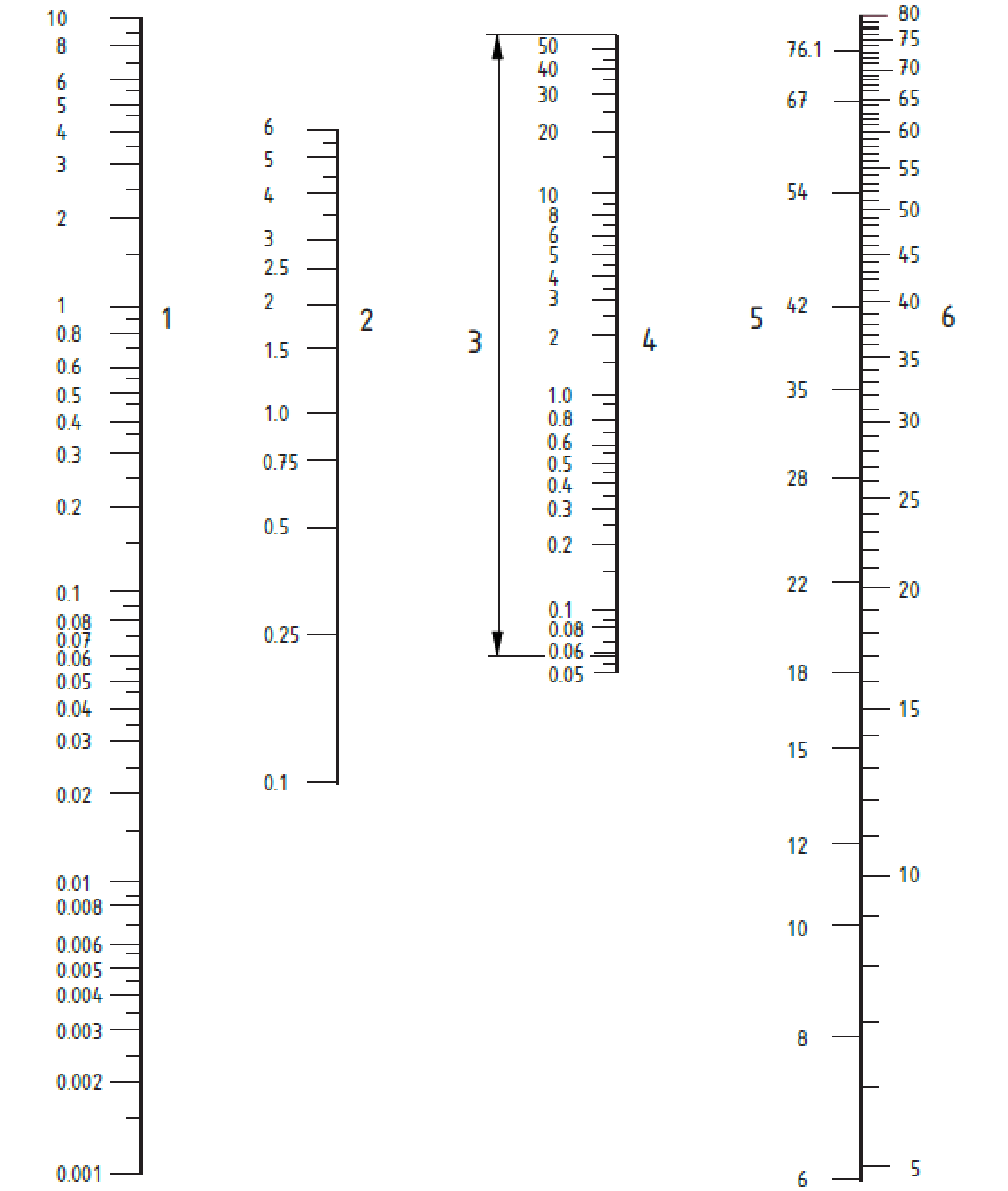


FIGURE 24: CONVERSION OF LOADING UNITS TO DESIGN FLOW RATE

Source: British Standards Institute. (Ed.). (2009). *BS 6700: Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages-Specification*. (3rd ed.). London: BSI.



Key

1 Wall friction gradient (head loss) in kPa per metre

2 Velocity in metres per second

3 Formula applicable between these limits only

4 Flow in litres per second

5 Outside diameter of copper tube in millimetres

6 Actual bore of pipe in millimetres

Lamont's smooth pipe formula S3 is:

$$v = 0.5545 d^{0.6935} i^{0.5645}$$

where

v is the velocity (m/s);

d is the diameter (mm);

i is the hydraulic gradient; and

$$R = 10\left[\frac{v}{0.5545 d^{0.6935}}\right]^{1.7715}$$

where

R is the wall friction gradient (kPa).

FIGURE 25: DETERMINATION OF PIPE DIAMETER – WATER AT 10 ℃

Source: British Standards Institude. (Ed.). (2009). *BS 6700: Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages-Specification*. (3rd ed.). London: BSI.

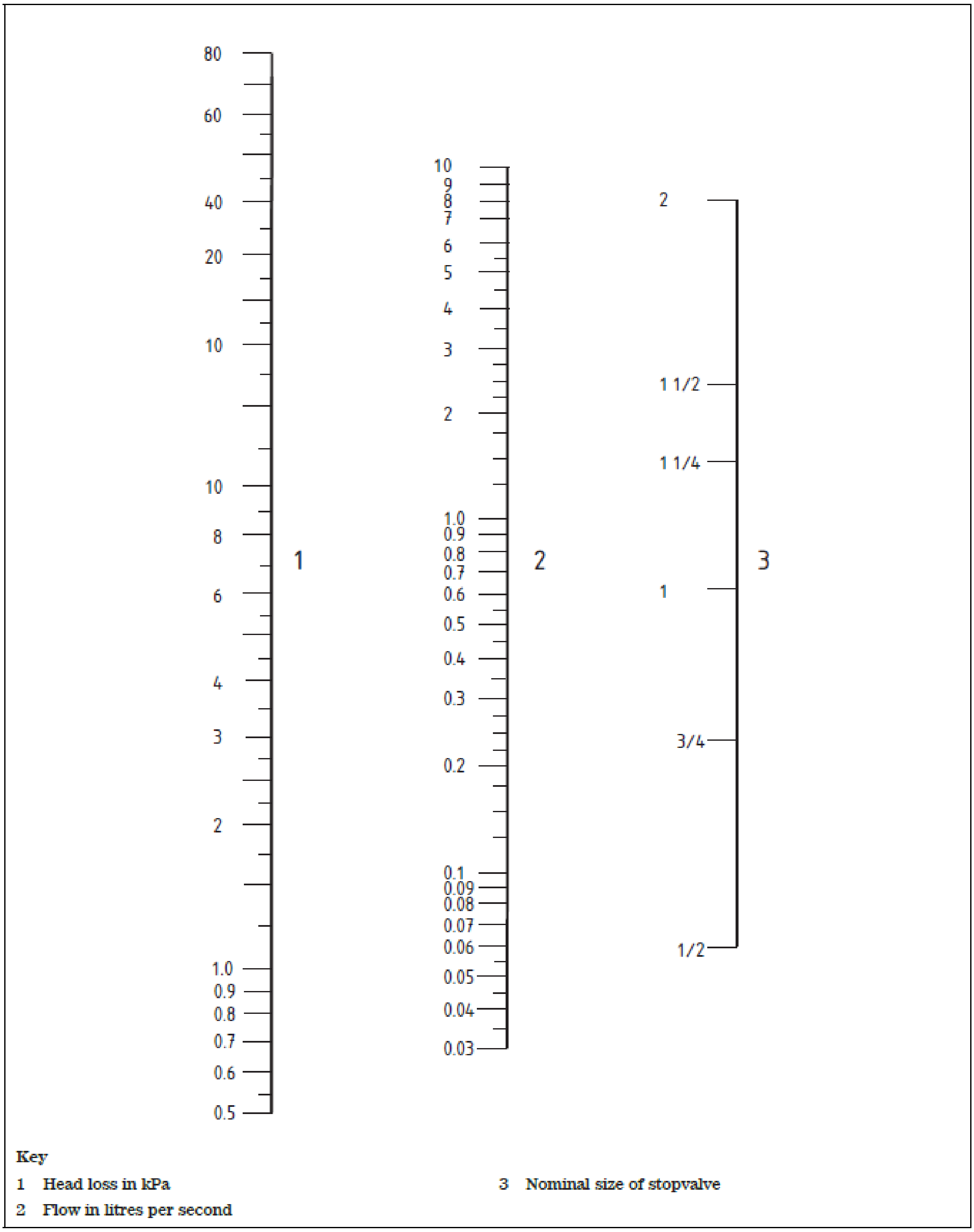
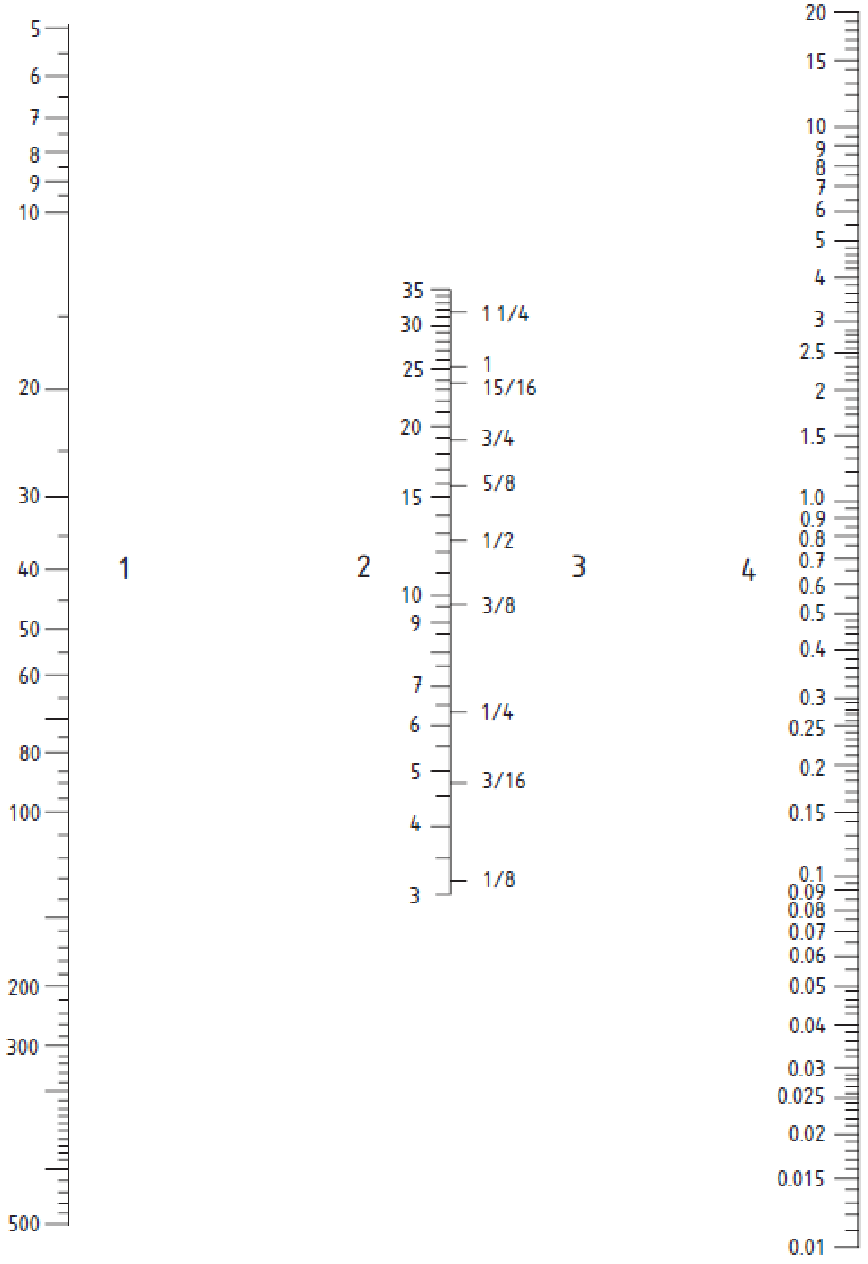


FIGURE 26: HEAD LOSS THROUGH STOPVALVES

Source: British Standards Institute. (Ed.). (2009). *BS 6700: Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages-Specification*. (3rd ed.). London: BSI.



Key

1 Pressure head of water in kPa

2 [A1] Diameter [A1] of orifice in millimetres

3 [A1] Diameter [A1] of orifice in inches

4 Flow through orifice in litres per second

Based on:

$$Q = AV \times 0.75$$
$$V = \sqrt{0.2gH}$$

where

Q is the flow (in litres per second);

V is the velocity of flow (metres per second);

g is the acceleration due to gravity (metres per second squared);

H is the pressure head of water at the float valve (kilopascals).

FIGURE 27: HEAD LOSS THROUGH FLOAT-OPERATED VALVES

Source: British Standards Institude. (Ed.). (2009). *BS 6700: Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages-Specification*. (3rd ed.). London: BSI.

TABLE 14 : PRELIMINARY SELECTION OF PIPE SIZES

The number of branches of a given size that can be supplied by a distribution pipe may be obtained from table below.

DIAMETER OF DISTRIBUTION PIPE	DIAMETER OF BRANCH PIPE								
	4”	3”	2 ½”	2”	1 ½”	1 ¼”	1”	¾”	½”
100 mm (4”)	1	2	4	6	12	16	30	60	100
80 mm (3”)		1	1	3	6	9	16	30	87
65 mm (2 ½”)			1	2	3	6	12	31	48
50 mm (2”)				1	2	3	6	12	32
40 mm (1 ½”)					1	2	3	6	16
32 mm (1 ¼”)						1	2	4	10
25 mm (1”)							1	2	6
20 mm (¾”)								1	3
15 mm (½“)									1

Source: *GUIDELINES ON THE DESIGN OF WATER SUPPLY PLUMBING SYSTEMS* (Vol. JKR 20200-0006-87). (1987). Kuala Lumpur: Cawangan Bekalan Air, Ibu Pejabat JKR Malaysia.

Table 15: DRAW-OFF FLOW-RATES Q_A , MINIMUM FLOW-RATES AT DRAW-OFF POINTS Q_{min} AND LOADING UNITS FOR DRAWOFF POINTS

Draw-off point	Q_A l/s	Q_{min} l/s	Loading units
Washbasin, handbasin, bidet, WC-Cistern	0.1	0.1	1
Domestic kitchen sink, washing machine, dish washing machine, sink, shower head	0.2	0.15	2
Urinal flush valve	0.3	0.15	3
Bath domestic	0.4	0.3	4
Tap (garden/garage)	0.5	0.4	5
Non domestic kitchen sink DN 20, bath non domestic	0.8	0.8	8
Flush valve DN 20	1.5	1.0	15

NOTE: For non domestic appliances check with manufacturer.

Source: *Plumbing Engineering Services Design Guide*. (2002). Essex: The Institute of Plumbing.

TABLE 16 : TYPICAL EQUIVALENT PIPE LENGTHS (copper, plastics and stainless steel)

Bore of pipe	Equivalent pipe length			
	ELBOW	**TEE**	**STOP VALVE**	**CHECK VALVE**
mm	m	m	m	m
12	0.5	0.6	4.0	2.5
20	0.8	1.0	7.0	4.3
25	1.0	1.5	10.0	5.6
32	1.4	2.0	13.0	6.0
40	1.7	2.5	16.0	7.9
50	2.3	3.5	22.0	11.5
65	3.0	4.5	-	-
73	3.4	5.8	34.0	-

NOTE 1: The losses through tees are taken to occur on a change of direction only. Losses through fully open gate valves may be ignored.
NOTE 2: In some systems special fittings and significant head losses are used. For information on head losses in these fittings, reference should be made to the manufacturers.

Source: British Standards Institude. (Ed.). (2009). *BS 6700: Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages-Specification*. (3rd ed.). London: BSI.

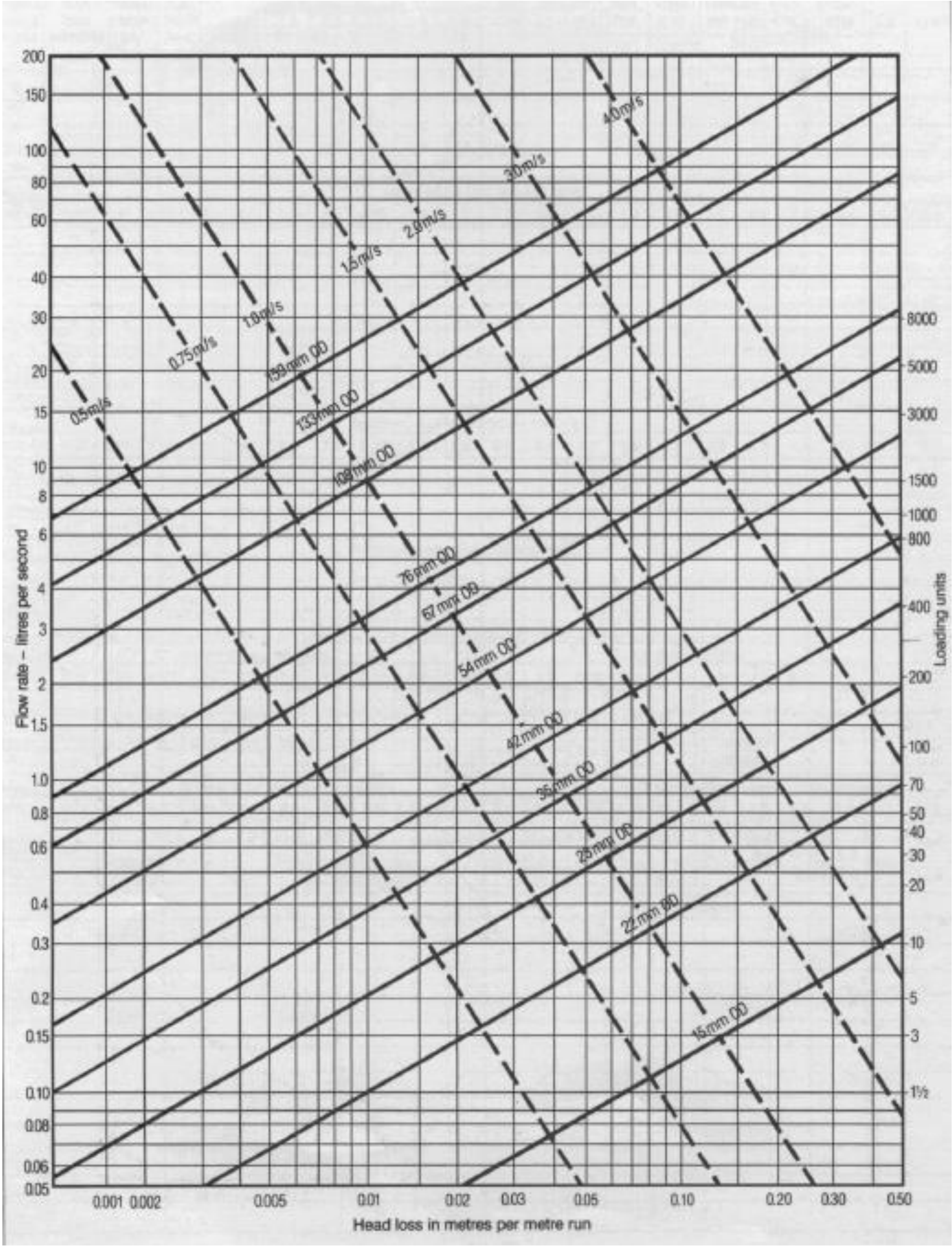
TABLE 17 : TYPICAL LOSS OF PRESSURE THROUGH UK LOW RESISTANCE TAPS AND EQUIVALENT PIPE LENGTHS

Nominal size of tap	Flow rate l/s	Loss of pressure kPa	Equivalent pipe m
½	0.15	5	3.7
½	0.20	8	3.7
¾	0.30	8	11.8
1	0.60	15	22.0

NOTE: Pressure losses and equivalent lengths are typical only and will vary with taps of different manufacture.

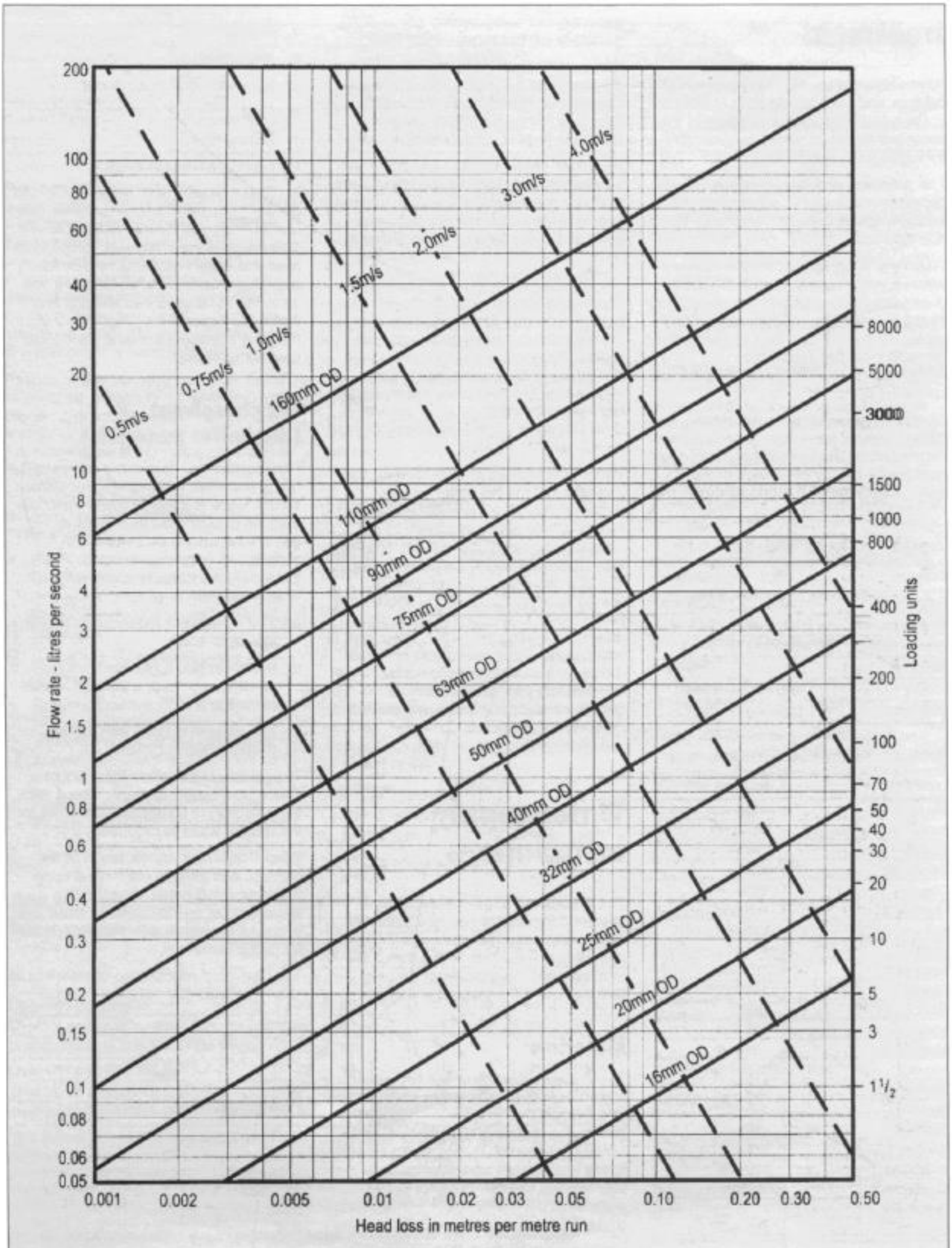
Source: British Standards Institude. (Ed.). (2009). *BS 6700: Design, installation, testing and maintenance of services supplying water for domestic use within buildings and their curtilages-Specification*. (3rd ed.). London: BSI.

GRAPH 1 : PIPE SIZING CHART – COPPER & STAINLESS STEEL

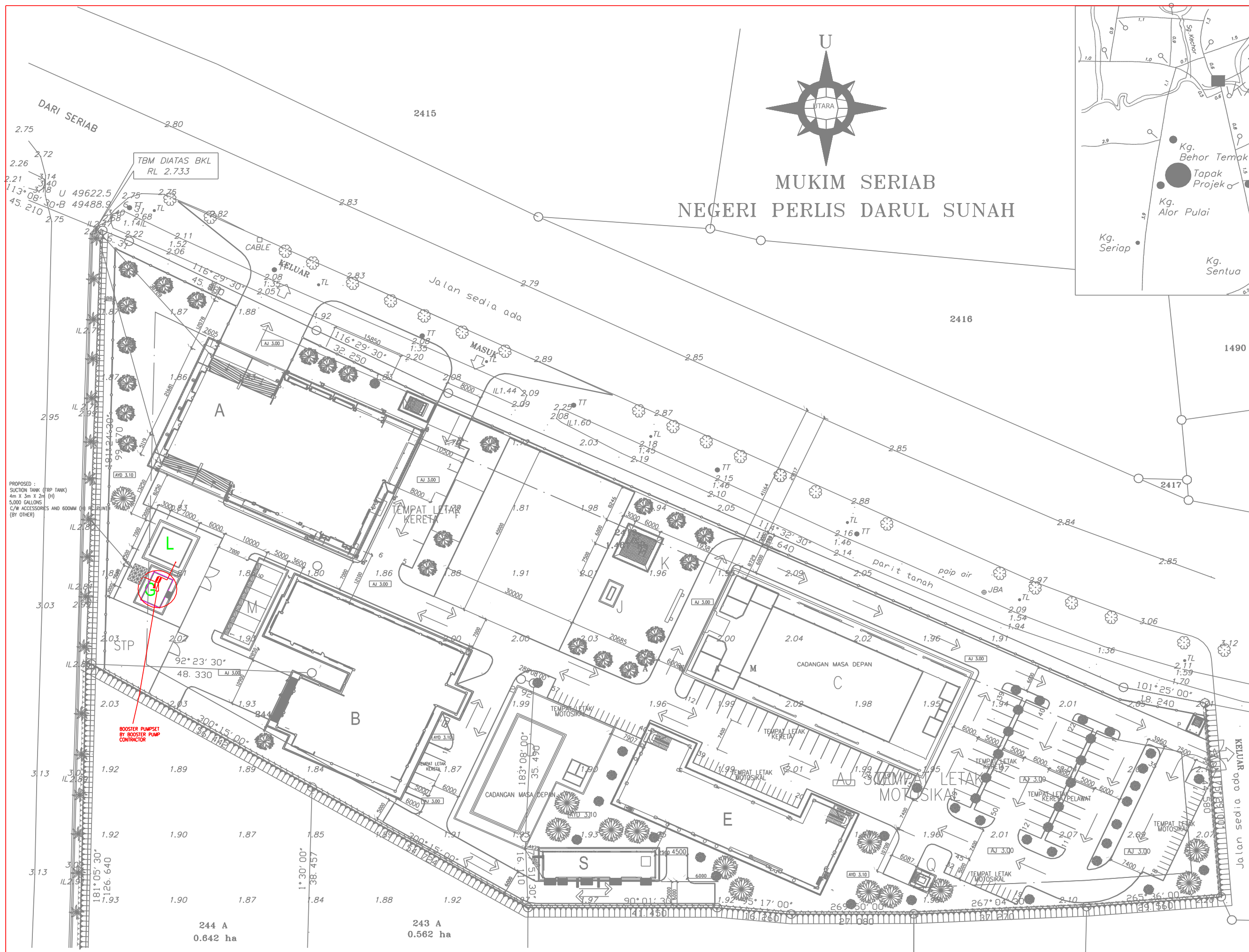


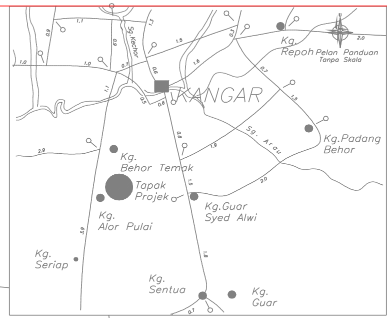
Source: *Plumbing Engineering Services Design Guide*. (2002). Essex: The Institute of Plumbing.

GRAPH 2 : PIPE SIZING CHART – PLASTIC



Source: *Plumbing Engineering Services Design Guide*. (2002). Essex: The Institute of Plumbing.





PETUNJUK

	KERJA KERJA AKAN DATANG
	KERJA BARU
	JALAN BARU
	PENANAMAN RUMPUT
	CERUN
PG	PINTU PAGAR GELANGSAR
	PINTU PAGAR
	PAGAR DAWAI BERANGKAI
	PAGAR KONKRIT BERHIAS
	POKOK
A	BLOK OPERASI 911
B	BLOK LATIHAN
C	DEWAN SERBAGUNA
D	KOLAM RENANG
E	DORMITORI
F	ASTAKA
G	RUMAH PAM
J	KOLAH AIR
K	MENARA LATIHAN
L	ELEVATED WATER TANK
M	PARKING BERBUMBUNG
N	PONDOK PENGAWAL
P	SENTRI POST
Q	RUMAH SAMPAH
R	PADANG KAWAD
S	TNB SUB-STATION
T	TEMBOK LOGO
	JALAN BERTURAP
TE	TIANG ELEKTRIK
TL	TIANG LAMPU JALAN
TT	TIANG TELEFON
	Batu sempadan
S7	Piket Stysen(Paku)
TA	Tangki Air
	Pokok Kelapa
	Sump dan Longkang Konkrit
	Pagar Dawai
SPT	Septic Tank
AC	Air Cond
WS	Paip LIne
	Gabion
PP	Pondok Pengawal
	Pokok
H	Pili Bomba
IL	Invert level
TBM	Temporary Banch Mark
A.Y.D	ARAS YANG DI BENTUK
A.J	ARAS JALAN

NOTA :-

1. Semua ukuran dalam milimeter
2. Datum Pugak berdasarkan DATUM TEGAK GEODESI SEMENANJUNG MALAYSIA (GTGSM)
3. Semua nilai ketinggian yang ditunjukkan adalah berdasarkan daripada DTGSM BM R 0219 (RL.3.484) di jalan Sekolah Derma di hujung jambatan Sg. Korok
4. Kawalan Ufuk berdasarkan PA 80333

DRAWING NO.1

NOTA PENENTUAN

1. This is tender drawing and should not be taken as a working drawing.
2. For other notes, refer to the specifications.

KERAJAAN MALAYSIA

PEJABAT PENGARAH KANAN
CAWANGAN KEJURUTERAAN MEKANIKAL
IBU PEJABAT JKR MALAYSIA
TINGKAT 18–21, CENTRE POINT NORTH
THE BOULEVARD, MIDVALLEY CITY
LINGKARAN SYED PUTRA
59200 KUALA LUMPUR

CAWANGAN KEJURUTERAAN MEKANIKAL

DISAHKAN

PENGARAH KANAN CAWANGAN KEJURUTERAAN MEKANIKAL

PENGARAH REKABENTUK CAWANGAN KEJURUTERAAN MEKANIKAL

JURUTERA MEKANIKAL PENGUASA KANAN

JURUTERA MEKANIKAL PENGUASA

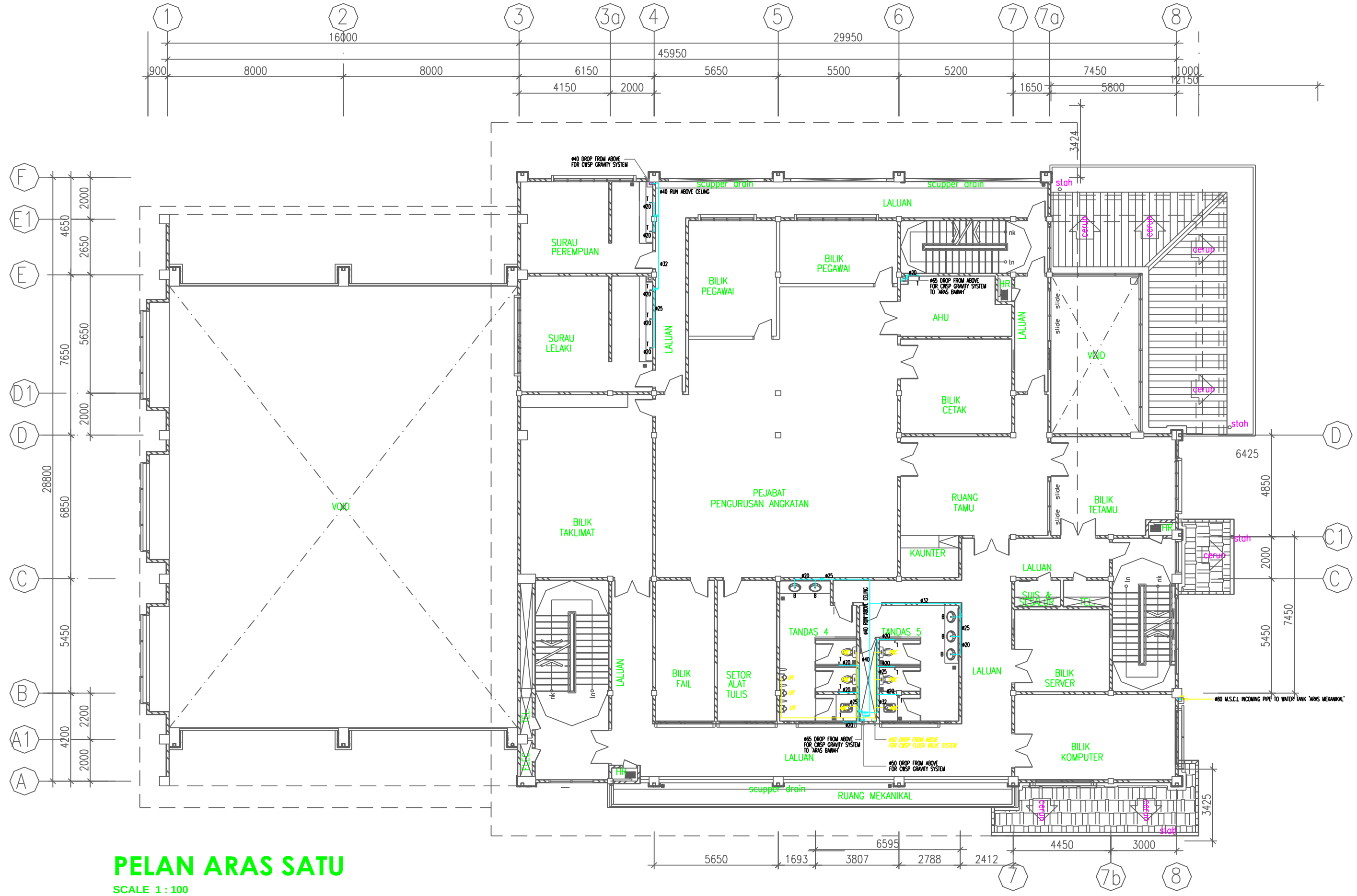
PROJEK:

PEMBINAAN
PUSAT PERTAHANAN AWAM
NEGERI PERLIS

TAJUK LUKISAN:

SISTEM PAM PENGGALAK
PELAN TAPAK

SKALA: 1 : 500	DIREKABENTUK OLEH:
DILUKIS OLEH:	DISEMAK OLEH:
TARIKH:	NO FAIL KOMPUTER:
NO LUKISAN:	



PELAN ARAS SATU

SCALE 1 : 100

NOTA PENENTUAN

1. This is tender drawing and should not be taken as a working drawing.
2. For other notes, refer to the specifications.
3. All pipes diameter are in mm unit

LEGEND:

ABS – ACRYLONIDDRILE BUTIENE STYRENE
SH – SHOWER
UR – URINAL
PWC – PEDESTAL WATER CLOSET
AWC – ASIAN WATER CLOSET
T – TAP
B – BASIN
– STOP COCK
CWSP – COLD WATER SUPPLY PIPE
M.S.C.L – MILD STEEL CEMENT LINE
PN – PRESSURE NOMINAL
– COLD WATER PIPES (GRAVITY) ABS PN 12
– FLUSH VALVE PIPES (PUMPING) ABS PN 15

NOTES :-

1. THE CONTRACTOR MUST ALLOW FOR BEAM OPENINGS/PIPE SLEEVES AND SHALL OBTAIN APPROVED FROM STRUCTURAL ENGINEER
2. THE CONTRACTOR SHALL BE RESPONSIBLE TO LOCATE THE EXACT POSITIONING OF BEAM OPENINGS/PIPE SLEEVES FOR PIPNG ROUTE
3. NO EXPOSED PIPEWORKS IS ALLOWED
4. ALL INTERNAL PIPE GRAVITY SYSTEM SHALL BE ABS CLASS PN 12.
5. ALL INTERNAL PIPE FLUSH VALVE SYSTEM SHALL ABS CLASS PN 15

KERAJAAN MALAYSIA

JKR
JASA KEPADA RAKYAT

CAWANGAN KEJURUTERAAN MEKANIKAL
Ibu Pejabat JKR Malaysia

DISAHKAN

PENGARAH CAWANGAN KEJURUTERAAN MEKANIKAL
DATO' Ir. CHE MAT BIN WANIK
JURUTERA MEKANIKAL KANAN PENGUASA
Ir. MUSTAFFA BIN TEK
JURUTERA MEKANIKAL KANAN
AISHAH HAZLINA BINTI MD. DEAN
JURUTERA MEKANIKAL
MOHD MAARIF BIN ABDUL MALIK

PROJEK

CADANGAN MEMBINA
DAN MENYIAPKAN
PUSAT PERTAHANAN AWAM
NEGERI PERLIS

TAJUK LUKISAN

SISTEM BEKALAN AIR DALAMAN

BLOK OPERASI 911
- PELAN ARAS SATU

SKALA	1 : 100	DIREKABENTUK	MOHD MAARIF
DILUKIS	SHAIFULAZ	DISEMAK	MOHD MAARIF
TARIKH	OGOS 2008	BIL. FAIL KOMPUTER	JPA3

NO. LUKISAN
MEK/K/CW/46A (3) /2008

DRAWING NO.2

NOTA:

1. KONTRAKTOR UTAMA HENDAKLAH MELANTIK PEGAWAI YANG BERKELAYAKAN (ORANG UTAMA YANG MENGEMUKAKAN – 'PRINCIPAL SUBMITTING PERSON' ATAU ORANG YANG MENGEMUKAKAN – 'SUBMITTING PERSON') YANG DIIKTIRAF OLEH SURUHANJAYA PERKHIDMATAN AIR NEGARA.
2. BAGI SEMUA TANGKI YANG DIBEKALKAN HENDAKLAH JUGA MENGIKUT SEPERTIMANA SPESIFIKASI PENGELUAR.
3. PEMASANGAN DAN PERINCIAN KESEMUA KELENGKAPAN SEPERTI DI NO. 1 DI ATAS HENDAKLAH DIRUJUK KEPADA PERINCIAN PEMBEKAL.
4. KEDUDUKAN YANG TEPAT BAGI PAIP PENCUCI, PAIP LIMPAH DAN PAIP AMARAN PADA SISTEM TANGKI SIMPANAN HENDAKLAH DITETAPKAN DI TAPAK OLEH PEGAWAI PENGUASA (MENGIKUT KESESUAIAN).
5. PENYAMBUNGAN BAGI SEMUA SALURAN PAIP MENGEPAM HENDAKLAH SEPERTIMANA SPESIFIKASI DAN PERINCIAN PENGELUAR.SAMBUNGAN SEKERU (SCREW DOWN) TIDAK DIBENARKAN.
6. KESEMUA PAIP DALAMAN ADALAH DARI JENIS 'ACRYLONITRILE BUTADIENE STYRENE' (ABS). PAIP BERGARISPUSAT DARI 20mm KELAS E (NOMINAL) HINGGA PAIP BERGARISPUSAT DARI 25mm – 150mm KELAS D (NOMINAL).
   PAIP BERTEKANAN ('PUMPING') HENDAKLAH DARI JENIS ABS KELAS PN 15, MANAKALA PAIP ('GRAVITY') HENDAKLAH DARI JENIS ABS KELAS PN 12.
7. KESEMUA BAHAN 'ABS' YANG DIBEKALKAN HENDAKLAH BERDASARKAN KEPADA B.S. 5391 DAN B.S 5392.
8. SEMUA INJAP PENAHAN (STOP VALVE) HENDAKLAH SAMA SAIZ DENGAN PAIP YANG DIGUNAKAN. INJAP PENAHAN (STOP VALVE) BERGARISPUSAT KURANG DARI 50mm HENDAKLAH DARI JENIS SKRU BIASA (SCREW DOWN) DAN INJAP PENAHAN BERGARISPUSAT 50mm ATAU LEBIH HENDAKLAH DARI JENIS INJAP PINTU (GATE VALVE).
9. KESEMUA PAIP DAN PEPASANGAN YANG MELALUI RUANG YANG DIDUDUKI, LALUAN AWAM, KAWASAN TANDAS DSB. HENDAKLAH DISEMBUNYIKAN DALAM SALURAN, DALAM SILING DSB. DIMANA PERLU, DINDING HENDAKLAH DIPAHAT UNTUK MENYEMBUNYIKAN PAIP DI BELAKANG PLASTER, JUBIN DAN LAIN-LAIN JENIS LEKAPAN DINDING SEBAGAIMANA SPESIFIKASI.
10. DI MANA PAIP TIDAK BOLEH DISEMBUNYIKAN SEMUA BAHAGIAN YANG KELIHATAN HENDAKLAH DICATKAN SEPERTI PERINCIAN PENGELUAR.
11. PAIP YANG MENEMBUSI DINDING BATA HENDAKLAH MELALUI LUBANG YANG DIBUAT SEMASA KERJA SEDANG BERJALAN. PAIP HENDAKLAH DIJARAKKAN DARIPADA BATA DENGAN MENGGUNAKAN SIMEN MORTAR MENYAMAI DINDING BATA TERSEBUT BAGI MENGELAKKAN TERJADINYA RONGGA.
12. DIMANA PAIP AIR PERLU MENEMBUSI RASUK, SESALUR KELULI SEDERHANA (M.S.) HENDAKLAH DIGUNAKAN UNTUK DISISIPKAN KE DALAM RASUK TERSEBUT. GARISPUSAT SEBELAH DALAM BAGI SESALUR KELULI SEDERHANA TERSEBUT MESTILAH LEBIH BESAR DARI PAIP YANG DIGUNAKAN. KEDUDUKAN PENYISIPAN MELALUI RASUK HENDAKLAH DITETAPKAN OLEH PEGAWAI PENGUASA ATAU PUN SEPERTI DINYATAKAN DI DALAM LUKISAN.
13. PAIP-PAIP MENEGAK DAN MENGUFUK HENDAKLAH DILEKAPKAN DENGAN SEMPURNA PADA KEDUDUKANNYA MENGGUNAKAN CARA ATAU ALAT YANG TELAH DILULUSKAN ATAUPUN SEPERTI PERINCIAN PENGELUAR.
14. KEDUDUKAN YANG TEPAT BAGI SESIKU, LENGKUNG, INJAP PENAHAN, PEPASANGAN DSB. HENDAKLAH DITETAPKAN DI TAPAK OLEH PEGAWAI PENGUASA ATAUPUN MENGIKUT SEPERTIMANA YANG TERCATIT DI LUKISAN.
15. SEMUA PILI CUCI UNTUK TANDAS HENDAKLAH BERADA PADA SEBELAH KANAN.
16. PAIP PENCUCI & PAIP LIMPAH HENDAKLAH DIALIRKAN KE TEMPAT YANG BERSESUAIAN DAN SENANG DILIHAT DI TINGKAT BAWAH SEPERTI KE LONGKANG ATAU SEBAGAINYA.
17. KESEMUA PEPASANGAN DAN PENYAMBUNGAN KE SISTEM SIMPANAN HENDAKLAH BERSESUAIAN DENGAN KAEDAH BEKALAN AIR SEMASA.
18. SEMUA PEPASANGAN DAN PENYAMBUNGAN HENDAKLAH ø20mm ATAUPUN SEPERTI YANG DITUNJUKKAN DIDALAM LUKISAN.
19. BAGI SETIAP PAIP PENCABANG YANG MEMPUNYAI LEBIH DARI 5 PEPASANGAN, 1 INJAP PENAHAN TAMBAHAN HENDAKLAH DIPASANG BAGI KEMUDAHAN PENYENGGARAAN.
20. KESEMUA UKURAN YANG DITUNJUKKAN ADALAH DALAM MILIMETER (mm) ATAU SEPERTI DINYATAKAN DI DALAM LUKISAN.

Nota Tambahan Untuk Kerja-kerja Penyelenggaraan.

1. Bagi kedudukan tangki di paras bumbung atau seumpamanya, tangga masuk yang bersesuaian mestilah disediakan.
2. Untuk tangki yang ditempatkan di dalam ruang yang bertutup, hendaklah dipasang dengan lampu yang mencukupi bagi memudahkan kerja-kerja pemeriksaan dan penyelenggaraan tangki.

NOTA PAIP AIR DALAMAN & TANGKI SIMPANAN

DRAWING NO. 3

NOTA PENENTUAN

1. This is tender drawing and should not be taken as a working drawing.
2. For other notes refer to the specifications.
3. All pipes diameter are in mm soft.

KERAJAAN MALAYSIA

JASA KEPADA RAKYAT

CAWANGAN KEJURUTERAAN MEKANIKAL
Ibu Pejabat JKR Malaysia

DISAHKAN

PENGARAH CAWANGAN KEJURUTERAAN MEKANIKAL
JURUTERA MEKANIKAL KANAN PENGUASA
JURUTERA MEKANIKAL KANAN
JURUTERA MEKANIKAL

PROJEK

CADANGAN MEMBINA
DAN MENYIAPKAN
PUSAT PERTAHANAN AWAM
NEGERI PERLIS

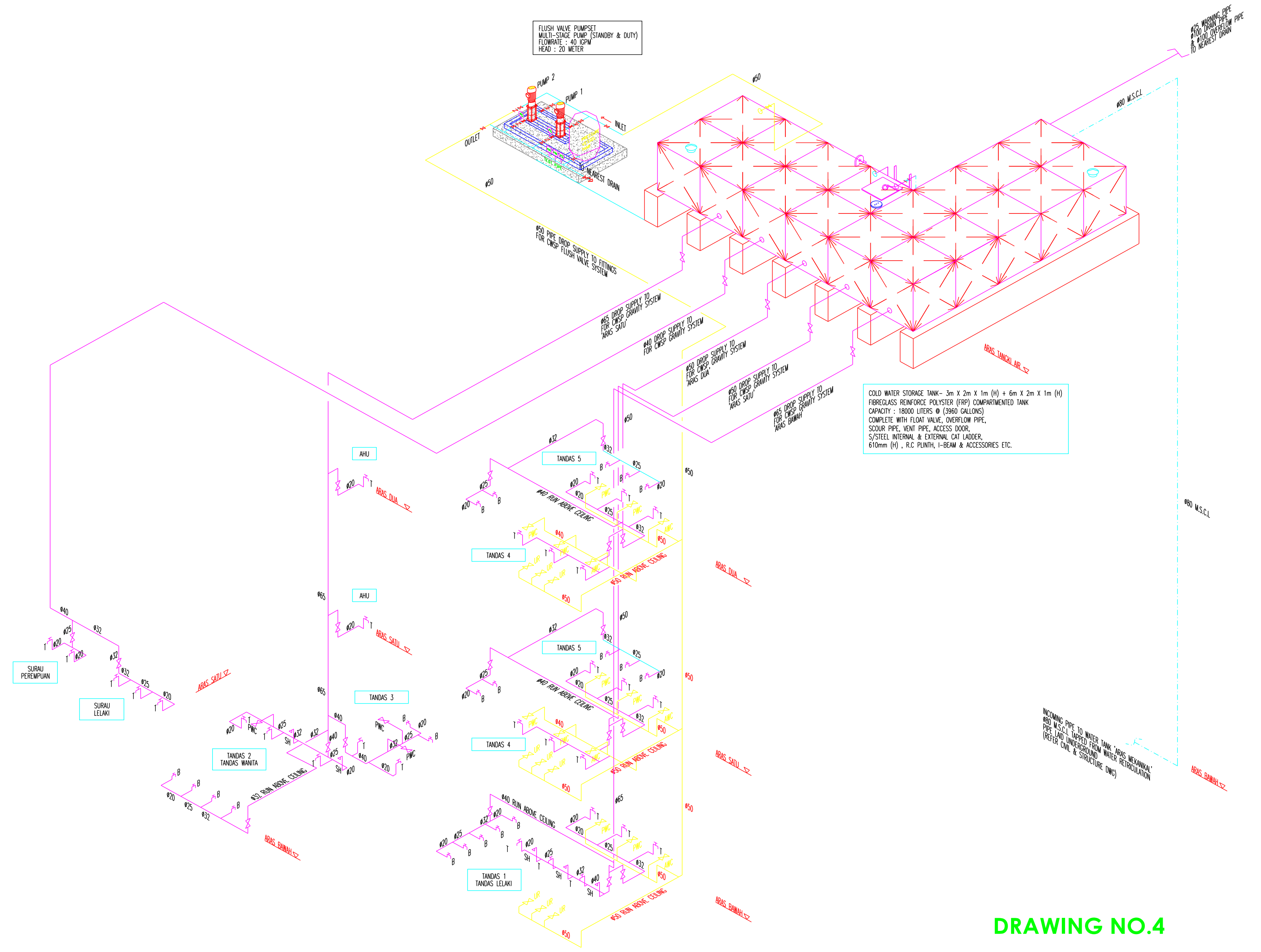
TAJUK LUKISAN

SISTEM BEKALAN AIR DALAMAN

NOTA

SKALA	not to scale	DIREKABENTUK
DILUKIS		DIREMAK
TARIKH		BIL. FAIL KOMPUTER

NO. LUKISAN



DRAWING NO.4

NOTA PENENTUAN

1. This is tender drawing and should not be taken as a working drawing.
2. For other notes, refer to the specifications.
3. All pipes diameter are in mm unit

LEGEND:

ABS	–	ACRYLONIDDRILE BUTIENE STYRENE
SH	–	SHOWER
UR	–	URINAL
PWC	–	PEDESTAL WATER CLOSET
AWC	–	ASIAN WATER CLOSET
T	–	TAP
B	–	BASIN
	–	STOP COCK
CWSP	–	COLD WATER SUPPLY PIPE
M.S.C.L	–	MILD STEEL CEMENT LINE
PN	–	PRESSURE NOMINAL
	–	COLD WATER PIPES (GRAVITY) ABS PN 12
	–	FLUSH VALVE PIPES (PUMPING) ABS PN 15

NOTES :–

1. THE CONTRACTOR MUST ALLOW FOR BEAM OPENINGS/PIPE SLEEVES AND SHALL OBTAIN APPROVED FROM STRUCTURAL ENGINEER
2. THE CONTRACTOR SHALL BE RESPONSIBLE TO LOCATE THE EXACT POSITIONING OF BEAM OPENINGS/PIPE SLEEVES FOR PIPNG ROUTE
3. NO EXPOSED PIPEWORKS IS ALLOWED
4. ALL INTERNAL PIPE GRAVITY SYSTEM SHALL BE ABS CLASS PN 12.
5. ALL INTERNAL PIPE FLUSH VALVE SYSTEM SHALL ABS CLASS PN 15

KERAJAAN MALAYSIA

JASA KEPADA RAKYAT

CAWANGAN KEJURUTERAAN MEKANIKAL
Ibu Pejabat JKR Malaysia

DISAHKAN

PENGARAH CAWANGAN KEJURUTERAAN MEKANIKAL
DATO' Ir. CHE MAT BIN WANIK

JURUTERA MEKANIKAL KANAN PENGUASA
Ir. MUSTAFFA BIN TEK

JURUTERA MEKANIKAL KANAN
AISHAH HAZLINA BINTI MD. DEAN

JURUTERA MEKANIKAL
MOHD MAARIF BIN ABDUL MALIK

PROJEK

CADANGAN MEMBINA
DAN MENYIAPKAN
PUSAT PERTAHANAN AWAM
NEGERI PERLIS

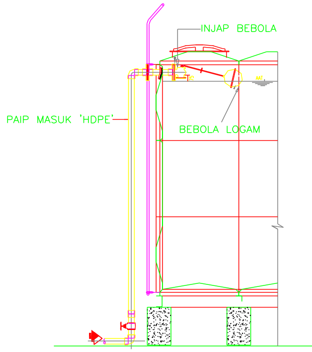
TAJUK LUKISAN

SISTEM BEKALAN AIR DALAMAN

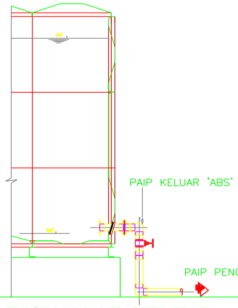
BLOK OPERASI 911
- SKEMATIK

SKALA	not to scale	DIREKABENTUK	MOHD MAARIF
DILUKIS	SHAIFULAZ	DISEMAK	MOHD MAARIF
TARIKH	OGOS 2008	BIL. FAIL KOMPUTER	JPA3

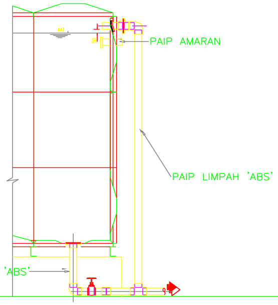
NO. LUKISAN
MEK/K/CW/46A (6) /2008



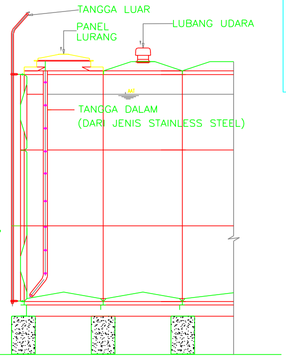
PERINCIAN PAIP MASUK



PERINCIAN PAIP KELUAR



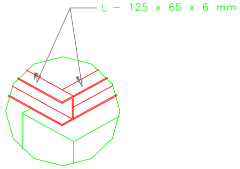
PERINCIAN PAIP PENCUCI
DAN PAIP LIMPAH



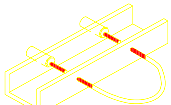
BUTIRAN LURANG MASUK
DAN LUBANG UDARA

NOTA:

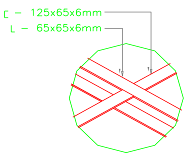
1. Semua laluan dan kedudukan pepasangan paip adalah sebagai petunjuk dan saranan sahaja.
2. Kedudukan sebenar untuk semua paip masuk, paip keluar ,paip pencuci, paip limpah, paip amaran dan paip contoh serta semua injap akan ditentukan ditapak
3. Lokasi sebenar untuk semua panel pengudaraan serta panel lurang (lengkap dengan tangga luar dan dalam) adalah ditentukan oleh Pegawai Penguasa.
4. Paip limpah/paip amaran hendaklah dialirkan ke tempat pembuangan yang bersesuaian dan senang kelihatan
5. Paip pencuci (dengan injap jenis 'gate') dan paip limpah hendaklah dibekalkan bagi setiap tangki.
6. Injap-injap untuk paip keluar, paip masuk, paip sambungan dan sebelum meter hendaklah menggunakan injap jenis 'gate'.
7. Lukisan ini adalah berdasarkan kepada aliran graviti.



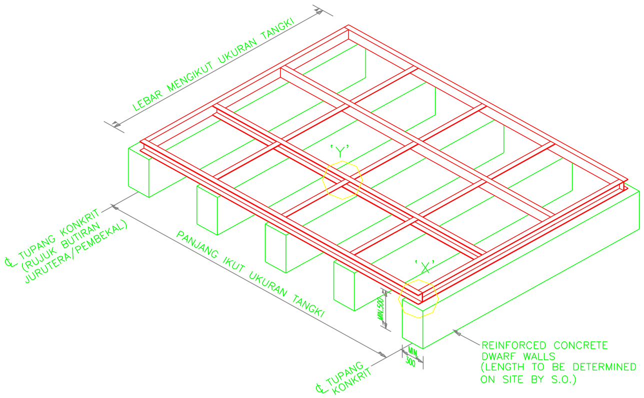
PERINCIAN ` X '



PANDANGAN ISOMETRIK



PERINCIAN ` Y'



BUTIRAN TIPIKAL
`TAPAK KELINCIR KELULI'

TIDAK MENGIKUT UKURAN

DRAWING NO. 5

NOTA PENENTUAN

1. This is tender drawing and should not be taken as a working drawing.
2. For other notes, refer to the specifications.
3. All pipes diameter are in mm unit

KERAJAAN MALAYSIA

JKR

JASA KEPADA RAKYAT

CAWANGAN KEJURUTERAAN MEKANIKAL
Ibu Pejabat JKR Malaysia

DISAHKAN

PENGARAH CAWANGAN KEJURUTERAAN MEKANIKAL

JURUTERA MEKANIKAL KANAN PENGUASA

JURUTERA MEKANIKAL KANAN

JURUTERA MEKANIKAL

PROJEK

CADANGAN MEMBINA
DAN MENYIAPKAN
PUSAT PERTAHANAN AWAM
NEGERI PERLIS

TAJUK LUKISAN

SISTEM BEKALAN AIR DALAMAN

PERINCIAN PEMASANGAN 4

SKALA	DIREKABENTUK
DILUKIS	DISEMAK
TARIKH	BIL. FAIL KOMPUTER
NO. LUKISAN	