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Design Of Hot And Cold Water Supply To Ahigh-RiseResidentialbuilding.

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ABSTRACT
This paper highlights the importance of Mechanical Engineers in providing mechanical services to the building sector, focused on the supply of hot and cold water to a high-rise building, made of a 24-storey building with 48 flats, each floor having three (3) bedrooms of two (2) flats. The building was divided to three zones of which each zone contains eight floors. The water requirement for the entire building per day was estimated to be 64541.3litres and hence the discharge at each zones were obtained to be 0.00398 m^3/s. the mechanical zone station water power was considered to be of PVC materials whereas that of hot water was copper materials. Hot water usage and heating by electricity is expensive due to payment of bills so if the gas heating could be properly developed this could be of help to the building sector and the country at large.
KEYWORDS:*Hot and Coldwater,Plumbing, Fittings, High Rise Building,Cpvc/pvc*

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I. INTRODUCTION

As Nigeria becomes more developed, tall structures are usually preferred to house its ever-increasing population. These buildings have to be comfortable and the level of luxury depends on the amount of money the occupants are prepared to pay.

One such building is the 48 flats in a 24-storey building. The compartments require both hot and cold water in all the parts of the house. Each flat is to have three bedrooms, a study room, a large sitting parlor, dinning and a kitchen. Each room is to have its own bathroom and water closet system with both water services

The economic importance of the work is that it will impact useful skill to the builder on how to tackle this type of problems. High rise building pose great challenges to the engineer since many services have to be mechanized. Building of this nature allows a large population to live in a small space very comfortably. A good designof the system is very important to prevent the need to carry out costly alteration in the future, moreover the cost of maintenance of such a good design is usually relatively low and even though the building will be slightly more expensive, eventually the low maintenance will justify it.

Before an engineer sets out the design of any building project that includes (plumbing), it is necessary that he has a predefined plan in order to install efficient and economic plumbing system (Hammond, 2005).However, careless plumbing of a building can cause leakages, inconvenience in homes as well as embarrassment to the plumber. Table 4.1 and 4.2 presents the bill of material and quantity whereas pictorial view of plumbing fittings and the designed building is presented in the appendix.

II. MATERIALS AND METHOD

Design Specifications

Table 3.1 Specifications considered

Wet riser sizes diameter [cold]	48.26mm [1.5 inch]
Wet riser pipe sizes copper diameter [hot]	6.5mm [3/4 inch]
Piping length per flat copper	39m
Piping length for each flat PVC	40.7m
Pipe material	Copper/poly Vinyl Chloride [PVC]
The numbers of floors	24
The number of flats per floor	2
The numbers of bedrooms	3x2x24 = 144 bedrooms
The numbers of persons per room	2x3x144 = 864 persons
Pump type	Centrifugal Pump

Calculation for Building Water Capacity [cold]

Average Daily Water Requirement for Storage
1 gallon = 231 cubic inches = 3.785411784 litres.

Usage;

Each occupant uses 35 – 50 Gallons [per day] in the building.

Calculation of daily domestic water requirement;

There are 24 floors with each floor having 2 flats, each consisting of three bedrooms with 1 maid each.

As a rule of thumb, we take two persons/bedrooms;

Calculation for Building Water Capacity [HOT]

Each occupant uses – 15 – 20 Gallons per person per day in the building.

Calculation of daily domestic water requirement;

There are 24 floors with each floor having 2 flats, each consisting of three bedrooms with 1 maid each.

As a rule of thumb, we take two persons/bedrooms;

Table 3.2[a] and [b] Usage Considerations

Total number of persons per floor	2x3x2 = 14 persons/floor
Total number of occupants	14 x 24 + 5 [labours + conciergies etc] = 341 persons
The daily water requirement [cold]	Between 35 – 50 gal/day [residential building]
The daily water requirement [hot]	Between 15 -20 gal/day [residential building]
The daily water requirement for the whole building. [cold]	50 x 341 = 17050 gallons/day = 64541.3 litres/day. [cold]
The daily water requirement for the whole building [hot]	20 x 341 = 6820 gallons/day = 25816.50837 litres/day. [hot]

Capacity of Underground and service tanks or mechanical stations [3 zoned] tanks

Based on plumbing code, the daily water requirement is been divided between the zones and the underground tank as follows;

As a rule, [one [1] day water storage on the mechanical stations and 2 days at the basement may be satisfactory, if water flow from well pump is not guaranteed, maybe due to maintenance etc.]

As mentioned before the total amount of water needed for the 24 floor building is 64541.3 litres/per day, this is equivalent to 23.1457 tonnes divided by the 3 service tanks at each mechanical stations, which is 7.7152 tonnes equivalent to 21513.7667 litres. On the other hand, 2 x 64541.3 = 129082.6 litres must be stored in the basement storage tanks. [cold].

While for the hot water it is capacity of the storage tanks that holds the volume of water, at each stations. Been total hot water required for building 25816.50837 litres / 3[zones] = 8605.50279litres [hot].

The mechanical stations were designed to;

- Avoid excessive pressure
- Achieve an economical, efficient and conserving installation
- Maintain a constant flow rate in all draw off points.

For this work, I considered dividing the building into three [3] zones, each having 8 floors with three [3] mechanical stations each, which will have both small PVC storage tank and a huge electrical water heater of 3000 galloons [11356.23535 litres] to supply hot water to the 16 flats after every 8 floors.

Pump Design

Length of wet riser pipe from basement to the 8^{th} floor = 27m

Length of wet riser pipe from the 8^{th} to 16^{th} floor = 24m

Length of wet riser pipe from the 16^{th} to 24^{th} floor =24m

Total head = static lift + loss in height due to acceleration and friction

Total head = 27m neglecting frictional loss and assuming equal size of pumps for each zone.

Discharge Quantity for pumps at each zone = 21513.8/1.5hr

= 14342.5 1/hr

= 2391/min = 0.00398 m^3/s

The tanks at each zone are expected to be filled within 1.5 hr[1hr, 30min]

Water power for pumps at each zone = [0.00398*27]/[0.102] from equation 2.2 = 1.05 kW

While for hot the pump at each zone = 8605.50279/1hr

= 143.4250456/hr

Drawings

Series-Connected Systems with Intermediate Break Tanks

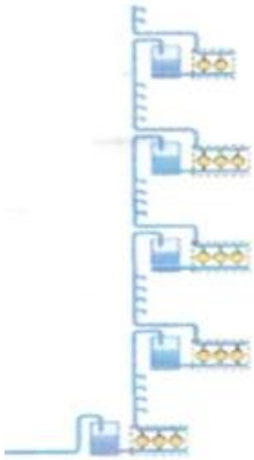


Fig 3.1 Series-connected systems with intermediate break tanks

This system utilizecentrally placed break tanks to supply both the taps in its own boosting zone and all the zones above it, as in figure 3.1above. With this system, the building is divided into three smaller and more manageable pressure zones of 8 floors each. Every zone is then served by its own booster set. No pressure reduction valves were required and in case of electrical break down the tanks will be able to supply pressure and water for up to 12 hours; see appendix 3below for 8th floor mechanical station design and for detailed A1 mechanical station and also appendix 3 which entails detail A2 for flat plumbing layout all presented for larger view, and also the modeled view of the work for the 24-storey high-rise building is also presented below in figure 3.2. Figure 3.3 below is the proposed water heater of about 3000gallons ≈11356.23535 litres storage capacity.

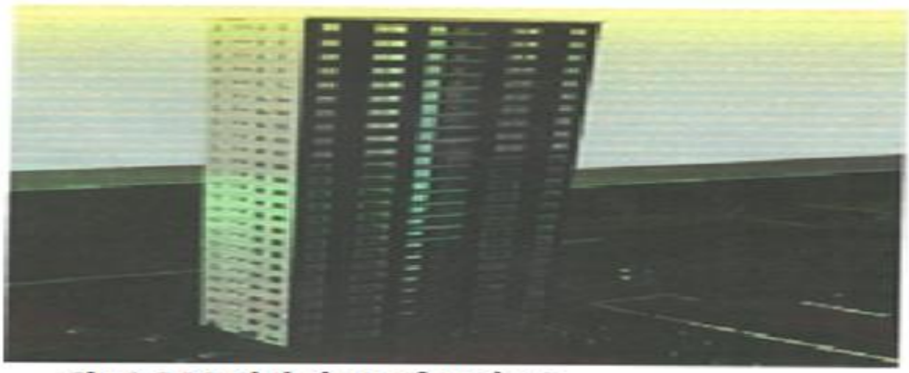


Fig 3.2 Model view of project

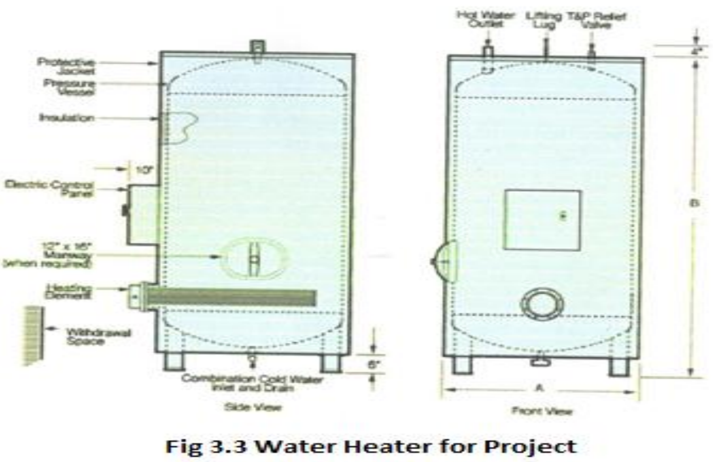
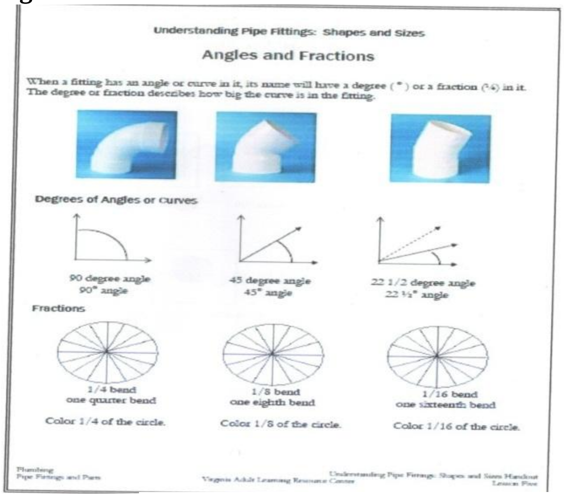
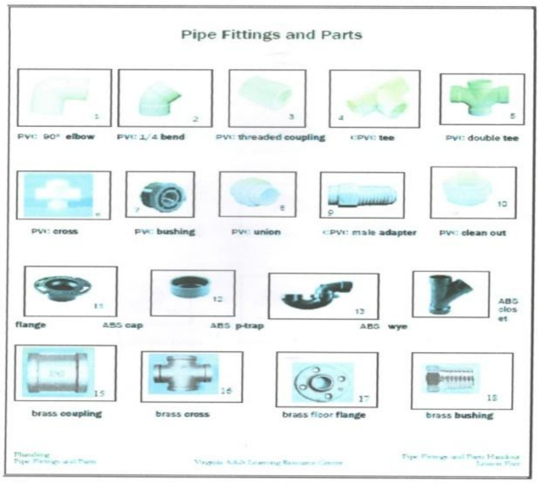


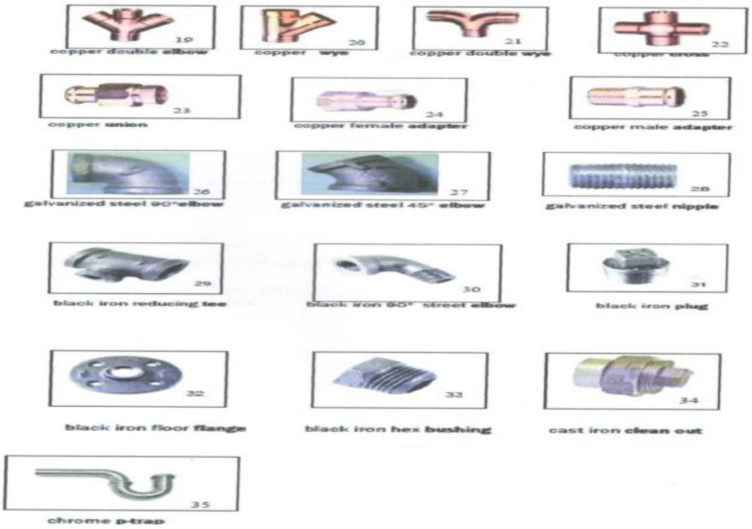
Fig 3.3 Water Heater for Project

III. RESULT ANDANALYSIS

Fittings







A bill of materials [BOM] sometimes referred to as the material take off [MTO] lists all the items that go into a finished project or subassembly of that project. The bill of Materials can be structured ion levels indicating all the steps to final completion. This can let the bill of materials look like a tree with the finished good or subassembly can be parts whose amounts would be counted as natural numbers of pieces or if it is simple materials being used, measurements of length or quantity. Bills of materials are used as documents supporting the assembly process. They also play a role in materials requirement planning [MRP] and Enterprise Resource Planning [ERP] management systems [Smith, 2014].

Table 4.1 Bill of Materials [all fitted to $^{3}/_{4}$- inch pipe]

Names/item, fittings/fixtures.	Size	Material	Quantity
Single kitchen sink	2.5ft	Stainless Steel	48
Bathtub	4.5ft	Fibre glass	48
Fountain	3ft	Stainless steel	5
Shower	Normal	Stainless steel	96
W/C	Normal	Ceramics	192
Bathroom sink	Normal	Ceramics	192
Mixer tap	Normal	Stainless steel	384
Elbow	Normal	Copper	384
Elbow	Normal	PVC	432
Tee	Normal	Copper	288
Tee	Normal	PVC	336
Union	Normal	PVC	100
Sockets	Normal	PVC	100
Hose Bibbs	Normal	Stainless steel	5
Adhesive	Normal bottle	Copper	480

Adhesive	0.5 litres	PVC	96
Transfer Pumps	0.00398m3/s, 27mH and 1.05kW	Centrifugal motor driven surface pump	6

Bill of Quantity

Table 4.2 bill of quantity

Names/item, fittings/fixtures.	Size	Material type	quantity	Unit price	Total price
Single kitchen sink	2.5ft	Stainless steel	48	5,000	240,000
Bathtub	4.5ft	Fibre glass	48	11,000	528,000
Fountain	3ft	Stainless steel	5		
Shower	Normal	Stainless steel	96	4,500	432,000
W/C	Normal	Ceramics	192	7,000	1,344,000
Bathroom sink	Normal	Ceramics	192	6,500	1,248,000
Mixer tap	Normal	Stainless steel	384	3,000	1,152,000
Elbow	Normal	Copper	384	200	76800
Elbow	Normal	PVC	432	100	43200
Tee	Normal	Copper	288	200	57,600
Tee	Normal	PVC	336	100	33600
Union	Normal	PVC	100	250	25000
Sockets	Normal	PVC	100	100	1000
Hose Bibbs	Normal	Stainless steel	5	500	2500
Adhesive	Normal bottle	Copper	480	200	96000
Adhesive	0.5liter	PVC	96	4,000	384,000

IV. DISCUSSION

The specification used came up with the consideration of pipe size of 11/2 inch for riser pipe and ¾ for the flat piping. In order to ensure that the materials stand the test of time, copper pipe was used for hot water and CPVC/PVC for cold water. Not with standing all these, the average daily water requirement per person which is about 35-50 gallons [per day] was consideredto calculate the total water capacity for the building, which came up to 17050 gallons/day [645413 litres/day].

The next step was to calculate the zones, which would break the building into 3 zones would be of 8 floors which contained 16 flats in each zone. This zone would help reduce the excessive pressure and maintain a constant flow rate at all draw off points.

The pumps at each zone were considered to be of the centrifugal and motor driven surface type. The head of the pumps was estimated to be 27m, the discharge was 0.00398 m3/s and the waterpower was calculated to be 1.05kw. The bill of material and bill of quantity was done with proper investigation and personal contact with those selling the products. On the hot water line, the type of heater used is the electric type, this was picked due to the fact that electricity is readily available and the type would be a 600 gallon storage type. This too would be at zoned mechanical stations to serve sixteen [16] flats and it would be connected to circulating pump to keep the hot water pressure constant at all draw off points.

V. CONCLUSION

This work is about the supply of hot and cold water to a high rise building. The building was made up of 24-storey,48 flats, each floor has two [2] flats of three [3] bedrooms.

Emphasis was also made on the type of design. Here, the series connected pumps with intermediate brake tanks were used. This was mainly used to reduce excessive pressure build ups and create more system resilience and pressure zones along the pipes. This would also reduce the grid and less sensitivity to electrical fall out.

The pumps were adequately calculated to the pump size needed for both basement and at each mechanical station. The materials used were of the best quality PVC and copper pipes.

From the result obtained, this work would help the building industry and the country at large in using electric water heaters. Although, heating with an electric system is overtly expensive than with gas, it is also a matter of concern when it comes to hazard with which gas facilities come with. One of the fundamental problems is the storage of the gas at the stations as it is highly inflammable and the fact that it is a residential building; all forms of accidents are reduced to the nearestminimum.

It is therefore recommended that gas heating systems, should be properly developed to reduce cost of bills paid to the electricity board.

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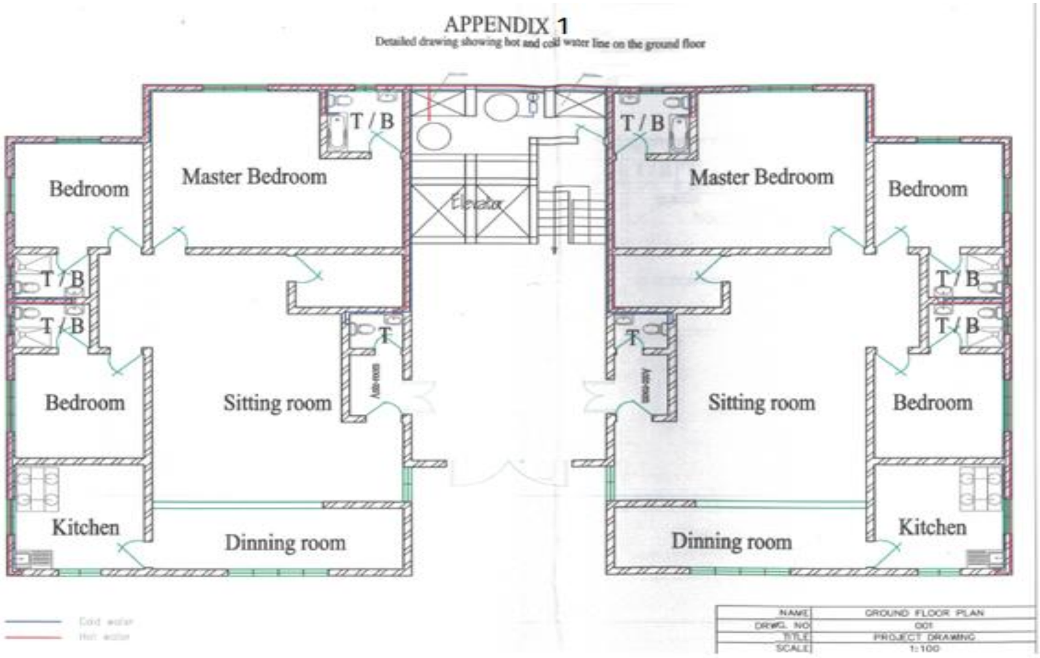
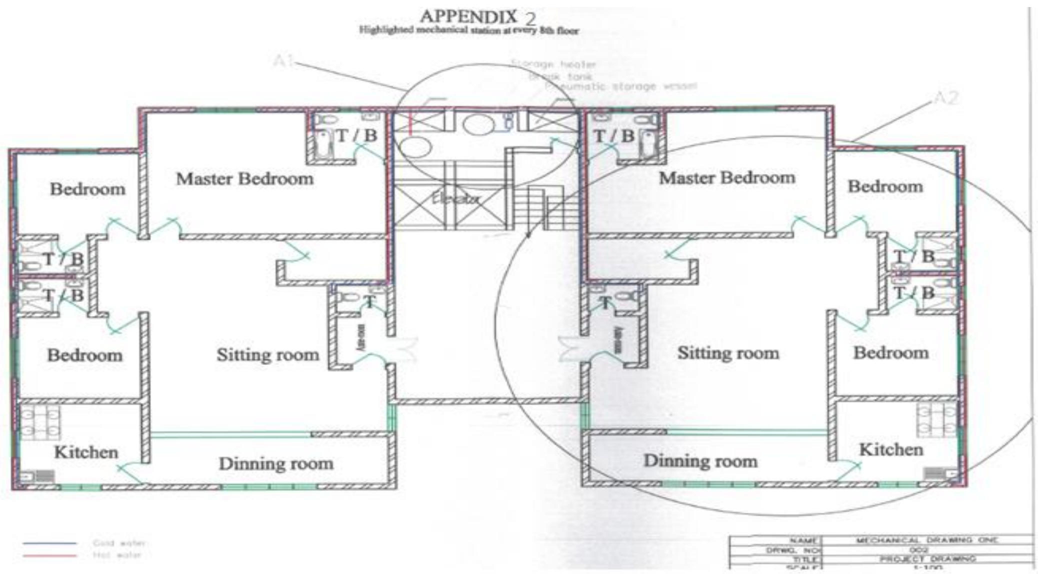
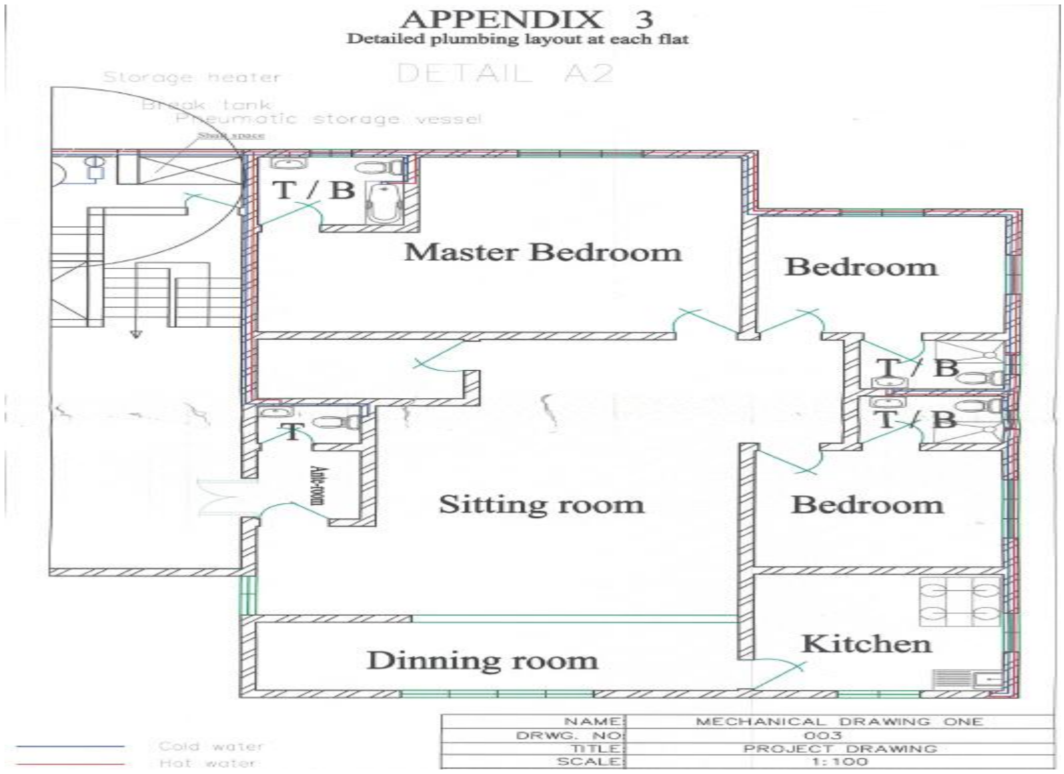
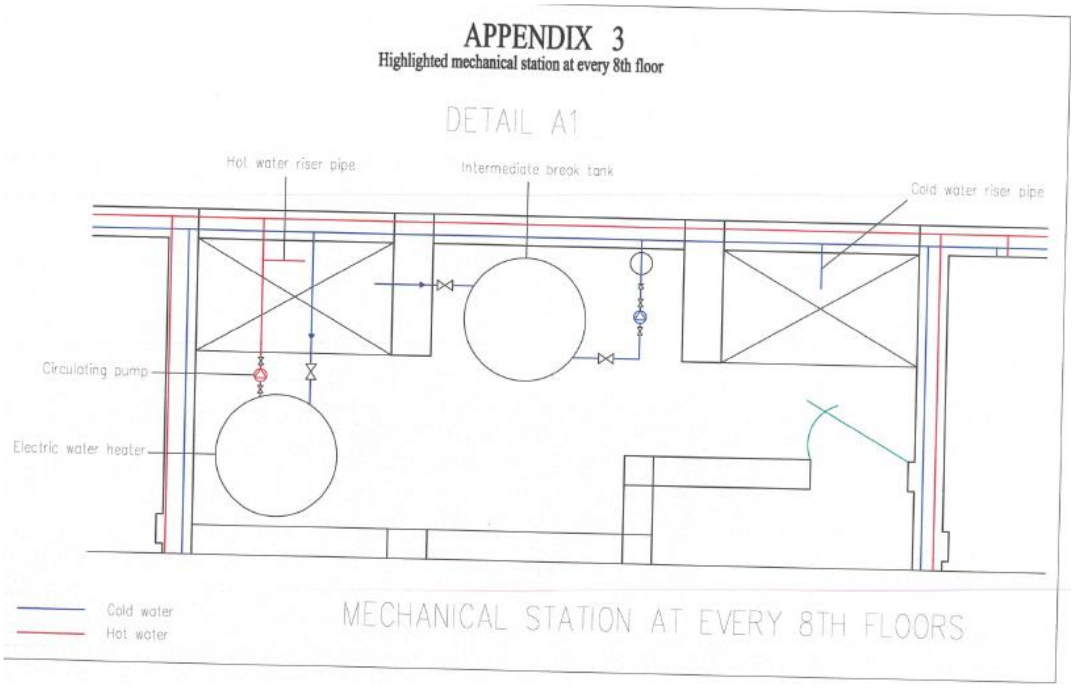
APPENDIX









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