# Narratives: 1- 3

**CE.1: Air-conditioning system by using steam.**

**CE.2: HVAC - Bone Marrow Transplant Unit**

**CE.3: Conventional Direct Pumping Systems Vs. Variable Flow Pumping Systems**

## Declaration

All the statements and facts mentioned in this report are true to the best of my knowledge and I have made claims of acquired competencies in good faith. This project report is written in my own words and is a true representation of my personal competence in the field of Mechanical Engineering and written English. I confirm that I understand that members of the engineering team in Australia are required to display a commitment to exercise professional and ethical responsibility in all aspects of their work.

Name: Peter Daniel Joseph

# Narratives: 1

## Airconditioning system by using steam.

**CE.1.1** Christian Medical College Hospital – Vellore is one of the reputed medical institutions in India. It caters to more than 5000 out patients and 2000 in patients per day. This 2000 bedded hospital has celebrated the centenary in 2000. It was a great privilege to work in this reputed institution as an Associate superintendent Engineer to Head HVAC department.

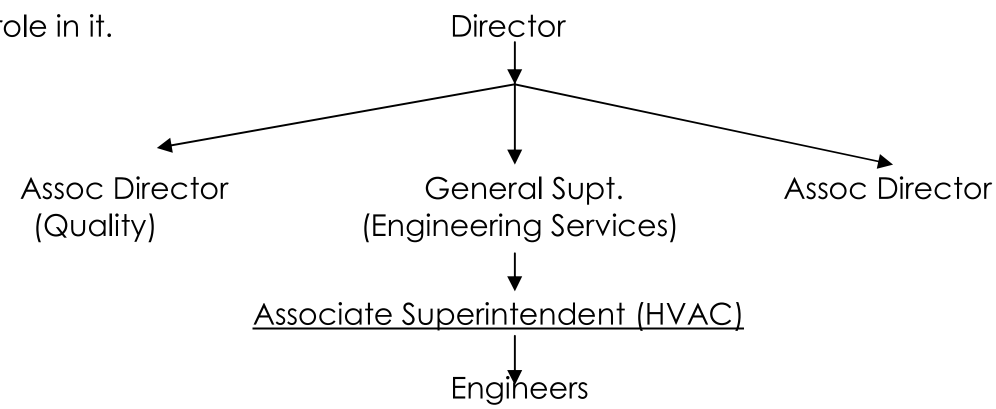
**CE.1.2** In 2006, CMC management has brought out the new thought of "Revamping the CMC hospitals". I was part of the team to give suggestion for improving the general services as well as HVAC systems.

**C.E. 1.3.** During the revamping meeting, Administration decided to shift the laundry outside so that more spaces can be created for Operation theatres and ICU'S. Due to this, the steam consumption will come down because laundry consumes more steam that the other services like Dietary, Auto clave, CSSD so the boiler will run in 50% of the load. It was not economical.

At this juncture, I intervened and proposed for steam produced airconditioning systems which will reduce the capital cost of purchasing additional transformer and generator. These suggestion appealed to everyone. Moreover CMC was not in a position to augment the electricity demand from 4MVA to 5MVA due to the conversion of incoming HT supply from 11kV to 33kV and also space constrain.

**C.E. 1.4**. Director appreciated me for giving suggestion at the critical situations. The management approved and requested me to present the paper regarding this.

**CE.1.5** The chart below represents the team structure for this project and my role in it.



**CE.1.6** My duties & responsibilities

- I designed the whole system with the help of boiler engineers.
- I prepared the drawings / coordination drawings for submitting to the General supt. for approval.
- I derived the Bill of quantities and calculate the CMC rate.
- I prepared the tender documents and circulated the same to selected contractors.
- I opened the tender and tabulated the technical specification and cost to analyses clearly.
- I called the lowest quotation contractor for negotiations.
- I finalized the order with help of Higher authorities and issue the order to the selected one.
- I checked the HVAC time schedule with other contractors work to avoid any overlapping.
- Reporting the developments of the project to the General Superintendent and Director.
- Execution of the work under direct supervision.

**C.E. 1.7** First, I studied the present central air conditioning unit and chilled water connection.

Secondly, I checked the space for installing the machine near to the boiler.

Thirdly, I inspected the place for installing cooling tower and pumps.

Fourthly, I studied the possibility of incorporating the unit to the present chilled water system so that it can be used as a standby for other reciprocating unit.

**C.E. 1.8.** Following are the observations in the old system.

1. I found that the chilled water pipeline needs to be modified to accommodate higher capacity.
2. I studied that the present chilled water pump is inadequate. So I have to go for one more pump with a standby dedicated to the VAM.
3. I studied to replace the existing natural draft cooling to induced draft cooling to safe some places for installing cooling tower for VAM.

**C.E. 1.9.** After above observation, I presented the salient points, drawbacks of using Vapour absorbtion Machine, working principles and capital cost.

## C.E. 1.10. *Salient Points:*

Lower Operating Cost: The VAM runs on heat energy. This results in tremendous savings in operating cost.
80% Depreciation : This enables to get the much needed tax cover in the first year of operation itself as compared to conventional machines which attract only 25% depreciation.

Non dependency on electric power. Vapor Absorption Machines operate on Kerosene or Diesel or Furnace oil or
Gas or Steam as the energy source and do not depend on the costly and unreliable electric power.
Hence,

(I) Not affected by power cuts.
(ii) *Minimal generator set backup is required resulting in tremendous savings*.
(iii) The capacity of the transformer required is reduced considerably.
(iv) Frequent hikes in power tariff would no longer affect you as much ever again.

The above results in savings in charges like EB deposit, Transformers etc.

Environmentally clean & safe :_Absorption machines use plain and simple water as refrigerant and hence environmental friendly. There are *no* punitive sanctions and drastic cuts in production of refrigerants as in the case of conventional machines.

NO CFC -- NO BAN !!!

Lower Noise Levels: Having no moving parts, the noise levels of the machine would be extremely low. As against this, the conventional chiller is noisy equipment.

Negligible Maintenance : Vapour Absorption machines is a set of simple heat exchangers with negligible moving parts, which results in the least wear & tear of the parts. By virtue of this VAM becomes the machine with the least maintenance.

Continous and stepless modulation: Capacity modulation from 10 to 100% stepless, continuous and automatic ensures that we pay only for what we need.

## C.E. 1.11. *Drawbacks:*

1. It consumes lot of furnace oil during the 20% load condition.
2. C.O.P is very less.
3. The double the capacity of VAM unit to let off the heat.
4. Consume lot of water – Cooling tower evaporation loss is high.
5. Large quantity of Soft water is needed for VAM.

**C.E. 1.12** At present, two chiller plants are catering to the peak load of Operation theatre and Intensive care unit. The third unit is used in night. The details of the three units are given below.

| TYPE OF UNIT | YEAR | RUNNING HOURS |
|---|---|---|
| 86 TR Voltas A.C. | 1980 | 15 hours |
| 90 TR Carrier A.C. | 2000 | 15 hours |
| 90 TR Bluestar A.C. | 1992 | 09 hours |

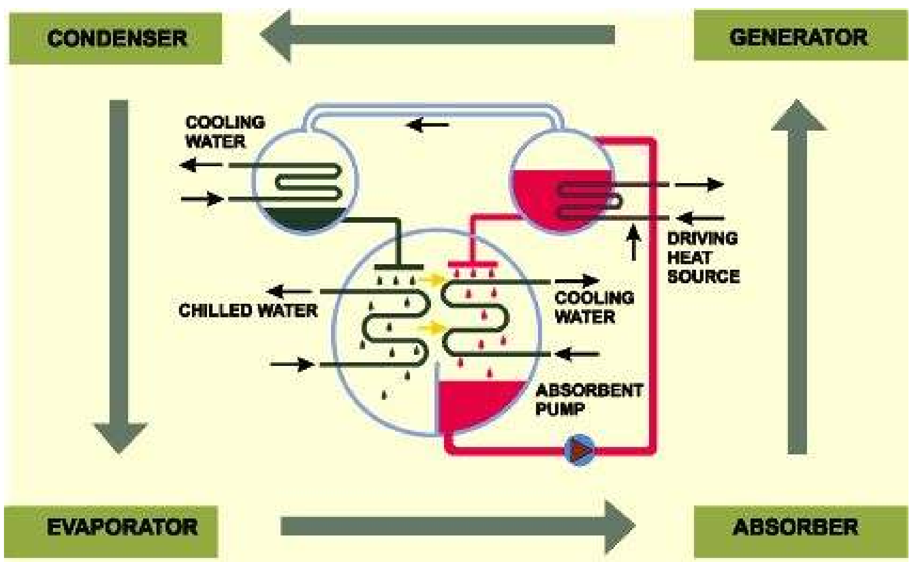
**C.E. 1.13 Basic Principles**

Absorption operates on a simple refrigeration principle using Lithium Bromide (LiBr.) – water cycle. The absorption Machine is static equipment consisting of simple shell and tube type heat exchangers and is powered by a convenient heat source.

The boiling point of water is a function of pressure. At atmosphere boils at 100 Deg. C. At lower pressure water boils at lower temperature. The boiling point of water at 6mm Hg is only 3.7 $^{o}$C.

Lithium Bromide (LiBr.) salt has the property to absorb water due to its chemical affinity. It is soluble in water. As the concentration of LiBr. increases its affinity towards water increases. Also as the temperature of LiBr. increases, its affinity decreases.

**C.E. 1.14** Water (the refrigerant) is made to flash cool at 3.9 $^{o}$C. under a vacuum of 6mm Hg. in the evaporator. This refrigerant produces the desired chilled water temperature and in turn becomes vapour.




LiBr. which is Hygroscopic in nature absorbs the refrigerant vapours and becomes dilute in the absorber.

Absorbent and refrigerant (the water) are once again separated in a generator with the help of a convenient heat source. The refrigerant vapour is condensed in the condenser. The cycle repeats itself.

**C.E. 1.15. Types of Vapour Absorption System:**

- Low pressure Steam fire absorption system – need boiler
- High pressure Steam fired absorption system – need boiler
- High temperature hot water absorption system – need waste heat
- Low temperature hot water absorption system – need waste heat
- Direct fired absorption system - Expensive
  - Diesel
  - LPG
  - High speed diesel

- Furnace oil
- Super kerosene oil

The steam fired absorption system is an ideal system because the existing boiler steam can be used for Vapour absorption system.

**C.E. 1.16** At present, one boiler is catering to the peak load of Laundry, CSSD, and Dietary. The other unit is used as a standby purpose. The details of the boilers are given below.

**A. Specification**

| Description | Old boiler | New boiler |
|---|---|---|
| **Type of Boiler** | Smoke tube package | Smoke tube package |
| **Model** | --- | Wee marshall IV |
| **Process** | Wet back | Wetback |
| **No. of passes** | 3 | 3 |
| **Steam generation** | 3000Kg/hr. | 2800kg/hr |
| **Design pressure** | 10.5kg/cm2 | 10.5kg/cm2 |
| **Operating pressure** | 10.5kg/cm2 | 10.5kg/cm2 |
| **Design code** | IBR | IBR |

**B. Steam Consumption:**

Total steam available ` 2800kg/hr.

- Laundry 1500
- CSSD & Dietary etc. 500

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2000 Kg/hr

- 1,400kg/hr. steam can be used for 320 TR vapour absorption system

- **1300kg/hr. steam can be used for 320TR Vapour Absorption System**
- **Vapour absorption system condensate water of 90 deg.C will be connected into boiler feed water**

**C.E. 1.17 Technical Specification:**

| DESCRIPTION | COOLING MODE |
|---|---|
| COMPANY | Thermax |
| CAPACITY +/- 3% | 320 TR |
| INLET TEMP. Deg. C. | 12 |
| OUTLET TEMP Deg C. | 7 |
| FLOW CUM/HR. | 524 |
| **COOLING WATER CIRCUIT** | |
| INLET TEMP. | 31 |
| OUTLET TEMP | 38.3 |
| *STEAM CIRCUIT* | |
| STEAM PRESSURE KG/Sq. cm. | 9 |

| | |
|---|---|
| STEAM CONSUMPTION KG/HR. | 1350 |
| **ELECTRICAL SPECIFICATIONS** | |
| ABSORBENT PUMP kW | 4 |
| REFRIGERANT PUMP kW | 3 |
| PURGE PUMP kW | 1.2 |
| SUPPLY | 3PH. 415V, 50HZ |

**C.E.1.18 Capital Cost:**

| | | |
|---|---|---|
| 320TR Steam driven VAHP with suitably inhibited | | **AUS $** |
| LiBr. Solution | | 1,28,571 |
| Erection and commission charges | | 5,000 |
| Ancillary work – chilled water connection Cooling tower connection, condensate water connection, steam pipe connection | | 1,50,000 |
| freight charge insurance And miscellaneous charges | | 17,142 |
| Total | AUS $ | 3,00,713 |

**CE.1.19** Above all mentioned processed the most challenging job was to convince the management about the implement of entirely different system and the involvement of cost. The accounts department has helped to find out the pay back period of purchasing VAM. It was amazing to see the benefits. Immediately, the director gave green signal for proceeding the project as well as appreciated my team work and data collected for taking prompt decisions.

**C.E. 1.20** I was responsible for coordinating and controlling the work operation. The coordination also included interaction with the supporting team and sharing the feedback from the field.

**CE.1.21** At problematic situations, I gave on the spot directions to my subordinates in consultation with my higher management and took corrective actions, depending on the nature and merit of problem.

**CE.1.22** I had to really put effort and time to complete the project on time. I organized my time very effectively and carried out my normal duties in parallel with the project. This demonstrated the best of my time management skills. I had to document all the proceedings, which I did using various MS Office programs.

**C.E. 1.23** I was able to satisfy the higher management with our work and the duration in which we completed the project.

**C.E. 1.24** Execution of work:

- Most challenging was to bring the whole unit without any damage to the valve or small components. The unit worked in the principle of vaccum. If moisture or air enters in to the system then it will take certain period to bring back to operational mode.
- Air was needed for operating steam valve. I coordinated with Medical gas engineer to provide sufficient air for operating the steam valve.
- The connection of the steam works were undertaken during the week ends. The works were completed with a short duration with cooperation with other departments and engineers.
- I had to do lot of mathematical calculation for installing the two cooling towers. The space was the constrain for keeping the units. As per the manufacturing requirements, I had to give space of 2 m. all around the cooling tower. I was not able to get it due to the compound wall. At last I installed in zigzag manner to get the clearance from the wall.
- Chilled water line and condenser water line were connected to made it ready for commissioning.
- Before commissioning, the unit needed to be approved by the Boiler authority. I had to do follow up work with the concern Government engineers to get the approval for the same.
- After getting approval, the unit was commissioned as per the procedure.

**CE.1.25 Testing and Commissioning work:**

- I tested the interlocking systems such as the condenser pump had to switch on first and followed by the chiller pump. Besides, steam valve had to be switched on according to the load. Finally the unit had to be switched on.
- The temperature and capacity of the unit was checked and found satisfactory.

**C.E. 1.26** Cost Benefit Analysis:

**A. Methodology of checking the fuel consumption:**

a. The fuel consumption with a running of VAM from
10:00 – 11:00. 260 liters per hour

b. The fuel consumption without running VAM from
11:00 – 12:00 200 liters per hour

The fuel consumption for VAM (a-b) 60 liters per hour.

**B. Saving in running cost (Energy Cost):**

*i) FCC vs VAM - TNEB supply:*

| Description | Freon (Recip) compressed compressor (FCC) | | Vapour absorption Machine (VAM) | |
|---|---|---|---|---|
| | **Description** | **Amount/day** | **Description** | **Amount/day** |
| Electrical energy | 320TR x 1.7 X 16hrs. X $AUS 0.17 | $US1480 | 30kW condener Pump +18kW cooling tower 4kW VAM = 52kW X 16hrs X AUS $ 0.17 | 141.44 |
| Fuel consumption | | | 60 X 16hrs. X AUS$ 0.8 | 768 |
| **Total** | | AUS $ **1480** | | AUS $ **909.44** |

Saving per day (16 hours) = AUS $ 571
Saving per year (571 X 300 days) = AUS $ 1,71,300

**C.E. 1.27** This project provided me with the opportunity to utilize my engineering skills and exposed me to learn the managerial skills. It thoroughly tested my technical skills and also enhanced my analytical skills. On the whole the project taught me to meet objectives in spite of many constraints. The project helped me gain the following competencies:

- Application of theoretical knowledge pertaining to engineering solutions.
- Efficient coordination, teamwork, and communication skills.
- Managing with limited data and resources.

# Narrative: 2

## HVAC for Bone Marrow Transplant Unit

**CE.2.1** Christian Medical College Hospital – Vellore is one of the reputed Medical Institutions in India. It caters to more than 5000 out patients and 2000 in patients per day. In the year of 2000, hospital has celebrated the centenary. It was a great privilege to work in this reputed Institution as an Associate superintendent Engineer and Head of HVAC Department.

**CE.2.2** Hematology department statistics reveal that the Leukemia patients were infected and the death rates have been increased. So the administration has requested me to study the present condition and report to Hospital infection control (HIC)

**C.E. 2.3.** In 1980, Christian Medical College has designed the first Bone marrow transplant unit in view of treating Leukemia patients whose have lost their immunity in their body. As per the patient's conditions they have to be treated in an isolated and clean environment room. The clean room was designed as per the parameters available on those days. Now there is lot of standards available which we have to adhere for getting accreditation. After the inspection, I found that the present rooms were lagged behind the present international standard.

**C.E. 2.4** First, I have studied the present bone marrow transplant units and noted down the pro's and con's of the design.

Secondly, I analyzed the design parameters in each and every room such as Positive pressure, Air changes per hour, Humidity and temperature.

Thirdly, I approached the concern doctor for getting first hand information about the present indoor air quality.

Fourthly, I contacted patient personally to know about their comfort level.

**C.E. 2.5.** Following are the observations in the old system.

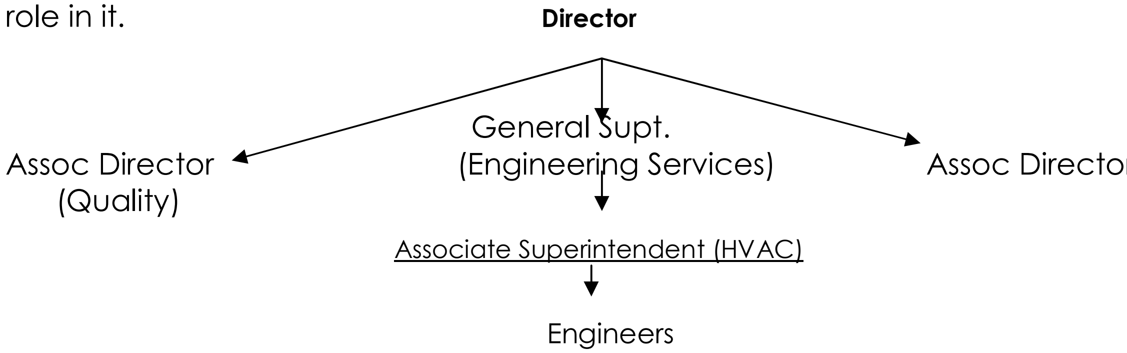
1. I observed that the supply air diffuser was mounted at 11' height on the corner of the wall so that there was no uniform air flow in the room.
2. The unit was tripped completely as soon as it reaches the temperature. So there was no airflow or no airchanges in the room which is needed for patient. I found that the control systems were faulty.
3. I measured the air flow and velocity of the air that was very low so that there was no positive pressure to egress the indoor air to corridor.

4. I analysis the system design due to the huge HVAC units for small room. I found out that fresh air intake was directly from the atmospheric air (43 deg. C). It increased the capacity of the unit. So the capital and running cost of the unit increased enormously.
5. I got the complaint often regarding smell inside the room. I went around the plant room and found that the incinerator was located nearby the BMTU plant room. Hence it sucks the contaminated air from the incinerators.
6. I inspected the cleanliness level of plant room. But it was not to the required parameters. There was a lot of gap in the ceiling due to metal sheet and improper thermal insulation. In addition, I found that the return air connected to the plant room not to the unit.
7. I checked the type of unit provided for the BMTU room. After checking, I found that the Ductable split unit installed with additional blower to create static pressure to push the supply air through HEPA filters. The arrangements made the indoor unit motor redundant. Moreover there was less heat transfer taking place across the indoor coil due to the fast movement of air through the evaporator coil.
8. I observed the filter section where the pre filter mounted on plenum box without any bolt connection which has developed air leak around the filter box. The air bye pass through the gap and choke the next level of 'HEPA' filter.

**C.E. 2.6.** I have presented the above studies to the HIC officers, group of Doctors, administrators and decision makers to know the present scenario of units and also to get their feedbacks for the improvements.

**C.E. 2.7** Our biggest challenges were to identify the basic problems of identifying the source of infection in the clean room area. Due to the non-availability of sufficient data, I collected from the field to support the documents.

**C.E. 2.8** The chart below represents the team structure for this project and my role in it.



**CE.2.9** My duties & responsibilities

- I designed the whole system with the help of available literature and standards.
- I prepared the drawings / coordination drawings for submitting to the General supt. for approval.
- I derived the Bill of quantities and calculate the CMC rate.
- I prepared the tender documents and circulated the same to selected contractors.
- I opened the tender and tabulated the technical specification and cost to analyses clearly.
- I called the lowest quotation contractor for negotiations.
- I finalized the order with help of Higher authorities and issue the order to the selected one.
- I checked the HVAC time schedule with other contractors work to avoid any overlapping.
- I convey the meetings Doctors, Other Engineering branch engineer to monitor the execution of work.
- Reporting the developments of the project to the General Superintendent and Director.
- Execution of the work under direct supervision.

**C.E. 2.10** I have done a lot of studies by referring ASHRAE journal, International code FED STD 209 and browse the website. After detailed mind boggling work, the design parameters have been derived according to the need of patients. I called the meeting once again with the same group to discuss about the following points.

- I proposed that the fresh air should be taken with the provision of heat recovery wheel (desiccant wheel) as it will give adequate fresh air as well as reduce the electricity consumption and the size of the units.
- I intended to provide HEPA filter at the terminals to filter any particles that carried by the air.
- I proposed two types of supply air with terminal HEPA filter. One was through Variable air volume (VAV) to control the air flow by adjusting thermostat and the other one was for fresh air without any control so that the room will be in pressure even though the VAV was partially closed or the room is empty.
- Each room has toilet facilities. The smell of the toilet should not come inside the room. I included to extract the air through exhaust fan.
- I designed the mixing box that has to be fixed in the airhandling unit with double skin insulation so that the removing of fiter will be easier as well restrict the leakages.

- Doctors gave suggestion of moving the return air and supply air location so that they can position the patient's bed properly. I incorporated their suggestion.

**C.E. 2.11** As per the design conditions, the air movement has to be in laminar flow from top to bottom. But these arrangements affect the patients due to direct flow of cold air. After the time of deliberation, I have agreed to keep it on the side wall.

**C.E. 2:12** Administration like to have one mock up before investing further. I modified two rooms to test the air movement from side throw as well as from the top. The end result was same for both of the room. But the patient complainted about more cooling in the top throw model. Doctors approved the side throw model room to keep in the mind of patient's comfort.

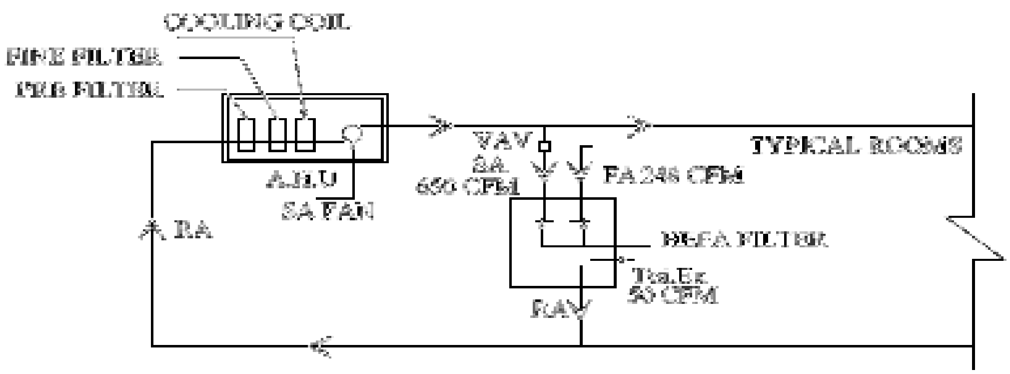
**CE.2.13** ROOM DESIGN PARAMETER – BMTU WARD

| | | |
|---|---|---|
| Indoor Temperature | : | 24 Deg C ± 1 Deg C |
| Relative Humidity | : | 55% ± 5% |
| Fresh Air Quantity | : | 248 CFM |
| Supply Air Quantity | : | 650 CFM |
| Total Air Quantity | : | 898 CFM |
| Toilet Exhaust | : | 50 CFM (Toilet room Maintained at negative Pressure) |
| Room Pressure | : | 10 TO 30 Pascals |

**CE.2.14** THE BMTU AND DESIGN CONSISTS OF THE FOLLOWING

- Terminal filtration using HEPA filters of 99.997% efficiency down to 0.3 micron.
- The room temperature is maintained based on the room load by varying air quantity by means of variable air volume boxes in the supply air ducts.
- The VAVs are controlled by the room thermostat.
- The VAVs modulate varying the supply air quantity based on the thermostat setting
- The fresh air is provided directly to the room without any controls. So the air will be circulated inside the room
- Positive pressure is maintained in the rooms by means of the return damper actuator with differential pressure sensor.
- The actuator senses the pressure between the corridor and the room and maintains the room pressure positive relative to the corridor.

**CE.2.15** BMTU – Air Distribution.

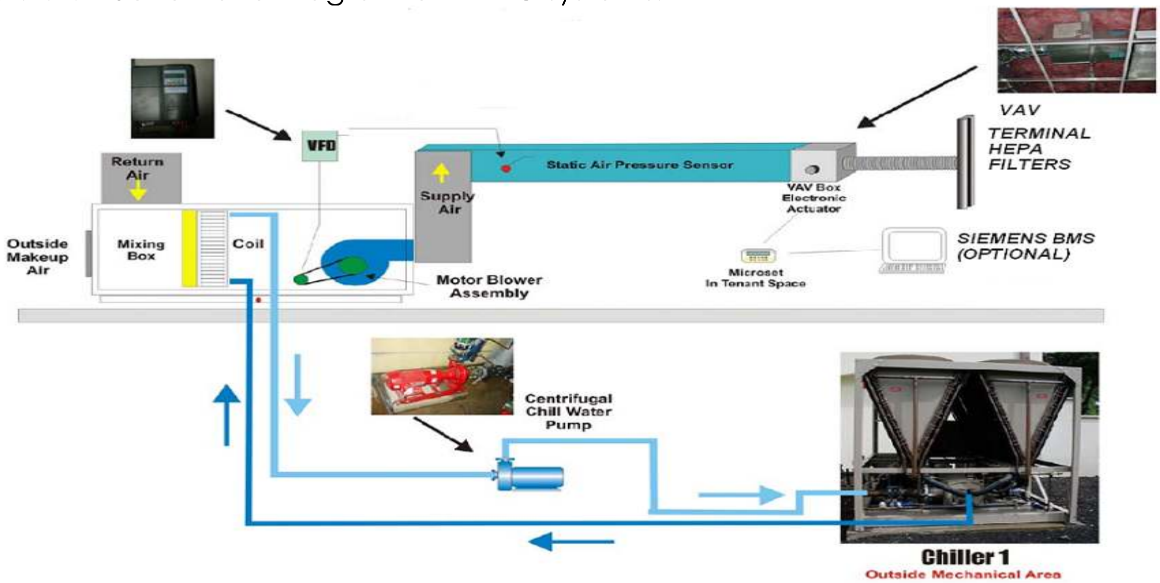



- VAV controls the temperature in a space by varying the quantity of air .
- Room positive pressure with respect to corridor is maintained by controlling damper.
- Toilet room negative pressure is maintained by exhaust 50CFM continuously.

**CE.2.16** FED STD 209:

| ISO | FED STD 209 | 0.1 µm | 0.2 µm | 0.3 µm | 0.5 µm | 5.0 µm |
|---|---|---|---|---|---|---|
| CLASS 3 | Class 1 | 1000 / 35 | | | 35 / 1 | |
| CLASS 4 | Class 10 | 10,000 / 345 | 75 | 30 | 352 / 10 | 0 |
| CLASS 5 | Class 100 | 100,000 / 3,450 | 750 | 300 | 3520 / 100 | 0 |
| CLASS 6 | Class 1,000 | 1,000,000 / 34,500 | N/A | N/A | 35,200 / 1,000 | 7 |
| CLASS 7 | Class 10,000 | 345,000 | N/A | N/A | 352,000 / 10,000 | 70 |
| CLASS 8 | Class 100,000 | 3,450,00 | N/A | N/A | 3,520,000 / 100,000 | 700 |

**C.E.2.17** Schematic Diagram of HVAC systems:

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**C.E. 2.22** I was able to satisfy the higher management with our work and the duration in which we completed the project.

**C.E. 2.23** Execution of work:

The execution was the main part in creating a proper clean room. It had to be coordinated with civil, electrical, plumbing and other small works. The construction work produces a lot of dust. I had to be in the site to monitor each and every parts to be dust free.

- I had to keep in mind that the dust is bad for the patients. So most of the time had gone for cleaning the HVAC units ducts and other spare parts.
- I made a duct and closed both the ends with plastic papers to avoid dust entering inside the duct.
- I made a mock up room to get the approval from the concern Doctors and Engineers who had contributed with me for designing the whole projects.
- I carried out the supply air duct, fresh air duct and return air duct work.
- I installed the VAV system and return air actuator.
- After HVAC works, false ceiling has been installed to cover the duct. Meanwhile, I completed the terrace Air Handling, TFA installion, pipeline and duct work.

**CE.2.24 Testing and Commissioning work:**

- For attaining FED STD 209, I had to do lot of minute work carefully. I installed a dummy filter in the supply air terminals.
- I switched on the HVAC systems for 48 hours to remove the dust inside the units, ducts and other places.
- I repeated the same procedure for three times to make sure all the dirt had removed from the systems.
- I arranged for cleaning the floor, walls and all items inside the room with prescribed chemicals.
- I checked two times to make sure that the room is clean.
- I inspected for any air leakages in different location. In some locations, I arranged for applying silicon sealant to arrest the leak.
- I called a meeting with Engineers, Doctors and Nurses to instruct about the next developments.
- I closed all the windows and doors and posted one security for restricting the entry to the BMTU room.
- I installed the HEPA filter and switched on the HVAC units.
- I adjusted the thermostat settings of VAV to provide adequate cooling inside the room. I partially closed the fresh air damper to reduce the air flow.
- I started to balance the air with the help of return air actuator, Pressure gauge provided in each room.
- I monitored the pressure gauge and set the positive pressure suited to the location of room.
- I found that the initial stage there was free flow of air without much restriction in the HEPA filter. So I checked the function of Variable frequency drive of each airhandling unit motor. It was running at 25% of the rated speed.

- I checked all parameters related to HVAC units expect LP test.
    - Laser particle count test to check whether the room abides by the FED 209 class 100,000 standard.

**CE.2.25** Result

- I proposed to the management for purchasing Laser particle count test machine so that the test can be carried out whenever the positive pressure reduced from the required parameters.
- The management agreed for buying one.
- I used the instrument to measure the particle count in three location.
    - Near filter
    - Near filter
    - Room count.
- After completing the checking, I got the result as follows

| FED STD 209 | 0.3 MICRON | 0.5 MICRON | 5.0 MICRON |
|---|---|---|---|
| Class 100000 | NA | 100000 | 700 |
| | | | |
| BMTU 1 to 10 | 0.3 MICRON | 0.5 MICRON | 5 MICRON |
| NEAR FILTER | 0 to 20 | 0 to 817 | 0 |
| NEAR FILTER | 3 to 66 | 0 to 9 | 0 |
| ROOM COUNT | 477 to 4666 | 182 to 817 | 3 to 18 |

**CE.2.26** The project had come out with fullest satisfaction of my management. Due to evaluate the systems completely, I monitored the room for seven months. Microbiology Doctors reported that the BMTU room has no (zero) fungus or bacteria. The report of infections has come down drastically.

**C.E. 2.27** This project was the first of its kind that was executed by our hospitals. Due to the success of this project, I got a lot of appreciation from the higher authorities. During the project also, I was recognized by the management and got good increments in the form of short-term bonuses. This was a good learning experience for me and helped me enhance my technical, management, and interpersonal skills

# Narrative: 3

## Conventional direct pumping Vs. Variable flow pumping system

**CE.3.1** Christian Medical College Hospital – Vellore is one of the reputed medical institutions in India. It caters to more than 5000 out patients and 2000 in patients per day. In the year of 2000, hospital has celebrated the centenary. It was a great privilege to work in this reputed institution as an Associate superintendent Engineer and Head of HVAC department.

"Eco Friendly", "Save Electricity", "Cogeneration". These are the catchy slogans of Government and other organizations. These statements have made me to think about conserving energy for Air-conditioning which accounts for nearly 70% of the total electricity consumption! In this line, I have taken an initiative to find out potentials for conserving energy especially in Central air-conditioning units.

**C.E. 3.2** First, I have studied the flow of chilled water system to find out how to optimize the flow of water into chiller and Air handling unit

Secondly, I have studied the possibilities of adding the additional capacities of 400 TR to the existing load of 180TR. During this study, I have been able to come out with a proposal of modifying the existing conventional type of water flow systems into variable water flow systems.

Thirdly, I have approached the management for the permission to implement the project. I am thankful to my superior who gave me approval for doing the same.

**CE.3.3** There are different methods to consume the energy in HVAC systems. I studied all the methodology and at last I found that the modification of pipeline from conventional direct piping to variable flow pumping system which has significant saving in HVAC systems.

**CE.3.4** The chart below represents the team structure for this project and my role in it.

Director

Assoc Director (Quality)

General Suptd (Engineering Services)

Assoc Director

Associate Superintendent (HVAC)

Engineers

**CE.3.5** My duties & responsibilities

- Designing the whole system
- Reporting the developments of the project to the General Superintendent.
- Calculating the pump capacity.
- Envisage future load and design the whole system.
- Prepare drawings with the help of Draughtsman
- Prepare tender documents for collecting the quotation from three MEP Contractors.
- Comparing the price and negotiating with the contractors.
- Finalising the price and placing the order.
- Preparation of the agreement and formalizing the same with the supplier and immediate superior.
- Execution of the work under direct supervision.
- Laying the new pipeline without disturbing the normal functioning of Operation theatres, ICU and Labs
- Commissioning of the Chiller units (90TR 3nos. Existing unit and 320TR 1no. New)


**C.E. 3.6** It was observed that the chilled water circulation is more than the design parameters so that the temperature differences between the chiller inlet and outlet is very less. Thus the chilled water pumps were pumping the water rapidly that caused the reduction of heat transfer in Chiller Air Handling Units and Fan Coil Units. The temperature differences were not maintained properly. It affected the cooling in operation theatres, ICU and other places.
The objective of the project were

- To optimize the water flow in chiller and air handling units
- To change the chilled water system from conventional type to variable water flow systems.
- Check the parameters and match with design parameters.
- To connect the additional load in the existing pipelines by installing new headers without disturbing the functions of operation theatres.

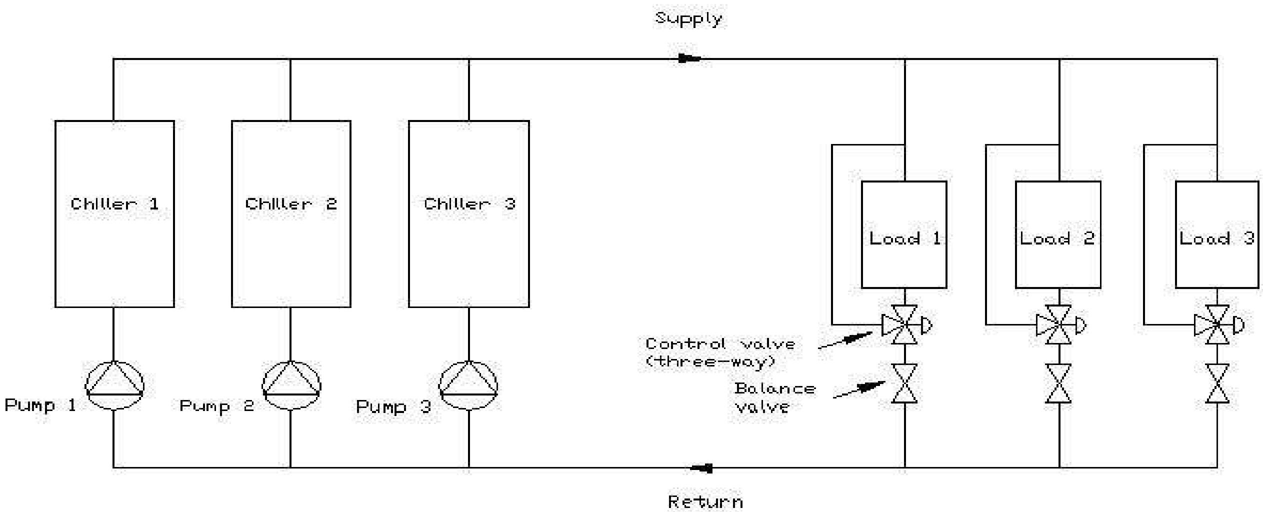
**CE.3.7** Following are the observations in the old conventional system.

Observation:

- Measuring the water flow in each individual Air handling unit and chiller.
- Observing pressure differences between the chiller units and Air handling units.

- Recording the water temperature differences between the chiller and Air handling units.
- Recording the temperature and Pressure
- Adjusting the water flow to maintain the temperature differences.

**CE.3.8** In the Conventional system, a single stage chilled water pump system has been used for circulating the water through the Chiller and then to Air Handling Units and Fan Coil Units in various buildings (Load).




The above circuit has been used since 1975. At that time, CMC introduced first chilled water systems for Operation theatres in India.

The chilled water pump 1,2&3 circulates the water through the chiller 1,2 &3. From the outlet of chiller it flows to the air handling unit through the M.S. Pipeline that has been insulated as per the ASHRAE standard. The water circulates through the Air Handling Unit coils and return back to the inlet of chiller pump.

The chilled water pump has been designed for one to one basis. It means that the chilled water pump 1 has to be switched on if the chiller one is in operation. The chiller pump has to run continuously irrespective of variation in the loads. There is no option for modulating the speed of the pump according to the load to ensure consumption of less energy. So, it maintains the same pressure and flows in the pipeline which reduces the life of the pipeline.

**CE.3.9** The proposed system is named as a variable water flow system. It has a two stage chilled water pump system.

1. Primary water flow, (constant flow rate)
2. Secondary water flow, (variable flow rate).

*Primary Water flow*:

Constant water flow through the chiller is required so that all liquid refrigerants are evaporated under any working conditions. The duty of the pump is determined only by this local circulation requirement, and the pump size is kept to a minimum.

*Secondary Pump Flow*:


The secondary water pumps circulate the water through each Air Handling Units (AHU) and each Fan Coil Units (FCU) in the various buildings served by the chilled water system.

AHU and FCU has a two way valve which is connected to its local thermostat. The thermostat senses the temperature inside the concerned room and opens or closes the water supply to the AHU or FCU coil. As the flow through the loads therefore varies, a varying pressure develops in the secondary loop. The variable frequency drives sense the pressure difference and varies the supply frequency to the motor which reduces the speed, thus reducing the pressure and flow rate. The electricity consumption has come down due to the minimum usage of power.

**C.E. 3.10** The crucial factors were execution of the work. The present pump was suppling to operation theatres and Intensive Care unit. It was not possible for me to stop the chilled water supply and execute the work. I had to do very cautiously without affecting the day to day activities. In such cases, I had done the work in the following sequences.

- I installed the first two headers parallel to the existing one.
- I took all the branches from the new header to the existing connections.
- I connected the pipeline with header during the government holidays.
- I replaced the old pumps with two stage chilled water pump.
- I replaced the three way valves with two way valve.
- I found the location for taking signal from last AHU to Variable frequency drive.

**C.E. 3.11** I was responsible for coordinating and controlling the work operation. The coordination also included interaction with my team members.

**C.E.3.12** At problematic situations, I gave on the spot directions to my subordinates in consultation with my higher management and took corrective actions, depending on the nature and merit of problem.

**CE.3.13** I had to really put effort and time to complete the project on time. I organized my time very effectively and carried out my normal duties in parallel with the project. This demonstrated the best of my time management skills. I had to document all the proceedings, which I did using various MS Office programs.

**CE.3.14** With proper coordination and control, the project of providing chilled water was completed in a short span of time.

We were able to satisfy the higher management with our work and the duration in which we completed the project.

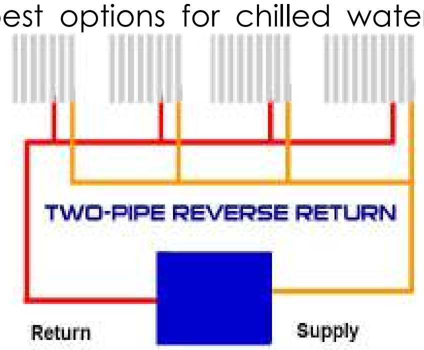
**C.E. 3.15** The chilled water line has been connected to Air Handling Units and Fan Coil units that have been located in various places. Each unit is connected through two way valve that shuts the water flow as soon as room attains the desired temperature. The pressure builds up due to closure of the valve. To maintain the pressure, the pressure sensor in the last Air handling unit senses the pressure and passes on the signal to Variable Frequency Drive. In turn the variable frequency drive modulates the secondary chilled water pump according to the load.

**CE.3.16** I monitored the system for five months. I got the enough savings of 4,82,000 by modifying the existing pipeline to be suitable for the present day load.

| **Conventional direct pumping** | | **Variable water flow system** | | | |
|---|---|---|---|---|---|
| **Old system only for theatres** | | **New system Primary side** | | **Secondary side Inclusive of Private ward** | |
| Conventional direct pumping | AUS $ 37,542 | Primary pump | AUS$ 13,765 | Secondary | AUS$ 10,011 |
| Total | AUS $ 37,542 | Total | AUS$ 13,765 + AUS$ 10,011 | | AUS$ 23,754 |
| **Savings** | AUS $ 37,542**–** AUS$ 23,754 **=** AUS$ **13,788 per annum.** | | | | |

**C.E. 3.17.** In continuation of the above project, I proposed the system of two pipe reverse return for the private ward block modification.

**C.E. 3.18** The reverse return is one of the best options for chilled water pipeline. This can be achieved by laying one more pipeline in addition two pipes namely supply and return.




In this project, the chilled water supply pipeline has been routed on the terrace at 9th floor. The return has been taken from basement. The supply line is connected to each FCU and the output of FCU has been connected to return pipeline. The diameter of the return pipeline is small in the ninth floor and it has been gradually increased to larger diameter in the basement. By using this method, the extra cost for the pipeline and balancing valve for each FCUs and AHUs have been saved. Moreover, the space has been freed by taking two pipelines instead of three.

## 1. SUMMARY STATEMENT OF COMPETENCIES DEMONSTRATED

### KNOWLEDGE BASE

| Competency element | | How & where demonstrated | Achieved | Paragraph reference in carrier episode |
|---|---|---|---|---|
| PE1.1 | **Knowledge of science and engineering fundamentals** | a. Sound knowledge about engineering field and relating the same with other field to fulfill the need of the society.<br>b. Strong grasping power to find out the faulty in the systems as well as environment by visualizing the Situations and surroundings.<br>c. Understanding the problems and tackling the problems with the help of engineering ideas and standards.<br>d. Ability to work from first principles in tackling technically challenging problems | Yes | C.E. 1.3,C.E. 1.4, C.E., 1.7, C.E. 1.9, C.E. 1.10, C.E. 2.5, C.E. 2.11, C.E. 3.6, C.E. 3.7 |
| PE1.2 | **In-depth technical competence in at least one engineering discipline** | a. Knowledge of understanding present situation and relating to the contemporary technologies and implementing the same with conviction.<br>b. Knowledge of current international standards and relate with the basics of engineering discipline and apply the same for present day issues.<br>c. Advanced knowledge in grasping potential skills and new developments from the different resources.<br>d. Knowledge of finding the problems and providing Appropriate solutions.<br>e. Ability to finding out the solution and evaluating the same with the help of test procedures. | Yes | C.E. 1.9,C.E. 1.10, C.E., 1.11, C.E. 1.15, C.E. 1.20, C.E. 1.21, C.E. 2.6, C.E. 2.11,C.E. 2.5, C.E. 3.6, C.E. 3.7, C.E. 3.8 |
| PE1.3 | **Techniques and resources** | a. Ability to implement the current technical skills and resources.<br>b. Proficiency in grasping the knowledge of designing the airconditioning unit according to the given situation.<br>c. Ability to provide 'Indoor Air Quality" with a available techniques and resources to meet the basic Requirements of users.<br>d. Ability to develop the model and template to the given solution and utilize such models for purpose of providing adequate comfort to the end users. | Yes | C.E. 1.10,C.E. 1.15, C.E., 1.22, C.E. 1.16, C.E. 1.17, C.E. 2.10, C.E. 2.11, C.E. 3.8, C.E. 3.9 |
| PE1.4 | **General Knowledge** | a. Broad educational background and/or general knowledge about the engineering filed and using the same for the purpose of sick people. | Yes | C.E. 1.3,C.E. 1.16, C.E., 1.17, C.E. 1.18, C.E. 1.19, C.E. 2.13, C.E. 2.14, C.E. 2.15, C.E. 2.16, C.E. 2.17, C.E. 3.8, C.E. 3.9, C.E. 3.18 |

## Engineering Ability

| Competency element | | How & where demonstrated | Achieved | Paragraph reference in carrier episode |
|---|---|---|---|---|
| PE2.1 | **Ability to undertake problem identification, formulation, and solution** | a. Ability to identify the nature of a technical problem, achieve a solution, and verify the solution with various stages by checking.<br>b. Ability to grasp a situation and ascertain relevant causes and effects<br>c. Ability to address issues and problems that have no obvious solution. | Yes | C.E. 1.3,C.E. 1.4, C.E. 1.19, C.e. 2.3, C.E. 2.4, C.E. 2.5, C.E. 3.2, C.E. 3.3, C.E. 3.6, C.E. 3.7, C.E. 3.9 |
| PE2.2 | **Understanding of social, cultural, global, and environmental responsibilities and the need to employ principles of sustainable development** | a. Relationship with the other engineers, Doctors, Patients and paramedical staff to find out the problems and their input for solutions.<br>b. Find out various approaches to developing and maintaining safe and sustainable systems<br>c. Ability to interact with people in other disciplines and professions to broaden knowledge, achieve multidisciplinary outcomes, and ensure that the engineering contribution is properly integrated into the total project<br>d. Appreciation of the nature of risk, both of a technical kind and in relation to clients, users, the community and the environment | Yes | C.E. 1.6,C.E. 1.10, C.E. 1.19, C.E.1.21, C.E. 1.22, C.E. 1.26, C.E. 1.22, C.E. 2.6, C.E. 2.7, C.E. 3.9, C.E. 3.10 |
| PE2.3 | **Ability to utilize a systems approach to complex problems and to design and operational performance** | a. Ability to define the problems in the systems and providing the reasons for the problem, Taking initiative to Implement the solutions.<br>b. Understanding the need of the society and integrating technical performance with the social environment and economical solutions.<br>c. Ability to utilize a systems-engineering or equivalent disciplined, holistic approach to incorporate all considerations<br>d. Understanding of the process of partitioning a problem, or system into manageable elements, for purposes of analysis or design; and of re-combining these to form the whole, with the integrity and performance of the overall system as the paramount consideration<br>e. Improve the performance of the systems by getting the feedback from the end users. | Yes | C.E. 1.3,C.E. 1.4, C.E. 1.7, C.E.1.8, C.E. 1.26, C.E. 2.10, C.E. 2.11, C.E. 2.12, C.E. 2.13, C.E. 2.14, C.E. 2.15, C.E. 2.15, C.E.2.16, C.E.2.17,C.E. 2.26,C.E. 3.9, C.E. 3.10, C.E. 3.11, C.E. 3.12, |
| PE2.4 | **Proficiency in engineering design** | a. Proficiency in employing technical knowledge, design the systems to meet specified performance criteria<br>b. Experience in personally conducting a major design exercise to achieve a substantial engineering outcome to professional standards, demonstrating capacity to: | Yes | C.E. 1.10,C.E. 1.11, C.E. 1.12, C.E.1.13, C.E. 1.14, C.E. 1.15, C.E. 1.16, C.E1:17 C.E. 2.13, C.E. 2.14, C.E. 2.15, C.E. 2.16, C.E. 2.17, C.E. 2.18, C.E. 3.9, C.E. 3.10, C.E. 3.11, C.E. 3.12, |
| PE2.5 | **Ability to conduct an engineering project** | a. Experience in personally conducting and managing an engineering project to achieve a substantial outcome to professional standards, and ability to demonstrate a key contribution to the team effort and the success of the outcome<br>b. Understanding of project management techniques and ability to apply them effectively in practice | Yes | C.E. 1.24, C.E.1.25, C.E. 1.26, C.E. 2.4, C.E. 3.3,C.E. C.E.3.9 |

| | | | | |
|---|---|---|---|---|
| PE2.6 | **Understanding of the business environment** | a. Appreciation of the commercial, financial, and marketing aspects of engineering projects and programs and the requirements for successful innovation<br>c. Ability to assess realistically the scope and dimensions of a project or task, as a starting point for estimating costs and scale of effort required<br>d. Understanding of the need to incorporate cost considerations throughout the design and execution of a project and to manage within realistic constraints of time and budget<br>d. Study cost analysis to implement this. Project. | Yes | C.E.1.18, C.E. 1.18, C.E.2.12, C.E. 2.18, C.E. 3.5, C.E. 3.16 |

| PROFESSIONAL ATTRIBUTES | | | | |
|---|---|---|---|---|
| **Competency element** | | **How & where demonstrated** | **Achieved** | **Paragraph reference in carrier episode** |
| PE3.1 | **Ability to communicate effectively, with the engineering team and with the community at large** | a. High level of competence in written and spoken English<br>b. Ability to make effective oral and written presentations to technical and non-technical audiences<br>c. Capacity to hear and comprehend others' viewpoints as well as convey information<br>d. Effectiveness in discussion and negotiation and in presenting arguments clearly and concisely<br>e. Ability to represent engineering issues and the engineering profession to the broader community | Yes | C.E. 1.2, C.E. 1.3, C.E. 1.6 C.E.1.9, C.E. 2.2, C.E.2.3, C.E. 2.10, C.E. 2.11, C.E. 2.12, C.E. 3.2, C.E. 3.3 C.E. 3.6, |
| PE3.2 | **Ability to manage information and documentation** | a. Ability to locate, catalogue and utilize relevant information, including proficiency in accessing, systematically searching, analyzing and evaluating relevant publications<br>b. Ability to assess the accuracy, reliability and authenticity of information<br>c. Ability to produce clear diagrams and engineering sketches | Yes | C.E. 1.10, C.E. 1.11, C.E. 1.12 C.E.1.13, C.E. 2.11, C.E.2.12, C.E.3.6, C.E. 3.8, C.E. 3.9 |
| PE3.3 | **Capacity for creativity and innovation** | a. Readiness to challenge engineering practices from technical and non-technical viewpoints, to identify opportunities for improvement<br>b. Ability to apply creative approaches to identify and develop alternative concepts and procedures<br>c. Awareness of other fields of engineering and technology with which interfaces may develop, and openness to such interactions | Yes | C.E. 1.10, C.E. 1.11, C.E. 1.16 C.E.1.13, C.E. 2.15, C.E.2.16, C.E.2.17 C.E.3.9, C.E. 3.10, C.E. 3.18 |
| PE3.4 | **Understanding of professional and ethical responsibilities, and commitment to them** | a. Familiarity with codes of ethics relevant to the engineering discipline and field of practice, and commitment to their tenets<br>b. Awareness of standards and codes of practice relevant to the discipline and field of practice | Yes | C.E. 1.24, C.E. 1.19, C.E. 2.25 C.E.3.11, C.E. 3.12, |
| PE3.5 | **Ability to function effectively as an individual and in multidisciplinary and multicultural teams, as a team leader or manager as well as an effective team member** | a. Manage the time and processes effectively, prioritizing competing demands to achieve personal and team goals and objectives<br>b. Earn trust and confidence of colleagues through competent and timely completion of tasks<br>c. Communicate frequently and effectively with other team members<br>d. Recognize the value of diversity, develop effective interpersonal and intercultural skills, and build network relationships that value and sustain a team ethic<br>e. Mentor others, and accept mentoring from others, in technical and team issues<br>f. Demonstrate capacity for initiative and leadership while respecting others' agreed roles | Yes | C.E. 1.24, C.E. 1.25, C.E. 1.3 C.E.1.4, C.E. 2.4, C.E.2.3, C.E.2.20, C.E. 2.22 C.E.3.11, C.E. 3.14, C.E. 3.12 |
| PE3.6 | **Capacity for lifelong learning and professional development** | a. Take charge of learning and development; understand the need to critically review and reflect on capability, invite peer review, benchmark against appropriate standards, determine areas for development and undertake appropriate learning programs | Yes | C.E. 1.16, C.E. 1.17, C.E. 2.16, C.E. 2.17 C.E.3.16, C.E. 3.17, |
| PE3.7 | **Professional Attitudes** | a. Present a professional image in all circumstances, including relations with clients, suppliers as well as professional and technical colleagues<br>b. Demonstrate intellectual rigor and readiness to tackle new issues in a responsible way | Yes | C.E. 1.3, C.E. 1.4,C.E. 1.17, C.E. 2.6, C.E. 2.7 C.E.3.3, C.E. 3.4 |