Manipal Education & Medical Group

Fulbari-11, Pokhara

Internship Report

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ABSTRACT

This report presents the first phase of our internship at Manipal Teaching Hospital, starting from April 22. It focuses on the detailed study of the hospital's backup generation and distribution systems. Key areas covered include generation mechanisms, load categorization, busbar coupling, circuit breaking systems, and cable sizing with their respective insulation types and ampere ratings. The report also examines the layout and components of the HT, MV, and generator panel rooms, along with the individual control mechanisms of the pump room and incinerator.

Furthermore, the use of star-delta motor starting techniques, power supply systems, and the configuration of lighting and power sub-circuits in various panels are analyzed. Finally, the detailed study of ETP plant was done, analysis of working mechanism of pumps, their starters and specifications of pumps are provided in the report. Site visits, technical reviews, and interactions with onsite electricians formed the basis of this study. This phase ensures a strong foundational understanding of the hospital's power infrastructure. The insights gained will guide the upcoming phases of our internship and reporting.

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1. Introduction

The purpose of this internship report is to present a comprehensive analysis of the electrical power generation and distribution system at Manipal Teaching Hospital, Pokhara.our team was tasked with documenting how electrical energy is produced, transferred, and delivered to various hospital segments while ensuring system reliability and safety. This Phase 1 report covers the primary generation units, grid interconnection, bus coupling strategy, load categorization, and initial protection schemes. Phase 2 will extend into floor- level sub- distribution board (SDB) assessments, detailed load audits, and switchgear requirements.

Objectives:

1. Describe the configuration and capacity of generation units (Diesel Generators).
2. Detail grid connection and transformer specifications.
3. Explain the bus coupling mechanism and operational logic.
4. Outline circuit breaking principles and protective device coordination.
5. Summarize voltage regulation strategies.
6. Evaluate SCADA integration and automation capabilities.
7. Provide initial observations and recommendations.

2. Methodology

• We were assigned to work directly with the Electrical and Maintenance Department of the hospital, alongside supervisors and site electricians.

• Site visits were conducted to the following locations:

- Main Distribution Board (MDB)
- DG Room
- Control Room
- Pump Room
- Indoor Transformer Room
- Incinerator Room

• Interviews were conducted with the hospital's electricians and operators to better understand the practical operation and monitoring strategies.

• We reviewed single-line diagrams, electrical layout plans, and equipment datasheets.

• Real-time data on breaker ratings, cable sizes, and categorized loads was recorded and summarized in tabular form

1. Grid Connection

1. Three -Phase 11 kV Incoming Supply

- Description:
  A three-phase, 11 kV supply is the primary grid connection to the hospital. Three-phase systems are used for high-power applications due to their efficiency in transmitting large amounts of energy.
- Why 11 kV?
  High voltage (11 kV) minimizes transmission losses over long distances. It is stepped down to lower voltages (e.g., 400 V) for hospital use.

2. Dropout Fuse

- Description:
  A fuse with a mechanical design that "drops out" visibly when blown.
- Function:
  Provides overcurrent protection for the transformer and downstream circuits. It interrupts the circuit during faults (e.g., short circuits, overloads).
- Advantage:
  Easy to identify when tripped, simplifying maintenance.

3. TOD Meter (Time-of-Day Meter)

- Description:
  A smart energy meter that records electricity consumption based on time intervals.
- Function:
  Tracks usage during peak/off-peak hours, enabling cost-saving strategies by shifting non-essential loads to cheaper off-peak times.
- Hospital Use:
  Helps manage energy costs for high-consumption systems like HVAC and lighting.

4. Vacuum Circuit Breaker (VCB)

- Description:
  A circuit breaker that uses a vacuum to extinguish arcs during interruption.
- Function:
  Protects the system from overloads and short circuits. It operates faster and more reliably than oil or air-based breakers.
- Why Vacuum?
  Maintenance-free, compact, and ideal for high-voltage applications (11 kV).

5. 1000 kVA Delta-Star OLTC Indoor Transformer

- Description:
  - Delta-Star Configuration: Delta-connected primary (11 kV), star-connected secondary (400 V).
  - OLTC (On-Load Tap Changer): Adjusts transformer taps without disconnecting the load to regulate output voltage.
- Function:
  Steps down 11 kV grid voltage to 400 V for hospital distribution. The OLTC compensates for grid voltage fluctuations (±5%).
- Indoor Design:
  Protects the transformer from environmental factors (dust, moisture), ensuring reliability in hospital settings.

6. 1600 A, 50 kA Air Circuit Breaker (ACB)

- Description:
  A high-current circuit breaker with a 1600 A continuous rating and 50 kA breaking capacity.
- Function:
  - Main Distribution Protection: Installed at the transformer’s secondary side (400 V) to protect downstream circuits.
  - Short-Circuit Protection: Can safely interrupt fault currents up to 50 kA, preventing catastrophic damage.

System Integration & Workflow

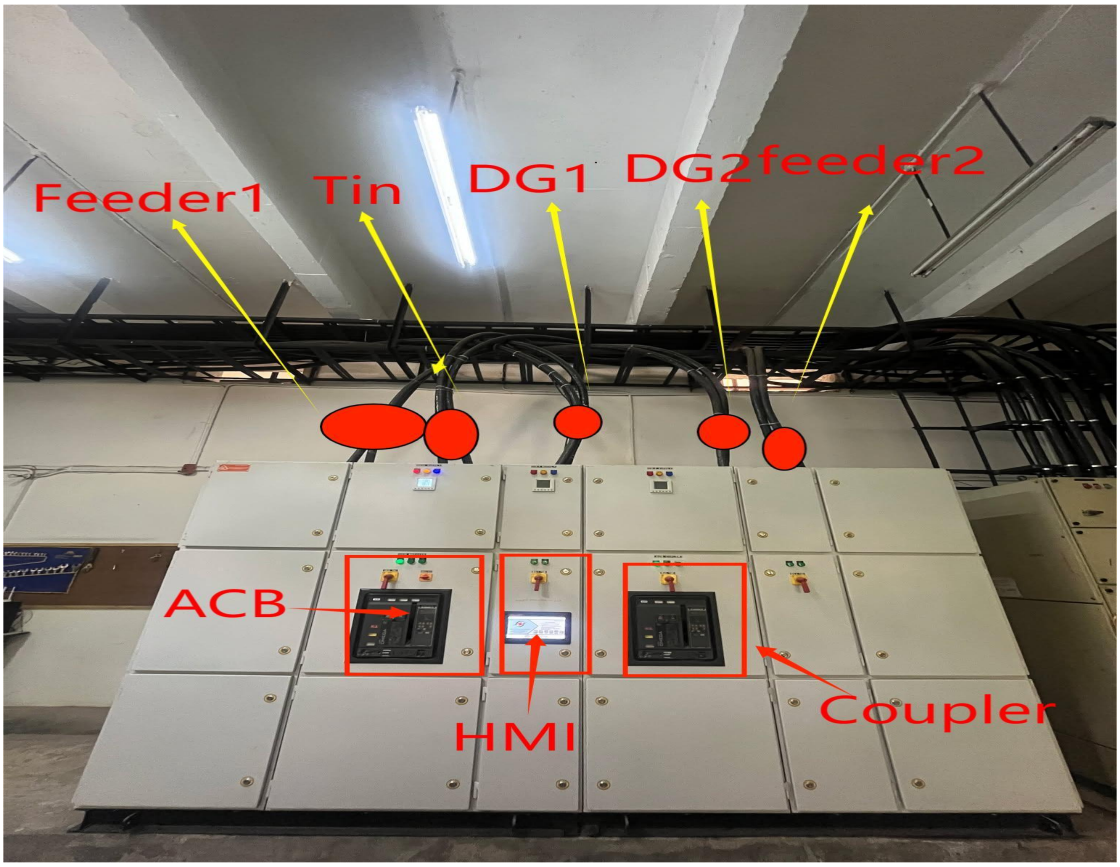
1. Grid Power Flow:
   11 kV supply → Lightning arrester → Dropout fuse → VCB → OLTC transformer (step-down to 400 V) → ACB → Hospital distribution.

2. Bus coupling and switching action

The matrix in Figure 1 defines operational modes for generators (DG1, DG2) and the Bus Complex:

State	**DG1**	**DG2**	**GRID**	**Bus coupler ststus**	**ACB STATUS**
Normal Grid Mode	O	O	1	ON	Acb tx -ON Acb dg1- OFF Acb dg2- OFF

State	DG1	DG2	GRID	Bus coupler ststus	ACB STATUS
Grid Failure (Both DGs)	1	1	O	OFF	Acb tx -OFF Acb dg1- ON Acb dg2- ON
DG2 Active Only	O	1	O	ON	Acb tx -OFF Acb dg1- OFF Acb dg2- ON
DG1 Active Only	1	O	O	ON	Acb tx -OFF Acb dg1- ON Acb dg2- OFF

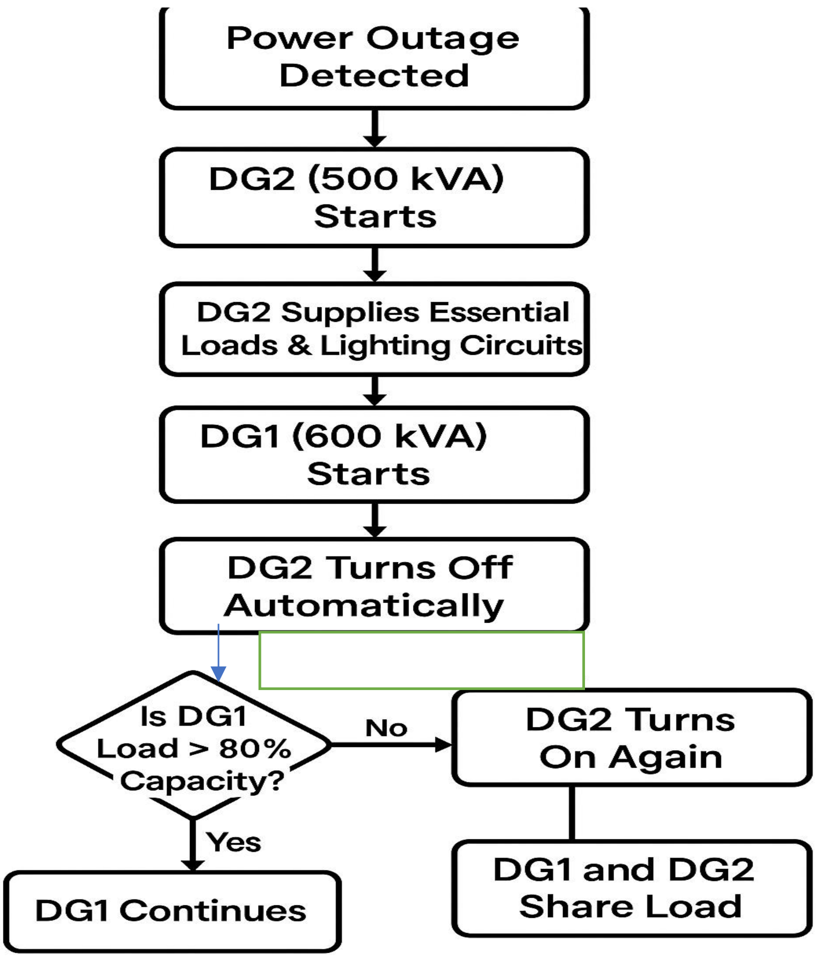


Generation System

The Manipal Teaching Hospital relies on two diesel generators—a 500 kVA (DG2) and a 600 kVA (DG1) unit—as critical backup power sources to ensure uninterrupted electricity supply during grid failures, These generators operate on a three-phase synchronous alternator system, producing 400V output, and are designed with electronic governors to maintain a stable 50 Hz

- **DG1:** 600 kVA, **DG2:** 500 kVA.

Generator Operation



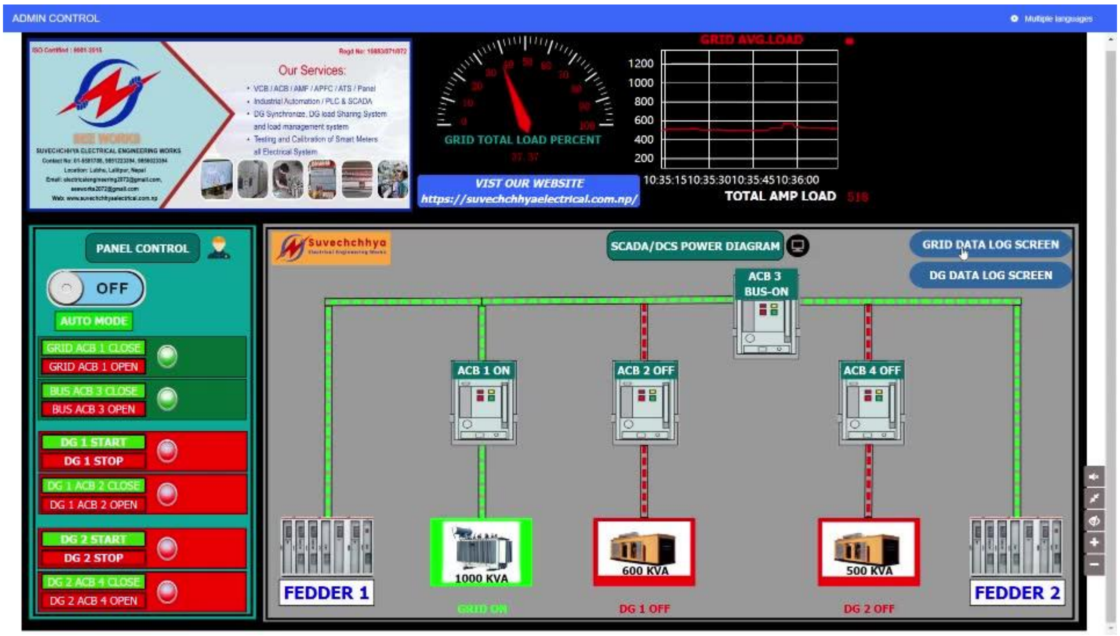
In the event of a power outage at the hospital, an intelligent and sequential generator system is employed to ensure uninterrupted power supply with optimal efficiency and safety. The process begins with the automatic activation of DG2, a 500 kVA generator, which is designed to quickly start up and supply only the most essential loads, such as emergency lighting circuits, life-support systems, and critical medical equipment. This happens almost immediately after the power loss is detected, minimizing downtime for the most vital operations.

Within approximately one minute of DG2's operation, DG1—a larger 600 kVA generator—is automatically triggered. Once DG1 is fully operational and stable, it takes over the supply of all electrical loads in the hospital, including both essential and non-essential circuits. At this point, DG2 is automatically turned off to conserve fuel and reduce mechanical wear since DG1 alone is capable of handling the load under normal conditions.

However, the system is designed with intelligent load monitoring. If the load on DG1 exceeds 80% of its rated capacity—indicating a risk of overloading or reduced efficiency—DG2 is brought back online. When both generators are running, the load is automatically shared between DG1 and DG2 to balance the electrical demand and prevent strain on either unit. During this dual operation phase, the bus coupler is intentionally kept off. This prevents synchronization issues and back-feeding problems between the two generator systems, ensuring safety and maintaining the integrity of both supply lines.

This approach is considered optimal because it combines fast response, fuel efficiency, system protection, and load flexibility. By initially prioritizing DG2, the hospital guarantees that life-critical systems remain operational within seconds. DG1's delayed startup reduces mechanical stress and ensures a smoother transition for larger loads. The conditional reactivation of DG2 based on DG1's load status provides a smart, demand-driven backup, optimizing generator usage without unnecessary redundancy. Moreover, the decision to keep the bus coupler off during dual operation adds a layer of safety by isolating the two sources and preventing complex synchronization issues, which are especially important in high-reliability environments like hospitals.

5. Bus Coupling



Normal Operating Condition – Grid Supply Mode:

In the default or **normal condition**, the **Grid ACB (Air Circuit Breaker)** is **closed**, allowing the **NEA (Nepal Electricity Authority) 1000 kVA supply** to power the entire system. Both **Diesel Generators (DG1 and DG2)** are **OFF**, and their ACBs are **open**, meaning they are not contributing to the power supply.

- **Feeder 1 and Feeder 2** are both energized **from the grid** through their respective connections.
- These feeders further divide the load based on the **priority system**:
  - **Feeder 2** may supply **Most Essential** loads.
  - **Feeder 1** may handle **Essential** and **Non-Essential** and remaining loads.
- Each of these sub-sections has its own **individual ACB or MCCB**, as described in our table, ensuring protection and load management.
- The **Bus Coupler ACB** is typically **closed** in this scenario, which means **Feeder 1 and Feeder 2 are interconnected**, allowing for better load distribution and system balance.

This setup ensures that the grid is the **main and stable source** of power, and **both feeders are powered simultaneously** via the common busbar system.

Generator Mode – Grid Failure Condition:

When the **grid supply fails**, the system responds automatically or manually based on how it's configured. In this state:

- The **Grid ACB opens** to disconnect the faulty or unavailable grid line.

- Both **DG1 (600 kVA)** and **DG2 (500 kVA)** are **turned ON**, but their operations are **independent**, meaning:
    - Their **ACBs (DG1 ACB and DG2 ACB)** are **closed**, allowing them to feed their respective sections.
    - However, the **Bus Coupler ACB remains open** – this is **critical** because it means **there is no synchronization** between DG1 and DG2.

Why No Synchronization?

Since DG1 and DG2 are not synchronized (i.e., not running in parallel and not phase-locked), their outputs **must not be mixed**. Hence, the **Bus Coupler ACB stays open** to prevent damage or instability due to phase mismatch.

Each DG, therefore, **feeds one side of the bus**:

- **DG2** supplies Feeder 2 (likely powering most Essential loads).
- **DG1** supplies Feeder 1 (likely powering Essential and Non-Essential loads, as capacity permits).

This separation allows **manual or programmed load shedding** based on priority ensuring DG2, which is smaller, doesn't get overloaded.

Flexible Operations – Independent DG Mode:

The system is also designed to **operate each generator separately** at any time:

- You can run only **DG1 or only DG2** based on load demand, fuel availability, or maintenance needs.
- Again, **Bus Coupler ACB must remain open** unless full synchronization is done — which, in this case, **is not implemented**.

This setup allows for **flexibility, maintenance, and redundancy**. If one generator fails, the other can still handle part of the system based on load prioritization.

Bus Coupler Role in Summary:

- **Closed in grid mode**, allowing common supply from grid to both feeders.
- **Open in generator mode**, isolating DG1 and DG2 from each other to prevent phase conflict.
- **Manual or automatic control** based on load condition and maintenance needs

Load Priority Chart

Priority	Load Type	Loads	Cable Size	Protection Device
1	Essential	Hospital (basement, ground, 1,2,5 floor)	300 mm^2 cable XLPE insulation	1600 A ACB
		Classroom	50 mm^2 cable PVC insulation	1000 A MCCB
		Hostel	300 mm^2 cable	630 A MCCB
		Incinerator	25 mm^2 cable	400 A MCCB
		Pump	35 mm^2 cable	630 A MCCB
2	Most Essential	Lighting Load (3rd & 4th floor)	300 mm^2 cable	1000 A ACB
3	Non-Essential	Linen, CSSD Machine	185 mm^2 cable	1000 A ACB

Essential loads, classified under Priority 1, include the most crucial parts of the hospital, like the basement, ground, 1st, 2nd, and 5th floors, along with classrooms, hostels, incinerator units, and waste dump areas. These areas must stay powered at all times, no matter what. To make sure they do, they're connected using large cables — some as thick as 300 mm^2 — and are protected with heavy-duty circuit breakers, including ACBs (Air Circuit Breakers) and MCCBs (Moulded Case Circuit Breakers), ranging from 400 A to 1600 A. This setup ensures that even during unexpected power disruptions, these vital services stay up and running without any hiccups.

Moving on to **Most Essential loads**, under Priority 2, the focus shifts slightly to areas like lighting on the 3rd and 4th floors. While these aren't as critical as life-support systems, they still play a big role in keeping things functional and safe, especially at night or during procedures. These lighting systems are usually powered by 300 mm^2 cables and protected by a 1000 A ACB, giving them a reliable supply even if the main grid fails.

Then we have the **Non-Essential loads**, or Priority 3. These include support services like linen management and the CSSD (Central Sterile Services Department) machines. While these areas are certainly important for comfort and hygiene, they can temporarily be turned off during a power shortage without affecting life-critical operations. These loads are generally connected using 185 mm^2 cables and are also protected by 1000 A ACBs.

The hospital's protection system has been cleverly built using a mix of ACBs and MCCBs. ACBs are generally used for handling the main, high-capacity circuits — the ones that power large areas of the hospital — while MCCBs are used to protect smaller, more specific zones. This layered approach ensures that any fault in the system is quickly and effectively isolated, keeping the rest of the network safe and stable.

Cable sizes across the hospital aren't just chosen at random. They're very deliberately matched to the expected current, the distance electricity needs to travel (to avoid voltage drop), and safety requirements. This means that electricity reaches where it's needed efficiently and safely, without overheating the wires or damaging equipment.

Power typically flows from a main supply, probably coming in from a utility transformer, into the hospital's main distribution board. From there, it's branched out into sub-distribution boards that handle each priority level. Just in case there's a power cut, automatic backup systems — like diesel generators or UPS — kick in almost instantly, ensuring that essential systems never go offline.

Cables used and reason

The hospital's main power distribution system uses 300 mm², 3.5-core XLPE-insulated and PVC-sheathed cables due to their high current capacity (350–400 A) and long-term durability. This cable type ensures efficient power transmission with reduced material cost through a reduced neutral conductor, suitable for balanced load conditions. Other areas like hostels, classrooms, incinerator rooms, and pump systems use smaller-sized PVC or XLPE insulated cables, selected based on specific load demands and equipment ratings.

The detailed cable sizes, insulation types, and their corresponding ampere ratings are described below.

Area	**Cable Size**	**Insulation Type**	**Approx. Ampere Rating**
Main Distribution/ Hospitals	• 300 mm², 3.5-core	• XLPE / PVC	350–400 A
Hostel Blocks	• 300 mm² 3.5-core	• XLPE/PVC	350–400 A
Classrooms	• 50 mm² 3.5-core	• XLPE/PVC	150 A
Incinerator Room	• 25 mm² 3.5-core	• PVC	80 A
Pumps	• 35 mm² 3.5-core	• PVC	120 A

Detailed Study of the Pump House

A major focus of the third day was on the **pump house**, which plays a vital role in the facility's water management and pressure regulation. The pump house is equipped with **four motors**, one of which is a **40 HP induction motor**. This motor is protected by a **140 A Miniature Circuit Breaker (MCB)**, which is appropriately rated to handle the motor's full-load current and inrush conditions during startup.

The motor was operated using a **Star-Delta Starter**, which is a commonly used method to reduce the starting current in large motors. The **star-delta system** consisted of **three main contactors** – one each for line (main), star, and delta configurations. Additionally, a **timer relay** was integrated into the system to automatically switch from star to delta after a preset time delay. The system also featured an **Over Current Relay (OCR)** to protect the motor from overload or fault conditions, and **start/stop push buttons** for user control. These push buttons were wired in a **series combination** to ensure that both manual and automatic controls could work safely and efficiently.

The **power wiring** for the motor was implemented using **25 mm² copper cables**, suitable for handling the high current required by the motor. Meanwhile, the **control wiring** – including the push buttons, contactor coils, and relays – was neatly arranged using **0.75 mm² copper wire**, which is standard for low-current control circuits. Other components observed in the star-delta starter panel included **fuses**, **auxiliary contact blocks**, **indicator lamps** to show operational status, **terminal blocks**, and in some cases, a **control transformer** to step down voltage for the control circuit.

Through careful observation and discussions with the on-site engineers, we developed a clear understanding of the operational principle of the star-delta starter and how the transition from star to delta helps minimize torque shock and electrical stress on the motor

Motor Delta Star starter and Control Scheme

In addition to the primary pump motor, the other motors in the pump house also employed **star-delta starter configurations**. These starters followed a consistent design pattern. A typical setup included:

- A **main contactor** that initially connects the motor in star configuration.
- A **star contactor**, which connects the motor windings in star for a brief starting interval.
- A **delta contactor**, which is energized after a timer delay, transitioning the motor to full-load running condition in delta mode.
- A **time delay relay**, often adjustable, that sets the switching time between star and delta.
- **Thermal overload relays** for motor protection based on current and duration.
- **Fuses** to protect against short circuits.

- **Start and stop push buttons** connected through latching logic.
- **Indicator lights** (red, green, yellow) indicating different states such as running, fault, or idle.
- **Current transformer**, measure current
- **Auxiliary contacts** for interlocking and sequencing the starter operation.

We paid close attention to how each of these components interacts within the control circuit to ensure safe motor operation and automatic shifting from star to delta mode.

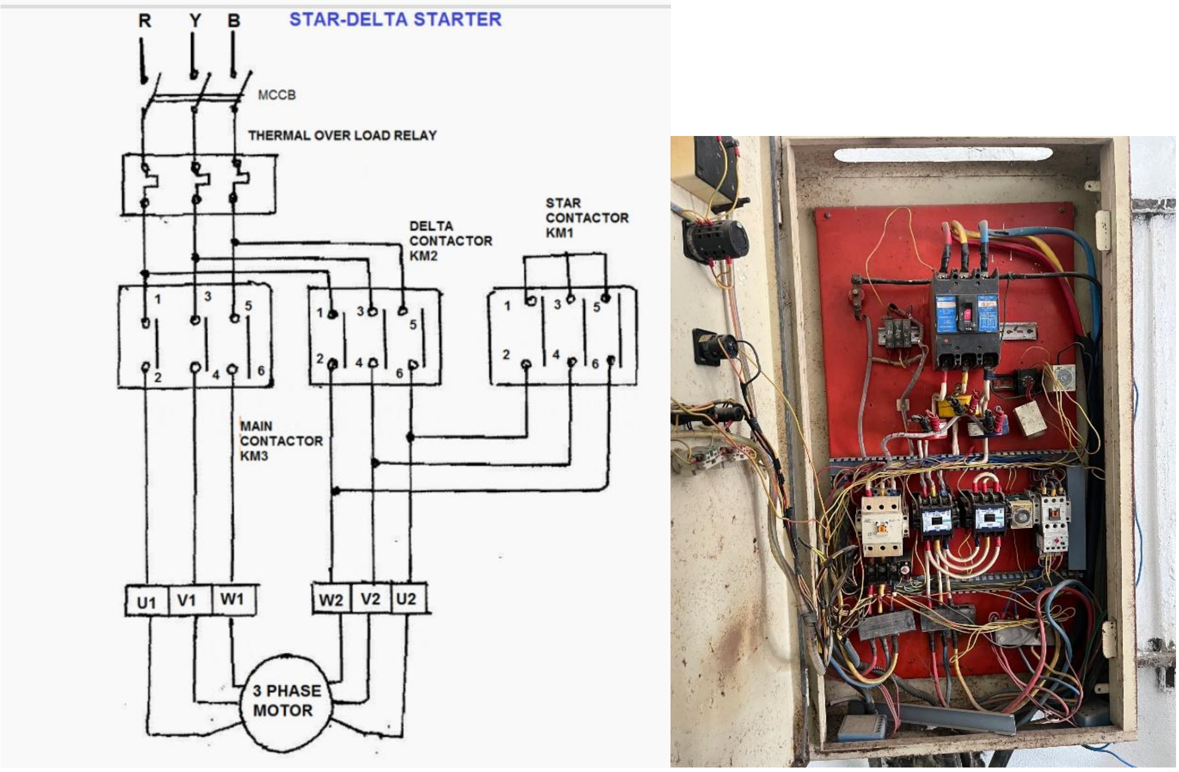
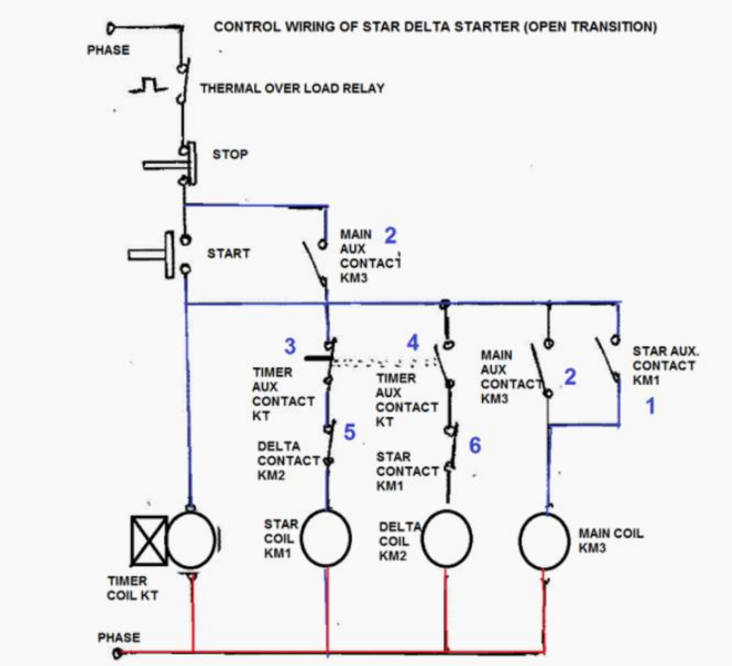


Fig:Power wiring

Need of Delta Star starter.

The Star-Delta starter is used to reduce the high starting current of motors, which can otherwise be 4–6 times the full-load current. Starting in star mode lowers the voltage to each winding to about 58%, reducing the initial current to one-third. Once the motor reaches 70–80% of its speed, it switches to delta mode for full voltage operation. This method protects the electrical system, prevents voltage dips, and extends motor life.



Working Mechanism:

1. **Start Command Given:**
   - The **main contactor** energizes, supplying power to the motor.
   - The **star contactor** closes simultaneously, connecting motor windings in star configuration.
   - The motor starts with reduced voltage and lower current.
2. **After a Delay (2–15 seconds):**
   - The **star contactor** opens.
   - A brief interlock delay ensures no short circuit occurs.
   - The **delta contactor** then closes, switching the motor windings to delta configuration.
   - The motor now runs at full speed and full load capacity.
3. **Run Time:**
   - The **main contactor** remains closed throughout operation.
   - Protection devices (overload relays, fuses, timers) ensure safety in case of fault or abnormal current draw.

2. DOL Starter (Direct-On-Line Starter)

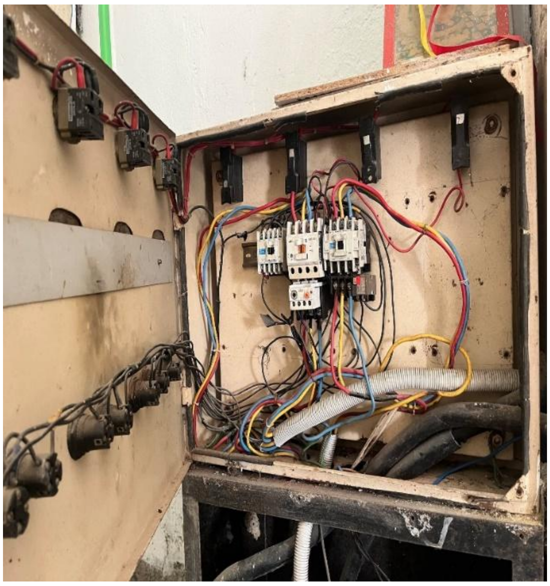
How It Works:

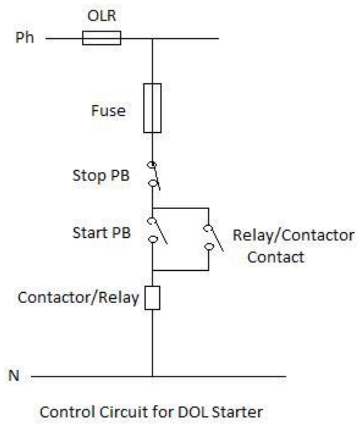
A **Direct-On-Line (DOL) starter** is the simplest and most straightforward method for starting an electric motor. When this starter is used, the motor is directly connected to the power supply, receiving the **full line voltage** from the start.

This means the motor immediately begins to operate at its full capacity as soon as the starter is engaged. The typical DOL starter circuit includes:

- A **contactor** (electromagnetically operated switch)
- An **overload relay** (for protection)
- A **start/stop push button** or switch

When the **start button** is pressed, the contactor closes, and the motor gets full voltage. When the **stop button** is pressed or an overload occurs, the contactor opens, cutting off power to the motor.





Working of the Incinerator System

The hospital's biomedical waste management system relies on two high-capacity incinerators designed for the safe and effective disposal of hazardous medical waste, including contaminated dressings, used syringes, infectious laboratory waste, and other non-recyclable materials generated from patient care activities. These incinerators operate on a robust three-phase 415V electrical supply, which is essential for powering the intensive heating elements and combustion systems that require sustained high power output. The electrical infrastructure supporting these units features heavy-duty 25 sq mm copper cabling, selected for its superior current-carrying capacity and ability to minimize voltage drop over long runs, ensuring stable operation even during extended burning cycles.

Power protection is provided by a 400A Molded Case Circuit Breaker (MCCB) that serves as the primary safeguard against electrical faults. This advanced protection device features both thermal and magnetic trip mechanisms to respond to overloads (thermal) and short circuits (magnetic), with adjustable settings that allow for precise coordination with the incinerator's load characteristics. The control system incorporates multiple layers of automation, including

PID-controlled heating elements that maintain optimal combustion temperatures between 800-1000°C, critical for complete pathogen destruction. Digital timer systems enable programmed operation cycles, while mechanical interlocks prevent door opening during active combustion for operator safety. Integrated sensor arrays continuously monitor chamber temperature, flue gas composition, and pressure differentials, with feedback loops that dynamically adjust air intake dampers and fuel injection rates to maintain clean combustion and maximize energy efficiency. The system includes fail-safe mechanisms that automatically initiate cool-down cycles if parameters deviate from setpoints, and all critical functions are duplicated in a redundant control circuit to ensure reliability during extended operation periods. Regular maintenance protocols include thermocouple calibration, burner nozzle inspections, and insulation resistance testing of all heating elements to maintain peak performance and compliance with environmental emission standards.

Layout Planning: Generator Room, MV Room, and HV Room

Following the pump house study, we shifted focus to the **electrical infrastructure layout** of the **Generator Room**, **MV Room**, **HV Room,R1, R2, Transformer room and Old Transformer** Room . We physically inspected each room and documented the equipment positions, and existing routing of cables and panels and no of loads along with teir wattage rating and developed the deatiled electrical layout analayis of building.

In this section,we planned and balanced the electrical load distribution across a 3-phase (R, Y, B) single-phase 230V system for a generator room, HV/MV rooms, and auxiliary spaces. We assigned 6 lighting circuits (10A MCBs) and 3 power socket circuits (20A MCBs) across the phases, labeling them systematically (e.g., 1L, 4L for R-phase lighting). Each load—LED lamps, wall lights, and sockets—was allocated to specific MCBs to ensure no circuit exceeded its capacity.

1. Components of the Distribution Board

A. Molded Case Circuit Breaker (MCCB) – 40A

- Role: Acts as the main incoming circuit breaker for the distribution board.
- Function:
  - Provides overcurrent/short-circuit protection for the entire board.
  - Can be manually switched off for maintenance.

- Rated for 40A, meaning it trips if the total current exceeds 40A (protecting cables and downstream devices).

B. Earth Leakage Circuit Breaker (ELCB) – 40A

- Role: Detects earth leakage currents (ground faults) to prevent electric shocks or fire hazards.
- Function:
  - Monitors the balance of current between live (phase) and neutral.
  - If a leakage current (typically >30mA) is detected, it trips instantly, disconnecting power.
  - Also rated for 40A, matching the MCCB for coordination.

C. Single Pole MCBs (Per Phase)

Each phase from the ELCB splits into three branches protected by:

1. 20A SP MCB
   - Purpose: Supplies a power sub-circuit (e.g., sockets, heavy appliances like heaters, or kitchen equipment).
   - Why 20A?
     - Handles higher loads (up to 4.6 kW at 230V).
     - Protects wiring (typically 2.5mm^2 copper cable).
2. 10A SP MCB (x2)
   - Purpose: Dedicated to lighting circuits (e.g., bulbs, tube lights, fans).
   - Why 10A?
     - Lighting loads are lighter (up to 2.3 kW at 230V).
     - Uses thinner cables (1.5mm^2 copper).
     - Prevents overloading delicate lighting wiring.

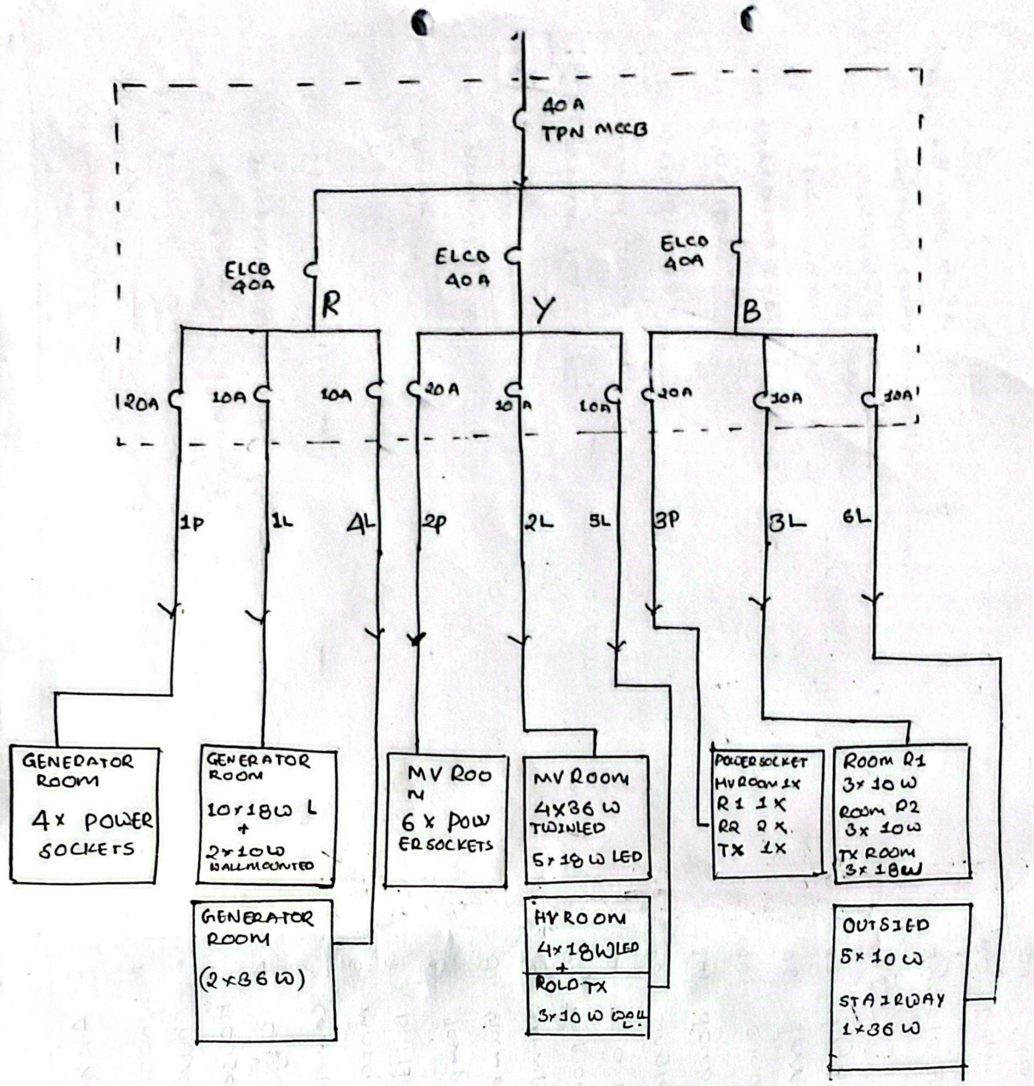


FIG: LIGHTING AND POWER SOB CIRCIUT OF CONTROL STATION

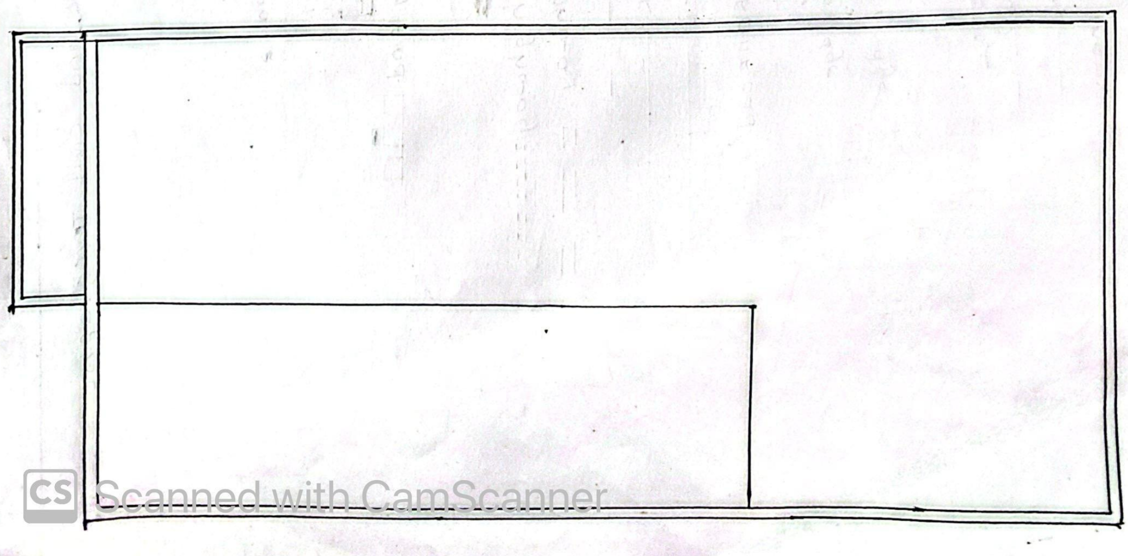


Fig (a) Design of Distribution board

Fig (b) Layout Diagram of building

Electrical Load Distribution table

Room	Load Type	Qty	Power (W)	Total (W)	Phase	MCB (A)	Circuit Type
Generator Room	18W LED Lamp	10	18	180	R	10	Lighting
	10W Wall Light	2	10	20	R	10	Lighting
	36W LED	2	36	72	R	10	Lighting
	Power Socket	4	-	-	R	20	Power
MV Room	36W Twin LED	4	36	144	Y	10	Lighting
	18W LED Lamp	5	18	90	Y	10	Lighting
	10W LED Lamp	1	10	10	Y	10	Lighting
	Power Socket	6	-	-	B	20	Power
HV Room	18W LED Lamp	4	18	72	Y	10	Lighting
	Power Socket	1	-	-	Y	20	Power
Room R1	10W Wall Light	3	10	30	B	10	Lighting
	Power Socket	2	-	-	B	20	Power

Room	Load Type	Qty	Power (W)	Total (W)	Phase	MCB (A)	Circuit Type
Room R2	10W Wall Light	3	10	30	B	10	Lighting
	Power Socket	2	-	-	Y	20	Power
Transformer Room	18W LED Lamp	3	18	54	B	10	Lighting
	Power Socket	1	-	-	B	20	Power
Old Transformer	10W Wall Light	3	10	30	B	10	Lighting
Stairway	36W LED	1	36	36	B	10	Lighting
Outside Building	10W LED Lamp	5	10	50	B	10	Lighting

The table outlines a structured electrical load distribution plan for a building, systematically organizing lighting and power circuits across various rooms. Each entry specifies the room name, load type (such as LED lamps, wall lights, or power sockets), quantity, individual and total wattage, assigned phase (R, Y, or B), MCB rating (10A for lighting, 20A for power sockets), and circuit classification (lighting or power).

Lighting loads predominantly consist of energy-efficient LED fixtures, with wattages ranging from 10W to 36W. For instance, the **Generator Room** includes multiple 18W LED lamps, while the **MV Room** features higher-capacity 36W twin LEDs. Power sockets are distributed strategically, with higher concentrations in areas like the **MV Room** (6 sockets) and fewer in technical spaces like the **Transformer Room** (1 socket). Each socket circuit is protected by a 20A MCB, ensuring safe operation for connected devices.

1. MCB Naming Convention

Phase	10A MCB (Lighting - "L")	20A MCB (Power - "P")
R	1L, 4L	1P
Y	2L, 5L	2P
B	3L, 6L	3P

Explanation:

- **1L, 2L, 3L, 4L, 5L, 6L**: 10A MCBs for lighting circuits.
- **1P, 2P, 3P**: 20A MCBs for power sockets.
- **Phase Assignment**: Ensures each phase (R, Y, B) has 2 lighting MCBs and 1 power MCB.

2. Circuit Allocation to MCBs

A key assumption in this analysis is that each power socket carries a 100W load, which provides a standardized basis for calculating the total connected load.

MCB	Connected Loads	Total Load (W)	Remarks
1L (R)	Generator Room (10×18W + 2×10W)	200W	Lighting
4L (R)	Generator Room (2×36W)	72W	Emergency Lighting
1P (R)	Generator Room (4×100W sockets)	400W	Power
2L (Y)	MV Room (4×36W + 5×18W)	234W	Lighting

MCB	Connected Loads	Total Load (W)	Remarks
5L (Y)	HV Room (4×18W) + Old TX (3×10W)	102W	Lighting
2P (Y)	MV Room (6×100W sockets)	600W	Power
3L (B)	Room R1 (3×10W) + Transformer (3×18W)+ Room R2(3*10W)	114W	Lighting
6L (B)	Stairway (1×36W) + Outside (5×10W)	86W	Lighting
3P (B)	HV Room + R1 + R2 + Transformer (5×100W sockets)	500W	Power

This table provides a structured overview of the building's wiring system, detailing how electrical circuits are allocated across different rooms and connected to the panel board. It outlines the distribution of lighting and power circuits, ensuring proper load management and phase balancing. The system is designed for safety and efficiency, with clear segregation of circuits based on their function and location. Emergency and general lighting are appropriately separated, while power outlets are systematically assigned to prevent overloading. Overall, the table serves as a comprehensive guide to the electrical layout, ensuring organized and compliant wiring throughout the building.

3. Phase Balance Verification

Phase	Lighting (W)	Sockets (W)	Total (W)
R	272W (1L+4L)	400W (1P)	**702W**
Y	336W (2L+5L)	600W (2P)	**936W**
B	170W (3L+6L)	500W (3P)	**670W**

The phase balance verification table evaluates the electrical load distribution across phases R, Y, and B, considering both lighting circuits and power sockets.The table confirms that the combined lighting and socket loads remain within safe operational limits for each phase, with no significant imbalance that could risk overloading. While minor variations exist between phases, the overall distribution maintains electrical stability. This verification demonstrates proper load planning, though actual socket loads may vary depending on connected equipment. The 100W-per-socket assumption serves as a conservative estimate for safety calculations.

STUDY OF ETP PLANT

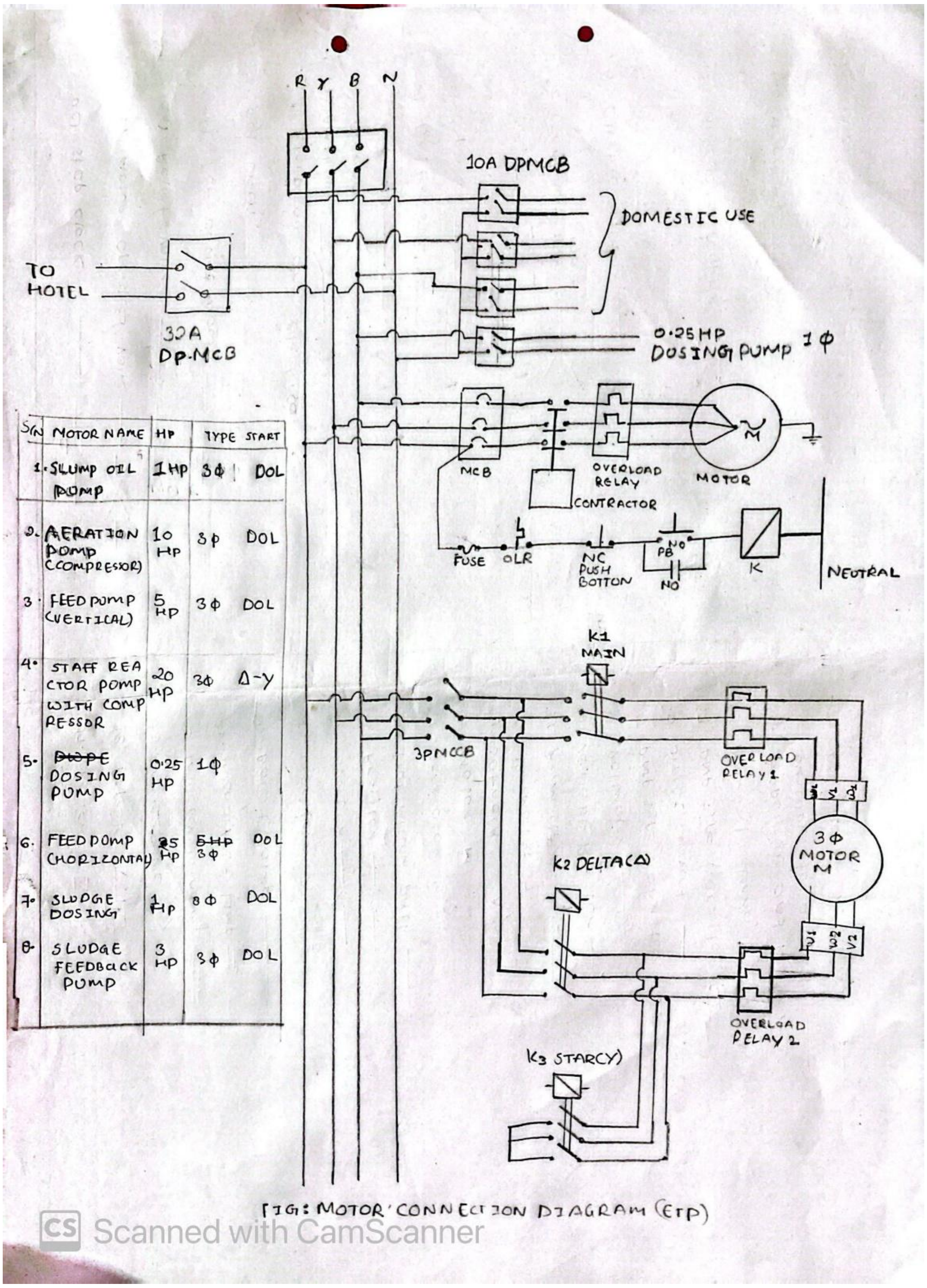
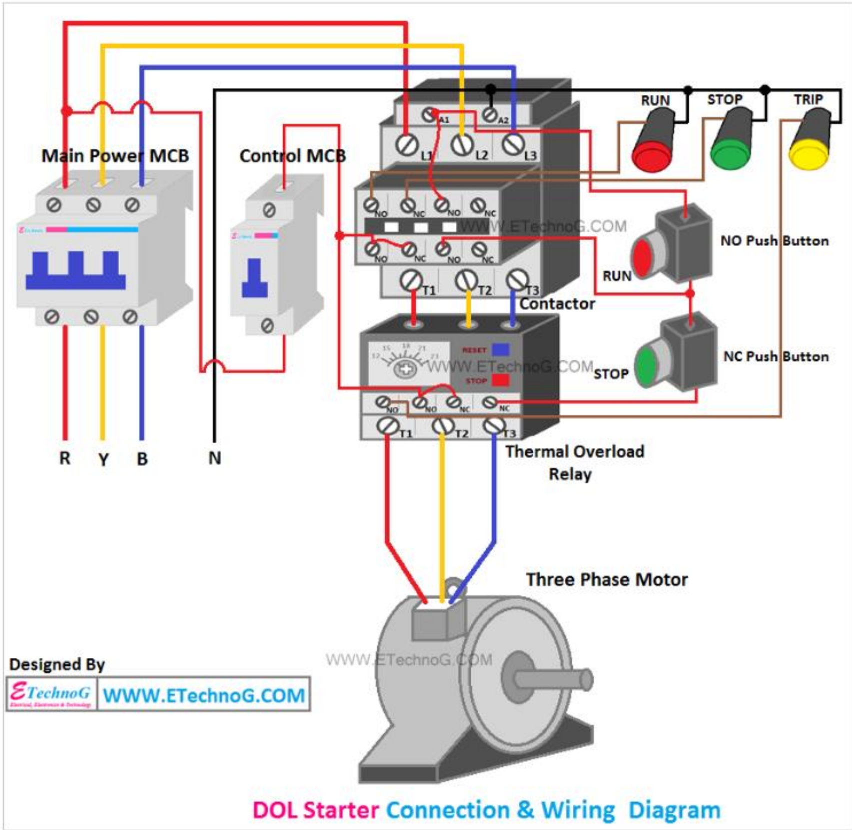


FIG: MOTOR CONNECTION DIAGRAM (ETP)

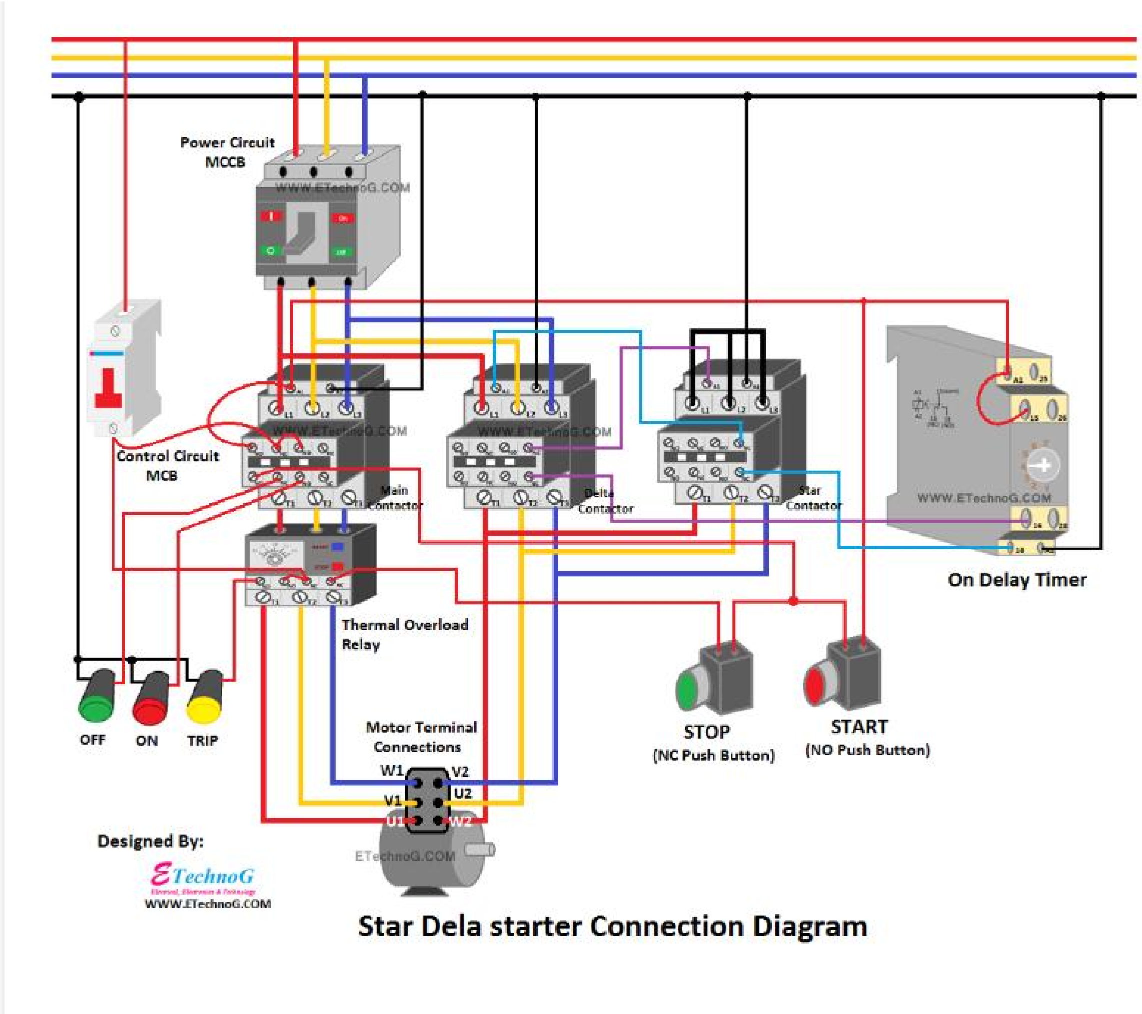
At Manipal, the ETP operation follows a carefully monitored routine where technicians conduct hourly checks on parameters like pH, dissolved oxygen, and sludge volume index. The system's electrical infrastructure features specialized motor control panels with DOL and star-delta starters for pumps ranging from 0.25 HP dosing units to 20 HP aeration blowers, all protected by appropriately sized circuit breakers and overload relays. The plant's necessity stems from both regulatory compliance requirements under the Water (Prevention & Control of Pollution) Act and the hospital's commitment to environmental stewardship. Without this facility, the institution would face legal penalties exceeding ₹1 crore annually while contributing to groundwater contamination and ecosystem damage. The ETP not only neutralizes hazardous components like pharmaceutical residues and biological contaminants but also enables water reuse for non-potable applications, demonstrating Manipal's dedication to sustainable healthcare practices. Regular maintenance of mechanical components like sludge pumps and electrical systems including motor starters ensures consistent performance of this vital pollution control infrastructure.

DOL Wiring Configuration in control panel of ETP



The Direct-On-Line (DOL) starter control panel features a well-organized wiring layout designed for safe and efficient motor operation. The system incorporates two key

MCBs - a three-pole main power MCB that delivers three-phase supply to the motor, and a single-pole control MCB that energizes the control circuits when activated. Operation requires sequential switching: first engaging the main power MCB followed by the control MCB. The heart of the starter is a three-pole contactor with a 230V AC magnetic coil, featuring three power contacts for motor connection and four auxiliary contacts for control functions. Protection is provided by a three-phase thermal overload relay equipped with both normally closed (NC) and normally open (NO) contacts to monitor current draw. User interface consists of two color-coded push buttons - a red NO button for starting and a green NC button for stopping the motor. Visual status indication is achieved through three lamps: a red lamp illuminates during motor operation, a green lamp shows standby/off status, and a yellow lamp combined with green provides immediate visual alert for overload tripping conditions. The entire assembly represents a comprehensive motor control solution integrating power distribution, operational control, protective functions, and clear status indication in a single panel-mounted unit.



Star Delta Starter Wiring Configuration

The star-delta starter control panel incorporates a sophisticated wiring layout designed for reduced-voltage starting of three-phase motors. The power circuit begins with a Molded Case Circuit Breaker (MCCB) receiving three-phase input power, with output connections feeding both the main contactor and delta contactor in parallel. A thermal overload relay (OLR) is series-connected to the main contactor's output, providing motor protection. The motor terminals are strategically connected across six points - three from the OLR output and three from the delta contactor output, with additional looping from the delta contactor to the star contactor, whose terminals are internally shorted to create the star configuration.

For control circuit implementation, a single-pole MCB derives power from the 'R' phase to energize the system. The circuit incorporates an on-delay timer with terminals A1 (power) connected to both the NO start pushbutton and terminal 15 (common), while A2 connects to neutral. The timer's NC terminal (16) controls the star contactor coil through the delta contactor's NC auxiliary contacts, and its NO terminal (18) governs the delta contactor coil via the star contactor's NC auxiliaries. Pushbutton wiring follows standard practice with the stop button (NC) in series with the start button (NO), creating a holding circuit through the main contactor's NO auxiliary contacts.

Status indication is achieved through a three-lamp system: the yellow trip lamp connects to the OLR's NC contacts, the green standby lamp to the main contactor's NC auxiliaries, and the red running lamp to the main contactor's NO auxiliaries, all sharing a common neutral connection. This comprehensive arrangement ensures proper motor starting sequence (initial star connection followed by timed transition to delta), while providing clear operational status and overload protection throughout the starting cycle. The design incorporates necessary electrical interlocks through NC auxiliary contacts to prevent simultaneous energization of star and delta contactors, ensuring safe and reliable operation.

	Pump	**No of pump**	**Rating (hP)**	**Condn**	**MCCB**	**Fuse**	**Phase & Starter type**
1.	Oil2 pump	1	1	Not working	32 A	20 A	3 phase Direct on load starter
2.	Areation pump	2	10	Only one working	32 A	20 A	3 phase Direct on load starter
3.	Feeder pump	2	5	Only one working	63 A	20 A	3 phase Direct on load starter
4.	Saft reactor pump	2	20	Both working	63 A	20 A	3 phase Star-delta starter
5.	Feed pump (H)	2	5	Both working	32 A	20 A	3 phase Direct on load starter
6.	DWP Dosing pump	1	0.25	Not working	10 A	20 A	1 phase

7.	DWPE Dosing pump	1	1	Working	32 A	20 A	3 phase Direct on load starter
8.	Sludge pump	2	3	Both working	32 A	20 A	3 phase Direct on load starter
9.	Sludge feedback pump	1	3	Not working	32 A	20 A	3 phase Direct on load starter

1.Description of motors

1.a Sludge Oil Pump

Sludge/slump oil pump (or **oil skimmer pump**) used in an **ETP for hospital wastewater**, its main role is to **remove floating oil, grease, and screenings** from the equalization tank or oil-water separator. Hospital wastewater often contains fats, oils, and grease (FOG) from kitchens, labs, and medical waste, which must be separated to prevent clogging and improve treatment efficiency.

Function of the Sludge/Slump Oil Pump in Hospital ETP:

1. **Removes floating oil & grease** from the water surface.
2. **Extracts screenings** (solid debris like rags, plastics, etc.).
3. **Prevents clogging** in downstream processes (e.g., biological treatment)..

Electrical & Control Recommendations:

Since the pump handles **oil, grease, and solids**, its electrical system must be **safe, reliable, and properly protected**.

1. Motor & Starter (Current Setup: 1 HP, 3-Phase, DOL, 32A MCB, 20A Fuse)

- **Issue:**
  - **32A MCB is too high** for a 1 HP motor (typical full load current ~1.5-2A).
  - **20A fuse is acceptable** but should match starting current.
- **Recommendations:**
  - **Replace MCB with 10A (Type D – for motor inrush current).**
  - **Keep 20A fuse** (acts as backup protection)

2. Cable & Wiring Safety

- **Use 1.5 sq.mm copper cable** (3-core + earth) for 1 HP motor.
- **Ensure waterproof connections** (since ETP areas are damp/wet).
- **Install an functioning emergency stop switch** near the pump.

4. Control & Automation (Optional but Useful)

- **Float switch** – To auto-start/stop the pump based on oil level.
- **Timer control** – To prevent dry running & optimize runtime.

Since the pump is at non working condition,it should immediately be replaced.

Effects of a Non-Functional Sludge/Oil Pump in Hospital ETP

A failed sludge/oil pump in a hospital ETP can lead to **clogging, poor treatment efficiency, foul odors, and regulatory violations**. Immediate troubleshooting (electrical & mechanical) is needed, along with temporary manual oil removal until the pump is fixed.

Sludge oil pump

1 HP, 3-Phase, DOL, 32A MCB, 20A Fuse

1.b Aeration Pump

An aeration pump is a critical component in an Effluent Treatment Plant (ETP), responsible for supplying oxygen to the wastewater to support aerobic bacterial activity, which breaks down organic pollutants. Typically, these pumps are 10 HP motor-driven rotary lobe blowers (Roots blowers) or centrifugal compressors, Electrically, the pump operates on a 3-phase, 400V supply, protected by a 32A MMCB and a 25 fuse, with a DOL starter for motor control.

Currently, **only one of the two aeration pumps is operational**, leading to reduced oxygen supply in the aeration tank. This imbalance causes low dissolved oxygen (DO) levels, resulting in inefficient organic breakdown, sludge bulking, and foul odors. The working pump is also overloaded, increasing energy consumption and risking premature failure. Immediate troubleshooting—checking electrical connections, motor windings, and belt alignment—is necessary to restore full aeration capacity and prevent treatment process disruptions.

Effects of a Non-Functional Aeration Pump in ETP

Since one of the two 10 HP aeration pumps is not working, the following issues can arise in the Effluent Treatment Plant (ETP

1. Reduced Oxygen Supply in Aeration Tank

2. Overloading the Working Pump

The single running 10 HP pump must work twice as hard, increasing:

- Energy consumption (higher electricity bills).
- Risk of motor overheating & premature failure.
- Maintenance frequency (bearing wear, seal leaks is also observed)

Immediate Actions to Take

1. Check Why the Pump is Not Working:
    - Electrical Checks:
        - Test 3-phase supply (voltage imbalance can trip motors).
        - Verify 32A MMCB & 20A fuse (replace if blown).
        - Inspect DOL starter (overload relay tripped?).
    - Mechanical Checks:
        - Look for blocked impeller/diffuser.
        - Check coupling alignment & bearing condition.
2. Temporary Measures:
    - Run the working pump intermittently to prevent overheating.

Recommendations for Electrical Setup

- MCB Rating:
    - A 32A MMCB is acceptable (10 HP motor ≈ 14A full load current).
    - But overload relay in DOL starter must be set to ~14A.

- Fuse Rating:
    - 20A fuse is too low (should be 25-32A for motor starting current).
- Additional Protection:
    - Install an ELCB/RCCB (30mA) for leakage protection
    - Use a thermal overload relay to prevent burnout.

1.c Feed Pump

The feed pump is a crucial component in the Effluent Treatment Plant (ETP), responsible for transferring wastewater from the ground equalization tank to the segmented aeration tank, where further biological treatment occurs with bacterial action.

- Motor Specifications:
    - 2 x 5 HP, 3-phase motors (400 V, ~7A full load current each).
    - Starter: DOL (Direct-On-Line).
    - Protection:
        - 63A MCCB (oversized for 5 HP motor).
        - 20A fuse (acceptable but should match motor starting current).
- Function:
    - Ensures continuous flow of wastewater for aeration.
    - Maintains hydraulic balance between treatment stages.

Effects if One Feed Pump Fails (Only 1 Working Out of 2)

1. Reduced Flow Rate → Overloading of the working pump, leading to:
    - Higher energy consumption.
    - Increased wear & tear (risk of motor burnout).

2. Risk of Overflow → If inflow exceeds pumping capacity.
3. Electrical Risks →
    - 63A MCCB is too high (should be 16–20A for 5 HP).
    - 20A fuse may blow frequently due to motor inrush current.

Recommended Solutions & Actions

1. Immediate Actions

Check Why the Pump Failed:

- Electrical: Test motor windings, check DOL starter contacts, verify fuse & MCCB.
- Mechanical: Inspect for blockages, impeller damage, or coupling misalignment.

Temporary solutions :

- Run the working pump intermittently to prevent overheating.
- Manually balance flow to avoid overflow.

2. Corrective Measures

Electrical Upgrades:

- Replace 63A MCCB with 16–20A (properly sized for 5 HP motor).
- Upgrade fuse to 25A (to handle starting current).
- Install thermal overload relay (set to ~7A per motor).
- Sensor system to automatically run the pump should be repaired.

Mechanical Improvements:

- Clean filters & check valves for clogging.
- Align motor-pump coupling to reduce vibration.

1.d. Staff Reactor Pump

Staff reactor pumps (two units, 20 HP each) provide aeration in the segmented reactor tank, where bacterial treatment breaks down organic pollutants. These pumps ensure proper oxygen mixing and sludge suspension for efficient biological degradation.

- **Motor Specifications:**
    - 2 x 20 HP, 3-phase motors (415V, ~27A full load current each).
    - Starter: Star-Delta (to reduce inrush current).
    - Protection:
        - 63A MCB (main circuit breaker).

- 20A fuse (control circuit protection).

- Key Role:
    - Maintain Dissolved Oxygen (DO) for bacterial activity.
    - Prevent sludge settling in the reactor.

Recommended Solutions & Action

Upgrade Protection:

- Replace 20A fuse with 32A (to handle starting current).
- Ensure overload relay is set to ~27A (motor FLC).

1.Monitor Motor Current (clamp meter checks).
2.Clean Air Filters & Diffusers (monthly).
3.Lubricate Bearings (if non-sealed type).

1.d. Dosing Pump in ETP System (Bleaching Powder Injection)

Background & Function

The 0.25 HP single-phase dosing pump plays a critical role in the final disinfection stage of the Effluent Treatment Plant (ETP). This small but vital component is responsible for the precise injection of bleaching powder solution (calcium hypochlorite) into the treated wastewater stream. The pump operates on a 230V single-phase supply, drawing approximately 1.5-2 amps during normal operation, and is currently protected by a 10A miniature circuit breaker (MCB) in the control panel. The dosing mechanism typically consists of a diaphragm or peristaltic pump design, which ensures accurate chemical metering even at low flow rates. The system may incorporate either manual control or an automated timer circuit to regulate the chlorine dosing based on effluent flow rates.

- 0.25 HP (≈ 0.18 kW), Single-phase (230V)
- Full Load Current: ~1.5-2A
- Protection: 10A MCB (oversized but common for small pumps)
- Control: manual switch

Effects of Non-Functional Dosing Pump

1. Bacterial Survival in Treated Water →
   - Risk of pathogen discharge (non-compliance with health regulations).
   - Increased fecal coliform levels in effluent.
2. Poor Disinfection →
   - Algae & biofilm growth in outlet channels.
   - Bad odor due to untreated organic matter.
3. Regulatory Violations →
   - Failed water quality tests (if chlorine residual is too low).
   - Possible fines or shutdown orders from pollution control boards.

Why the Pump is Not Running? (Possible Causes)

Electrical Issues:

- Tripped 10A MCB (check for short circuits).
- Burnt motor windings (test with multimeter).
- Faulty power supply (verify 230V at terminals).

Mechanical Issues:

- Clogged dosing line (bleaching powder can solidify).
- Seized piston/diaphragm (due to lack of lubrication).
- Blocked suction
  filter

2. Corrective Measures

- Replace 10A MCB with 6A (better protection for 0.25 HP motor).
- Test continuity of windings (no open/short circuit).
- Manually rotate motor shaft (check if seized).
- Use anti-clogging additives (if bleaching powder hardens).

1.d. Horizontal Feed Pump for Activated Carbon Filtration

Description & Function

The horizontal feed pumps (three units, 5 HP each) only 2 are in running condition, transfer treated wastewater from the final settling tank to the activated carbon filter tank, where remaining dissolved impurities are adsorbed. These centrifugal pumps operate in parallel to ensure continuous flow through the filtration system.

- **Motor Specifications:**
  - 5 HP, 3-phase (415V), ~7A full load current per motor
  - Starter: DOL (Direct-On-Line)
  - Protection:
    - 32A MCB (oversized, should be 16-20A)
    - 20A fuse (acceptable)
  - Pump Type: Horizontal end-suction centrifugal
- **Key Role:**
  - Maintains **consistent flow rate** for proper carbon filtration.
  - Ensures **optimal contact time** between wastewater & activated carbon.
  - Prevents **dry running** of the filter system

Current Electrical Setup Analysis

32A MCB is too large (should be 16-20A for 5 HP motor).
DOL starter is standard but lacks advanced protection features.

Recommended Solutions & Actions

1. Electrical Improvements

a.Replace 32A MCB with 16-20A (properly sized for 5 HP).

b. Install Third Pump to restore design capacity
c. Upgrade to a Star-Delta Starter (if frequent starts are needed).
d. Install Thermal Overload Relay (set to ~7A per motor).

2. Operational Optimization

a. Alternate Pump Usage – Extends motor life by reducing continuous load.
b. Install Flow Sensors – Detect low flow/pump failure automatically.

1.e. DWPE Dosing Pump System for Sludge Recirculation

DWPE (Digested Wastewater Processing Equipment) dosing pump is an essential component of the sludge management system in the effluent treatment plant (ETP). Its primary function is to recirculate sludge from the equalization tank and segmented aeration tank back into the treatment process for further biological breakdown.Current

Configuration The DWPE (Digested Wastewater Processing Equipment) dosing pump is a critical component in sludge:

Current Configuration:

- Motor: 1 HP, 3-phase (415V), ~2A full load current
- Starter: DOL (Direct-On-Line)
- **Protection:**
    - 32A MCB (oversized, should be 6-10A)
    - 20A fuse (acceptable but could be optimized)
- **Control**:
    - Level sensor (non-functional) → Currently manual operation under operator supervision
    - Manual start/stop based on visual sludge level checks

Impacts of Non-Functional Level Sensor & Improper Electrical Setup

1. Operational Challenges

- Manual Dependency:
    - Operators must physically check sludge levels, leading to:
        - Inconsistent recirculation rates
        - Risk of over-pumping or under-pumping
        - Increased labor costs
- Sludge Thickening Issues:
    - Improper recirculation → Sludge stratification (thicker at bottom, watery at top)
    - Potential pump clogging from over-concentrated sludge

2. Electrical Risks

- 32A MCB is dangerously oversized for a 1 HP motor:
    - Will not trip during winding faults or minor overloads

Recommended Solutions & Upgrades

- Repair/Replace Level Sensor
- Replace 32A MCB with 6A (Type D for motor starting)
- Retain 20A fuse (or downgrade to 10A for better protection)
- Programmable Logic Controller (PLC) for timed dosing

1.e. Sludge Pump System for Filter Cake & Wet Cake Processing

The sludge pumps (two units, 3 HP each) are designed to handle dosed sludge from the treatment process and facilitate filter cake formation and wet cake correction. These pumps play a crucial role in the dewatering stage, transferring thickened sludge to filter presses, centrifuges, or drying beds for final solids separation.

System Description & Function

- **Motor Specifications:**
  - 3 HP, 3-phase (415V), ~5A full load current per pump
  - Starter: DOL (Direct-On-Line)
  - Protection:
    - 32A MCB (oversized, should be 10-16A)

        - 20A fuse (acceptable but could be optimized)

- **Operational Role:**
    - Pump concentrated sludge to dewatering equipment
    - Maintain proper sludge consistency for optimal cake formation
    - Prevent clogging in downstream filter systems

Current Status & Performance

Both pumps operational
Manual control (no auto-alternation between pumps)
Potential electrical risks due to oversized MCB

Potential Risks & Improvement Opportunities

1. Electrical Protection Issues

- 32A MCB is too large (does not provide adequate motor protection)
- 20A fuse may not prevent minor faults from escalating

2. Operational Concerns

- No duty-standby rotation → Uneven wear on pumps
- Risk of overpressure if both pumps run simultaneously

Recommended Upgrades & Maintenance

1. Electrical Corrections

Replace 32A MCB with 16A (proper protection for 3 HP motor)

Add thermal overload relay (set to ~5A)

1.e. Sludge Feedback Pump System for Recirculation

System Description & Function

The sludge feedback pump serves as a critical component in the wastewater treatment process, specifically designed to maintain process efficiency through controlled sludge recirculation. This 3 HP pumping system is designed to return settled biological sludge from secondary clarifiers back to the equalization tank, creating a continuous treatment loop that enhances overall plant performance.

System Description & Function

- Prevention of sludge accumulation in settling tanks
- Maintenance of optimal MLSS (Mixed Liquor Suspended Solids) concentration

Current Configuration:

- Motor: 3 HP, 3-phase (415V), ~5A full load current
- Starter: DOL (Direct-On-Line)
- Protection:
  - 32A MCB (oversized, should be 10-16A)
  - 20A fuse (acceptable but not ideal)
- Status: Non-functional (causing sludge buildup in clarifiers)

The sludge feedback pump is not operating ,Due to the non-functional sludge feedback pump (3 HP motor), untreated sludge is bypassing the treatment process and being discharged directly into the river. This uncontrolled release introduces highly concentrated pollutants—including toxic heavy metals, pathogenic bacteria, and organic waste—into the waterway. The sludge's high biochemical oxygen demand (BOD) depletes dissolved oxygen, suffocating aquatic life, while suspended solids cloud the water and settle as hazardous sediment. Without immediate repair of the feedback pump system (including correction of the oversized 32A MCB and faulty starter), this violation compromises regulatory compliance, risks severe ecosystem damage, and exposes downstream communities to contaminated water supplies. Urgent intervention is required to restore proper sludge recirculation to the equalization tank and prevent further environmental harm.

Critical Recap: Why the Failed Sludge Pump Must Be Repaired

1. Environmental & Legal Consequences

- River Pollution:
    - Untreated sludge contains toxic heavy metals (Pb, Hg, Cd), pathogens, and organic pollutants.
    - Kills aquatic life due to oxygen depletion (sludge has extremely high BOD/COD).
    - Violates EPA/CPCB standards → Risk of heavy fines or criminal charges.
- **Public Health Crisis:**
    - Contaminated river water spreads cholera, dysentery, and skin diseases.
    - Long-term exposure to heavy metals causes cancer, organ damage.

2. Treatment Plant Breakdown

- Loss of Active Biomass:
    - Sludge not recycled → Aeration tank microbes starve → Biological treatment fails.
- **Clogged Systems:**
    - Raw sludge hardens in pipes/filters → costly unclogging repairs.

3. Financial & Reputational Risks

- Regulatory fines (up to ₹1 crore+).
- Plant shutdown orders until compliance is proven.

Urgent Solutions Required

1. Restore Pump Functionality:
    - Replace: Faulty starter contacts/overload relay.
    - Downgrade 32A MCB → 10A Type D (proper motor protection).

1. Install Redundancy:
   - Add a standby pump (3 HP) with auto-changeover.
2. Automate Controls:
   - Sludge depth sensors sensors + PLC to auto-adjust recirculation.

CONCLUSION

The internship study at Manipal Teaching Hospital provided critical focus into the hospital's electrical infrastructure and effluent treatment systems. The analysis revealed a robust yet aging power distribution network, with a well-structured hierarchy of grid supply, diesel generators, and bus-coupling mechanisms to ensure uninterrupted power for critical loads. However, significant vulnerabilities were identified in the **Effluent Treatment Plant (ETP)**, where improper motor protection, non-functional pumps, and manual control dependencies threaten treatment efficiency and regulatory compliance.

Key findings include:

1. **Electrical Protection Flaws**: Oversized MCBs (e.g., 32A for 1–3 HP motors) and mismatched fuses (20A for high starting currents) risk motor burnout and system failures.
2. **ETP Operational Risks**:
   - Non-functional pumps (sludge feedback, dosing) directly discharge untreated sludge into water bodies, violating environmental regulations.
   - Overloaded aeration pumps (only 1 of 2 operational) degrade biological treatment efficiency, causing sludge bulking and odor issues.
   - Manual sludge level monitoring due to faulty sensors increases human error and labor costs.
3. **Load Management Gaps**: Phase imbalance in distribution panels and lack of redundancy in critical pumps heighten operational risks.

The ETP's role in neutralizing hazardous waste, including pharmaceutical residues and pathogens, is vital for environmental safety and public health. Addressing its electrical and mechanical shortcomings is urgent to prevent legal penalties (exceeding ₹1 crore annually) and ecological damage.

RECOMMENDATIONS

1. Electrical System Upgrades

- **Motor Protection**:
  - Replace oversized MCBs with correctly rated devices:
    - **1–3 HP motors**: 6–16A MCBs (Type D for inrush tolerance).
    - **5–10 HP motors**: 16–32A MCBs.
  - Upgrade fuses to match starting currents (e.g., 25–32A for 10 HP motors).
  - Install **thermal overload relays** calibrated to motor full-load currents.
- **Automation**:
  - Integrate PLCs with float switches, timers, and sludge density sensors for auto-control of pumps.
  - Add SCADA systems for real-time monitoring of ETP parameters (pH, DO, sludge levels).

2. ETP-Specific Improvements

- **Sludge Feedback Pump (3 HP)**:
  - Immediate repair: Test windings, replace faulty DOL starter, and downgrade 32A MCB to 10A.
  - Install a **standby pump** with auto-changeover to ensure redundancy.
- **Aeration Pumps (10 HP)**:
  - Restore the non-functional pump; balance load between both units.
  - Replace 20A fuses with 32A to handle starting currents.
- **Dosing Pump (0.25 HP)**:
  - Clear clogged lines; replace 10A MCB with 6A for better protection.
  - Install timer-based automation to regulate chlorine dosing.
- **Horizontal Feed Pumps (5 HP)**:
  - Replace 32A MCBs with 16A; add flow sensors to prevent dry running.
  - Install the missing third pump to restore design capacity.