REPORT ON ENERGY AUDIT

VANESA COSMETICS PVT LTD

INDUSTRIAL AREA, AKBARPUR BAROTA, SECTOR 42, SONIPAT, HARYANA 131104

PERIOD OF STUDY: NOVEMBER 2024

REPORT PREPARED BY:

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We sincerely thank **Mr Chandrakant Rao**, **GM, Mr Himanshu Parashar** & **Mr Govind Shukla**, and the engineering staff for their keen interest in and cooperation in conducting the energy audit.

We are deeply grateful for the helpful attitude and unwavering cooperation of all technical staff who rendered their valuable assistance during the Audit. The support extended by the facility's staff has been instrumental in the success of our study.

The audit team comprised of the following officers from SGS:

Name	Designation
Mr. Vibhu Wadhwa	Team Leader – Energy Audits
Mr. Aaryan Puru Jindal	Sr. Manager – Energy Audits
Mr. Lokesh Fagna	Engineer – Energy Audits
Mr. Arjun Sharma	Engineer – Energy Audits

WORK METHODOLOGY

Assessment of the Current Operational Status and Energy Savings included the following:

Discussions with the unit's concerned officials to identify significant areas of focus and related systems detailing the current operating status and the challenges faced for smooth operations.

A team of professionals visited the plant and discussed the load distribution and energy consumption pattern with the concerned officials/ supervisors to collect data/ information. The data was analysed to evaluate the specific power consumption and to arrive at a baseline energy consumption pattern.

Using appropriate instruments, including continuous and/ or time-lapse recording and appropriate visual observations, measurements and monitoring were made to identify the system's energy usage pattern and losses.

Computation and in-depth analysis of the collected data, including analysis and other techniques as appropriate, were used to evolve suitable energy conservation plans for improvement to reduce Specific Energy Consumption.

INSTRUMENTS USED FOR ENERGY AUDIT

1. Power & Harmonics Analyzer –Alm-36

The **KRYKARD ALM 36** is a sophisticated **Power and Harmonics Analyser** designed to comprehensively analyse and monitor electrical systems. It enables users to measure critical electrical parameters such as voltage, current, power, power factor, and frequency across three phases. Equipped with advanced harmonic measurement capabilities, the ALM 36 identifies harmonic distortions up to the 50th order, helping diagnose issues caused by non-linear loads.

2. Ultrasonic Water Flow Meter-TUF2000H

A handheld ultrasonic flow meter was designed to measure the flow of liquids in closed pipes. It uses the **transit-time principle** to provide highly accurate and non-invasive flow measurements. Using ultrasonic transit clamped on the pipe to the external se pipe, the TUF-2000H measures the time difference between ultrasonic pulses travelling with and against the flow, allowing it to calculate the flow rate without interrupting the process.

3. Thermography Camera –Bosch GTC 400

A **thermography camera**, also known as an **infrared camera** or **thermal imaging camera**, is a device that captures images based on infrared radiation (heat) emitted by objects. Unlike standard cameras that capture visible light, thermography cameras detect temperature variations and convert them into visual representations, called thermo grams, where different temperatures are displayed in a colour gradient.

4. **Temperature Gun:** A **temperature gun**, also known as an **infrared** or **IR thermometer**, is a handheld device that measures surface temperatures from a distance without physical contact. It works by detecting infrared radiation emitted by an object and converting it into a temperature reading. Temperature guns are commonly used in various industries and everyday applications to assess temperatures quickly when direct contact is impractical or unsafe.

5. **Anemometer**

   An **anemometer** is a device used to measure wind speed and, in some cases, wind direction. It is commonly used in meteorology, environmental studies, HVAC systems, and various industrial applications to monitor airflow. The most recognisable type of anemometer features rotating cups or blades that capture the wind and translate its speed into a readable value.

6. **Hot Wire Anemometer**

   A **hot wire anemometer** is a device used to measure fluid flow velocity, typically air, by detecting changes in temperature on a heated wire exposed to the flow. The principle behind this instrument is based on the cooling effect of air or gas as it passes over the thin, electrically heated wire. As the flow increases, the wire cools down more rapidly, and the device adjusts the current to maintain a constant wire temperature. The anemometer can calculate the airflow velocity by measuring the electrical current needed to keep the wire's temperature.

7. **Flue Gas Analyser - Optima 7 MRU Air Fair**

   The **Optima 7 MRU Air Fair** is a high-performance **flue gas analyser** designed for precise measurement and analysis of combustion gases in industrial and commercial heating systems. It is primarily used to optimise combustion efficiency, monitor emissions, and ensure compliance with environmental regulations. The device is equipped with advanced sensors to measure various gases such as oxygen (O_2), carbon monoxide (CO), nitrogen oxides (NOx), and other combustion-related parameters, making it ideal for applications involving burners, engines, and other combustion equipment.

SUMMARY OF ENERGY AUDIT RECOMMENDATIONS

Below is a concise **SUMMARY OF THE ENERGY AUDIT RECOMMENDATIONS** in tabulated form, covering each chapter's key findings and proposed improvements. The table includes the chapter name, system, current situation, recommendations, expected impact, and approximate figures for energy savings, monetary savings, investment, and payback.

CHAPTER NAME	SYSTEM	CURRENT SITUATION	RECOMMENDATIONS	IMPACT	ENERGY SAVING POTENTIAL	MONETARY SAVING POTENTIAL	TENTATIVE INVESTMENT	PAYBACK
ELECTRICAL SYSTEM	**PF & Harmonics, Capacitor Banks, Earthing**	- PF ~0.90, Harmonics ~15% (vs. 8% IEEE limit) - Multiple derated/non-functional capacitors - Earthing resistances above 2 Ω in some panels - Load imbalance in feeders	- Install de-tuned reactors & 525 V-rated capacitors - Improve earthing rods/connections - Balance loads & address high-current feeders - Strengthen APFC settings	- Near-unity PF & reduced harmonic distortion - Lower energy losses & equipment stress - Safer earthing & compliance with standards	~10% of annual consumption (e.g., 75,928 kVAh)*	~₹5,04,927/year*	~₹2,50,000 (Capacitors + Reactors)	~0.5 years (~6 months)
COMPRESSED AIR SYSTEM	**4 KAESER Compressors**	- The specific CFM/kW below is rated for Comp. #2 & #4 - Over-	- Install VFDs & intelligent controls - Optimize pressure setpoints & usage - Leak detection &	- Up to 20% energy savings - Lower operating	~67,860 kWh/year	~₹6,91,487/year (at ₹10.19/kWh)	~₹14,65,000 (VFDs + Controls)	~2.12 years

		pressurization (8.5 bar vs. 8 bar needed) - Intermittent load fluctuations	repair - Sequence compressors by efficiency	pressures & reduced idle running - Extended compressor life & improved reliability				
AIR HANDLING UNITS (AHUs)	**DX Coil AHUs & Outdoor Units**	- Missing/ non-functional outdoor units (AHU-1 & 4) - Dusty/damaged filters, motor vibration in AHU-3 - No VFDs, limited monitoring	- Repair/replace non-functional units - Clean/replace filters, fix belts & motor vibration - Install/repair VFDs, gauges, actuators - Set up preventive maintenance	- Restored cooling capacity & efficiency - Lower power draw via VFD speed control - Better indoor air quality & reduced downtime	~20% reduction (e.g., 14,900 kWh/year)	~₹1,51,831/year (at ₹10.19/kWh)	~₹3,00,000 (VFDs + Overhauls)	~2.0 years
FIRE PUMPS	**Jockey Pump & Hydrant Pump**	- Jockey Pump consuming ~19.89 kW vs rated 10 kW - Hydrant Pump at 67.25 kW vs. rated 45 kW - Both operating	- Overhaul pumps & correct mechanical issues - Consider VFD or IVS-based pumps - Check pump sizing & pipeline restrictions	- Significant reduction in excessive load - Lower power consumption & improved reliability - Prevent	~14,700 kWh/year (42 kW/day × 350 days)	~₹1,49,793/year (at ₹10.19/kWh)	~₹1,20,000 (Overhaul + VFD)	~0.8 years (~10 months)

		above the design load		pump overheating & breakdowns				
BUILDING ENVELOPE	**400 kW Solar PV, Insulation, Roofing**	- 400 kW rooftop PV partially reduces heat gain - Potential for more solar coverage - High cooling loads due to solar radiation	- Expand PV capacity (e.g., +100 kW) - Reflective/cool roof coatings - High-performance glazing & shading devices	- Increased clean energy generation - Lower building heat load & reduced HVAC usage - Enhanced comfort & sustainability	~1,40,000 kWh from PV + 3,725 kWh HVAC saving	~₹1,80,600/year (combined)*	Depends on PV scale & roof upgrades	Varies (1–3 years)
BOILER SYSTEM	**Revomax Packaged Steam Generator**	- Operating near design (85–88% efficiency) - Proper water treatment, minimal scaling - Minor scope for immediate efficiency gains	- Fine-tune burner (1–2% efficiency gain) - Maintain rigorous water treatment - Continue preventive checks & calibrations	- Slight fuel savings (0.5–1 L/day) - Sustained compliance & equipment longevity	~175–350 L diesel/year saved	~₹15,750–₹31,500/year (at ₹90/L)	Minimal (maintenance & tuning)	~1 year or less
EFFLUENT TREATMENT PLANT	**5 KL ETP**	- Reuses treated water for landscaping - Satisfactory performance,	- Continue monitoring inlet/outlet parameters - Optimise chemical dosing, aeration rates	- Maintains compliance, saves freshwater - Minor	~5–10% blower/pump savings (~200 kWh/year)	~₹2,038/year + ₹75,000 (water reuse)	Minimal (VFDs or minor upgrades)	<1–2 years (primarily water savings)

		stable outlet parameters - Low risk of non-compliance	- Maintain a preventive maintenance schedule	blower/pump efficiency improvements - Reduced water procurement costs				
ELECTRICAL THERMAL IMAGING	**Switchgear, Panels, Bus Bars**	- All panels & connections at normal temperature - No abnormal hotspots detected	- Continue periodic thermography - Tighten connections regularly - Ensure proper cable sizing & load balancing	- Avoid future failures & downtime - Indirect energy savings via lower resistive losses - Prolonged equipment lifespan	1–2% potential in reduced losses	~₹50,950/year for 1% of 500,000 kWh load	Minimal (maintenance tools & labour)	Indirect / Ongoing

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Notes:

- **Energy/Monetary savings** and **investment costs** are approximate and may vary based on actual site conditions and the scope of each upgrade.
- **Payback periods** are based on indicative annual savings divided by the estimated investment. Real-world figures depend on equipment prices, installation complexity, and operational patterns.
- *The electrical system's PF/harmonic improvements and the additional power factor corrections (e.g., for AHUs or Chiller 2) can overlap, meaning overall facility savings must be evaluated holistically.*

This table provides an at-a-glance summary of the significant audit recommendations, helping stakeholders prioritise upgrades and plan for energy efficiency investments.

Below is a **summarised version** of the energy audit recommendations, showing each chapter's main improvement areas, approximate annual monetary savings, indicative investment costs, and payback periods.

SHORT SUMMARY OF ENERGY AUDIT RECOMMENDATIONS

Chapter & System	Recommendations	Annual Monetary Savings (₹/year)	Approx. Investment (₹)	Payback (Years)
Electrical System *(PF & Harmonics, Capacitor Banks, Earthing)*	- Install de-tuned reactors & 525 V capacitors - Improve earthing & balance loads - Strengthen APFC	**5,04,927**	2,50,000	~0.5
Compressed Air System *(4 KAESER Compressors)*	- Add VFDs & intelligent controls - Optimize pressure setpoints - Leak detection & repair	**6,91,487**	14,65,000	~2.12
AHUs *(DX Coil, Outdoor Units)*	- Repair non-functional units (AHU-1,4) - Clean/replace filters, fix belts/motors - Install/repair VFDs & gauges	**1,51,831**	3,00,000	~2.0
Fire Pumps *(Jockey & Hydrant)*	- Overhaul pumps & address mechanical issues - Install VFDs/IVS - Check pump sizing	**1,49,793**	1,20,000	~0.8
Building Envelope *(400 kW Solar, Roofing)*	- Expand rooftop PV capacity (+100 kW) - Use reflective coatings/glazing	~1,80,600	Varies	1–3
Boiler System *(Revomax Steam Generator)*	- Fine-tune burner (1–2% gain) - Maintain robust water treatment	15,750–31,500	Minimal	~1 or less
ETP *(5 KL Effluent Treatment)*	- Optimize aeration/blower speeds - Continue water reuse (gardening)	~2,000–2,000+ + ₹75k water savings	Minor upgrades	<1–2

Electrical Thermal Imaging *(Panels, Cables)*	- Continue thermography & tighten connections - Maintain cable sizing & load balance	Indirect (1–2% load)	Minimal	Ongoing
Totals (Approx.)		**~17.0 lakh/year**	**~₹21–22 lakh**	**~1.2 years**

Notes:

1. **Building Envelope Savings** combine potential from additional PV (₹1.42 lakh) and 5% cooling load reduction (₹0.38 lakh).
2. **Totals** represent a ballpark figure by summing significant quantifiable savings from PF/harmonics, AHUs, compressed air, fire pumps, building envelope, and minor boiler/ETP measures.
3. **Approx. Investment** tallies the main system upgrades (capacitors/reactors, VFDs, etc.) but excludes some items (e.g., solar expansion or deep insulation retrofits) which vary widely in cost.
4. **Overall Payback** is indicative—actual values depend on which measures are prioritised, equipment pricing, and operational factors.

Annual Electricity Expense for Comparison

- **Estimated Annual Electricity Expense**: ~₹76.84 lakh (from the facility's 12-month data).
- **Potential Total Savings**: ~₹17.0 lakh/year.
- **Net Impact**: Up to ~22% reduction in annual electricity costs through recommended measures.

By implementing these priority actions, the facility can achieve substantial energy savings, lower operational costs, and improve reliability—all with an overall payback of one to two years.

STUDY OF ELECTRICAL SYSTEM

INTRODUCTION

The facility receives an 11-kV electrical supply from the grid, which is stepped down by a 1600 kVA transformer equipped with an On-Load Tap Changer (OLTC). Backup power is provided by a 500 kVA Diesel Generator (DG) set with Electronic Speed Protection (ESP) technology. The site also utilises a 400 kW on-grid solar power system for renewable energy generation. With a sanctioned demand of 1050 kVA, the facility manages its power factor using a capacitor panel totalling 300 kVAr in capacity.

State Electricity Board Billing Details

MONTH	PF	KWH	KVAH	SOLAR GENERATED UNITS IN KVAH	ENERGY CHARGES IN RS	SANCTIONED DEMAND KVA	DEMAND CHARGES	TOTAL BILL	RATE/UNIT WITH MSEDCL UNITS
YEAR 2023									
23-JAN	0.99	63920	64711.75	16860	6.65	401	67433.89	521504.37	8.06
23-FEB	0.98	59405	60498.63	15360	6.65	401	67433.89	489690.28	8.09
23-MAR	0.98	58115	59270.05	13800	6.65	401	60908.03	477566.44	8.06
23-APR	0.98	82510	83783.42	11940	6.65	401	67433.89	662662.48	7.91
23-MAY	0.99	88995	89850	12060	6.65	401	65258.61	920916.33	10.25
23-JUN	-				6.65	401			-
23-JUL	-				6.65	401			-
23-AUG	-				6.65	401			-
23-SEP	-				6.65	401			-
23-OCT	0.98	293000	298266	148512	6.65	401	263209.71	2500871.31	8.38
23-NOV	0.98	100000	101923	17520	6.65	1050	176572.54	945388.24	9.28
23-DEC	1.00	64000	64000	16200	6.65	1050	239227.31	725205.46	11.33
AVERAGE									**8.92**

MONTH	PF	KWH	KVAH	SOLAR GENERATED UNITS IN KVAH	ENERGY CHARGES IN RS	SANCTIONED DEMAND KVA	DEMAND CHARGES	TOTAL BILL	RATE/UNIT WITH MSEDCL UNITS
YEAR 2024									
24-JAN	1.00	90000	90000	14400	6.65	1050	199356.09	877959.21	9.76
24-FEB	0.98	82000	84000	14400	6.65	1050	153788.98	778147.84	9.26
24-MAR	0.95	40000	41905	15600	6.65	1050	96830.1	410182.83	9.79
24-APR	0.97	56000	57931	14400	6.65	1050	176572.54	615496.5	10.62
24-MAY	1.00	58000	58000	14760	6.65	1050	170876.65	609313.38	10.51
24-JUN	0.90	66000	73135	16800	6.65	1050	176572.54	726420.04	9.93
24-JUL	0.90	44000	49077	15600	6.65	1050	170876.65	536676.43	10.94
24-AUG	0.91	62000	67812	16200	6.65	1050	176572.54	677998.84	10.00
24-SEP	0.87	48000	55111	19320	6.65	1050	176572.54	585733.72	10.63
24-OCT	0.90	50000	55769	24120	6.65	1050	170876.65	585546.74	10.50
AVERAGE	**0.96**	**5,96,000**	**6,32,740**	**1,65,600**			**16,68,895**	**64,03,475**	**10.19**
FOR 12 MONTHS		**7,15,200**	**7,59,288**	**1,98,720**			**20,02,674**	**76,84,170**	
AVERAGE			**63,274**						

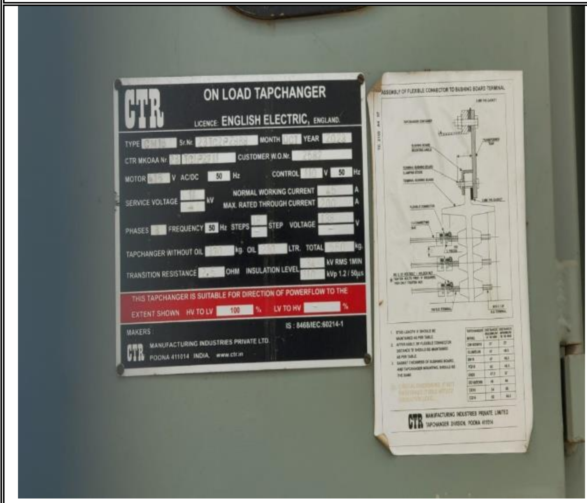
NOTE: *THE YEAR 2024 TAKEN IN CONSIDERATION FOR ALL THE CALCULATIONS IN THE REPORT.*

STUDY OF TRANSFORMER LOAD PROFILING

MEASUREMENT

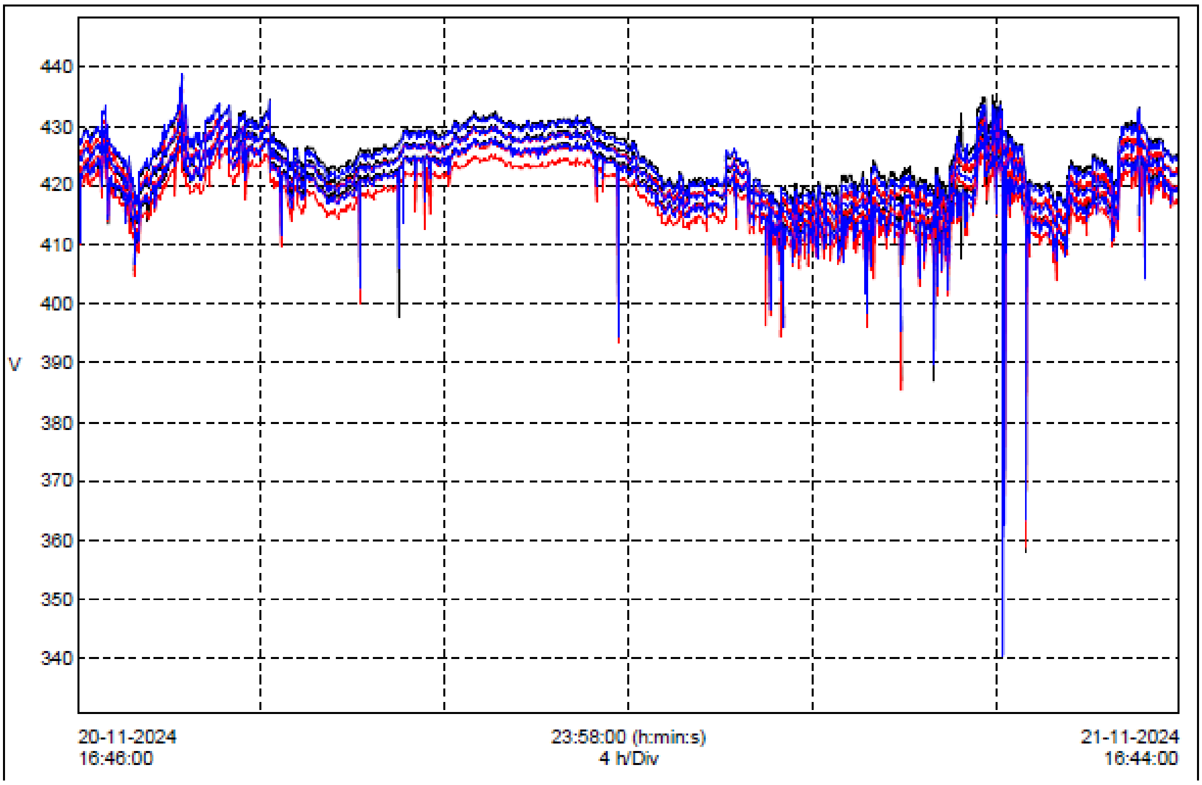
TRANSFORMER-1							
VOLTAGE	VTHD	CURRENT	ITHD	KW			PF
				MIN	AVG	MAX	
421.6	1.3	146.9	15.3	0	59	289	0.78

TRANSFORMER



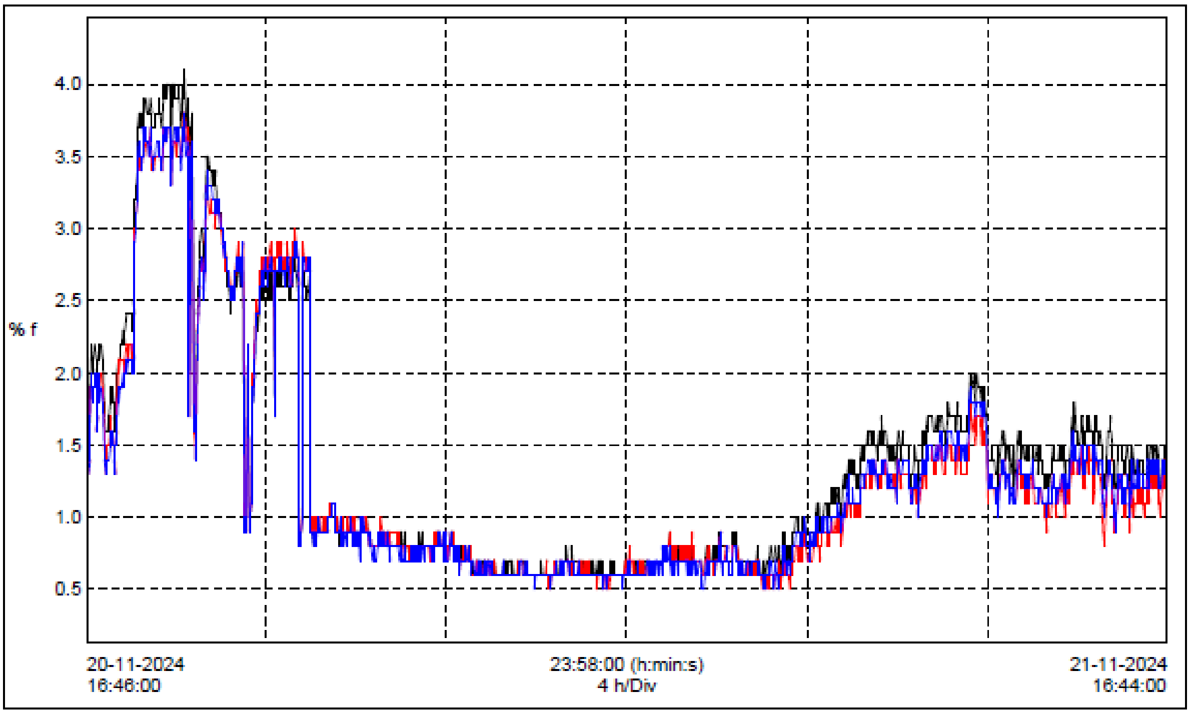
VOLTAGE

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
V1-2 RMS	20-11-2024	16:46:00	422.9	357.9	438.3	V	23:59:00	(h:min:s)
V2-3 RMS	20-11-2024	16:46:00	420.5	358.8	436.3	V	23:59:00	(h:min:s)
V3-1 RMS	20-11-2024	16:46:00	422.4	340.5	438.7	V	23:59:00	(h:min:s)



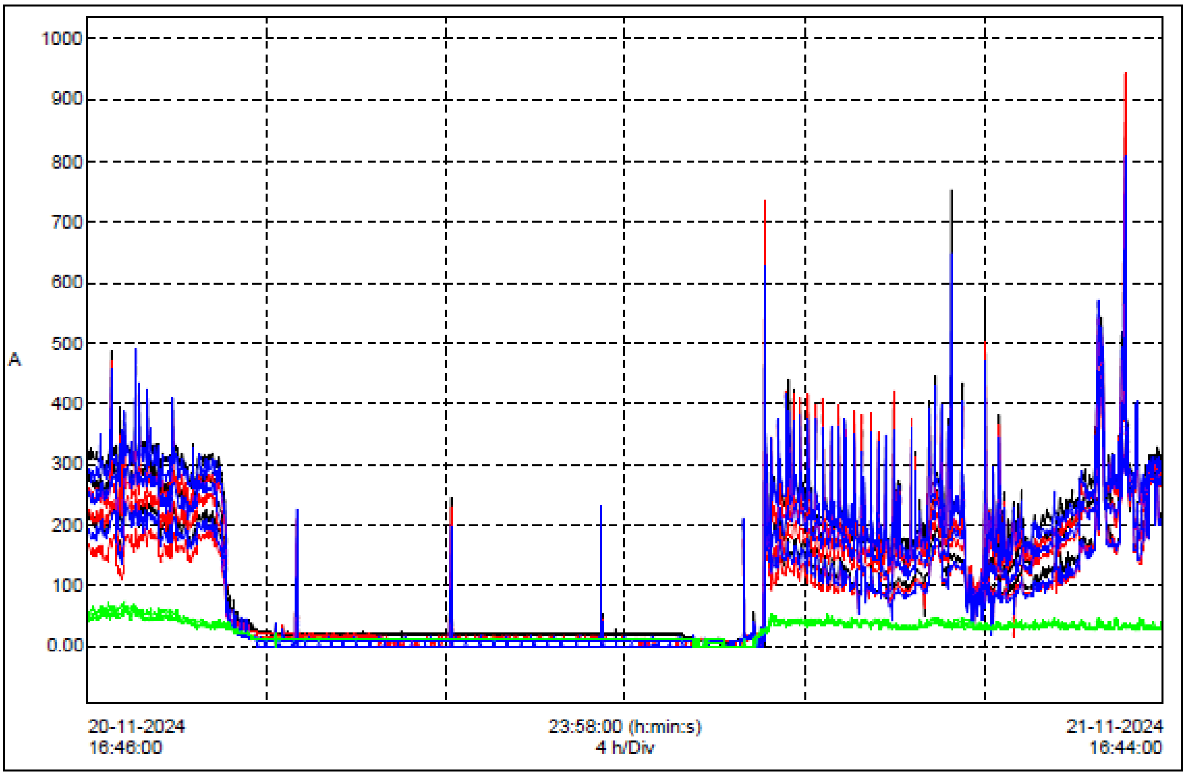
VOLTAGE THD

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
V1-2 THDf	20-11-2024	16:46:00	1.396	0.600	4.100	% f	23:59:00	(h:min:s)
V2-3 THDf	20-11-2024	16:46:00	1.286	0.500	3.800	% f	23:59:00	(h:min:s)
V3-1 THDf	20-11-2024	16:46:00	1.296	0.500	3.800	% f	23:59:00	(h:min:s)



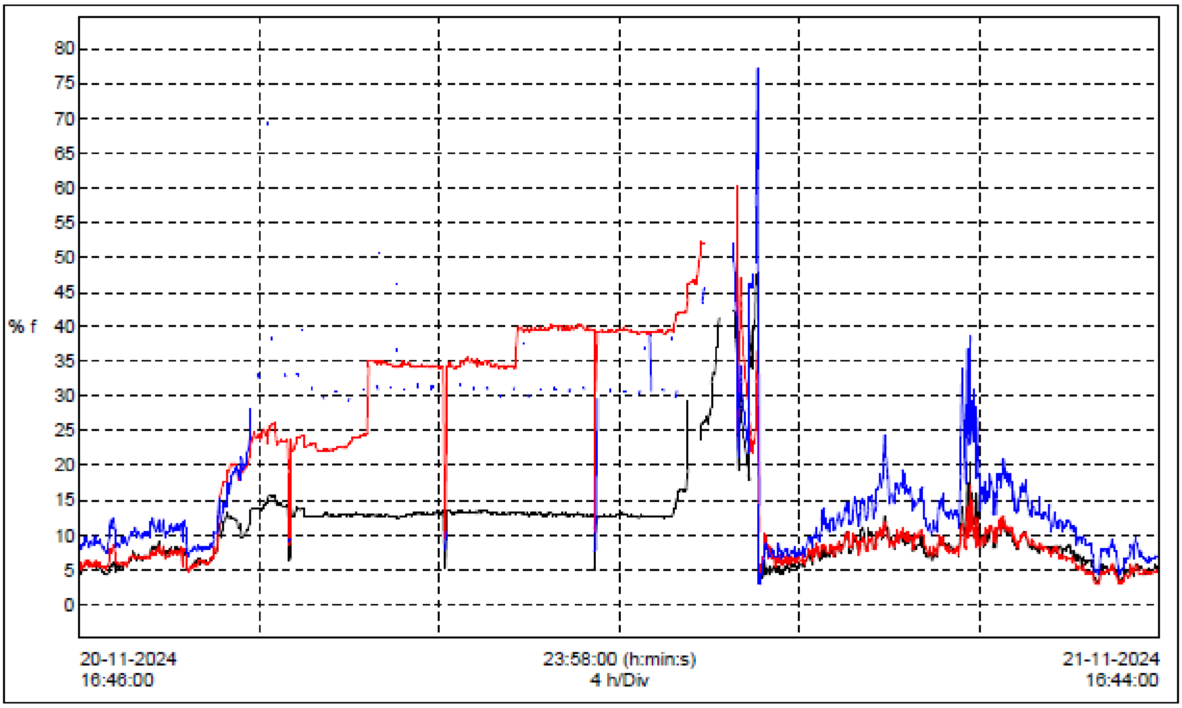
CURRENT

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
A1 RMS	20-11-2024	16:46:00	156.2	0.0	838.0	A	23:59:00	(h:min:s)
A2 RMS	20-11-2024	16:46:00	136.4	0.0	943.5	A	23:59:00	(h:min:s)
A3 RMS	20-11-2024	16:46:00	148.0	0.0	806.0	A	23:59:00	(h:min:s)
AN RMS	20-11-2024	16:46:00	28.66	0.0	73.90	A	23:59:00	(h:min:s)



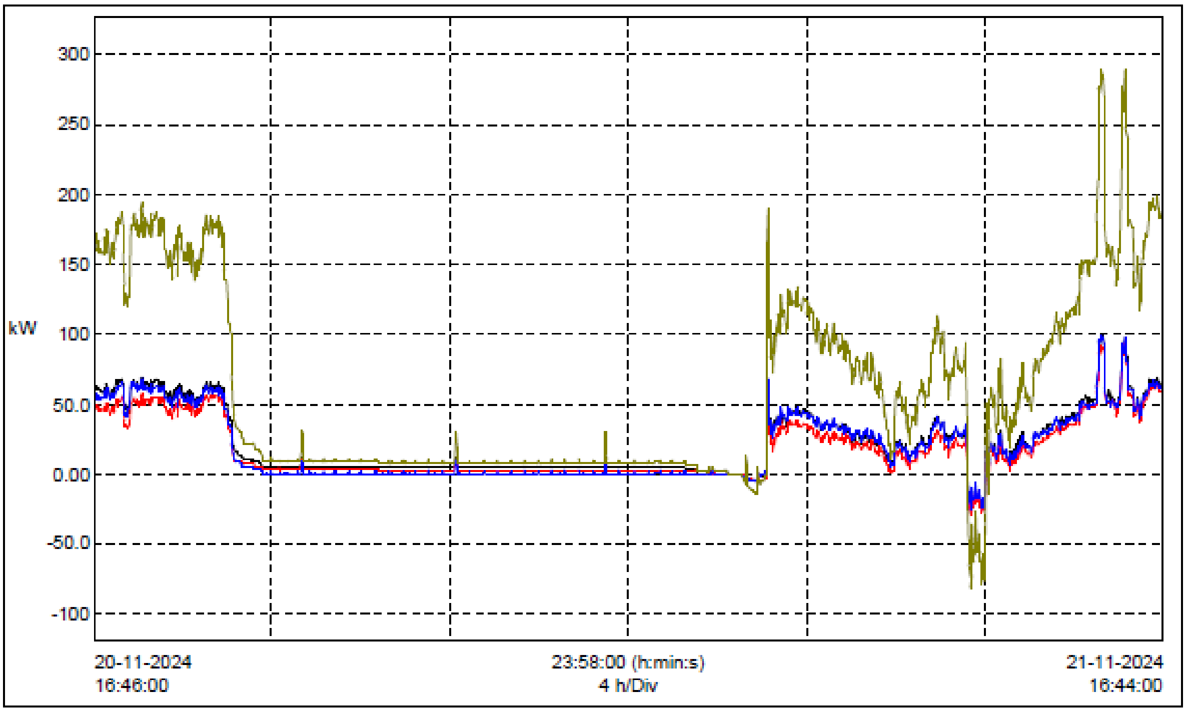
CURRENT THD

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
A1 THDf	20-11-2024	16:46:00	10.92	2.900	47.40	% f	23:59:00	(h:min:s)
A2 THDf	20-11-2024	16:46:00	19.86	2.900	60.10	% f	23:59:00	(h:min:s)
A3 THDf	20-11-2024	16:46:00	14.78	3.100	77.10	% f	23:59:00	(h:min:s)



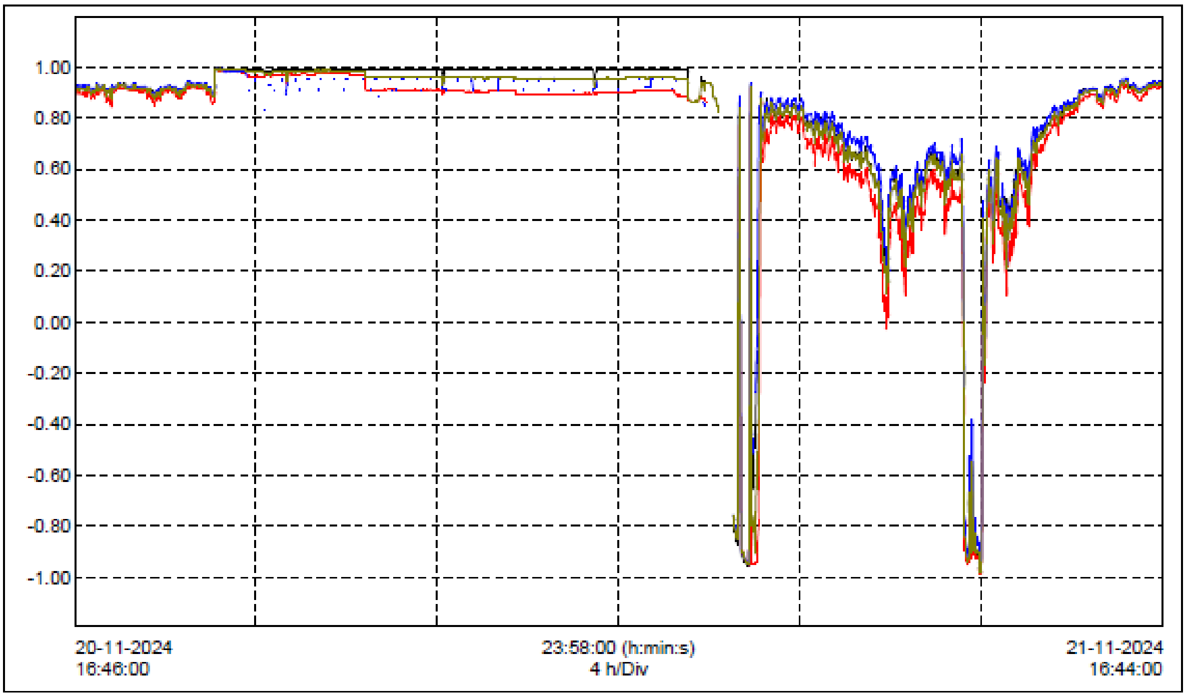
POWER (KW)

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
P1 (W)	20-11-2024	16:46:00	22.47	-27.35	99.14	kW	23:59:00	(h:min:s)
P2 (W)	20-11-2024	16:46:00	17.66	-29.28	94.36	kW	23:59:00	(h:min:s)
P3 (W)	20-11-2024	16:46:00	19.57	-25.24	98.32	kW	23:59:00	(h:min:s)
PT (W)	20-11-2024	16:46:00	59.70	-81.87	289.2	kW	23:59:00	(h:min:s)



POWER FACTOR (PF)

Name	Date	Time	AVG	MIN	MAX	Units	Duration	Units
PF1	20-11-2024	16:46:00	0.807	-0.989	0.993		23:59:00	(h:min:s)
PF2	20-11-2024	16:46:00	0.745	-0.991	0.985		23:59:00	(h:min:s)
PF3	20-11-2024	16:46:00	0.716	-0.973	0.993		23:59:00	(h:min:s)
PFT	20-11-2024	16:46:00	0.787	-0.985	0.990		23:59:00	(h:min:s)



ANALYSIS

The current harmonics trend, as recorded in the load profiling, states that the current harmonics shoot up to 15% during daytime operation, from 9 AM to 6 PM, which is a matter of concern. According to IEEE norms, the electrical network's current harmonics should not exceed 8 % during daily facility load operations.

OBSERVATIONS

- **Voltage Levels**: The average line-to-line voltages are slightly higher than the nominal voltage, with V1-2 RMS at 422.9 V, V2-3 RMS at 420.5 V, and V3-1 RMS at 422.4 V. However, there are significant voltage fluctuations, with minimum voltages dropping to as low as 340.5 V (V3-1 RMS) and maximum voltages reaching up to 438.7 V (V3-1 RMS).
- **Current Levels**: The average current readings are 156.2 A (A1 RMS), 136.4 A (A2 RMS), and 148.0 A (A3 RMS). The maximum currents are notably high, peaking at 943.5 A (A2 RMS). The neutral current (AN RMS) has an average of 28.66 A and a maximum of 73.90 A, indicating a significant imbalance in the system.
- **Voltage Total Harmonic Distortion (THD)**: The average voltage THD percentages are low, with V1-2 THD at 1.396%, V2-3 THD at 1.286%, and V3-1 THD at 1.296%. Maximum values remain below 5%, which is within acceptable industry standards.
- **Current Total Harmonic Distortion (THD)**: The average current THD percentages are relatively high—A1 THD at 10.92%, A2 THD at 19.86%, and A3 THD at 14.78%. Maximum THD values are exceedingly high, reaching up to 77.10% (A3 THD).
- **Power Consumption**: The average phase powers are 22.47 kW (P1), 17.66 kW (P2), and 19.57 kW (P3), with a total average power (PT) of 59.70 kW. Maximum total power peaks at 289.2 kW, while minimum total power dips to -81.87 kW, suggesting instances of power generation or regenerative loads.
- **Power Factor**: The average power factors are below optimal levels—PF1 at 0.807, PF2 at 0.745, PF3 at 0.716, and a total power factor (PFT) of 0.787. Negative power factors occur, with minimum values reaching as low as -0.991, indicating leading power conditions at times.

RECOMMENDATIONS

The harmonics mitigation system must be developed and strengthened to optimise the current harmonics within the limits. The APFC panel should include:

- **Load Balancing**: Redistribute single-phase loads evenly across all three phases to minimise current imbalance and reduce neutral current. Regularly monitor and adjust load distribution as necessary.
- **Harmonic Filtering**: Install harmonic filters (either passive or active) to mitigate high current THD levels. This will protect equipment from the adverse effects of harmonics and improve power quality.
- **Power Factor Correction**: Enhance the existing capacitor bank capacity and incorporate de-tuned reactors for harmonics filtering with a new capacitor with a design voltage of 525v to improve the power factor to near unity. This will reduce reactive power demand and lower utility charges.

ENERGY AND MONETARY SAVING POTENTIAL

Implementing de-tuned reactors for harmonic filtering and installing new capacitors rated at 525 V to replace the existing 300 kVAr capacitor bank is expected to reduce harmonic distortion levels from 15% to 8% and improve the power factor from 0.787 to 0.98. This enhancement will significantly improve the electrical system's efficiency, saving energy and cost.

Key Figures (Jan 2024 – Oct 2024)

Parameter	Value	Notes
Total kVAh Consumption (12 months)	632740 kVAh	The sum of monthly kWh from Jan–Oct 2024
Average Monthly Consumption	~63,274 kVAh/month	632740 kVAh ÷ 10 months
Annualised Consumption (Projected)	~759,288 kVAh/year	63,274 kVAh/month × 12 months
Total Demand Charges (10 months)	~₹1,668,895.28	The sum of monthly demand charges
Total Billing (10 months)	~₹6,403,475.53	The sum of monthly total bills
Approx. Electricity Tariff	₹6.65/kVAh (average)	Based on energy rates and billing

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Energy and Monetary Saving Potential

Parameter	Calculation/Assumption	Value
Baseline Annual Consumption	From annualised figure	~759,288 kVAh/year
Baseline Electricity Tariff	Given/Approximation	₹6.65/kVAh
Estimated Energy Savings (10% Reduction in Losses, PF has degraded to 0.9 in the year 2024)	10% of 759,288 kVAh/year = 75928.8 kVAh	75928.8 kVAh/year
Annual Monetary Savings (Energy)	75928.8 kVAh/year × ₹6.65/kWh	~₹5,04,926.5/year
Investment Cost (with de-tuned reactor)	400kVAr capacitors with de-tuned reactor	₹2,50,000
Payback Period	₹120,000 ÷ ₹112,700/year	~0.5 years (~6 months)

Notes:

- Achieving a near-unity power factor and reducing harmonics from 15% to 8% is expected to yield approximately 1% energy savings.
- The payback period of about one year indicates that the recommended interventions are highly cost-effective.

Additional Benefits

- **Improved Power Quality:** Reducing harmonic distortion from 15% to 8% enhances the reliability and efficiency of electrical equipment.
- **Extended Equipment Life:** Lower harmonic levels decrease thermal stress on equipment, potentially reducing maintenance costs and extending equipment lifespan.
- **Compliance with Utility Requirements:** Achieving a power factor near unity ensures compliance with utility regulations and avoids potential penalties.

STUDY OF CAPACITOR BANKS

MEASUREMENT

300 KVAR Capacitor Bank Deration Profile									
S. No.	**Capacitor Bank No**	**kVar**	**Unit**	**R**	**Y**	**B**	**Average Current**	**Rated Current**	**% Deration**
1	Capacitor Bank No-1	25	KVAR	17.6	16.4	1.8	11.9	32.75	63.56
2	Capacitor Bank No-2	25	KVAR	0	0	0	0.0	32.75	100.00
3	Capacitor Bank No-3	25	KVAR	0	0	0	0.0	32.75	100.00
4	Capacitor Bank No-4	25	KVAR	0	0	0	0.0	32.75	100.00
5	Capacitor Bank No-5	25	KVAR	0	0	0	0.0	32.75	100.00
6	Capacitor Bank No-6	25	KVAR	0	0	0	0.0	32.75	100.00
7	Capacitor Bank No-7	25	KVAR	28.8	29	28.6	28.8	32.75	12.06
8	Capacitor Bank No-8	25	KVAR	17.2	0	17.4	11.5	32.75	64.78
9	Capacitor Bank No-9	25	KVAR	0	0	0	0.0	32.75	100.00
10	Capacitor Bank No-10	25	KVAR	29.5	17.6	7.4	18.2	32.75	44.53
11	Capacitor Bank No-11	20	KVAR	0	0	0	0.0	26.2	100.00
12	Capacitor Bank No-12	15	KVAR	0	0	0	0.0	19.65	100.00
13	Capacitor Bank No-13	10	KVAR	0	0	0	0.0	13.1	100.00
14	Capacitor Bank No-14	5	KVAR	0	0	0	0.0	6.55	100.00

OBSERVATIONS

- **Underperforming Capacitor Banks**: Out of 14 capacitor banks totalling 300 kVAr:
  - **Capacitor Banks with Zero Current**: Banks No. 2, 3, 4, 5, 6, 9, 11, 12, 13, and 14 show zero current in all phases, indicating they are either switched off, disconnected, or faulty.
  - **Significant Deration**: Banks No. 1, 8, and 10 exhibit high deration percentages of 63.56%, 64.78%, and 44.53%, respectively.
  - **Optimal Performance**: Only Bank No. 7 is operating near its rated capacity with a deration of 12.06%.
- **Imbalance in Phase Currents**:
  - Several banks display uneven current distribution across the R, Y, and B phases.
    - For example, Bank No. 1 has phase currents R: 17.6 A, Y: 16.4 A, B: 1.8 A.
    - Bank No. 10 shows R: 29.5 A, Y: 17.6 A, B: 7.4 A.
- **Average Current vs. Rated Current**:
  - The average currents for most banks are significantly lower than their rated currents, leading to high deration percentages.
  - The rated currents are based on a design voltage of 440 V, but the actual operating voltage may differ.

ANALYSIS

- **Ineffective Power Factor Correction**:
  - The majority of the capacitor banks are not contributing to power factor correction due to being offline or underperforming.
  - This situation leads to a reliance on a smaller portion of the total installed capacity, reducing the effectiveness of the power factor correction system.
- **Capacitor Aging and Failure**:
  - Capacitor banks naturally degrade over time due to thermal stress, overvoltage, harmonics, and other operational factors.
  - High deration percentages suggest capacitors have lost capacitance, likely due to dielectric breakdown or other failures.
- **Impact of Harmonics**:
  - The presence of harmonics in the system can lead to overheating and premature failure of capacitors not designed to handle harmonic currents.
  - Standard capacitors (designed at 440 V) without de-tuned reactors are susceptible to damage in environments with high harmonic distortion.
- **Phase Imbalance Issues**:
  - Uneven current distribution among phases indicates potential issues with capacitor connections or internal failures.
  - Phase imbalance can exacerbate voltage imbalance in the system, affecting equipment performance.

RECOMMENDATIONS

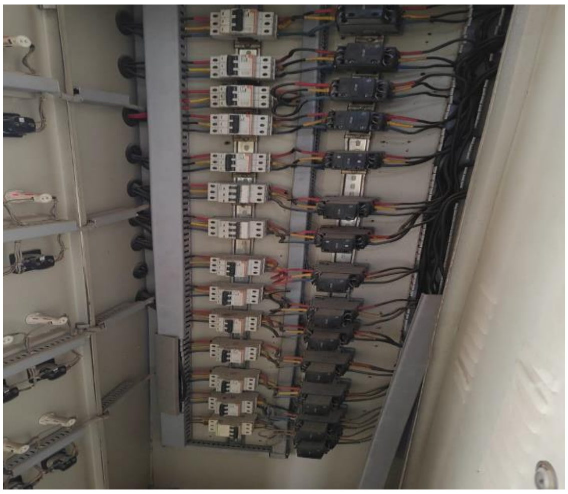
1. **Replace Defective Capacitor Banks**:
   - Replace non-functional capacitors (Banks No. 2, 3, 4, 5, 6, 9, 11, 12, 13, 14) with new units designed to handle the system's harmonic levels.
   - Consider capacitors with a higher voltage rating (e.g., 525 V) and de-tuned reactors to mitigate the effects of harmonics.
2. **Install De-tuned Reactors**:
   - Integrate de-tuned reactors with the capacitor banks to filter out harmonic frequencies, thereby protecting capacitors and enhancing their lifespan.
   - De-tuned reactors help prevent resonance conditions and reduce the risk of capacitor failure due to harmonics.
3. **Balance Phase Loads**:
   - Investigate and rectify the imbalance in phase currents by checking connections and properly configuring capacitors.
   - Regularly monitor phase currents to maintain balance and optimise power factor correction.
4. **Regular Maintenance and Monitoring**:

    - Implement a preventive maintenance schedule for capacitor banks, including periodic inspections, cleaning, and testing of capacitance values.
    - Power quality analysers monitor system parameters such as voltage, current, power factor, and harmonic levels.
5. **Upgrade Capacitor Bank Capacity if Necessary**:
    - Evaluate the reactive power demand of the facility to determine if additional capacitance is required to achieve a near-unity power factor.
    - Ensure the total installed capacitor capacity matches the reactive power compensation needs of the facility.
6. **Employee Training**:
    - Train maintenance personnel on the importance of power factor correction equipment and the proper procedures for inspection and replacement.

ENERGY AND MONETARY SAVING POTENTIAL

Considering that the investment in de-tuned reactors and new capacitors was already accounted for in the **Transformer Load Profiling** section, where the payback period and savings were calculated, the energy and monetary saving potential associated with replacing the faulty capacitor banks is inherently included in those previous calculations. Therefore, this chapter focuses on ensuring the effectiveness of the existing investment by addressing the non-functional and underperforming capacitor banks.

Note: By addressing the issues with the capacitor banks, the facility can ensure that the previously calculated energy and monetary savings are fully realised. This action is essential for the overall success of the energy efficiency measures implemented as part of the transformer load profiling and power quality improvement initiatives.

CAPACITOR BANKS	
	

LTCCD325B2	Increase life of capacitor by switching with MO C capacitor duty contactor Benefits of MO C: Reduced inrush current Safe shrouded design surge suppressor LTCCD325B2 Standard Duty 25 kVAr Power Capacitor Un Qn 50 Hz In 50 Hz 440 V 25.0 kVAr 32.9 Amp 415 V 22.3 kVAr 31.0 Amp 400 V 20.7 kVAr 29.9 Amp 3 X 137.5 µF 3 Phase SH MPP -25/D Case Max 65° C Ui 3/- kV NPCB IS:13340 IS 13340:2012 CM/L 0006700260 Sr. No: AEWC2500311 MADE IN INDIA 11.23 Warning: Wait 5 Minutes After Isolating Supply Before Handling

STUDY OF MAIN LT PANEL AND SUB-DISTRIBUTION PANEL LOAD PROFILE

The main LT panel feeders were measured through power analysers during the study to determine the operational electrical parameters. The details of the measurements are as follows:

MEASUREMENT

During the energy audit, power analysers were deployed to measure the operational electrical parameters of the feeders connected to both the Main LT Panel and the Sub Distribution Panels. The measurements captured include voltage (V), voltage total harmonic distortion (VTHD), current (I), current total harmonic distortion (ITHD), power consumption (kW), and power factor (PF).

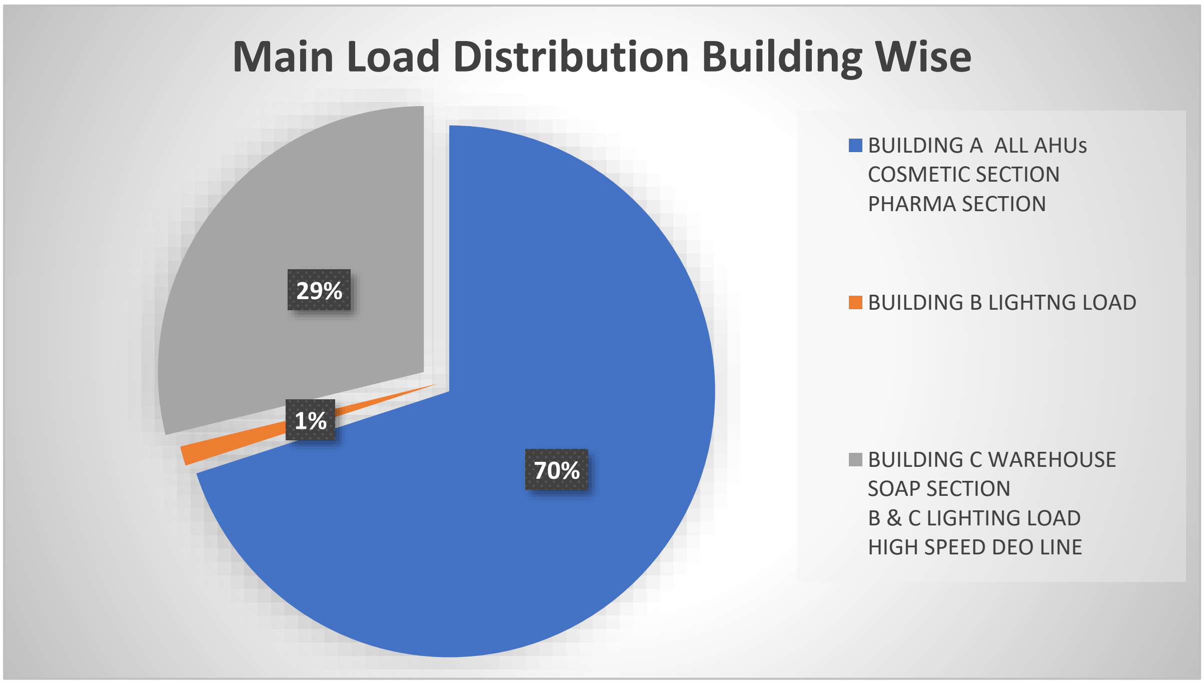
MAIN LT PANEL OLD FEEDERS LOAD PROFILE														
S. NO.	FEEDER NO	FEEDER DESCRIPTION	SWITCHGEAR TYPE	SWITCHGEAR RATING	ELECTRICAL LOAD PROFILE						POWER CABLE DETAILS			
					V	VTHD	I	ITHD	KW	PF	SIZE IN SQMM	NO OF CORE	NO OF CABLE	LENGTH
1	1F1	MAIN TR INCOMER	MCCB	1000	NO LOAD									
2	1F2	DG	MCCB	800	NO LOAD									
3	1F3	DG 125 KVA	MCCB	800	NO LOAD									
4	2F1	A BUILDING GROUND FLOOR, DEO, PERFUME, SECTION,1ST FLOOR PHARMA SECTION	MCCB	400	412	1.2	67.5	3.1	56.26	0.96	300	3.5	1	250
5	2F2	B&C BUILDING LIGHT PANEL			NO LOAD									
6	2F3	ALL COMPRESSOR MAIN	MCCB	630	414	1.7	211.5	3.5	134.7	0.88	300	3.5	1	275
7	3F1	A BUILDING 2ND FLOOR DB. ALL AHU & 2ND FLOOR ALL MACHINE & EQUIPMENT	MCCB	250	413	1.5	18	3.1	12.48	0.96	300	3.5	1	275
8	3F2	C BUILDING 1ST FLOOR FOR HIGH-SPEED DEO LINE	MCCB	200	421	1.3	82.2	1.7	60	0.99	185	3.5	1	170
9	3F3	SPARE												
10	3F4	OFFICE LIGHTING & 25 KVA UPS	MCCB	125	415	1.3	30	81	16.28	0.75	50	3.5	1	125
11	3F5	A BUILDING LIGHTING	MCCB	125	416	1.2	17.41	1.78	12.14	0.97	50	3.5	4	125

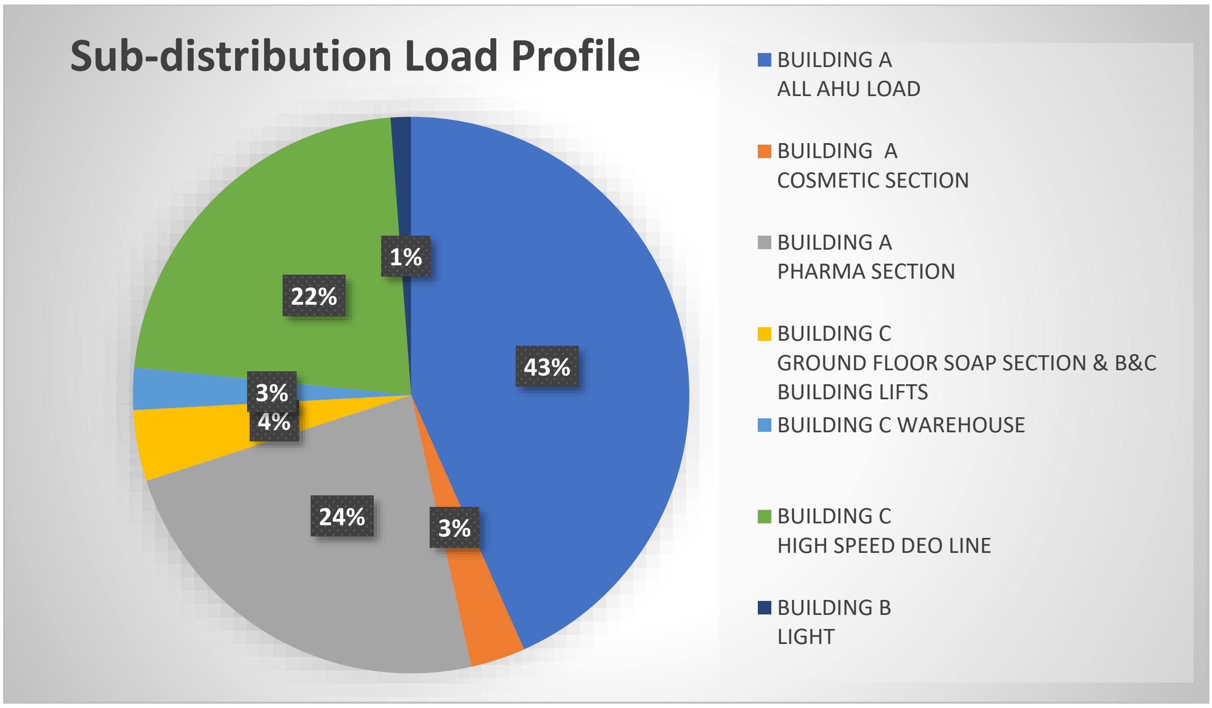
MAIN LT PANEL NEW FEEDERS LOAD PROFILE															
S. NO.	**FEEDER NO/ LOCATION**	**FEEDER DESCRIPTION**	**SWITCHGEAR TYPE**	**SWITCHGEAR RATING**	**ELECTRICAL LOAD PROFILE**						**POWER CABLE DETAILS**			
					V	**VTHD**	**I**	**ITHD**	**KW**	**PF**	**SIZE SQMM**	**NO OF CORE**	**NO OF CABLE**	**LENGTH**
1	1F1	METERING												
2	1F2	TR-1 INCOMER	ACB	1600							400	3.5	3	25
3	1F3	VACANT												
4	2F2	METERING												
5	2F2	DG 500 KVA	ACB								185	3.5	2	25
6	2F3	VACANT												
7	3F1	METERING												
8	3F2	DG SPARE	ACB											
9	3F3	VACANT												
10	4F1	VACANT												
11	4F2	VACANT												
12	4F3	VACANT												
13	4F4	VACANT												
14	4F5	VACANT												
15	5F1	VACANT												
16	5F2	FIRE PANEL	MCCB	200	415	1.9	135	1.8	86.23	0.91	150	3.5	1	200
17	5F3	VACANT												
18	5F4	LIGHTING B&C BUILDING BACKSIDE	MCCB	125	417	1.2	6.1	14.8	4.2	0.96	25	4	4	100
19	5F5	SPARE												
20	6F1	SPARE												
21	6F2	SPARE												
22	6F3	SOAP PLANT & WARE HOUSE	MCCB	250	417	1.2	4.3	3.1	25.19	0.95	185	3.5	1	200
23	6F4	SPARE												
24	6F5	SPARE												

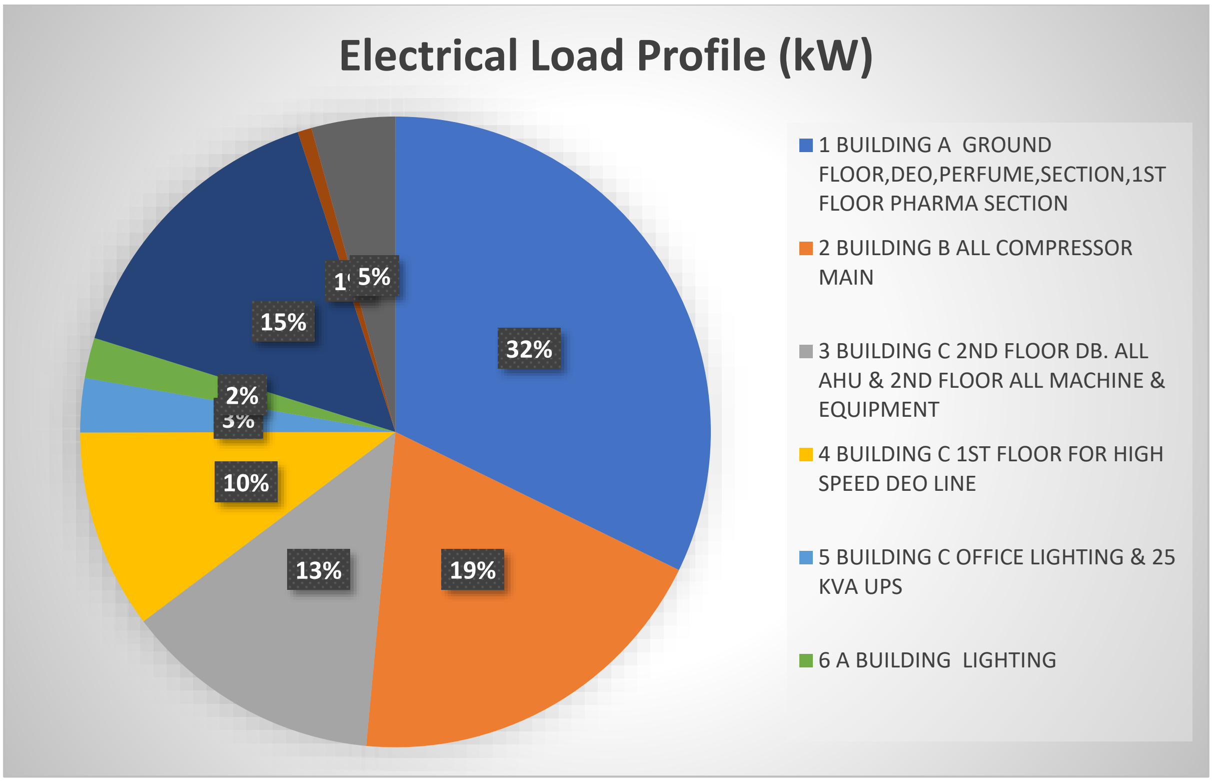
SUB DISTRIBUTION PANEL LOAD PROFILE							
S. NO.	**FEEDER DESCRIPTION**	**ELECTRICAL LOAD PROFILE**					
		V	**VTHD**	**I**	**ITHD**	**KW**	**PF**
1	A-BUILDING ALL AHU LOAD	403	1.1	219	2.1	117	0.8
2	A-BUILDING COSMETIC SECTION	417	1.4	12.1	2.4	8.6	0.97
3	A-BUILDING PHARMA SECTION	422	1.1	91.6	2.7	63.36	0.94
4	C-BUILDING GROUND FLOOR SOAP SECTION & B&C BUILDING LIFT	426	1.6	14.9	4	11.16	0.94
5	C-BUILDING WAREHOUSE	423	1.7	10.1	4.6	6.6	0.91
6	C-BUILDING HIGH-SPEED DEO LINE	421	1.3	82.2	1.7	60	0.99
7	B-BUILDING LIGHT	417	1.2	5	2.3	3.2	0.9

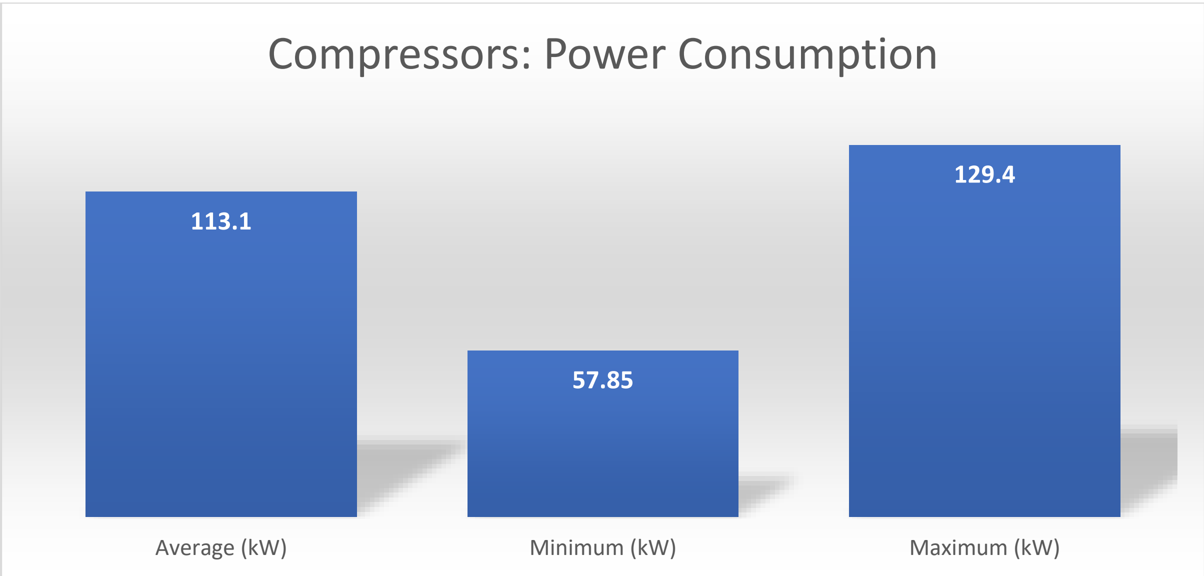
S. NO.	**FEEDER DESCRIPTION**	**AREA**	**ELECTRICAL LOAD PROFILE**
			KW
1	BUILDING A	ALL AHU, COSMETIC SECTION, PHARMA SECTION	188.96
2	BUILDING B	LIGHTING LOAD	3.2
3	BUILDING C	WAREHOUSE, SOAP SECTION, B &C LIGHTING LOAD, HIGH-SPEED DEO LINE	77.76
		TOTAL	269.92

ANALYSIS


Main Load Distribution Building Wise
29%
1%
70%
BUILDING A ALL AHUs
COSMETIC SECTION
PHARMA SECTION
BUILDING B LIGHTNG LOAD
BUILDING C WAREHOUSE
SOAP SECTION
B & C LIGHTING LOAD
HIGH SPEED DEO LINE


Sub-distribution Load Profile
1%
22%
43%
3%
4%
24%
3%
BUILDING A
ALL AHU LOAD
BUILDING A
COSMETIC SECTION
BUILDING A
PHARMA SECTION
BUILDING C
GROUND FLOOR SOAP SECTION & B&C
BUILDING LIFTS
BUILDING C WAREHOUSE
BUILDING C
HIGH SPEED DEO LINE
BUILDING B
LIGHT





- **Voltage Levels**
  - **Operating Voltage**:
    - Main LT Panel: Feeders under load have voltages ranging from 412 V to 421 V.
    - Sub Distribution Panels: Voltages range from 403 V to 426 V.
    - **Observation**: All voltages are within the acceptable range for a 415 V system.
  - **Voltage Total Harmonic Distortion (Vthd)**:
    - Both panels exhibit low Vthd values between 1.1% and 1.9%.
    - **Conclusion**: Good voltage quality, with Vthd well below the industry limit of 5%.

- **Current Levels and Load Distribution**
    - **High Current Feeders**:
        - **Main LT Panel**:
            - Feeder 2F3 (All Compressor Main): 211.5 A (33.6% of 630 A rating).
            - Feeder 5F2 (Fire Panel): 135 A (67.5% of 200 A rating), unusually high for a fire panel.
            - Feeder 3F2 (High-Speed DEO Line): 82.2 A (41.1% of 200 A rating).
    - **Sub Distribution Panels**:
        - A-BUILDING ALL AHU LOAD: 219 A, significant consumption by air handling units.
        - A BUILDING PHARMA SECTION: 91.6 A, substantial load from pharma equipment.
    - **Low Current Feeders**:
        - Feeder 3F1 and Feeder 6F3 have low currents, indicating underutilisation.
        - B BUILDING LIGHT: 5 A, minimal consumption.
- **Current Total Harmonic Distortion (Ithd)**
    - **Acceptable Ithd Levels**:
        - Most feeders have Ithd between 1.7% and 4.6%, which is acceptable.
    - **High Ithd Feeder**:
        - Feeder 3F4 (Office Lighting & 25 KVA UPS): Ithd at 81%, indicating significant harmonics due to non-linear loads.
        - C BUILDING GROUND FLOOR SOAP SECTION & B & C BUILDING LIFT: Ithd at 4%, slightly higher but acceptable.
- **Power Factor (Pf)**
    - **Good Power Factor**:
        - Most feeders have Pf ranging from 0.88 to 0.99.
        - Sub Distribution Panels show Pf between 0.90 and 0.99.
    - **Low Power Factor**:
        - Feeder 3F4: Pf is 0.75, indicating inefficiency.
        - A-BUILDING ALL AHU LOAD: Pf is 0.80, suggesting room for improvement.

- **Load Distribution by Area**
    - **Total Power Consumption**:
        - Building A: 188.96 kW (70% of total measured load).
        - Building C: 77.76 kW (28.8%).
        - Building B: 3.2 kW (1.2%).
    - **Observation**: Building A is the primary consumer, mainly due to AHUs, cosmetic, and pharma sections.
- **Underutilized Infrastructure**
    - Multiple feeders are vacant or spare, indicating capacity for future use or load balancing.

OBSERVATIONS

- **Feeder Overload Risks**:
    - High current feeders could risk overloading if additional loads are added without assessment.
- **Harmonic Distortion**:
    - Significant harmonic distortion on Feeder 3F4 poses risks to equipment and efficiency.
- **Inefficient Power Usage**:
    - Low power factor on Feeder 3F4 and A-BUILDING AHU load results in higher energy losses.
- **Load Imbalance**:
    - Disproportionate load distribution may lead to inefficiencies.
- **Fire Panel Feeder**:
    - Feeder 5F2 shows unusually high current for a fire panel, warranting investigation.

RECOMMENDATIONS

- **Harmonic Mitigation**
    - **Implement Facility-Wide APFC Enhancement**:
        - Utilize the planned upgrade of the APFC panel with de-tuned reactors and new capacitors rated at 525 V.
        - **Benefit**: This will address harmonic distortion issues on feeders like 3F4 and improve power factor across the facility.
- **Power Factor Correction**
    - **Optimize APFC Settings**:
        - Adjust settings post-implementation to ensure feeders with low Pf (e.g., Feeder 3F4 and A-BUILDING AHU) achieve Pf ≥0.98.
        - **Benefit**: Reduces reactive power demand and energy losses.
- **Load Redistribution**
    - **Balance Loads Across Feeders**:
        - Redistribute loads from heavily loaded feeders to underutilised ones (e.g., Feeder 3F1, Feeder 6F3, and vacant feeders).
        - **Benefit**: Prevents overloading and improves system efficiency.

- **Investigate High Current on Fire Panel Feeder**
    - **Audit Feeder 5F2**:
        - Determine the cause of high current draw; ensure only fire safety equipment is connected.
        - **Action**: Disconnect any non-essential loads.
- **Improve Power Factor of A-BUILDING AHU Load**
    - **Install Capacitor Banks**:
        - Add power factor correction capacitors specific to the AHU load if necessary.
        - **Benefit**: Improves PF from 0.80 to near unity, reducing energy consumption.
- **Energy Efficiency Measures for Major Equipment**
    - **Air Handling Units (AHUs)**:
        - Install Variable Frequency Drives (VFDs) to optimise motor speed based on demand.
    - **Compressors**:
        - Continue with the recommended VFD installation from previous sections.
- **Monitoring and Maintenance**
    - **Regular Monitoring**:
        - Continuously track electrical parameters using power quality analysers
    - **Preventive Maintenance**:
        - Schedule routine inspections of switchgear, cables, and connected equipment.
- **Utilise Spare Capacity**
    - **Plan for Expansion or Load Balancing**:
        - Use vacant feeders for future loads or to redistribute existing ones.

ENERGY AND MONETARY SAVING POTENTIAL

Planned Enhancements are Sufficient: The upgrade of the APFC panel with de-tuned reactors and new capacitors is expected to sufficiently address the recommendations for the Main LT Panel and Sub Distribution Panel Load Profile.

No Additional Equipment Required: Unless post-implementation monitoring indicates persistent issues, extra harmonic filters or capacitors for specific feeders are not needed.

Benefits Expected:

- **Reduction in Harmonic Distortion**: From current levels (up to 81% in some feeders) down to acceptable levels (<8%).

- **Improvement in Power Factor**: From as low as 0.75 to near unity (≥0.99), enhancing energy efficiency.

- **Energy and Cost Savings**: Realization of the previously calculated annual savings of ₹5,04,926.5.

Enhanced Equipment Performance: Improved power quality will reduce thermal stress on equipment, lowering maintenance costs and extending lifespan.

Compliance and reliability: meeting IEEE standards and utility regulations ensures reliable operations and avoids penalties.

STUDY OF CABLE LOSSES

MEASUREMENTS

During the energy audit, detailed measurements and calculations were performed to assess the cable losses associated with various feeders. The data collected includes:

- **Cable Specifications**: Size, number of cores, length, the resistance per kilometre, and the number of cables.
- **Electrical Parameters**: Voltage (kV), current (A), power (kW), and power factor (PF) under both existing and proposed scenarios.
- **Calculated Losses**: Existing and proposed power losses in kilowatts (kW), along with the net loss reduction.

Cable Details

Table 1: Cable Specifications

S.NO.	FEEDER NAME	CABLE SIZE (SQMM)	NO. OF CORES	LENGTH (KM)	RESISTANCE (Ω/KM)	NO. OF CABLES
1	A BUILDING GROUND FLOOR, DEO, PERFUME SECTION, 1ST FLOOR PHARMA SECTION	300	3.5	0.25	0.128	1
2	ALL COMPRESSOR MAIN	300	3.5	0.27	0.128	1
3	A BUILDING 2ND FLOOR DB, ALL AHU & 2ND FLOOR MACHINES & EQUIPMENT	300	3.5	0.27	0.128	1
4	C BUILDING 1ST FLOOR FOR HIGH-SPEED DEO LINE	185	3.5	0.17	0.210	1
5	OFFICE LIGHTING & 25 KVA UPS	50	3.5	0.12	0.820	1
6	A BUILDING LIGHTING	50	3.5	0.12	0.820	4
7	FIRE PANEL	150	3.5	0.20	0.264	1
8	LIGHTING B & C BUILDING BACK SIDE	25	4	0.10	1.540	4
9	SOAP PLANT & WAREHOUSE	185	3.5	0.20	0.210	1

Electrical Parameters

Table 2: Existing and Proposed Electrical Parameters

S.NO.	FEEDER NAME	VOLTAGE (KV)	CURRENT (A)	POWER (KW)	POWER FACTOR	VOLTAGE (KV) (PROPOSED)	CURRENT (A) (PROPOSED)	POWER (KW) (PROPOSED)	POWER FACTOR (PROPOSED)
1	A BUILDING GROUND FLOOR, DEO, PERFUME SECTION, 1ST FLOOR PHARMA SECTION	0.41	82.5	56.26	0.96	0.41	83.40	56.26	0.95
2	ALL COMPRESSOR MAIN	0.41	215.6	134.70	0.88	0.41	199.67	134.70	0.95
3	A BUILDING 2ND FLOOR DB, ALL AHU & 2ND FLOOR MACHINES & EQUIPMENT	0.41	18.3	12.48	0.96	0.41	18.50	12.48	0.95
4	C BUILDING 1ST FLOOR FOR HIGH-SPEED DEO LINE	0.41	85.3	60.00	0.99	0.41	88.94	60.00	0.95
5	OFFICE LIGHTING & 25 KVA UPS	0.41	30.6	16.28	0.75	0.41	24.13	16.28	0.95
6	A BUILDING LIGHTING	0.41	17.6	12.14	0.97	0.41	18.00	12.14	0.95
7	FIRE PANEL	0.41	133.4	86.23	0.91	0.41	127.82	86.23	0.95
8	LIGHTING B & C BUILDING BACK SIDE	0.41	6.2	4.20	0.96	0.41	6.23	4.20	0.95
9	SOAP PLANT & WAREHOUSE	0.41	37.3	25.19	0.95	0.41	37.34	25.19	0.95

Calculated Losses

Table 3: Existing vs. Proposed Cable Losses

S.NO.	FEEDER NAME	EXISTING LOSS (KW)	PROPOSED LOSS (KW)	NET LOSS REDUCTION (KW)
1	A BUILDING GROUND FLOOR, DEO, PERFUME SECTION, 1ST FLOOR PHARMA SECTION	0.76	0.78	-0.02
2	ALL COMPRESSOR MAIN	5.62	4.82	0.80
3	A BUILDING 2ND FLOOR DB, ALL AHU & 2ND FLOOR MACHINES & EQUIPMENT	0.04	0.04	0.00
4	C BUILDING 1ST FLOOR FOR HIGH-SPEED DEO LINE	0.91	0.99	-0.08
5	OFFICE LIGHTING & 25 KVA UPS	0.32	0.20	0.12
6	A BUILDING LIGHTING	0.03	0.03	0.00
7	FIRE PANEL	3.29	3.02	0.27
8	LIGHTING B & C BUILDING BACK SIDE	0.01	0.01	0.00
9	SOAP PLANT & WAREHOUSE	0.20	0.20	0.00
	TOTAL LOSSES			1.09

Note: Negative values in Net Loss Reduction indicate an increase in losses.

ANALYSIS

Calculation Methodology

Cable losses are calculated using the formula:

Loss (kW)=I2×R×L×Number of Cables

Where:

- I= Current in kiloamperes (kA)
- R = Resistance per kilometre (Ω/km)
- L = Length of the cable (km)
- Number of Cables = Total number of parallel cables carrying the current

Key Findings

1. **Impact of Power Factor Improvement**:
    - **ALL COMPRESSOR MAIN**:
        - Current decreased from 215.6 A to 199.67 A due to power factor improvement from 0.88 to 0.95.
        - Resulted in a significant loss reduction of **0.80 kW**.
    - **OFFICE LIGHTING & 25 KVA UPS**:
        - Current decreased from 30.6 A to 24.13 A with power factor improvement from 0.75 to 0.95.
        - Loss reduction of **0.12 kW**.
2. **Increase in Losses**:
    - **Feeder 1 and Feeder 4** experienced a slight increase in current, leading to marginal increases in losses of 0.02 kW and 0.08 kW, respectively.
3. **Major Contributors to Cable Losses**:
    - **ALL COMPRESSOR MAIN** and **FIRE PANEL** feeders have the highest losses due to higher currents and longer cable lengths.
4. **Total Net Loss Reduction**:
    - The overall net loss reduction across all feeders is **1.09 kW.**

Interpretation

- **Positive Net Loss Reduction**: Indicates successful reduction in cable losses due to decreased current from power factor correction.
- **Negative Net Loss Reduction**: Increases are minimal and may not significantly impact overall efficiency.

OBSERVATIONS

1. **Effectiveness of Power Factor Correction**:
   - The planned enhancements to the APFC panel are effective in reducing currents in key feeders, thereby reducing cable losses.
2. **Load Distribution**:
   - Some feeders are operating close to capacity, which may lead to higher losses and potential overheating.
3. **Cable Sizing**:
   - The existing cable sizes are generally appropriate for the current loads, but there may be opportunities for optimisation.
4. **Potential Overheating Risks**:
   - High current feeders like the ALL-COMPRESSOR MAIN should be monitored for thermal stress.

RECOMMENDATIONS

1. **Proceed with APFC Panel Enhancements**:
   - Implement the planned power factor correction measures, as they have a positive impact on reducing cable losses and improving overall system efficiency.
2. **Monitor High-Current Feeders**:
   - **ALL COMPRESSOR MAIN** and **FIRE PANEL** feeders should be regularly monitored for temperature and load to prevent overheating and ensure safety.
3. **Optimize Cable Sizes Where Feasible**:
   - Evaluate the cost-benefit of upsizing cables for high-loss feeders to further reduce losses.
4. **Regular Maintenance and Inspection**:
   - Conduct periodic inspections of cables and connections to ensure they are in good condition and operating efficiently.
5. **Load Balancing**:
   - Redistribute loads where possible to underutilised feeders to minimise losses and improve system reliability.
6. **Implement Energy Management Practices**:
   - Use energy monitoring systems to continuously track consumption and losses, enabling proactive management of the electrical network.

STUDY OF EARTHING SYSTEM

MEASUREMENTS

The table below summarises the measured values of earthing resistance and leakage current across various panel locations:

- **Earthing Resistance**: The standard limit is between 0 and 2 ohms. Any value exceeding this indicates poor earthing.
- **Leakage Current**: The acceptable range is between 0 and 300 mA. Higher values can suggest insulation issues or other faults.

EARTHING RESISTANCE AND LEAKAGE CURRENT							
S. NO.	**DESCRIPTION OF PANEL LOCATION**	**RESISTANCE**	**UNIT**	**LIMIT VALUE**	**LEAKAGE CURRENT**	**UNIT**	**LIMIT VALUE**
1	LT PANEL OLD	19	OHM	0 < OHM < 2	23.12	MA	0 < MA < 300
2	LT PANEL NEW	11.4	OHM	0 < OHM < 2	31.6	MA	0 < MA < 300
3	BUILDING ALL AHU LOAD	1.3	OHM	0 < OHM < 2	11.12	MA	0 < MA < 300
4		0.8	OHM	0 < OHM < 2	70.8	MA	0 < MA < 300
5	A BUILDING COSMETIC SECTION	0.02	OHM	0 < OHM < 2	7.15	MA	0 < MA < 300
6	A BUILDING PHARMA SECTION	1	OHM	0 < OHM < 2	11.85	MA	0 < MA < 300
7	C BUILDING GROUND FLOOR SOAP SECTION & B&C BUILDING LIFT	OL	OHM	0 < OHM < 2	7.4	MA	0 < MA < 300
8	BUILDING C WAREHOUSE	0.089	OHM	0 < OHM < 2	77.89	MA	0 < MA < 300
9	BUILDING C HIGH SPEED DEO LINE	0.34	OHM	0 < OHM < 2	13.17	MA	0 < MA < 300
10	B BUILDING LIGHT	0.78	OHM	0 < OHM < 2	12.17	MA	0 < MA < 300
11	TRANSFORMER BODY	0.78	OHM	0 < OHM < 2	78.67	MA	0 < MA < 300
12		0.87	OHM	0 < OHM < 2	78.23	MA	0 < MA < 300
13	TRANSFORMER NEUTRAL	1	OHM	0 < OHM < 2	13.27	MA	0 < MA < 300

ANALYSIS

- Earthing Resistance:
  - Resistance values for LT Panel Old (19 ohms) and LT Panel New (11.4 ohms) exceed the standard limit (0-2 ohms), indicating insufficient earthing that may compromise system safety.
  - An open loop (OL) was identified at the C Building Ground Floor Soap Section & Lift, suggesting a potential break in the earthing connection.
  - The rest of the measured locations are within acceptable limits.
- Leakage Current:
  - All measured leakage currents are within the acceptable range (0-300 mA), but higher values at Building C Warehouse (77.89 mA) and Transformer Body (78.67 mA) should be monitored for further assessment.
  - Impact on Energy: High earthing resistance can increase fault energy, leading to higher energy loss and electricity costs.

OBSERVATIONS

- High Resistance Locations:
  - LT Panel Old and New show significantly higher resistance than acceptable limits.
  - Open-loop resistance (OL) at the soap section and lift may create hazardous conditions.
- Leakage Current:
  - Transformer Body and Warehouse have higher leakage currents, indicating potential insulation breakdown or ageing cables.
- Compliance:
  - Except for the identified issues, most locations comply with the earthing resistance and leakage current standards.

RECOMMENDATIONS

- Improve Earthing Connections
  - Replace or repair earthing rods and connections for LT Panel Old, LT Panel New, and C Building Soap Section.
  - Check and fix the open-loop condition at the Soap Section and Lift.
  - Monitor High Leakage Areas: Conduct insulation resistance tests for Warehouse and Transformer bodies to identify possible faults or ageing components.
  - Regular Maintenance: Schedule periodic earthing and leakage current checks to ensure compliance and safety.
- **Implement Surge Protection**:
  - Install surge protection devices to secure sensitive equipment further.

ENERGY AND MONETARY SAVING POTENTIAL

Savings from Reducing LED Input Voltage

Parameter	Value
Total Annual Consumption	7,15,200 kWh
Average Lighting Consumption (5%)	35,760 kWh
Reduced Power Consumption (5% savings)	1788 kWh
Energy Cost (C)	₹10.19 per kWh
Monetary Energy Savings	₹18,220/year
Tentative Total Investment	To be determined

Note: All calculations are based on measurements and data collected during the audit. Actual savings may vary based on operational conditions and implementation efficiency.

Saving from Installing Motion Detector on Lights

The electrical lighting in non-essential areas currently operates at full capacity around the clock. To address this, the audit team recommends installing auto-dimming lights equipped with motion sensors, allowing the lights to run at only 25% brightness when no one is present. This approach offers a more sustainable solution for continuously powered zones—such as B block corridors, fire exits, and storage areas—by substantially cutting energy usage. Additionally, implementing motion-activated lighting extends the operational life of LEDs, ensuring they remain functional for an extended period.

STUDY OF COMPRESSED AIR SYSTEM

INTRODUCTION

The facility operates four KAESER air compressors installed in a well-ventilated room. These compressors are critical to the production processes, supplying compressed air for various applications such as pneumatic controls, packaging machinery, and general plant utilities. The compressors vary in capacity, age, and efficiency, reflecting a mix of older and newer technologies within the system.

Compressor Details

Compressor No.	Make	Year Manufactured	Rated Motor Power (kW)	Rated Capacity (CFM)
Compressor No. 1	KAESER	2015	37	247
Compressor No. 2	KAESER	2017	30	158
Compressor No. 3	KAESER	2018	37	247
Compressor No. 4	KAESER	2022	75	485

MEASUREMENTS

Comprehensive measurements were conducted to assess each compressor's performance and efficiency. The key parameters recorded include power consumption, actual delivered airflow (CFM), specific energy consumption (CFM/kW), and electrical parameters using a power analyser over time.

Compressor Performance Measurements

Summary of Compressor Measurements

Parameter	Unit	Compressor No. 1	Compressor No. 2	Compressor No. 3	Compressor No. 4
Initial Pressure	kg/cm²	0	0	0	0
Final Pressure	kg/cm²	8	8	8	8.5
Receiver Volume	m³	3	1	3	3
Specific Time	minutes	2.88	2.3	2.56	1.88
Power Consumption	kW	44.25	33	48.41	92
Actual CFM	CFM	285.99	119.37	321.74	465.50
Specific CFM Generation	CFM/kW	6.46	3.62	6.65	5.06
Rated Specific CFM Generation	CFM/kW	6.68	5.3	6.7	6.5

Note: CFM stands for Cubic Feet per Minute.

Power Analyzer Measurements

A power analyser was installed to record the electrical parameters of the compressed air system for 1 hour and 40 minutes on 20-11-2024, starting at 13:15:00.

Voltage Profile

Parameter	Average (V)	Minimum (V)	Maximum (V)	Duration
V1-2 RMS	406.9	383.4	425.4	1:40:00 (h:min:s)
V2-3 RMS	404.2	387.8	422.7	1:40:00 (h:min:s)
V3-1 RMS	405.9	374.0	424.8	1:40:00 (h:min:s)

Current Profile

Parameter	Average (A)	Minimum (A)	Maximum (A)	Duration
A1 RMS	194.3	98.00	258.0	1:40:00 (h:min:s)
A2 RMS	194.2	99.00	253.5	1:40:00 (h:min:s)
A3 RMS	182.3	94.00	244.0	1:40:00 (h:min:s)

Power Profile

Parameter	Average (kW)	Minimum (kW)	Maximum (kW)	Duration
P1	37.88	19.40	43.36	1:40:00 (h:min:s)
P2	39.42	20.70	44.99	1:40:00 (h:min:s)
P3	35.84	17.67	41.22	1:40:00 (h:min:s)
Total Power (PT)	**113.1**	**57.85**	**129.4**	1:40:00 (h:min:s)

Note: PT represents the total power consumption across all three phases.

ANALYSIS

Compressor Performance Analysis

- **Compressor Efficiency Variance:**

  Compressor No. 1:

  - Specific CFM/kW is **6.46**, close to the rated **6.68**, indicating efficient operation.

  Compressor No. 2:

  - Specific CFM/kW is significantly lower at **3.62** compared to the rated **5.3**, suggesting inefficiencies.

  Compressor No. 3:

  - Specific CFM/kW is **6.65**, matching its rated value of **6.7**, indicating optimal performance.

  Compressor No. 4:

  - Specific CFM/kW is **5.06**, below the rated **6.5**, indicating room for improvement.

- **Power Consumption Discrepancies:**
  - Compressors No. 1 and No. 3 consume more power than their rated motor power, possibly due to increased load, inefficiencies, or lack of maintenance.
  - Compressor No. 4 operates at a higher final pressure (**8.5 kg/cm²**) than the others (**8 kg/cm²**), contributing to higher energy consumption.

Electrical Parameter Analysis

- **Voltage Stability:**
  - The average voltages between phases are stable and within acceptable operational ranges, indicating a reliable power supply.
  - Voltage fluctuations are minimal, suggesting that power quality is not a significant concern.
- **Current Imbalance:**
  - There is a slight imbalance in phase currents, with Phase 3 carrying less current. While within acceptable limits, monitoring is warranted to prevent equipment stress.
- **Power Consumption Patterns:**
  - Total average power consumption is **113.1 kW**.
  - Significant variations between minimum (**57.85 kW**) and maximum (**129.4 kW**) total power indicate fluctuating load conditions, possibly due to varying compressed air demand or compressor cycling.

Energy Consumption Estimation

- **Monitoring Duration:** 1 hour and 40 minutes (**1.6667 hours**).
- **Total Energy Consumed during Monitoring:** 113.1 kW × 1.6667 h **≈ 188.5 kWh**.
- **Estimated Daily Energy Consumption:**
  - **Operating Hours per Day:** 10 hours.
  - **Daily Energy Consumption:** 113.1 kW × 10 h = **1,131 kWh/day**.
- **Estimated Annual Energy Consumption:**
  - **Operating Days per Year:** 300 days.
  - **Annual Energy Consumption:** 1,131 kWh/day × 300 days = **339,300 kWh/year**.

***Note**: These estimates assume continuous operation and consistent load patterns, which may vary in practice.*

OBSERVATIONS

- **Compressor Inefficiencies:**
  - **Compressor No. 2** operates at a lower efficiency, with a specific CFM/kW significantly below its rated value.
  - **Compressor No. 4**, despite being the newest and largest, operates below its rated efficiency, suggesting potential issues or suboptimal settings.
- **Over-pressurization:**
  - **Compressor No. 4** operates at a higher final pressure (**8.5 kg/cm^2**), leading to unnecessary energy consumption if the process does not require this pressure.
- **Load Fluctuations:**
  - Significant variations in power consumption indicate that compressors may frequently cycle between loaded and unloaded states or that demand varies significantly.
- **Lack of Monitoring Equipment:**
  - The absence of dedicated compressed air flow meters and energy meters on individual compressors limits the ability to monitor performance precisely.
- **Current Imbalance:**
  - A slight imbalance in phase currents could lead to equipment stress over time and should be addressed.
- **Maintenance Practices:**
  - Discrepancies between actual and rated performances suggest that maintenance routines may need improvement.

RECOMMENDATIONS

To achieve up to **20% energy savings** from the current operating scenario, the following recommendations are proposed:

Operational Improvements

- **Optimize Compressor Usage:**
  - **Base Load Management:** Utilize the most energy-efficient compressors (**No. 1** and **No. 3**) to handle the base load continuously.
  - **Peak Load Handling:** Deploy less efficient compressors (**No. 2** and **No. 4**) only during peak demand periods.
  - **Pressure Standardization:** Reduce the final pressure of **Compressor No. 4** from **8.5 kg/cm²** to **8 kg/cm²** to match other compressors and minimise unnecessary energy consumption.
- **Implement Intelligent Control Systems:**
  - **Install Intelligent Flow Controllers** To balance air supply with demand and optimise compressor operation dynamically.
  - **Sequencing Control:** Automate compressor sequencing to ensure optimal combinations based on efficiency and load requirements.
- **Reduce Unloaded Running Time:**
  - **Automatic Shut-off Controls:** Install controls that stop compressors during periods of no demand to prevent energy wastage.
  - **Start/Stop Optimization:** Adjust settings to minimise energy consumption without affecting production needs.

Equipment Upgrades

- **Install Variable Frequency Drives (VFDs):**
  - **Demand Matching:** VFDs allow compressors to adjust motor speed based on real-time demand, improving efficiency during partial load conditions.
  - **Soft Starting:** Reduces mechanical and electrical stress on compressors during start-up.
- **Upgrade Monitoring Instruments:**
  - **Install Flow Meters and Energy Meters:** Equip each compressor with meters to track real-time airflow and energy consumption for precise monitoring.
  - **Data Analysis Tools:** Use software to analyse collected data for continuous performance assessment.

Maintenance and Power Quality

- **Enhance Maintenance Practices:**
    - **Regular Preventive Maintenance:** Establish and adhere to a maintenance schedule focusing on filters, lubrication, and component wear.
    - **Performance Testing:** Periodically test compressors to ensure they operate close to their rated efficiencies.
- **Power Quality Improvements:**
    - **Power Factor Correction:** Install capacitor banks to improve power factor, reduce reactive power charges and enhance system efficiency.
    - **Monitor Harmonics:** Regularly check for harmonics affecting power quality and equipment performance.

Distribution Network Enhancements

- **Optimize Piping Layout:**
    - **Install a Ring Main Loop Header** To minimise pressure losses and ensure consistent air supply throughout the facility.
    - **Proper Slope and Drainage:** Provide a 1-inch slope per 10 feet of piping and install auto drain traps every 30 meters to remove moisture.
    - **Minimize Bends and Turns:** Redesign the network to reduce friction losses.
- **Leak Management:**
    - **Leak Detection and Repair:** Conduct regular inspections using ultrasonic leak detectors and repair leaks promptly.
    - **Isolation of Unused Lines:** Isolate-compressed airlines are not required for prolonged periods to prevent leakage.
- **Install Separate Pressure Lines:**
    - **High and Low-Pressure Lines:** Segregate applications based on pressure requirements to prevent over-pressurization.

Staff Training and Awareness

- **Employee Training Programs:**
    - **Best Practices in Compressed Air Usage:** Educate staff on efficient use and the importance of reporting issues.
    - **Energy Conservation Culture:** Promote awareness and encourage proactive participation in energy-saving initiatives.

ENERGY AND MONETARY SAVING POTENTIAL

Energy Savings Calculation

1. **Current Annual Energy Consumption Estimate:**
    - **Total Energy Consumption:** Approximately **3,39,300 kWh/year**.
2. **Target Energy Savings (20%):**
    - **Total Energy Savings:** 20% of 339,300 kWh = **67,860 kWh/year**.
3. **Breakdown of Energy Savings by Recommendation:**
    - **Optimize Compressor Usage (8%):**
        - Savings: 8% of 339,300 kWh = **27,144 kWh/year**.
    - **Implement Intelligent Control Systems (5%):**
        - Savings: 5% of 339,300 kWh = **16,965 kWh/year**.
    - **Install Variable Frequency Drives (VFDs) (5%):**
        - Savings: 5% of 339,300 kWh = **16,965 kWh/year**.
    - **Leak Detection and Repair Program (2%):**
        - Savings: 2% of 339,300 kWh = **6,786 kWh/year**.
    - **Total Estimated Energy Savings:** 27,144 + 16,965 + 16,965 + 6,786 = **67,860 kWh/year**.

Monetary Savings Calculation

1. **Electricity Cost:**
    - **Unit Rate:** ₹10.19 per kWh.
2. **Annual Cost Savings:**
    - **Savings:** 67,860 kWh × ₹10.19/kWh **≈ ₹6,91,487** per year.

Investment and Payback

- **Estimated Investment Costs:**
    - **VFDs Installation:** Approximately **₹6,00,000**.
    - **Intelligent Control Systems:** Approximately **₹8,15,000**.
    - **Leak Detection Equipment:** Approximately **₹50,000**.
    - **Total Investment: ₹14,65,000**.
- **Simple Payback Period:**

    - **Payback Period:** ₹14,65,000 / ₹691,487 ≈ **2.12 years**.

Environmental Impact

- **Reduction in CO_2 Emissions:**
    - **Assumed Emission Factor:** 0.92 kg CO_2 per kWh.
    - **Annual CO_2 Reduction:** 67,860 kWh × 0.92 kg/kWh ≈ **62,431 kg CO_2/year**.
- **Equivalent Benefit:**
    - **Tree Planting:** Equivalent to planting approximately **10,405 trees** (assuming one tree absorbs about 6 kg CO_2 per year).
    - **Vehicle Emissions:** This is equivalent to removing approximately **13 passenger vehicles** from the road annually (assuming an average vehicle emits about 4,600 kg CO_2 per year).

CONCLUSION

By implementing the designated recommendations—optimised compressor usage, intelligent control systems, installation of VFDs, and a leak detection and repair program—the facility can achieve the targeted **20% energy savings**. These measures are aligned with industry best practices and standard procedures, ensuring energy efficiency and enhanced system reliability and performance. The investment required has a reasonable payback period, making it financially viable. Additionally, these initiatives contribute to environmental sustainability by significantly reducing CO_2 emissions.

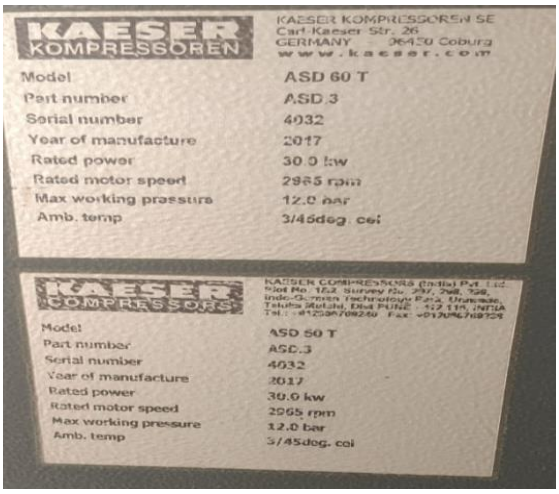
COMPRESSOR


KAESER
COMPRESSORS No.01
CAPACITY -247 CFM

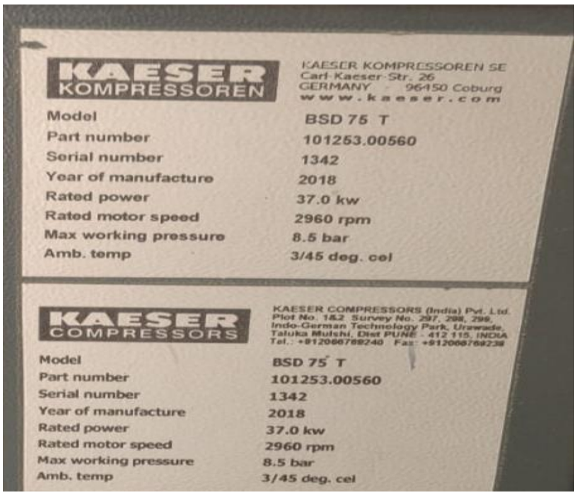

KAESER KOMPRESSOREN
Kältetrockner
Refrigeration dryer
ABT 33
Artikel – Nr.
Part No.
1.8172.0
Serien – Nr.
Serial No.
1900
Baujahr
Year of production
2015
Kältemittel
Refrigerant
R134a
Kältemittel – Füllmenge
Charge of refrigerant
1,05 kg
2,3 lb
21,0 bar
300
16,0 bar
230
Dichtheit geprüft
Tested leak – free
Max. Betriebsdruck (Luftsystem)
Max. working pressure (Air system)
16,0 bar
230
Nennspannung / Phase / Frequenz
Rated voltage / Phases / Frequency
400 | 460V/3/50 | 60Hz
Nennstrom
Rated current
Umgebungstemperatur
Ambient temperature
+3°C / +45°C
+37°F / +115°F
MADE IN GERMANY


COMPRESSORS No.02
CAPACITY - 158 CFM
KAESER


Modell
ABT 60
Material No. / Serial No.
1.8173.0
3925
Year of manufacture
02
2017
KAESER KOMPRESSOREN
Refrigeration dryer
ABT 60
Material No.
1.8173.0
Max. gauge working pressure
16 bar
230 psig
Compressed air inlet temp.
Ambient temperature
Refrigerant system
Contains fluoridated greenhouse gases
Refrigerant
R – 134a
Refrigerant charge
0,80 kg
1,76 lb
Global warming potential
1430
CO2 – equivalent
Max. working pressure HP
21 bar
300 psig
Max. working pressure LP
16 bar
230 psig
MADE IN GERMANY


KAESER KOMPRESSOREN
Model
ASD 60 T
Part number
ASD 3
Serial number
4032
Year of manufacture
2017
Rated power
30.0 kw
Rated motor speed
2965 rpm
Max working pressure
12.0 bar
Amb. temp
3/45deg. cel
KAESER COMPRESSORS
Model
ASD 60 T
Part number
ASD.3
Serial number
4032
Year of manufacture
2017
Rated power
30.0 kw
Rated motor speed
2965 rpm
Max working pressure
12.0 bar
Amb. temp
3/45deg. cel

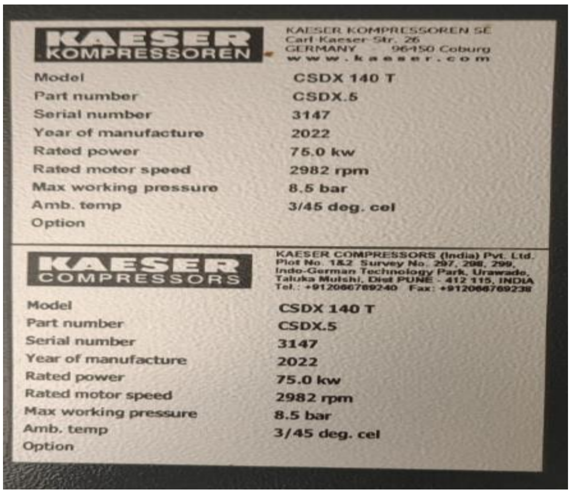

COMPRESSORS No.03
CAPACITY - 247 CFM


KAESER KOMPRESSOREN
KAESER KOMPRESSOREN SE
Carl-Kaeser-Str. 26
GERMANY - 96450 Coburg
www.kaeser.com
Model BSD 75 T
Part number 101253.00560
Serial number 1342
Year of manufacture 2018
Rated power 37.0 kw
Rated motor speed 2960 rpm
Max working pressure 8.5 bar
Amb. temp 3/45 deg. cel
KAESER COMPRESSORS
KAESER COMPRESSORS (India) Pvt. Ltd.
Model BSD 75 T
Part number 101253.00560
Serial number 1342
Year of manufacture 2018
Rated power 37.0 kw
Rated motor speed 2960 rpm
Max working pressure 8.5 bar
Amb. temp 3/45 deg. cel


KAESER KOMPRESSOREN
KAESER KOMPRESSOREN SE
Carl-Kaeser-Str. 26
GERMANY - 96450 Coburg
www.kaeser.com
Model: ABT 83
Material No.: 1.8172.0
Year of manufacture: 10 / 2018
Serial No.: 4180 - 6747156
KAESER KOMPRESSOREN
KAESER KOMPRESSOREN SE
Carl-Kaeser-Str. 26
GERMANY - 96450 Coburg
www.kaeser.com
Refrigeration dryer ABT 83
Material No. 1.8172.0
Max. working pressure PS 16 bar / 230 psig
Compressed air inlet temp. TS 3 – 60 °C / 37 – 140 °F
Ambient temperature 3 – 45 °C / 37 – 115 °F
Refrigerant system
Contains fluorinated greenhouse gases
Refrigerant R-134a: 1,20 kg / 2.65 lb
Greenhouse warming potential 1430
CO2 equivalent 1,5 t / 3310 lb
Max. working pressure HP PS 21 bar / 300 psig
Max. working pressure LP PS 16 bar / 230 psig
Option
EAC
MADE IN GERMANY


KAESER
RFID
SIGMA CONTROL 2


COMPRESSORS No. 04
CAPACITY-485 CFM


KAESER KOMPRESSOREN
KAESER KOMPRESSOREN SE
Carl-Kaeser-Str. 26
GERMANY - 96450 Coburg
www.kaeser.com
Model CSDX 140 T
Part number CSDX.5
Serial number 3147
Year of manufacture 2022
Rated power 75.0 kw
Rated motor speed 2982 rpm
Max working pressure 8.5 bar
Amb. temp 3/45 deg. cel
Option
KAESER COMPRESSORS
KAESER COMPRESSORS (India) Pvt. Ltd.
Model CSDX 140 T
Part number CSDX.5
Serial number 3147
Year of manufacture 2022
Rated power 75.0 kw
Rated motor speed 2982 rpm
Max working pressure 8.5 bar
Amb. temp 3/45 deg. cel
Option


KAESER KOMPRESSOREN
KAESER KOMPRESSOREN SE
Carl-Kaeser-Str. 26
GERMANY - 96450 Coburg
www.kaeser.com
Material No.: 1.8168.1
Serial No.: 1533 - 8910818
Constr yr/mth (YYYY MM): 2022/11
KAESER KOMPRESSOREN
KAESER KOMPRESSOREN SE
Carl-Kaeser-Str. 26
GERMANY - 96450 Coburg
www.kaeser.com
Refrigeration dryer ABT 165
Material No. 1.8168.1
Max. working pressure PS 16 bar / 230 psig
Compressed air inlet temp. TS 3 – 60 °C / 37 – 140 °F
Ambient temperature 3 – 45 °C / 37 – 115 °F
Refrigerant system
Contains fluorinated greenhouse gases
Refrigerant R-513A: 1,60 kg / 3.53 lb
Greenhouse warming potential 631
CO2 equivalent 1,01 t / 2226 lb
Max. working pressure HP PS 21 bar / 300 psig
Max. working pressure LP PS 16 bar / 230 psig
Option
CE 0575 UK CA EAC
Made in Germany

<u>Intelligent Energy Saving Compressed Air Flow Control System</u>

Features

- Precise control through 32-bit Intelligent Microprocessor Controller
- Detects the rate of change of demand to increase/decrease the flow/pressure.
- Fail-safe operation with fail-to-open flow control modules & additional auto bypass
- Less than 1 psig / 0.07 bar pressure drop across the IFC system at nominal flow
- Built-in filters air dryer with automatic condensate drains for instrument-quality pilot air
- Inlet and outlet headers provided with No-Air Loss automatic condensate drains
- Power failure Auto-restart facility
- Analogue input for compressed air flow meter built-in flow totaliser software as standard
- Customized Upstream & Downstream Flow Control Systems as per system requirements
- Available for higher working pressures of 13 / 16 / 40 bar(g)
- Aesthetically designed ergonomic enclosure
- Control AiRTM IFC is a patented product of Godrej
- Industry 4.0 Ready

Operational Features

- Remote Operation (Start/ Stop, Target Pressure setting)
- 3 Preset Target Pressures can be remotely selected
- Weekly Programmable 99 Pressure settings scheduler
- Special program to work with Centrifugal compressors to avoid surge
- Optional PC connectivity

Rein in your Compressed Air Energy…
…with Godrej ControlAiR™ IFC system

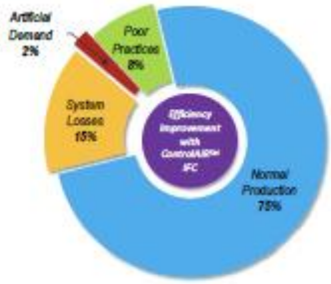
ControlAiR™ Intelligent Flow Control System (IFC) reduces artificial demand by controlling the air flow & pressure being delivered to the plant. The IFC is designed specifically to operate at an intermediate point of the compressed air system i.e. on the downstream side of the air treatment equipment and upstream side of the main piping distribution system.

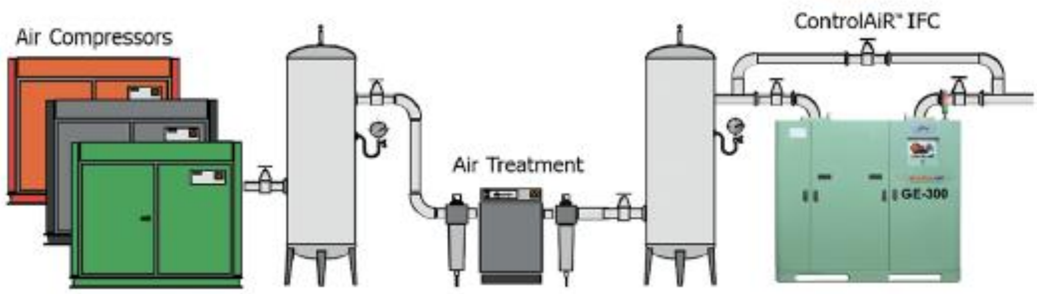
ControlAiR™ IFC creates useful storage by introducing a controlled differential pressure across an upstream receiver and itself. This storage isolates the Compressors from demand side fluctuations.

Peaks are dealt with releasing the stored reserve energy instead of additional horsepower, facilitating the Compressors to run on reduced load. ControlAiR™ IFC provides air at a controlled differential and optimum pressure to the plant, which reduces the mass of air consumed by pneumatic equipment, tools & amount of leakages, which ultimately result in the reduction in energy consumed by Air Compressors.

Benefits

- Saves Compressed Air Energy by 4~25 % through reduction in Artificial Demand
- Constant air pressure to pneumatic tools within the range of +/- 1 psig (0.07 barg)
- Improves the response time of system to meet instantaneous demand
- Reduction in compressor's operation and maintenance
- Reduction in compressed air leakages
- Works with all brands and types of compressors
- Payback period between 1~2 years
- Improves VSD Performance





Typical Installation of IFC in a Compressed Air System

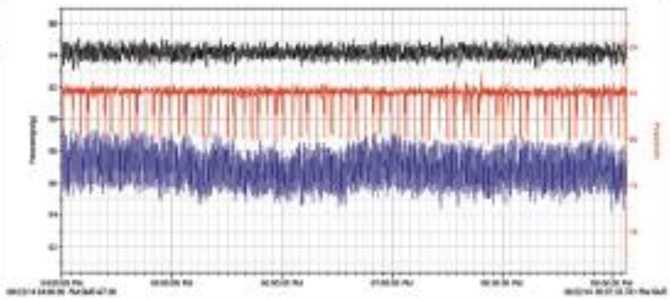
Typical Case Studies

VSD Compressor : Energy Consumption for 500 cfm, 100 psig (850 m^3/hr, 7 kg/cm^2), 120 HP / 90 kW

Without ControlAiR™ IFC

Demand Cycle:
Load Factor = 80%
Daily Power Consumed:
P_{INPUT} = 90 kW X 0.90 X 24 hrs = 1944 kWh

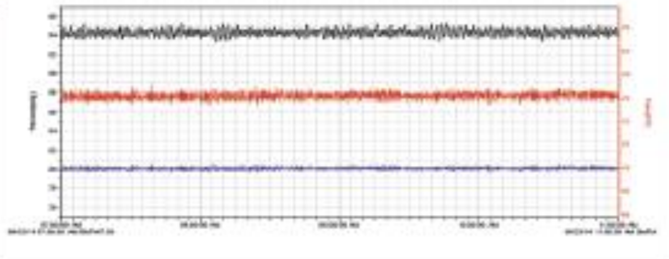
Comp Pressure (psig)
Power (kW)
Plant Pressure (psig)



With ControlAiR™ IFC

Demand Cycle:
Load Factor = 70%
Daily Power Consumed:
P_{INPUT} = 90 kW X 0.80 X 24 hrs = 1728 kWh

Comp Pressure (psig)
Power (kW)
Plant Pressure (psig)



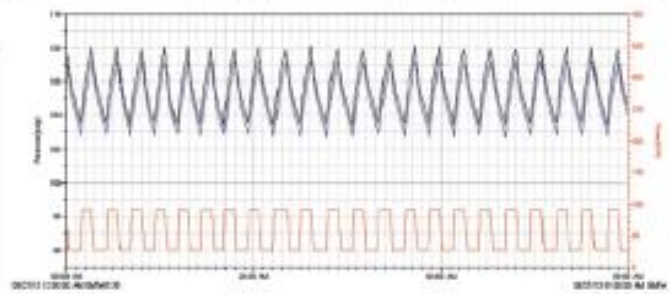
$$Energy\ Savings = \frac{(1944 - 1728)}{1944} x\,100 = 11\,\%$$

Fixed Speed Compressor : Energy Consumption for 500 cfm, 100 psig (850 m^3/hr, 7 kg/cm^2), 120 HP / 90 kW

Without ControlAiR™ IFC

Demand Cycle:
Load Period = 70%, Unload Period = 30%
Power Consumed:
P_{Load} = 90 kW X 17 hrs = 1530 kWh
P_{Unload} = 30 kW X 07 hrs = 210 kWh
P_{INPUT} = P_{Load} + P_{Unload} = 1740 kWh

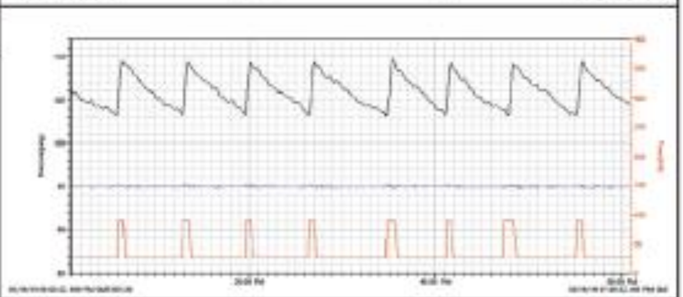
Comp Pressure (psig)
Power (kW)
Plant Pressure (psig)



With ControlAiR™ IFC

Demand Cycle:
Load Period = 60%, Unload Period = 40%
Power Consumed:
P_{Load} = 90 kW X 14 hrs = 1260 kWh
P_{Unload} = 30 kW X 10 hrs = 300 kWh
P_{INPUT} = P_{Load} + P_{Unload} = 1560 kWh

Comp Pressure (psig)
Power (kW)
Plant Pressure (psig)



$$Energy\ Savings = \frac{(1740 - 1560)}{1740} x\,100 = 10\,\%$$

STUDY OF AIR HANDLING UNIT & DX COOLED OUTDOOR UNITS

INTRODUCTION

Direct Expansion (DX) Coil-based Air Handling Units (AHUs) play a vital role in maintaining appropriate air quality, temperature, and humidity levels within the perfume and deodorant manufacturing facility. By using refrigerant to cool the incoming air directly, these AHUs contribute significantly to controlled environmental conditions essential for product quality and process stability. This assessment focuses on evaluating the efficiency, operational condition, and performance of the AHUs, highlighting their energy consumption, cooling capacity, and maintenance requirements.

MEASUREMENTS

Key performance parameters were recorded for four AHUs, including both indoor and outdoor components.

1. **AHU Details:**
    - Filter dimensions
    - Rated airflow (CFM)
    - Inlet and outlet air conditions (Dry Bulb Temperature (DBT) and Wet Bulb Temperature (WBT))
    - Mass flow rate, enthalpy, and resultant cooling capacity (TR)
2. **Outdoor Units:**
    - Airflow parameters
    - Inlet and outlet temperatures
    - Rejected tonnage (TR)
    - Power input and associated cooling delivery
3. **Condition and Availability of Components:**
    - Indoor unit components: Blower, coil, filters, belts, motor vibration, actuators, Variable Frequency Drives (VFDs), pressure/temperature gauges, and condensate drainage.

Recorded Data

Thermal and Electrical Performance

AHU-2 OUTDOOR			
	Unit 1	Unit 2	Unit 3
Measured Airflow in CFM	3609	4673	2479
Ambient Temp. in Deg C	29	29	29
Hot Air Exit Temp. in Deg C	33	32.2	33.2
Delta T in deg F	7.2	5.76	7.56
TR rejected	2.338632	2.4224832	1.6867116
Power Input kW	1.6	1.7	1.6
Cooling Delivered	1.884	1.939	1.232
ikW/TR	**0.849**	**0.877**	**1.299**

S. No.	Location	CFM/kW	Voltage	Current	Power	KW/TR	PF
			V	A	kW		
1	**AHU -1**	592.1	420.0	6.4	4.0	2.6	0.8
2	**AHU-2**	813.2	418.0	7.4	4.7	0.9	0.9
3	**AHU-3**	561.6	414.0	7.8	4.9	0.8	0.9
4	**AHU-4**	1509.3	409.0	3.1	1.3	0.1	0.6

AHU-3 OUTDOOR	
	Unit 1
Measured Airflow in CFM	4091
Ambient Temp. in Deg C	29
Hot Air Exit Temp. in Deg C	33.2
Delta T in deg F	7.56
TR rejected	2.7835164
Power Input kW	2
Cooling Delivered	2.215
ikW/TR	**0.903**

S. No.	Location	Filter Size (mm)		Quantity	Rated CFM	Rated SP	Rated KW	SP
		Width	Height	NOS.				
1	**AHU -1**	500	400	1	4110	130	5.5	80
2	**AHU-2**	650	610	1	6640	130	7.5	70
3	**AHU-3**	510	510	4				30
4	**AHU-4**	510	510	2				

S. No.	Location	Inlet Temperature/suction side temperature		Outlet Temperature/ discharge side temperature		Area	Velocity	CFM
		DBT (ºC)	WBT (ºC)	DBT (ºC)	WBT (ºC)	(m^2)	(m/s)	(ft3/min)
1	**AHU -1**	24.7	15.5	15	12.2	0.2	5.58	2362.35
2	**AHU-2**	24.8	16	15.2	12.4	0.39	4.62	3814.1
3	**AHU-3**	26	17.4	14.5	12	1.04	1.25	2751.8
4	**AHU-4**	26	15.8			0.52	1.81	1992.3

Condition Assessment of Components

Location	Blower	Coil	Filter	Belt	Motor Vibration
AHU-1	Good	Good	Dusty	Good	No Vibration
AHU-2	Good	Good	Dusty	Good	No Vibration
AHU-3	Good	Good	Damaged	Loose	Yes
AHU-4	Good	Good	Dusty	Good	No Vibration

Availability of Key Features

Location	VFD	Condensate
AHU-1	No	No
AHU-2	No	No
AHU-3	No	Yes
AHU-4	No	Yes

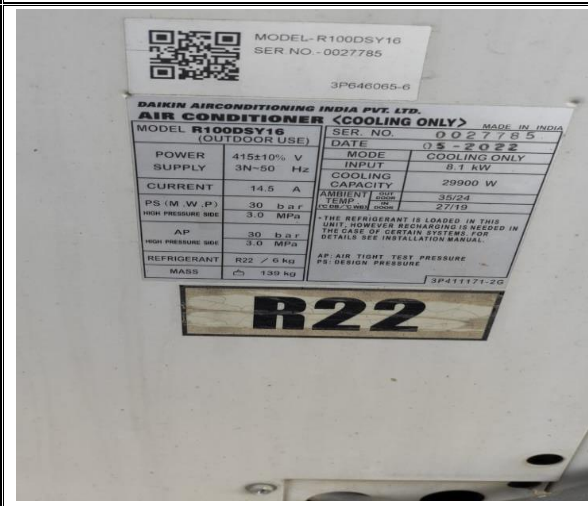
ANALYSIS

- **AHU-1:**
  - Cooling Capacity: 1.5 TR
  - Efficiency: High power consumption (2.6 kW/TR)
  - Outdoor units are non-functional, severely impacting efficiency.
- **AHU-2:**
  - Cooling Capacity: 5.5 TR
  - Efficiency: Good performance at 0.9 kW/TR
  - Outdoor Units' Performance:
    - Unit 1: iKW/TR = 0.849
    - Unit 2: iKW/TR = 0.877
    - Unit 3: iKW/TR = 1.299 (Less efficient than the other two)
- **AHU-3:**
  - Functioning Outdoor Units: Only one operational
  - Cooling Capacity: 6.1 TR (under compromised conditions)
  - Efficiency: iKW/TR = 0.903

    - Indoor Issues: Damaged filter and loose belt, motor vibration indicates possible mechanical issues.
- **AHU-4:**
    - Rated Cooling Capacity: 10.4 TR
    - Efficiency: Recorded at 0.1 kW/TR; this value is likely skewed due to non-functional outdoor units and measurement anomalies.

OBSERVATIONS

- **Cooling Efficiency:**
    - AHU-2 demonstrates the best overall performance and more stable operation.
    - AHU-1 and AHU-4 performance is hindered by non-operational outdoor units.
    - AHU-3's efficiency is compromised by limited outdoor unit functionality and indoor component issues.
- **Maintenance Shortcomings:**
    - Dust accumulation and damaged filters reduce effective airflow and cooling capacity.
    - Lack of VFDs, actuators, and functioning gauges reduces operational flexibility and monitoring capabilities.
    - Motor vibration in AHU-3 suggests impending mechanical wear or imbalance.

AHU	
	
	
	MODEL-R100DSY16 SER.NO.-0027785 3P646065-6 DAIKIN AIRCONDITIONING INDIA PVT. LTD. AIR CONDITIONER <COOLING ONLY> MADE IN INDIA MODEL R100DSY16 (OUTDOOR USE) POWER SUPPLY 415±10% V 3N~50 Hz CURRENT 14.5 A PS (M.W.P) HIGH PRESSURE SIDE 30 bar 3.0 MPa AP HIGH PRESSURE SIDE 30 bar 3.0 MPa REFRIGERANT R22 / 6 kg MASS 139 kg SER. NO. 0027785 DATE 05-2022 MODE COOLING ONLY INPUT 8.1 kW COOLING CAPACITY 29900 W AMBIENT TEMP. (°C DB/°C WB) OUT DOOR 35/24 IN DOOR 27/19 -THE REFRIGERANT IS LOADED IN THIS UNIT. HOWEVER RECHARGING IS NEEDED IN THE CASE OF CERTAIN SYSTEMS. FOR DETAILS SEE INSTALLATION MANUAL. AP: AIR TIGHT TEST PRESSURE PS: DESIGN PRESSURE 3P411171-2G R22

RECOMMENDATIONS

- **Outdoor Unit Restoration:**
  - Repair or replace non-functional outdoor units for AHU-1 and AHU-4 to restore intended cooling capacity.
  - For AHU-2, balance the outdoor units' load to improve overall efficiency and reduce the stress on the least efficient unit.
- **Filter Maintenance:**
  - Clean the dusty filters in AHU-1, AHU-2, and AHU-4.
  - Replace the damaged filter in AHU-3 to ensure proper airflow and cooling efficiency.
- **System Upgrades:**
  - Install or repair VFDs and temperature/pressure gauges to enhance control and real-time monitoring.
  - Ensure proper actuator functionality for better regulation of air distribution.
- **Mechanical Improvements:**
  - Address the motor vibration in AHU-3 by checking for imbalance, wear, or misalignment.
  - Tighten or replace the loose belt in AHU-3.
- **Scheduled Preventive Maintenance:**
  - Implement a periodic maintenance program, including filter cleaning, outdoor unit servicing, and component inspections to maintain optimal performance and efficiency.

ENERGY AND MONETARY SAVING POTENTIAL

A conservative estimate suggests that improving AHU efficiency through better maintenance, proper filtering, and restoring outdoor unit functionality can reduce energy consumption by at least 20%.

Parameter	Value
Baseline Energy Consumption	14.9 KW x 5000 Hours = 74,500 kWh
Estimated Energy Savings (20%)	14,900 kWh/year
Electricity Rate	₹10.19/kWh
Annual Cost Savings	₹1,51,831
Investment Cost	₹3,00,000
Payback Period	~1.98 years

STUDY OF AIR-COOLED PERFUME CHILLERS

INTRODUCTION

Air-cooled perfume chillers are essential in maintaining the precise cooling conditions required for perfume manufacturing. These chillers ensure that production processes are conducted at the right temperature to preserve product quality, stability, and aroma profile. By integrating filtration systems, the chillers also help maintain product purity. However, inefficiencies, inadequate maintenance, and operational imbalances can lead to increased energy consumption, reduced system longevity, and compromised cooling effectiveness. This study assesses the performance, operational challenges, and potential energy savings of two air-cooled chillers. Both chillers present opportunities for efficiency improvements through better maintenance practices, equipment restoration, insulation enhancements, and system optimisation.

MEASUREMENTS

CHILLER 1

Rated Data Chiller 1

AIR REQUIRED	10-15 CFM@2-3 KG/BAR
PRODUCTION CAPACITY CHILLER+ FILTER	500 LPH
POWER REQUIRED	15.5 KW, 3 PHASE
PRODUCTION CAPACITY-FILTER ONLY	2000 LPH
NO. OF FILTERS	4
TYPE OF FILTER	PP CANDLE

Measured Data Chiller 1

MEASURED AIRFLOW IN CFM	4847
AMBIENT TEMP. IN DEG C	29
HOT AIR EXIT TEMP. IN DEG C	32.2
DELTA T IN DEG F	5.76
TR REJECTED	2.5126848
POWER INPUT KW	3
COOLING DELIVERED	1.659
IKW/TR	1.808

CHILLER 2

Rated Data Chiller 2

CONNECTED LOAD	16KW
REFRIGERANT CHARGE	13KG (R-404A)
VOLTAGE REQUIRED	415 V
PHASE REQUIRED	3- PHASE
FLA REQUIRED	29.43 A
HEATING CAPACITY	NIL

COOLING CAPACITY	43.1 KW

Measured Data Chiller 2

S. NO.	FEEDER DESCRIPTION	ELECTRICAL LOAD PROFILE					
		V	VTHD	I	ITHD	KW	PF
1	CHILLER 2	416	1.3	26.1	2.1	14.76	0.78

Note: Chiller 2's cooling capacity could not be fully assessed due to its intermittent operation caused by a coolant alarm.

ANALYSIS

1. **Chiller 1 Analysis:**
    - **Performance:** An iKW/TR of 1.808 is higher than desired (target <1), indicating that the chiller consumes more power per ton of cooling than is optimal.
    - **Thermal Losses:** The system rejects approximately 2.51 TR but only delivers about 1.66 TR of effective cooling, pointing to significant thermal inefficiencies. Poor insulation and insufficient heat rejection (only one exhaust fan operational) are likely contributors.
    - **Airflow Mismatch:** The measured airflow (4,847 CFM) greatly exceeds the rated 10-15 CFM, causing increased energy usage and potentially uneven cooling distribution.
    - **Mechanical Issues:** Motor noise and vibration suggest mechanical wear or alignment issues, reducing efficiency and equipment lifespan.

2. **Chiller 2 Analysis:**
    - **Operational Instability:** The chiller runs only about 5 minutes before a coolant alarm triggers shutdown. This prevents the unit from reaching steady-state operation and delivering its rated 43.1 kW cooling capacity.
    - **Power Factor & Load:** The chiller operates below optimal electrical efficiency at 14.76 kW and PF of 0.78. Improving the power factor can reduce energy costs and reactive power consumption.
    - **Harmonics & Electrical Quality:** Voltage THD (1.3%) and Current THD (2.1%) are relatively low but could still be optimised to ensure system reliability and reduced losses.

OBSERVATIONS

- **Chiller 1:**
    - Only one exhaust fan is operational; restoring the second fan can improve heat rejection.
    - Weak insulation and excessive airflow contribute to inefficiency.
    - Motor vibration and noise indicate the need for mechanical servicing.

- **Chiller 2:**
  - The intermittent operation (coolant alarm) suggests refrigerant or sensor-related issues.
  - Low power factor and brief runtime reduce efficiency and may increase operating costs.

CHILLER	
	

RECOMMENDATIONS

1. **For Both Chillers:**
   - **Preventive Maintenance:** Implement a regular maintenance schedule to promptly address mechanical, electrical, and insulation issues.
   - **Insulation and Airflow:** Improve pipeline insulation and ensure airflow matches rated requirements to enhance energy efficiency.
2. **Chiller 1 Specific:**
   - **Exhaust Fan Restoration:** Repair the non-functional exhaust fan to stabilise heat rejection and improve efficiency.
   - **Motor & Mechanical Repairs:** Correct motor vibrations, check alignment and bearings, and ensure proper mechanical balance.
   - **Optimize Airflow:** Adjust system settings to achieve the rated 10-15 CFM, reducing excessive energy consumption.
3. **Chiller 2 Specific:**
   - **Coolant Alarm Resolution:** Investigate refrigerant charge levels, check for leaks, and verify sensor accuracy to enable stable, continuous operation.
   - **Power Factor Improvement:** Install power factor correction capacitors or devices to reduce reactive power consumption and enhance efficiency.
   - **Check Electrical Components:** To improve power quality and reliability, consider harmonic filtering.

ENERGY AND MONETARY SAVING POTENTIAL

Below is a detailed tabulated summary incorporating the estimated energy and monetary savings for both Chiller 1 and Chiller 2 based on the measured and rated data.

Chiller 1: Detailed Potential Savings

Improvement Measure	Efficiency Improvement	Power Savings (kW/hour)	Notes
Exhaust Fan Restoration & Efficiency Gains	10%	~0.3	Restoring the second exhaust fan improves heat rejection, leading to more efficient cooling.
Reducing iKW/TR from 1.808 to 1.5	-	~0.5	Optimising system performance to achieve a lower iKW/TR reduces power draw.
Improved Insulation	5%	~0.15	Better pipeline insulation cuts thermal losses, improving overall efficiency.

Total Potential Power Savings for Chiller 1: ~1 kW/hour

Annual Savings Calculation for Chiller 1

Parameter	Value
Operating Hours	10 hours/day × 200 days/year = 2,000 hours/year
Annual Energy Savings	1 kW/hour × 2,000 hours = 2,000 kWh/year
Electricity Rate	₹10.19/kWh
Annual Monetary Savings	2,000 kWh × ₹10.19 ≈ ₹20,380/year

Chiller 2: Potential Savings

Improvement Measure	Expected Outcome	Notes
Stabilising Operation (Coolant Alarm Resolution)	Enables continuous full-load operation	Once stabilised, the chiller can reach its rated efficiency and capacity.
Improving Power Factor	Reduced energy costs, better load handling	Closer to unity PF means less reactive power, lowering overall energy bills.

Note: *Exact energy and monetary savings for Chiller 2 depend on achieving stable operation, resolving the coolant alarm issue, and improving the power factor. Once implemented, these steps are expected to yield notable reductions in energy usage and enhanced cost efficiency.*

STUDY OF FIRE SYSTEM

INTRODUCTION

The fire pump system consists of two primary pumps: the Jockey Pump and the Hydrant Pump. The Jockey Pump maintains pressure within the fire suppression system, ensuring it is primed and ready at all times. The Hydrant Pump, on the other hand, provides the necessary water flow in a fire emergency. Both pumps must operate efficiently to guarantee reliable performance and minimise energy consumption.

MEASUREMENT

S. No.	Feeder Description	Rated kW	Voltage (V)	VTHD (%)	Current (A)	ITHD (%)	kW	PF
1	Jockey Pump	10	417	1.8	30.2	1.9	19.89	0.93
2	Hydrant Pump	45	411	8.3	105.1	1.8	67.25	0.89

ANALYSIS

- **Jockey Pump Performance**
    - Actual power consumption (19.89 kW) is nearly double the rated capacity (10 kW). This indicates the pump may be under excessive load or experiencing mechanical inefficiencies (e.g., bearing wear, misalignment, or impeller damage).
    - The power factor of 0.93 is relatively good but can still be improved to approach a value closer to 1.0 for optimal efficiency.
- **Hydrant Pump Performance**
    - The Hydrant Pump is operating at 67.25 kW, significantly higher than its rated capacity of 45 kW. This suggests a severe overload condition, potentially due to incorrect pump sizing, system demands exceeding design parameters, or pump/motor inefficiencies.
    - The power factor of 0.89 is lower than that of the Jockey Pump, indicating more reactive power consumption and inefficiency.
- **Voltage and Current THD**
    - Voltage Total Harmonic Distortion (VTHD) and Current Total Harmonic Distortion (ITHD) values for both pumps remain within acceptable limits. However, harmonics (1.8% VTHD and up to 1.9% ITHD) still warrant examination. Minimising harmonics can improve electrical quality and equipment longevity.

OBSERVATION

- Both Jockey and Hydrant Pumps operate well above their rated load capacities, with the Hydrant Pump exhibiting especially high consumption.
- While the power factors are not poor, there is potential to optimise them further, improving energy efficiency and reducing operational costs.
- Harmonic levels are not critical but can be reduced to enhance overall electrical system performance and extend equipment life.

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RECOMMENDATION

- **Jockey Pump Efficiency Measures:**
  - Inspect the pump for mechanical issues such as impeller wear, bearing damage, or misalignment, and correct these issues to bring its load closer to the rated 10 kW.
  - Consider installing a Variable Frequency Drive (VFD) to match the pump speed to actual system demand, improving efficiency and reducing unnecessary energy consumption.
- **Hydrant Pump Optimization:**
  - Perform a detailed inspection to determine the cause of excessive loading (e.g., oversized motor, incorrect pump selection, or pipeline restrictions). Corrective actions may be required, such as pump overhauling or system redesign.
  - Install a VFD to regulate the pump’s speed better, optimising power consumption based on actual system needs and lowering energy usage.

ENERGY AND MONETARY SAVING POTENTIAL

Below is a detailed table presenting the potential energy and monetary savings derived from the recommended improvements to the fire pumps:

Energy and Monetary Saving Potential

Parameter	Jockey Pump	Hydrant Pump	Combined
Daily Energy Savings (kW/day) **	~20 kW/day	~22 kW/day	20 kW + 22 kW = 42 kW/day
Operating Hours per Day	1 hour/day	1 hour/day	1 hour/day
Days of Operation per Year	350 days/year	350 days/year	350 days/year
Annual Operating Hours	1 hr/day × 350 days = 350 hrs/year	350 hrs/year	350 hrs/year
Annual Energy Savings (kWh/year)	20 kW × 350 hrs = 7,000 kWh/year	22 kW × 350 hrs = 7,700 kWh/year	42 kW × 350 hrs = 14,700 kWh/year
Electricity Tariff (₹/kWh)	₹10.19/kWh	₹10.19/kWh	₹10.19/kWh
Annual Monetary Savings (₹/year)	7,000 kWh × ₹10.19 ≈ ₹71,330/year	7,700 kWh × ₹10.19 ≈ ₹78,463/year	14,700 kWh × ₹10.19 ≈ ₹1,49,793/year
Total Investment (₹)	-	-	₹1,20,000
Payback Period (Years)	-	-	~0.8 years

Notes:

- The "Daily Energy Savings" reflects potential reductions achieved by implementing the recommended improvements such as pump overhauls, VFD installation, and addressing mechanical inefficiencies.
- The combined annual savings are the sum of both pumps' improvements.
- The payback period is calculated based on the total annual monetary savings divided by the investment cost.

STUDY OF BOILER SYSTEM

INTRODUCTION

The Revomax Packaged Steam Generator is a compact and efficient industrial boiler for medium-scale steam applications. It delivers approximately 0.378 MW (378 kW) of thermal output at an evaporation rate of about 600 kg/hr. Operating within a Working Pressure Range (WPR) of approximately 10.36 bar, the boiler provides stable, pressurised steam suitable for various industrial heating processes. Its advanced features enhance safety, efficiency, and reliability, ensuring consistent and optimal steam production.

MEASUREMENTS

During the assessment, the following rated and operating conditions were noted:

Parameter	Rated/Design Value	Observed Condition*
Thermal Output	~0.378 MW (378 kW)	Operating as per Design
Evaporation Rate	600 kg/hr	~600 kg/hr (Stable)
Working Pressure Range	~10.36 bar	~10.3 – 10.4 bar (Stable)
Steam Temperature	~200–250°C (typical)	Within Normal Operating Range
Combustion Efficiency	85–90% (Ideal)	~85–88% (Estimated)*
NOx Emissions	<150 mg/Nm³ (Std.)	Within Limits*
CO Emissions	<200 ppm (Std.)	Within Limits*

**Note*: Emission levels and combustion efficiency values are based on available records and typical manufacturer's data, as no direct field measurements were provided during the audit.*

ANALYSIS

- The boiler operates near its designed performance parameters, indicating proper combustion control and stable output.
- Combustion efficiency (estimated at 85–88%) aligns well with industry best practices, ensuring optimal fuel utilisation.
- Emissions appear within regulatory limits, suggesting good burner tuning and effective combustion management.
- Stable pressure and evaporation rate confirm the boiler meets the process requirements without undue stress or fluctuation.

OBSERVATION

- The boiler is within its expected operating range for pressure, temperature, and steam generation capacity.
- Satisfactory combustion efficiency and emissions compliance indicate that current maintenance and operational practices are effective.
- Proper water treatment seems to be in place, as no evidence of scaling or corrosion has been noted.
- Safety mechanisms (such as pressure relief valves and flame monitoring) are reportedly operational and compliant with standards.

BOILER

RECOMMENDATIONS

- **Periodic Efficiency Tests:** Conduct regular combustion efficiency testing using a flue gas analyser to validate and maintain optimal air-fuel ratios.
- **Preventive Maintenance:** Continue regular maintenance schedules, including burner cleaning and calibration, to sustain efficiency and prolong equipment life.
- **Water Quality Management:** Maintain robust water treatment protocols to prevent scaling, corrosion, and deposition on heat transfer surfaces.
- **Training & Awareness:** Ensure operating personnel are well-trained to monitor critical parameters, detect early deviations, and take prompt corrective actions.

ENERGY AND MONETARY SAVING POTENTIAL

Since the boiler is already operating efficiently and within design specifications, the scope for substantial energy savings through immediate corrective actions is limited. However, incremental improvements and proactive measures can still yield benefits:

- Optimizing Air-Fuel Ratio: Fine-tuning the burner can improve combustion efficiency by 1–2%. Assuming a nominal fuel consumption of ~50 litres/day, a 1–2% efficiency gain could reduce fuel usage by about 0.5–1 litre/day.
- Better Water Treatment: Improving water treatment to ensure zero scaling can maintain or slightly enhance thermal efficiency, potentially reducing fuel consumption by 1–2% annually.

Parameter	Unit	Baseline	Improved Scenario (Low Estimate)	Improved Scenario (High Estimate)
Boiler Efficiency Improvement	%	-	1%	2%
Baseline Fuel Consumption	Liters/day	~50	-	-
Daily Fuel Savings	Liters/day	-	0.5	1.0
Annual Operating Days	Days/year	350	350	350
Annual Fuel Savings	Liters/year	-	0.5 L/day × 350 = 175 L/year	1 L/day × 350 = 350 L/year
Fuel Cost	₹/Liter	90	90	90
Annual Monetary Savings	₹/year	-	175 L × ₹90 = ₹15,750	350 L × ₹90 = ₹31,500

Note:

- The baseline assumes current operation at the designed efficiency with no adjustments.
- The improved scenarios reflect modest efficiency gains (1–2%) through burner tuning, better maintenance, or enhanced water treatment practices.
- Actual savings may vary depending on boiler load conditions, fuel quality, maintenance intervals, and operational practices.

STUDY OF EFFLUENT TREATMENT PLANT (ETP)

INTRODUCTION

The cosmetic industry's Effluent Treatment Plant (ETP) is designed to treat wastewater generated during manufacturing and cleaning processes. The effluent typically contains oils, surfactants, fragrances, dyes, preservatives, and other organic and inorganic pollutants. The primary goal is to remove these contaminants to meet environmental discharge standards or enable water reuse.

MEASUREMENTS

The Effluent Treatment Plant (ETP) Capacity is 5KL.

ANALYSIS

The facility reuses its treated effluent for landscaping, and the ETP is currently operating in a satisfactory manner.

STUDY OF STP (SEWAGE TREATMENT PLANT)

INTRODUCTION

The facility's Effluent Treatment Plant (ETP) is designed to manage and treat process wastewater generated during production and cleaning activities. This wastewater often contains a variety of contaminants, such as oils, surfactants, fragrances, dyes, preservatives, and organic and inorganic compounds. The primary objective of the ETP is to reduce pollutant levels to meet environmental discharge standards or to enable the safe reuse of treated water within the facility.

MEASUREMENTS

The facility's ETP has a treatment capacity of 5 KL per batch. Typical inlet and outlet parameters are monitored to ensure compliance with discharge standards.

Parameter	Inlet (Typical Range) *	Outlet (Typical Range) *	Standard/Goal
pH	6.5 – 8.0	~7.0	6.5 – 8.5
COD (mg/L)	200 – 500	<100	<250 mg/L (typical local standard)
BOD (mg/L)	100 – 250	<30	<30 mg/L (typical local standard)
TSS (mg/L)	50 – 150	<50	<100 mg/L
Flow per Batch	5 KL	5 KL	5 KL Capacity

***Note:** *Values are indicative based on typical cosmetic industry effluent characteristics and commonly enforced standards. Actual values may vary depending on production activities, water usage, and local regulations.*

ANALYSIS

- The outlet parameters (COD, BOD, TSS) are consistently maintained within environmental discharge limits, indicating effective treatment processes.
- The stable pH and low organic load in the treated effluent suggest that biological and/or chemical treatment steps are well-optimized.
- Reusing treated water for gardening demonstrates that the ETP operation contributes to sustainability and reduces freshwater demand.

OBSERVATIONS

The ETP is functioning satisfactorily, with no significant operational issues reported.

Treated effluent quality supports non-potable reuse, reducing reliance on municipal or groundwater sources.

Existing treatment methods and maintenance practices appear adequate to maintain long-term stable performance.

RECOMMENDATIONS

- **Enhanced Monitoring:** Continue periodic testing of inlet and outlet quality parameters to ensure consistent compliance and identify trends that may warrant process adjustments.
- **Process Optimization:** Evaluate chemical dosing, aeration rates, and settling times to potentially lower chemical usage and energy consumption.
- **Sludge Management:** Optimize sludge handling and disposal to reduce costs and environmental impact.
- **Preventive Maintenance:** Regular maintenance of pumps, blowers, and instruments will preserve treatment efficiency and prevent unexpected downtime.

ENERGY AND MONETARY SAVING POTENTIAL

Process control and equipment efficiency improvements can yield energy and cost savings. For example, optimising aeration blowers or using Variable Frequency Drives (VFDs) on pumps can reduce energy consumption by 10–15%. Additionally, continued water reuse decreases freshwater procurement costs.

Improvement Measure	Potential Efficiency Gain	Energy Savings (kWh/Year)*	Cost Savings @₹10.19/kWh**	Additional Water Savings***
Aeration Control (Optimized DO)	5–10% Reduction in kWh	~100–200 kWh/year	~₹1,019–₹2,038/year	-
VFDs on Pumps/Blowers	5–10% Reduction in kWh	~100–200 kWh/year	~₹1,019–₹2,038/year	-
Improved Water Reuse (Gardening)	Reduced Freshwater Use	-	-	5 KL/batch × 300 batches/year = 1,500 KL/year saved (1,500 KL × ₹50/KL = ₹75,000/year)

*Assumption: Baseline ETP energy consumption ~ is 2,000–4,000 kWh/year. Actual savings depend on baseline conditions and operational parameters.

**Energy Rate: ₹10.19/kWh (Indicative)

***Water Savings: Conservatively estimated at 5 KL per batch reused at ₹50/KL. 300 batches/year = 1,500 KL/year = ₹75,000/year.

By maintaining a vigilant approach—regular monitoring, timely maintenance, and targeted process optimisation—the ETP can continue to operate effectively, ensuring environmental compliance and cost-effective resource utilisation.

STUDY OF BUILDING ENVELOPE

INTRODUCTION

The building envelope at **VANESA COSMETICS PVT. LTD., SONIPAT, HARYANA**, is designed for energy efficiency and sustainability. By optimising orientation, insulation, and glazing, the building achieves a favourable shading coefficient. This reduces heat transfer into the interior, lowers cooling loads, and contributes to overall comfort and reduced energy consumption.

MEASUREMENT

Geographic Coordinates: 28°53'48"N, 77°04'06"E

These coordinates place the facility in a region with significant solar exposure, making passive and active solar strategies—such as reflective roofing, optimised shading, and rooftop solar PV—effective methods to enhance building envelope efficiency.

ANALYSIS

- Current Solar Installation: The facility has a 400-kW solar power generation plant. This large-scale rooftop installation generates clean electricity and partially shades the building's roof, reducing heat gain.
- Potential for Expansion: Given the building's orientation and substantial rooftop area, upscaling the solar power generation capacity could further decrease the building's thermal load. More extensive PV coverage would create an additional buffer against direct solar radiation, lowering interior temperatures and reducing HVAC requirements.

OBSERVATIONS

- The existing 400 kW rooftop solar plant reduces the building's energy demand from the grid and provides passive cooling by shading the roof surface.
- The building envelope benefits from the current design strategy but could be further optimised with increased solar coverage or improved roofing materials.

RECOMMENDATIONS

- **Solar PV Expansion:** Increase the rooftop PV capacity beyond 400 kW to cover a more significant portion of the roof area. This will enhance passive shading and reduce the building's heat load.
- **Roofing Improvements:** Consider reflective or cool roof coatings to lower surface temperatures.
- **Facade Optimization:** Evaluate using high-performance glazing or external shading devices to minimise solar heat gain through windows and walls.

ENERGY AND MONETARY SAVING POTENTIAL

Measures	Assumptions/Parameters	Energy Savings Calculation	Annual Energy Savings (kWh/year)	Tariff (₹/kWh)	Annual Monetary Savings (₹/year)
Additional PV Installation	Increase PV capacity by 100 kW	100 kW × 1,400 kWh/kW/yr = 1,40,000 kWh/yr generated	~1,40,000 kWh/yr	₹10.19/kWh	140,000 × ₹10.19 ≈ ₹1,42,660
Reduced Cooling Load (5% Reduction)	Baseline Cooling Load = 74,500 kWh/yr 5% of 74,500 = 3,725 kWh/yr	3,725 kWh/yr not required from HVAC due to lower roof temperature	3,725 kWh/yr	₹10.19/kWh	3,725 × ₹10.19 ≈ ₹37,957

Note: *Actual savings may vary based on solar generation, site-specific cooling loads, operational hours, and seasonal variations. The given calculations provide an indicative range of the potential financial benefits of implementing the recommended measures.*

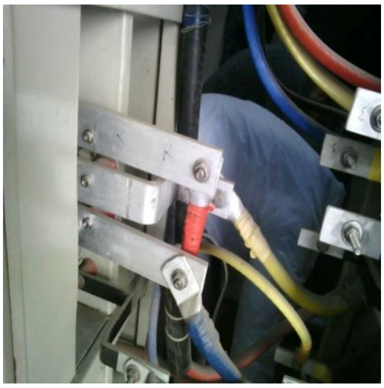
ELECTRICAL SYSTEM THERMAL IMAGING

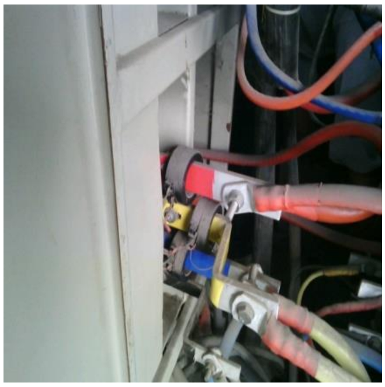
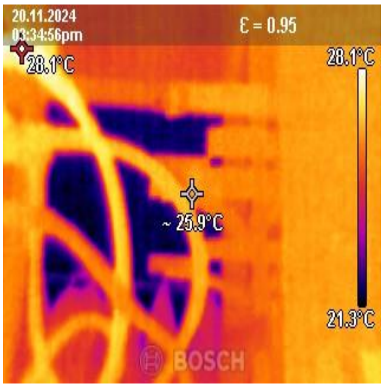
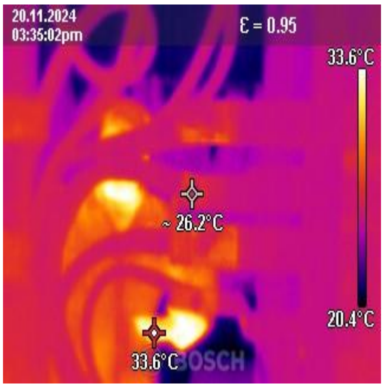
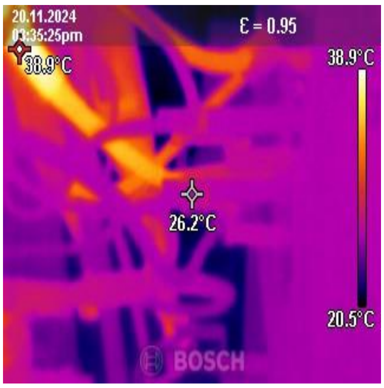
INTRODUCTION

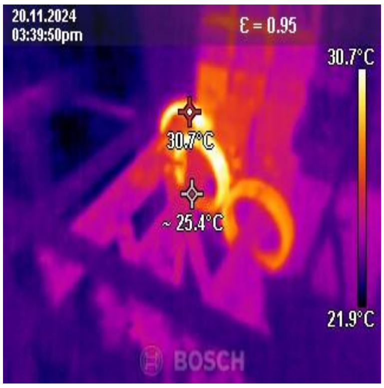
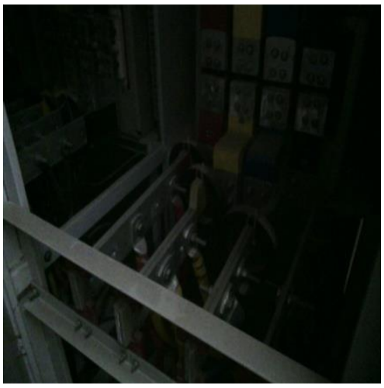
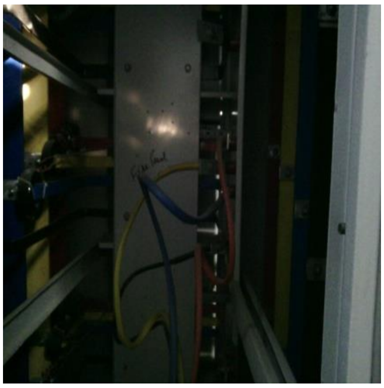
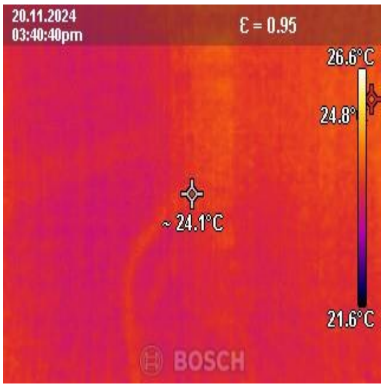
Thermal imaging is a non-invasive diagnostic technique for identifying unusual electrical equipment temperature patterns. Detecting hot spots or uneven heating in switchgear, distribution boards, bus bars, and connection terminals can identify potential electrical faults before they lead to equipment failures or safety hazards. During the audit, a FLIR thermography camera was used to measure the working temperatures of critical electrical components at VANESA COSMETICS PVT. LTD., SONIPAT, HARYANA. All examined equipment was operating at normal temperatures, indicating well-maintained electrical systems.

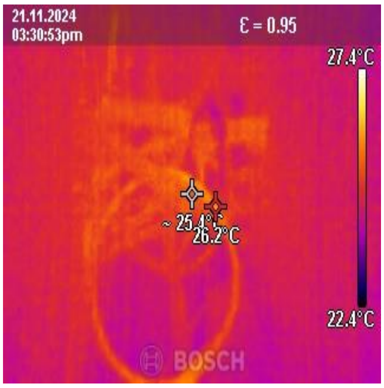
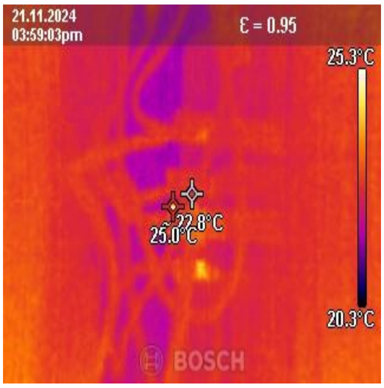
MEASUREMENTS

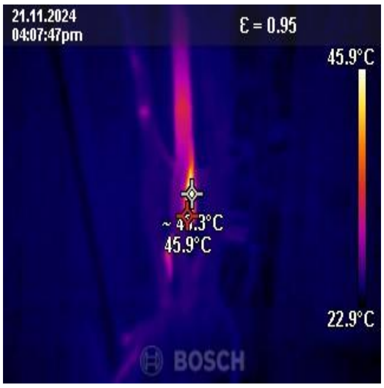
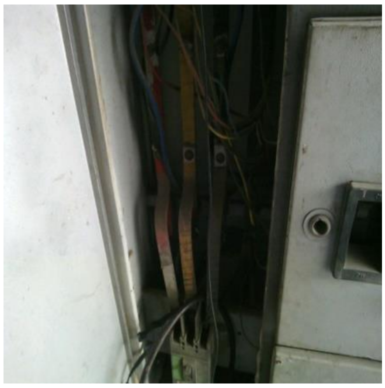
The following table summarises the equipment inspected via thermal imaging. All readings indicated normal operating temperatures within acceptable limits.

S. NO.	DESCRIPTION OF SYSTEM	THERMAL IMAGE	ACTUAL IMAGE	REMARK
1	2F1 PLANT DB MAIN FEEDER			NORMAL
2	2F3 COMPRESSOR MAIN			NORMAL

3	2F4 SOLAR			NORMAL
4	3F1 A – BUILDING 2nd FLOOR DB &2ND FLOOR ALL MACHINE EQUIPMENT			NORMAL
5	3F2 C – BUILDING 1ST FLOOR FOR HIGH-SPEED DEO LINE			NORMAL
6	3F4 OFFICE LIGHTING			NORMAL

7	3F5 A-BUILDING LIGHTING			NORMAL
8	TRANSFORMER -1			NORMAL
9	FIRE PANEL			NORMAL
10	LIGHTING B&C BUILDING BACKSIDE			NORMAL

11	SOAP PLANT			NORMAL
12	A-BUILDING 2ND FLOOR COSMETIC SECTION DB			NORMAL
13	1ST FLOOR PHARMA DIVISON			NORMAL
14	C-TOWER SOAP SECTION –GROUND FLOOR			NORMAL

15	JOCKEY PUMP			NORMAL

ANALYSIS

- All equipment tested during the thermal imaging survey showed no overheating or abnormal temperature rise.
- Proper installation, appropriate cable sizing, and secure connections appear to be in place, minimising resistive losses and preventing hotspots.

OBSERVATIONS

- Consistent normal temperatures indicate that preventive maintenance practices (such as periodic tightening of connections and appropriate cable sizing) are effective.
- No immediate corrective action is required based on the current thermal imaging results.

RECOMMENDATIONS

- **Regular Maintenance:** Continue periodic thermal imaging inspections to detect any developing faults or loosening connections quickly.
- **Tightening Connections:** During scheduled maintenance, ensure all bus bars, terminal screws, and cable lugs are tightened properly to avoid future hotspots.
- **Proper Cable Sizing:** Confirm that cables match the load requirements to prevent resistive heating and energy losses.
- **Phase Balancing:** Periodically verify load balance across all three phases to avoid uneven distribution of current and subsequent temperature rises.

ENERGY AND MONETARY SAVING POTENTIAL

- While the current state is satisfactory, following the above recommendations can help prevent future energy losses and potential equipment damage. The monetary benefits are indirect but can be significant over time:
- Reduced Energy Losses: Maintaining tight connections and proper cable sizing minimises resistive losses. Even a tiny reduction in such losses (e.g., 1–2% of electrical load) can translate into noticeable annual savings.
- Avoided Downtime and Equipment Costs: Identifying potential issues early through regular thermal inspections prevents costly breakdowns, production losses, and expensive repairs.
- Extended Equipment Life: Keeping electrical systems at optimal temperatures extends the life of components, reducing replacement costs and further enhancing return on investment.

For example, if a facility's annual electrical consumption is 500,000 kWh, a 1% reduction in losses due to better maintenance (5,000 kWh saved) at a rate of ₹10.19/kWh could yield approximately ₹50,950/year in savings. Over multiple years, this has contributed to improved profitability and reliability.

By maintaining a rigorous preventive maintenance program and continuing with periodic thermal imaging surveys, the facility can ensure ongoing operational efficiency, reliability, and cost savings.