Binod ji
Read this document and discuss on Tuesday 28 Nov 10:30 AM

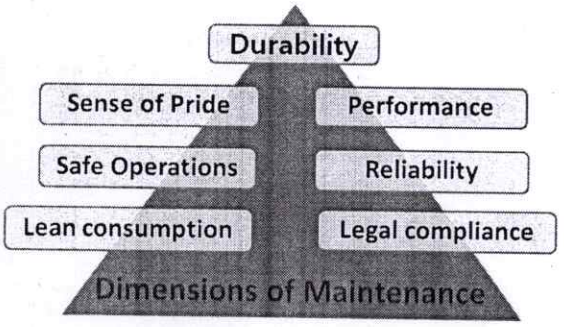
Energy Audit Report

for

M/s Amritsar Group of Colleges, Amritsar

Nov' 23

24/11/23



Centre for Excellence in Maintenance
www.cfeim.in

Content

ACKNOWLEDGEMENT

M/s Centre for Excellence in Maintenance expresses sincere thanks to the Management of M/s Amritsar Group of Colleges, Amritsar for inviting us to conduct the Energy audit study at the manufacturing facility and also for having excellent hospitality during the course of energy audit.

We are also highly thankful to Mr. Gaurav Tejpal (Principal, College of Engineering & Technology), Mr. Bimal Kumar (Associate Professor– Electrical), Mr. Vicky (OSD to Chairman) and Mr. Inderjeet (Associate, Electrical) & all the maintenance staff involved in the energy audit activities for their kind and whole hearted support, without which the audit team could not have collected the exhaustive data successfully.

The audit team is very thankful to the staff and management for providing all the required data for timely execution of the activities.

Rahul Saini
(EA-24286)
BEE Certified Energy auditor

For Centre for Excellence in Maintenance

ABBREVIATION

kWh	kilo watt hour
tCO2	Ton of carbon dioxide
kVAr	Kilo volt ampere reactive
TOD	Time of day
PSPCL	Punjab State Power Corporation Limited
APFC	Automatic Power Factor controller
PF	Power Factor
VSD	Variable speed Drive
THD	Total harmonic distortion
THDv	Total harmonics distortion in voltage
THDi	Total harmonics distortion in current
Urms	Phase to phase RMS voltage
WBT	Wet bulb temperature
DBT	Dry bulb temperature
EA	Energy Audit
GOT	Graphic operation terminal
HT	High tension
TDS	Total dissolved solids
CD	Contract demand
MDI	Maximum demand indicator

UNITS AND MEASUREMENT

° C	Centigrade
cfm	Cubic Feet per minute
kVAh	Kilo volt ampere hour
kWh	Kilo watt hour
kW	Kilo Watt
V	Voltage
A	Ampere
f	Frequency of supply voltage
η	Efficiency
bar (g)	Gauge pressure in bar
h	Hour
min	Minute
s	Second
kCal	Kilo calorie
mm	Milimeter
m^3	Cubic meter

CONVERSION FACTORS

1 kWh	860 kcal

EMISSION FACTORS

Electricity	0.79 kg CO_2/unit
Diesel	2.68 kg CO_2/ kg

EXECUTIVE SUMMARY

Major Energy conservation Opportunities

- Operation of DG set in synchronization with solar PV power plant. (annual ₹ 9.5 lakh rupees saving potential) --- REFER PAGE no.
- Regular cleaning of the solar PV power plant will enable to ensure higher generation *(there is gap of upto 1.42 kWh/kWp as per the energy generation data of solar Power plant)*
- Energy monitoring at Main LT panel and block wise panel meter will provide the necessary trend and enable further diagnosis of reason of energy consumption.
- Implement Daylight saving technique (DST) by shifting office commencement hour from 9AM to 8AM in the summer season.
- Reduction of contract demand to initial level by implementation of MDI controller. (maximum demand indicator controller) – annual energy bill reduction potential ₹ 7 lakh rupees.

Appreciable Actions taken

- Installation of the 300 kWp solar Power plant
- Energy efficient LED light installed in the campus.
- Automatic Power factor controller installed to maintain power factor upto 0.9998 level.

Improvement Area

Energy monitoring needs to be carried out at the main LT panel, Sub- panels and solar PV power plant.

Regular inspection of the equipment related to functional points must be carried out according to pre-defined check sheet, for improved energy performance and life of the equipment.

Transformer

The following observation needs immediate action.

- The transformer oil was NIL in both the transformer' s conservator tank.
- The 400 kVA Transformer oil temperature was found to be 50 ° C. The low oil could be the cause. It is recommended to take necessary action as soon as possible.
- The breather arrangement is found to be miss in the 600 kVA transformer.
- The transformer room should be made easy for access for regular inspection.
- The transformer being of OCTC type (Off- circuit tap changer) should be planned in future for the OLTC (on-load tap changer) so that voltage regulation can be done automatically.
- The low voltage results in higher line current drawn by the equipment and high voltage can consequential for the equipment.

Capacitor Bank

- The regular inspection of the capacitor bank should be carried out and current in all the three phases should be maintained.
- It is recommended to install 3 phase Ampere meter on the capacitor bus so that capacitor bus current can be observed at a glance. It will enable us to identify unbalance current.

DG set 250 kVA

- The DG set voltage is maintained at 400 V level which should be maintained between 410-415V.
- The frequency is slightly higher between 50.28-50.89 Hz. It should be maintained between 49.5 - 50 Hz.
- The SEGR **(unit/ liter)** trend should be monitored for the DG set operation.

DG set 320 kVA

- The DG set stack should be installed so that the exhaust gases are escaped out of the shed and enable the DG set to breathe fresh air for improved combustion efficiency.

- The SEGR **(unit/ liter)** trend should be monitored for the DG set operation.

Submersible Pump

- The submersible pump motor name plate data is not available due to which the judgement cannot made on the basis of current drawn by the pump.
- The monthly inspection of the motor current is recommended. Its record should be maintained.
- The flow meter data should be maintained for the water consumption check.

Water Cooler

- The water cooler condenser cleaning is required so that the efficiency of the cooler is maintained.
- ELCB/RCCB to be installed for tripping water cooler supply in case of leakage current. This is very critical for the person safety.
- The drinking water TDS should be monitored regularly.

Air Conditioning system

- The AC pipes insulation to be maintained so that heat gain in the gas pipe can be reduced.
- The regular cleaning of the AC filters, Evaporator coil, condenser is highly recommended every fortnight or month based on the cooling effect.
- The grill temperature at AC indoor unit should be monitored and necessary action be taken accordingly.
- The monthly inspection of the AC current is recommended. Its record should be maintained.
- The name plate data of the air conditioning unit be maintained in the equipment control register.
- The energy saving practice of *Daylight saving time (DST)* may be implemented to shift the office timing during peak summer season.

Solar Water Heater (Evacuated Tube collector, ETC)

- The ETC solar water heater is installed on the hostels roof top.
- The algae were found in the solar water heater line. The regular cleaning is recommended and avoid fouling of the solar water heater tubes.
- The Boys hostel–1 no. Solar water heater was found to be broken.
- The Girls hostel–1 no. solar water heater, water supply was not happening. The switching ON of the resistive heater may result in damage of the solar water

heater tank. It is recommended to ensure that the regular maintenance & checks are carried out related to solar water heater.

- There should be easy access for the visiting solar water heater.
- The TDS should be monitored regularly for water fed in solar water heater. The feed water TDS was found to be 368 ppm which is acceptable.
- The flushing of the solar water heater tubes is highly recommended.

Solar PV Power plant

- The energy monitoring data for the solar PV Power plant should be implemented as soon as possible.
- The regular cleaning of the solar PV power plant is highly recommended.
- The solar PV power plant is inactive during the DG set operation. It is recommended to operation the Solar PV power plant in synchronization with DG set. This will result in diesel bill reduction due to solar power plant operation in parallel with DG set.

Hidden Area

- **Design**
  - ***The GO switch area should be totally isolated to avoid any fatal accident.***
  - The transformer room should be ease of entrance for regular check-up of the transformer.
  - The LT panel room trench should be covered. To avoid fall in the pit.
  - The electrical panel rooms be maintained properly. The panel doors should be properly enclosed.
  - The ELCB/ RCCB should be installed in the water cooler to avoid electric shock to anyone in contact with water cooler.
- **Maintenance system**
  - The SLD should be available in the LT panel room.
  - The input- output diagram marking should be available on the LT panel.

- The insulation mat as per IS-15652-2006 should be installed at the front and back side (wherever possible) of the panel. **NO EARTHING MAT COULD BE FOUND.**

- The panel doors should be properly closed. It has been observed that there are panels in which the doors are not closed properly, especially in LT panel room, capacitor panel.

- The panel fans should be operational properly for rejection of the panel heat especially in the capacitor Panel. The capacitor life will be enhanced due to proper heat rejection.

▪ Training & Personnel behaviour

- The workplace safety training should be carried out for all the electrician/ staff.

- The workplace hazard assessment should be carried out for the near miss and proactive planning.

- The workplace training/ project should be taken up by the Faculty and students to facilitate

    - Energy monitoring (metering in Main LT panel and Sub-panel)
    - Regular inspection of the equipment
    - Equipment control register with detailed name plate data

CHAPTER 1: INTRODUCTION

1.1. Project Objective

The objective of the project is to identify the opportunities for improvement of energy performance of the utility & process equipment and suggest measures to minimise the energy losses in the plant.

1.2. Scope of Work

The scope of work is mentioned below for the EA

- Power distribution system performance assessment
- DG set performance assessment
- Electrical load check
- Solar Power plant
- Solar Water heater

1.3. Approach/Methodology

The methodology planned for accomplishing the above scope of work was divided into three phases as detailed below:

Phase 1: Inception

- Conduct meeting with the competent authority
- Schedule EA date and inform the pre requisites and support required for conducting EA

Phase 2: Detailed energy audit

- Walk-through of the site to understand the unit conditions and equipment involved
- Receive required data for EA (example, electricity bills, equipment details etc.)
- Electrical distribution system & Equipment performance EA being conducted on the site
- Inform the major observation to the concerned authority
- Existing practices to monitor energy consumption.

Phase 3: Analysis and EA report preparation

- Compilation and analysis of data collected from site
- Performance assessment of the equipment
- Conceptualization and development of energy cost reduction projects
- Cost benefit analysis

1.4. Details of the study undertaken

Dates of energy audit	6th Nov' 23 & 7th Nov' 23 (2 days)
Name of the expert involved	*Mr. Rahul Saini (EA-24286)* *Mr. Aanand Kumar (Engineer, Energy Audits)*
Name of the equipment used for Energy audit	• Power Analyser make Krykard ALM31 • Power clamp meter TESTO 770-3 • Temperature Gun Testo, 835-T2 • Surface Temperature meter, Testo 905-T2

CHAPTER 2: FACILITY OVERVIEW

Amritsar group of Colleges, Amritsar is an institutional body providing education services in the field ranging from Engineering, Hotel Management, Pharmacy & Law,

The significant energy usage of the campus includes the following

- Air conditioning system
- Diesel generator
- Water pumps
- Water coolers

The major energy systems in the plant are as follows

- Transformer 400 kVA & 600 kVA
- Air conditioning system
- Solar Power Plant 300 kWp

CHAPTER 3: REVIEW OF ENERGY BILLS

- The major energy consumption in the plant includes the following
  - Electricity
  - Diesel

- The plant has installed solar PV plant capacity of 300 kWp. However, the written name plate (of the solar plant) and commissioning documents for the solar power plant installation could not be found.

3.1 Electricity Bills analysis

The electricity is supplied by PSPCL. The tariff structure, as evident from the electricity bills from billing cycle 01-2022 to 12-2022 is mentioned below.

- The plant supply feeder voltage is 11 kV.
- Fixed charges (demand charges) are charged at 80% of contract demand or MDI whichever is higher. The demand charges are charged at ₹ 300/ kVA upto 15.05.2023. The fixed charges are charged at ₹ 340/ kVA w.e.f. 16.05.2023.
- The basic energy charges is charged at ₹ 6.38/ kVAh upto 15.05.2023 & ₹ 6.78/ kVAh w.e.f. 16.05.2023.
- The contract demand is observed to be 432 kVA for upto *01-2023* billing cycle. The contract demand was increased to 650 kVA due to MDI crossing the Contract demand in the *03-2022* billing cycle.
- It has been observed that the MDI has crossed *80% of contract demand* only 3 times since *01-2022*.
- The increase of the contract demand from 432 to 650 kVA has resulted in increase of 80% of Contract demand from 345.6 kVA to 520 kVA. The minimum fixed charges increased by ₹ 59,296/ month (@ ₹340/kVA)
- It is recommended to install MDI controller so that unnecessary load can be tripped when the maximum demand is about to cross the contract demand.
- This will result in annual energy saving of ₹ 7,11,552/- with investment of merely ₹ 50,000/-; **PAYBACK PERIOD < 1 month.**

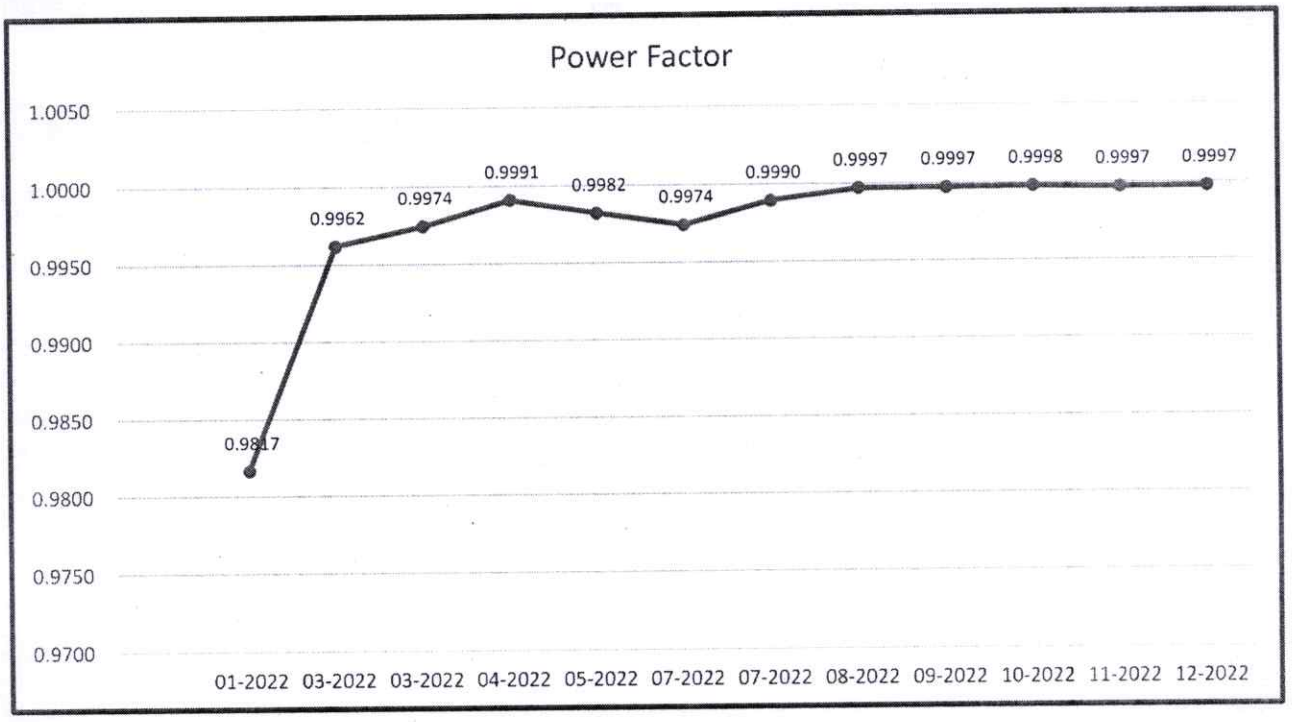
Electricity Bills Analysis 2022-23

Bill Cycle	Bill Date	Billing days	Import from grid			Export to grid			Net consumption			Solar generation		
			kWh	kVAh	kVA	kWh	kVAh	kVA	kWh	kVAh	kVA	kWh	kVAh	kVA
01-2022	28-04-2022	60	107100	109100	147	6050	6170	147	101060	102930	147	46785	47276	152
03-2022	02-06-2022	35	112760	113190	569	200	310	569	112550	112880	569	16946	17107	134
03-2022	24-06-2022	23	54650	54790	569	1050	1140	122.8	53610	53650	569	20531	20730	195
04-2022	29-07-2022	30	44080	44120	401.8	5210	5590	114.6	38860	38530	401.8	27367	27669	223
05-2022	30-08-2022	34	56610	56710	314.4	5540	5880	198.2	51080	50830	314.4	29747	30070	220
07-2022	01-10-2022	35	85450	85670	491.8	2440	2630	115.4	83010	83040	491.8	30357	30688	206
07-2022	27-10-2022	21	47690	47740	538.6	3330	3660	127.8	44360	44080	538.6	25974	26293	206
08-2022	23-11-2022	32	32540	32550	182	7250	7640	133.8	25280	24910	182	24192	24563	172
09-2022	30-12-2022	30	36060	36070	150.4	5200	5640	133.5	30870	30430	170	20366	20713	166
10-2022	27-01-2023	32	42950	42960	163.2	3320	3550	124.2	39640	39400	163.2	13211	13601	152
11-2022	23-02-2023	29	33650	33660	155.2	5740	6110	93.2	27910	27550	155.2	19967	20269	179
12-2022	29-03-2023	36	38260	38270	141.8	11000	11400	119.2	27250	26870	141.8	33466	33874	199

The month wise power factor is tabulated as below

Bill Cycle	Bill Date	Billing days	Import from grid			Net Consumption	Total consumption	Power Factor
			kWh	kVAh	kVA	kVAh	kVAh	
01-2022	28-04-2022	60	107100	109100	147	102930	150206	0.9817
03-2022	02-06-2022	35	112760	113190	569	112880	129987	0.9962
03-2022	24-06-2022	23	54650	54790	569	53650	74380	0.9974
04-2022	29-07-2022	30	44080	44120	401.8	38530	66199	0.9991
05-2022	30-08-2022	34	56610	56710	314.4	50830	80900	0.9982
07-2022	01-10-2022	35	85450	85670	491.8	83040	113728	0.9974
07-2022	27-10-2022	21	47690	47740	538.6	44080	70373	0.9990
08-2022	23-11-2022	32	32540	32550	182	24910	49473	0.9997
09-2022	30-12-2022	30	36060	36070	150.4	30430	51143	0.9997
10-2022	27-01-2023	32	42950	42960	163.2	39400	53001	0.9998
11-2022	23-02-2023	29	33650	33660	155.2	27550	47819	0.9997
12-2022	29-03-2023	36	38260	38270	141.8	26870	60744	0.9997

The Power Factor trend is tabulated as below



Comments & Recommendations

- **Solar Generation**
- The solar PV power plant generation effective is visible in the Electricity bill data. The total energy generated during ***billing cycle 01-2022 to 12-2022 is 3,08909*** kWh. The total energy exported to the grid is measured as ***56,330 kWh*** during the same period.

- The solar power plant orientation is acceptable with the
  - Solar panel installation facing south-west direction
  - No shading effect as there is no nearby high rise building or tree shade.

- The specific generation of the power plant is found to be *2.59 kWh/kWp* for the 397 days as per the billing data.

- The low specific energy generation can be attributed to the following reasons.

- Solar PV power plant not operational with the DG set.
- Regular cleaning and maintenance not being carried out.

▪ Contract demand

- The contract demand is observed to be 432 kVA for upto *01-2023* billing cycle. The contract demand was increased to 650 kVA due to MDI crossing the Contract demand in the *03-2022* billing cycle.
- It has been observed that the MDI has crossed *80% of contract demand* only 3 times since *01-2022*.
- The increase of the contract demand from 432 to 650 kVA has resulted in increase of 80% of Contract demand from 345.6 kVA to 520 kVA. The minimum fixed charges increased by ₹ 59,296/ month (@ ₹340/kVA)
- It is recommended to install MDI controller so that unnecessary load can be tripped when the maximum demand is about to cross the contract demand.
- This will result in annual energy saving of ₹ 7,11,552/- with investment of merely ₹ 50,000/-; **PAYBACK PERIOD < 1 month.**

▪ Power Factor

The Power factor is found to be operating in the range of 0.9962 to 0.9998 except for the billing cycle *01-2022* where the power factor was found to be 0.9817.

The capacitor bank should be checked regularly so that power factor is maintained properly.

CHAPTER 4: ENERGY PERFORMANCE ASSESSMENT

The plant is using electrical supply from PSPCL at 11 kV HT. The transformer 600 kVA & 400 kVA (make *Shiv Shakti*) is used for the power supply for the whole institution campus.

The major observation related to transformers are as follows

- **The transformer oil was NIL in both the transformer conservator tank.**
- **The 400 kVA Transformer oil temperature was found to be 50 ° C. The low oil could be the cause. It is recommended to take necessary action as soon as possible.**
- **The *breather arrangement* is found to be miss in the 600 kVA transformer.**
- **The transformer room should be made easy for access for regular inspection.**
- **The transformer being of *OCTC type (Off- circuit tap changer) should be planned in future for the OLTC (on-load tap changer) so that voltage regulation can be done automatically.***
- *The low voltage results in higher line current drawn by the equipment and high voltage can consequential for the equipment.*

4.1 Electrical Parameters at 400 kVA Transformer

Voltage (V) trend

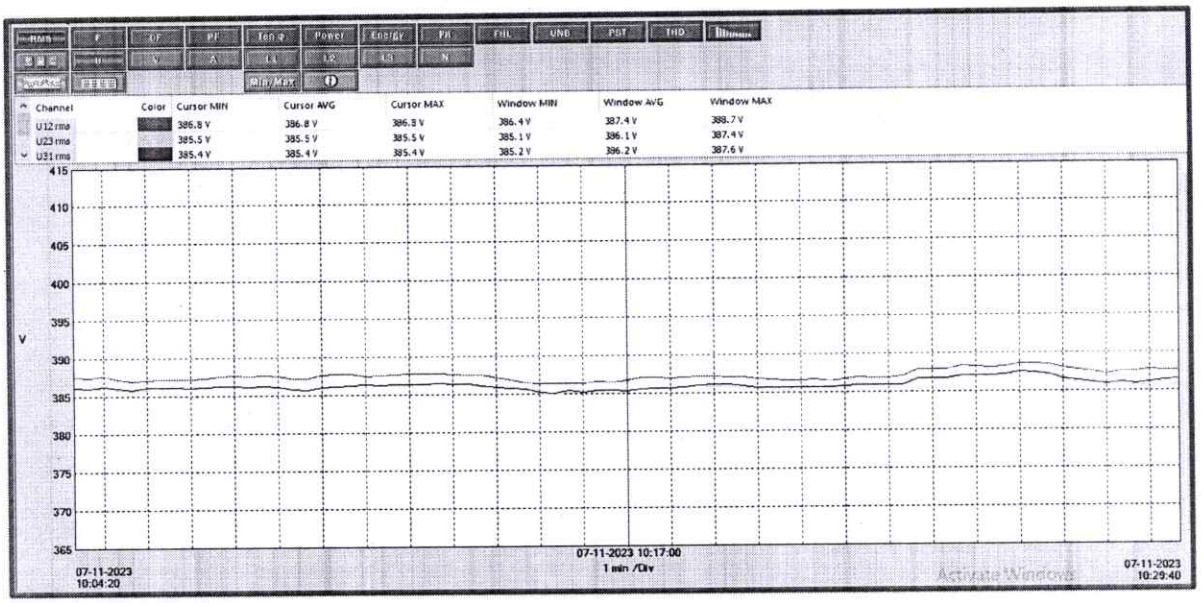


Fig. Voltage trend at Main ACB 400 kVA Transformer

Comments

- The voltage observed on the LT panel ACB 800 is observed in the range of (R/Y/B) ***386.4/385.1/385.2 V*** to ***388.7/387.4/387.6V.***
- The voltage level is low which will result in high current drawn by the load resulting in higher line losses.

Current (A) trend

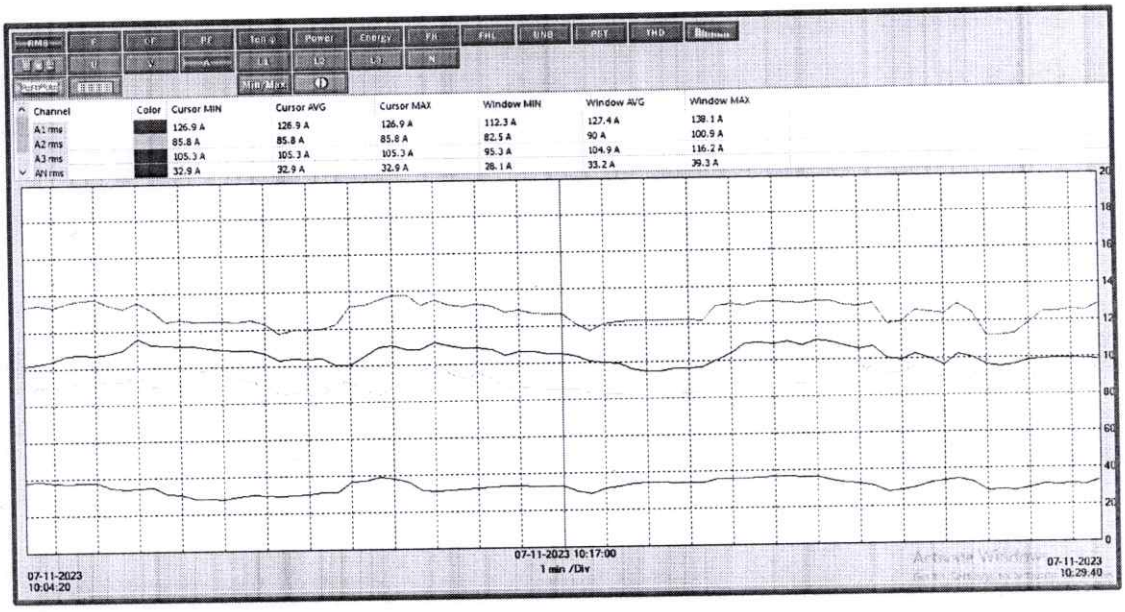


Fig. Current trend at Main ACB 400 kVA Transformer

Comments:

- The current drawn in the 3 phases is shown in the above snapshot. The unbalance current at the load end result in current flow in the neutral.

Total harmonic distortion in Voltage, THDf

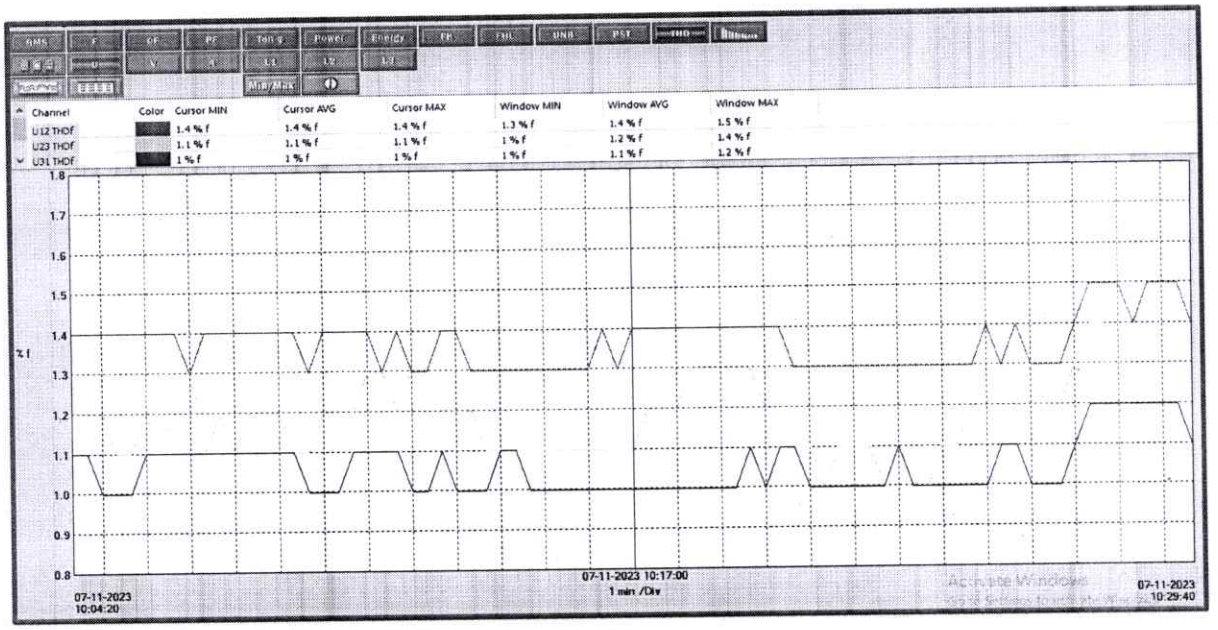
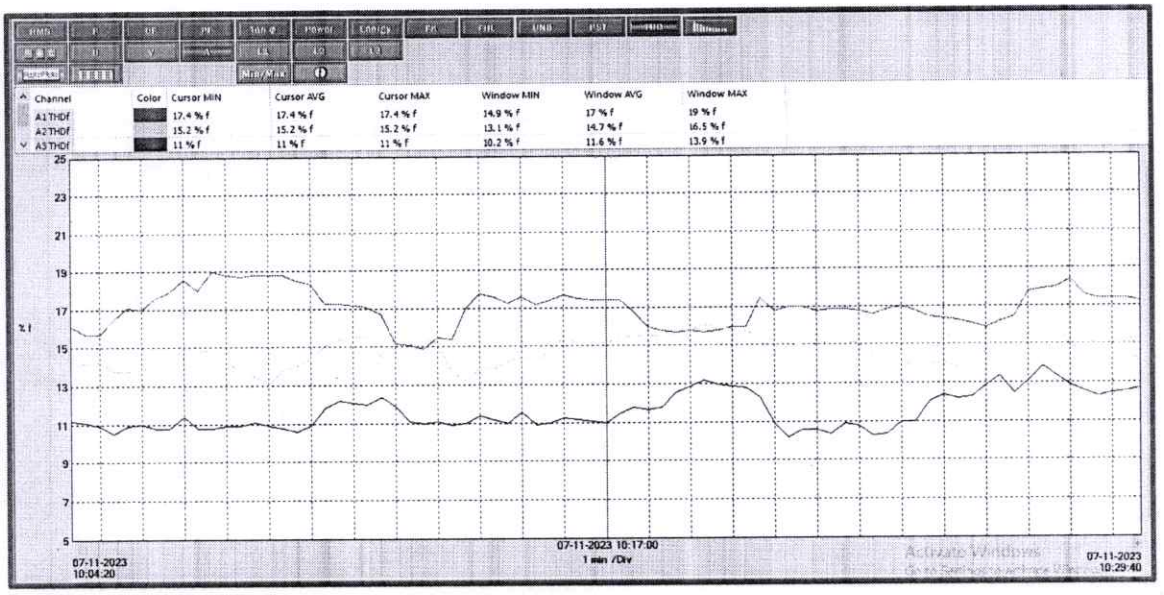


Fig. Total harmonics distortion Voltage trend at Mains ACB 400 kVA Transformer

Comments:

The total harmonics distortion in voltage is within the 5% limit specification defined as per IEEE 519:2014 standard.

Total Harmonics distortion in current (THDi) trend



Total harmonics distortion in current (THDi) trend at Main ACB 400 kVA Transformer

Comments

The total harmonics distortion in current is within the specification defined as per IEEE 519:2014 standard.

True Power, P (kW)

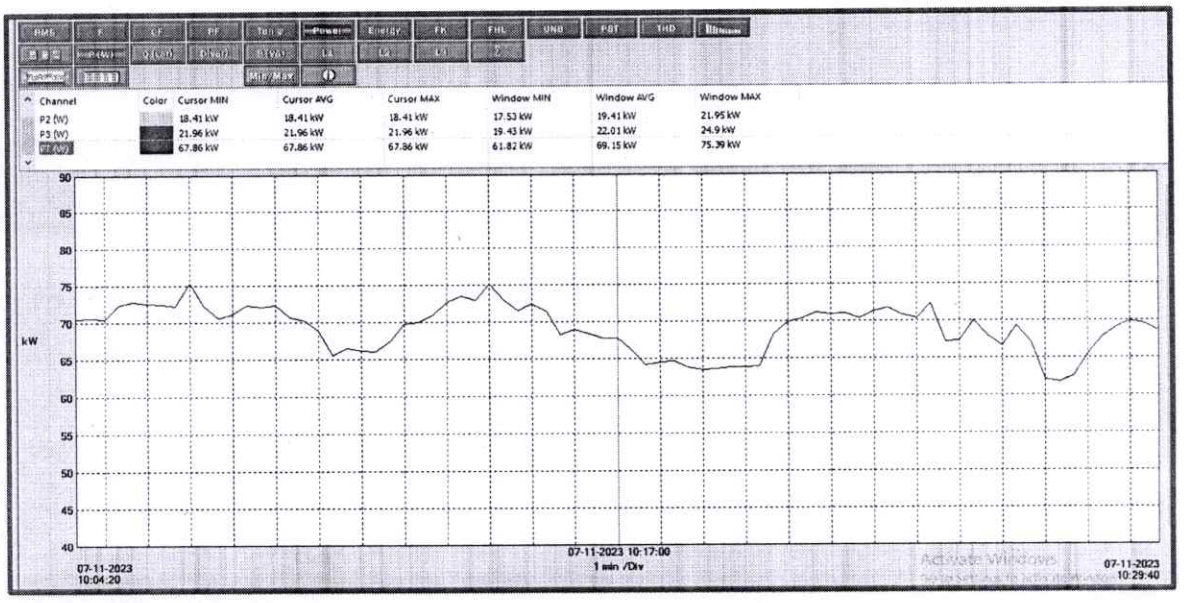


Fig. True Power trend at Mains ACB 400 kVA Transformer

Comments:

- The true power drawn at the 400 kVA transformer is tabulated as below

Parameter	Value	Unit
Average	69.15	kW
Maximum	75.39	kW
Minimum	61.82	kW

Reactive Power, Q (kVAr)

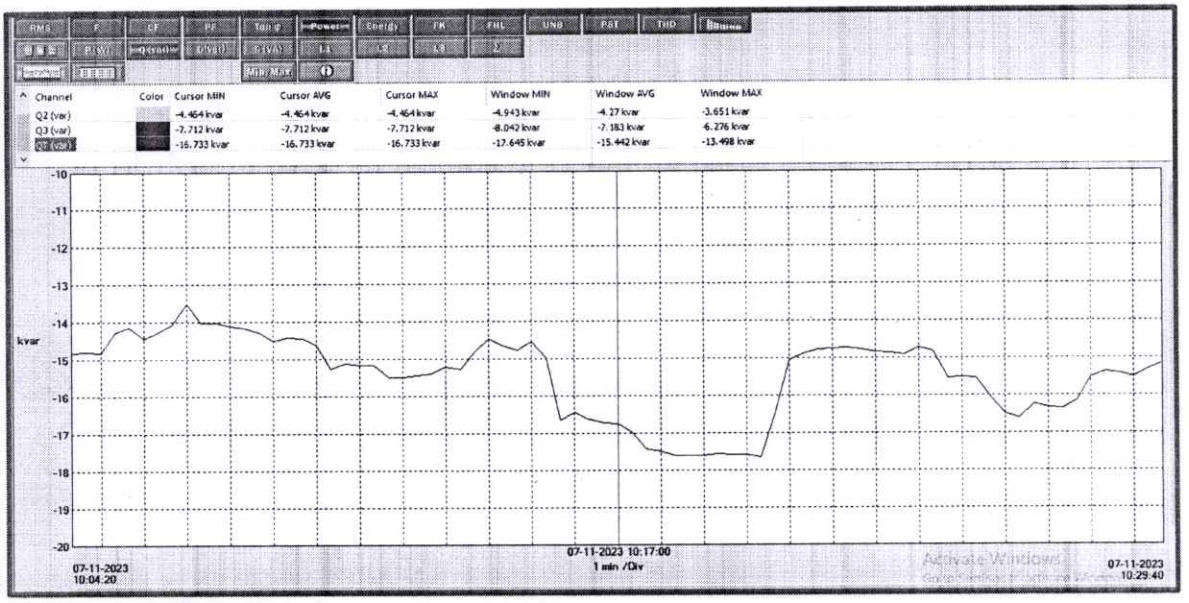


Fig. Reactive power trend at Main 400 kVA Transformer

Comments:

- The reactive power drawn at the Main *400 kVA Transformer* is tabulated as below

Parameter	Value	Unit
Average	−15.442	kVAr
Maximum	−13.498	kVAr
Minimum	−17.645	kVAr

- The negative sign indicates over-compensation of the reactive power i.e., extra capacitors are switched ON may be due to faulty contactors or improper command of APFC relay.

Apparent Power, kVA

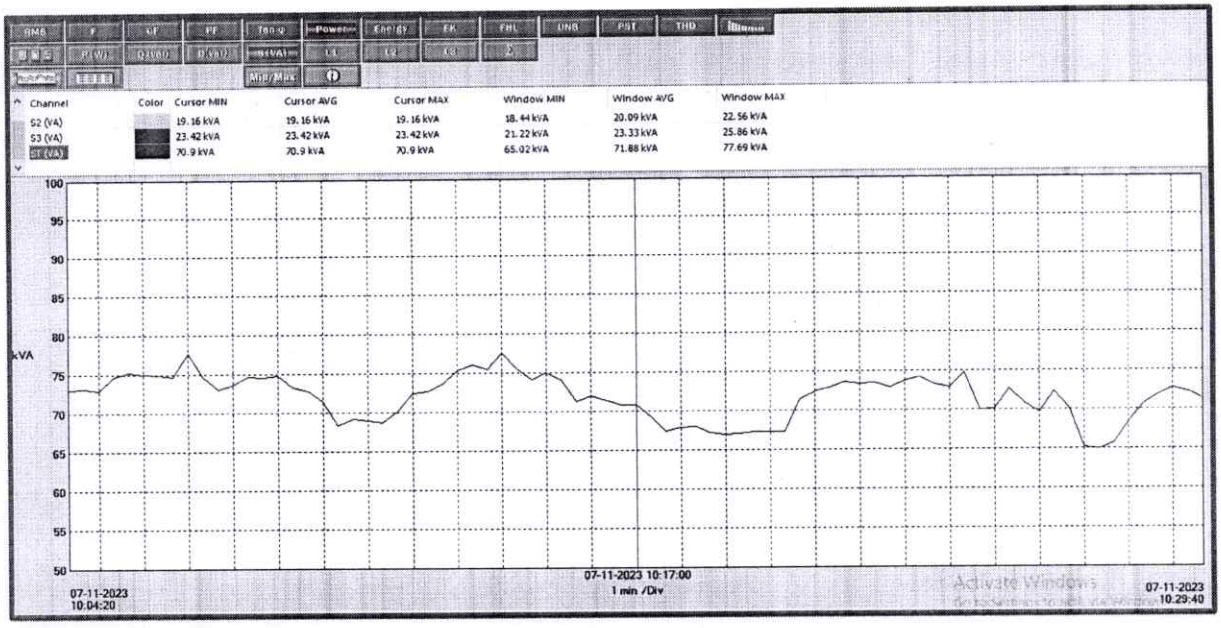


Fig. Apparent power trend at Main 400 kVA Transformer

Comments:

- The apparent power drawn at the Main *400 kVA Transformer* is tabulated as below

Parameter	Value	Unit
Average	71.88	kVA
Maximum	77.69	kVA
Minimum	65.02	kVA

Displacement Power Factor (Cos Ø) trend

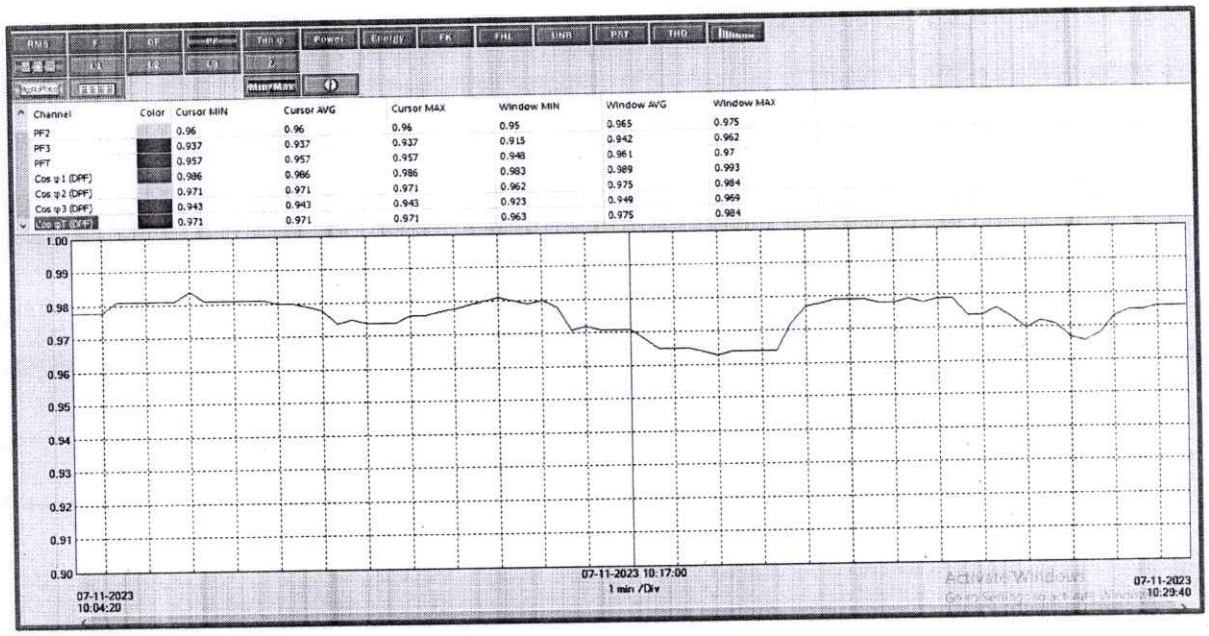


Fig. Displacement power factor trend at Main 400 kVA Transformer

Comments

- The average power factor is observed to be 0.975.

4.2 Electrical Parameters at 600 kVA Transformer

Voltage (V) trend

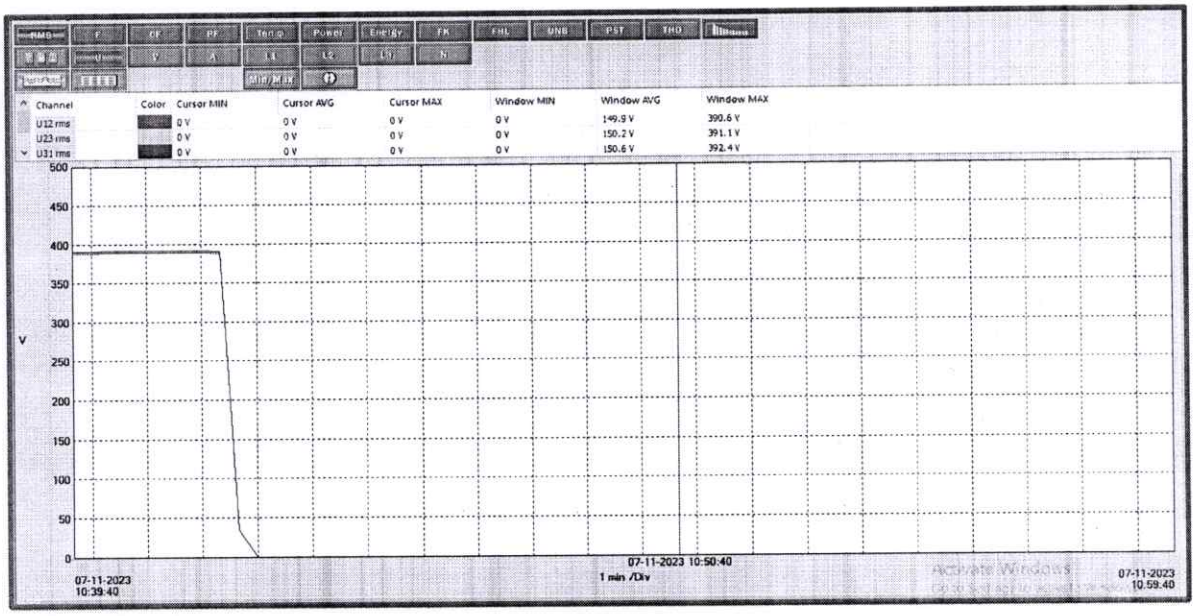


Fig. Voltage trend at Mains ACB 600 kVA Transformer

Comments

- The power cut observed after 10:42:20.

Current (A) trend

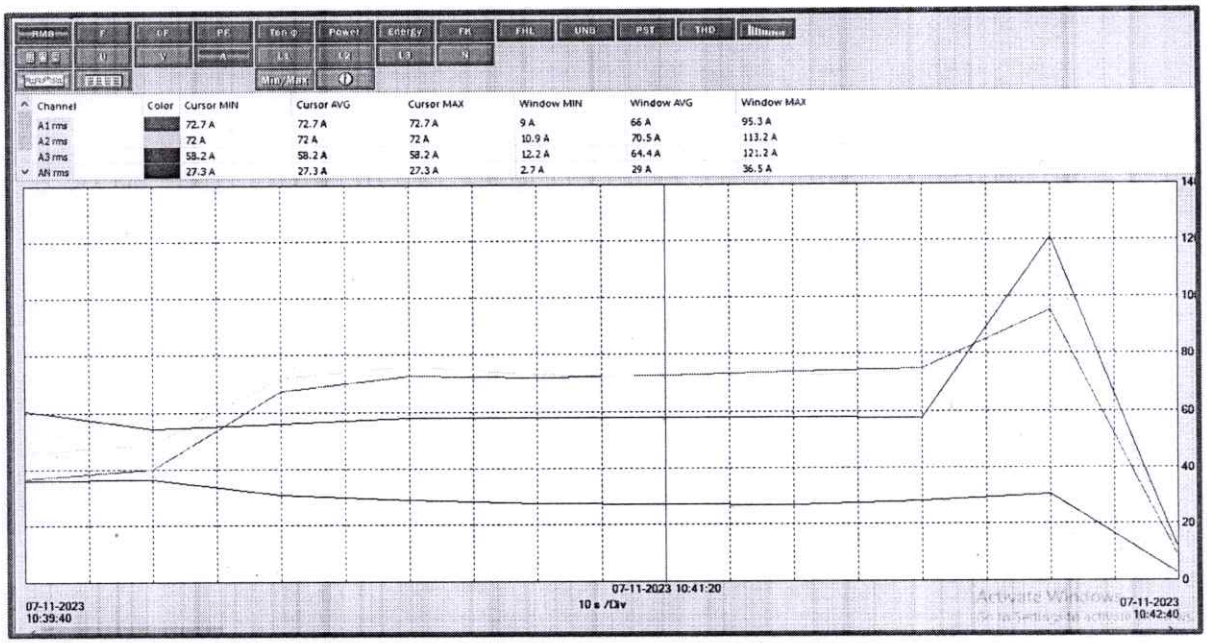


Fig. Current trend at Mains ACB 600 kVA Transformer

Comments:

- The current drawn in the 3 phases is shown in the above snapshot. The unbalance current at the load end result in current flow in the neutral.

Total harmonic distortion in Voltage, THDf

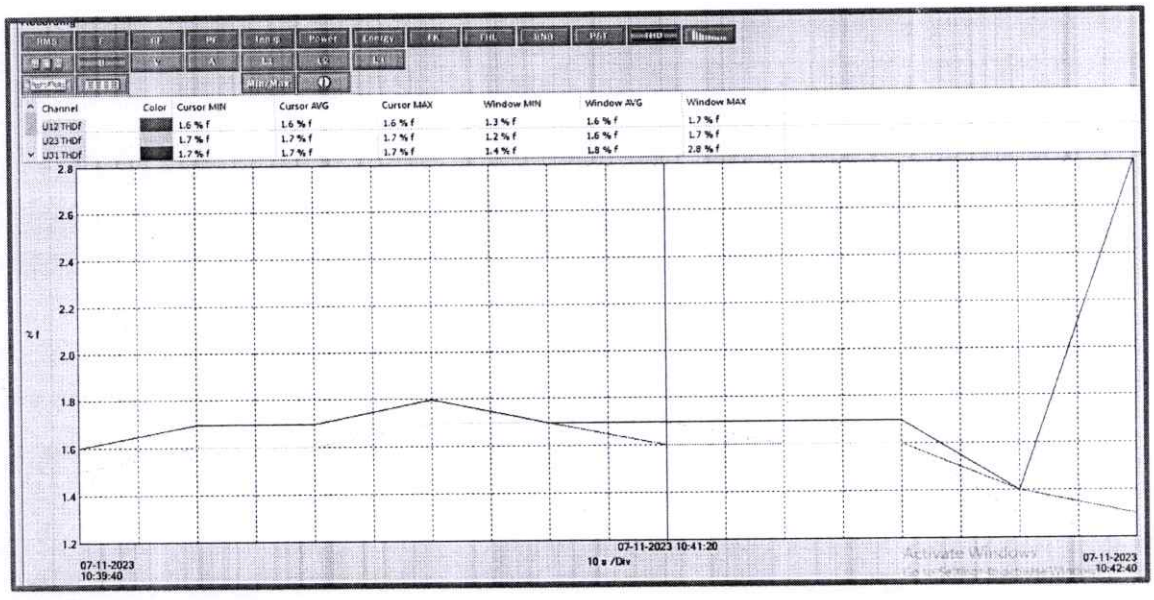


Fig. Total harmonics distortion Voltage trend at Mains ACB 600 kVA Transformer

Comments:

The total harmonics distortion in voltage is within the 5% limit specification defined as per IEEE 519:2014 standard.

True Power, P (kW)

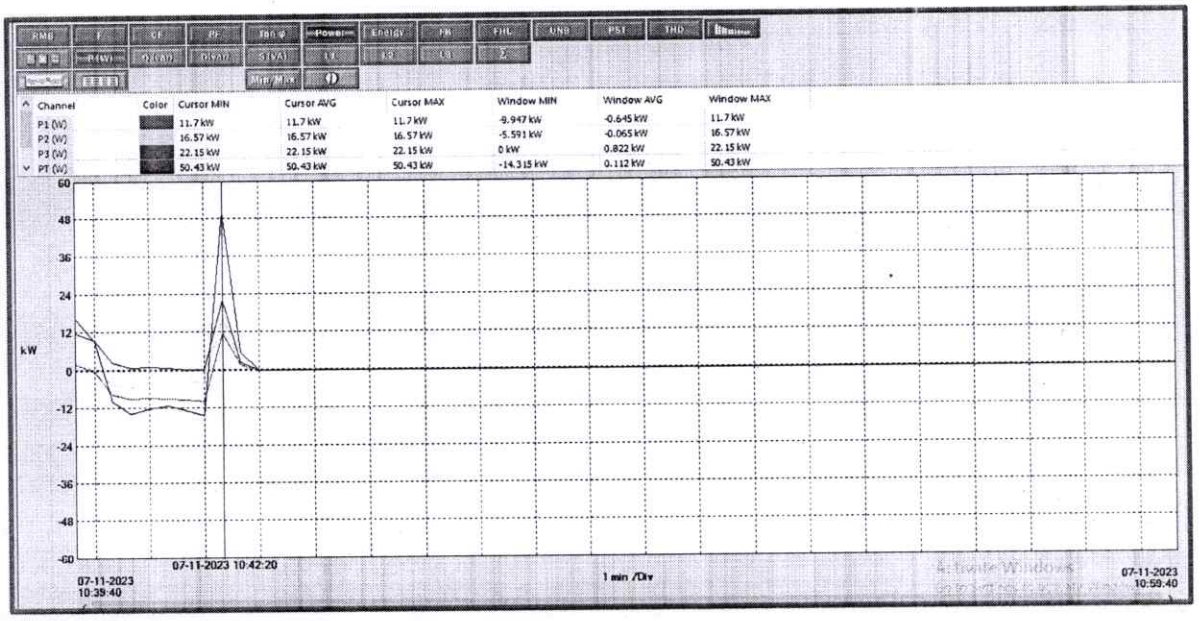


Fig. True Power trend at Mains ACB 600 kVA Transformer

Comments:

- The true power drawn at the Mains *ACB 600 kVA Transformer* is tabulated as below

Parameter	Value	Unit
Average	0.112	Kw
Maximum	50.43	Kw
Minimum	−14.315	Kw

- The negative power sign represents the power flowing back in the grid.

Reactive Power, Q (kVAr)

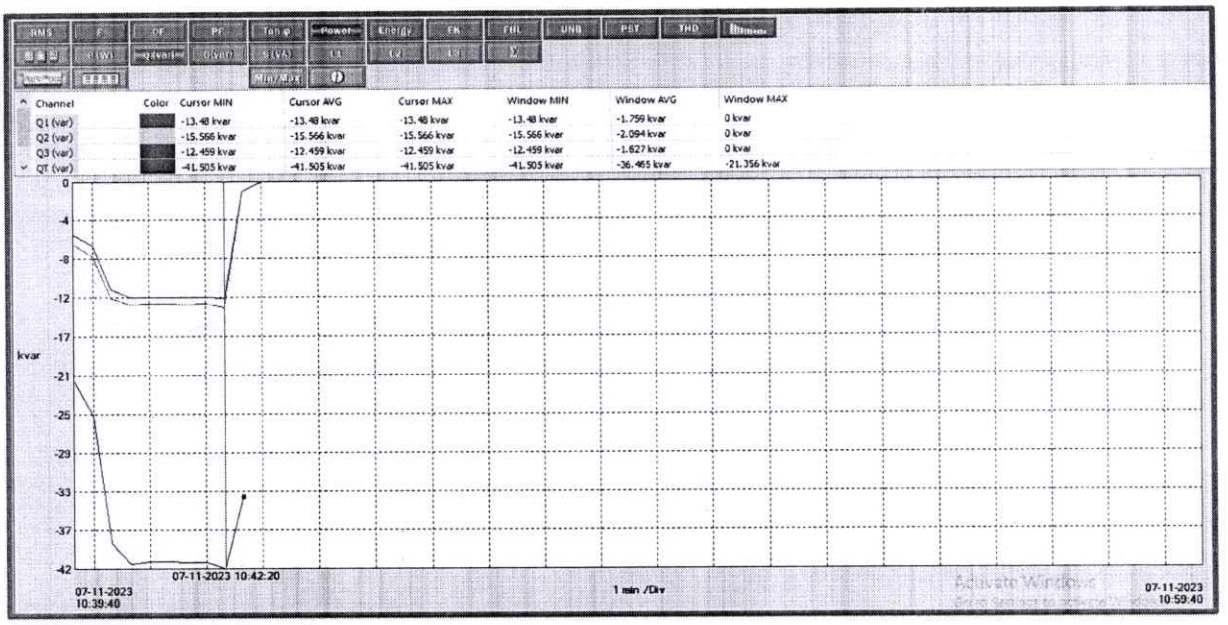


Fig. Reactive power trend at Mains ACB 600 kVA Transformer

Comments:

- The reactive power drawn at the Mains ACB *600 kVA Transformer* is tabulated as below

Parameter	Value	Unit
Average	−36.465	kVAr
Maximum	−21.356	kVAr
Minimum	−41.505	kVAr

- The negative reactive power represents the over−compensation of the reactive power which may be because of faulty contactors or defective APFC relay.

Apparent Power, kVA

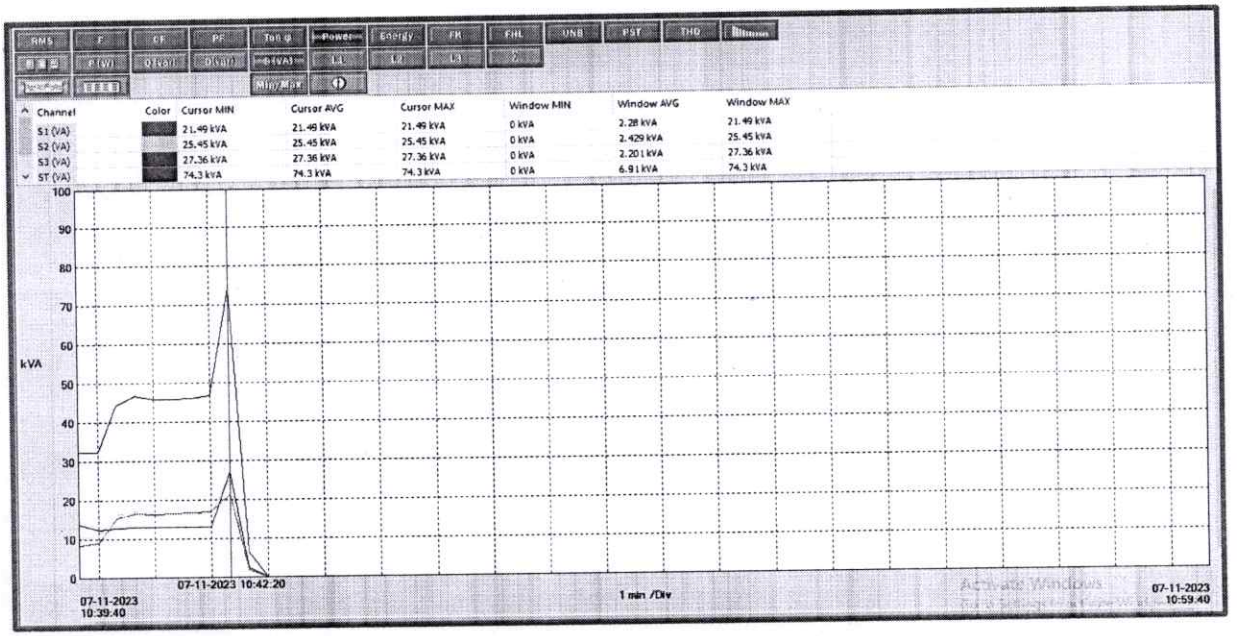


Fig. Apparent power trend at Mains ACB 600 kVA Transformer

Comments:

- The apparent power drawn at the Mains *600 kVA Transformer* is tabulated as below

Parameter	Value	Unit
Average	6.91	kVA
Maximum	74.3	kVA
Minimum	0	kVA

Displacement Power Factor (Cos Ø) trend

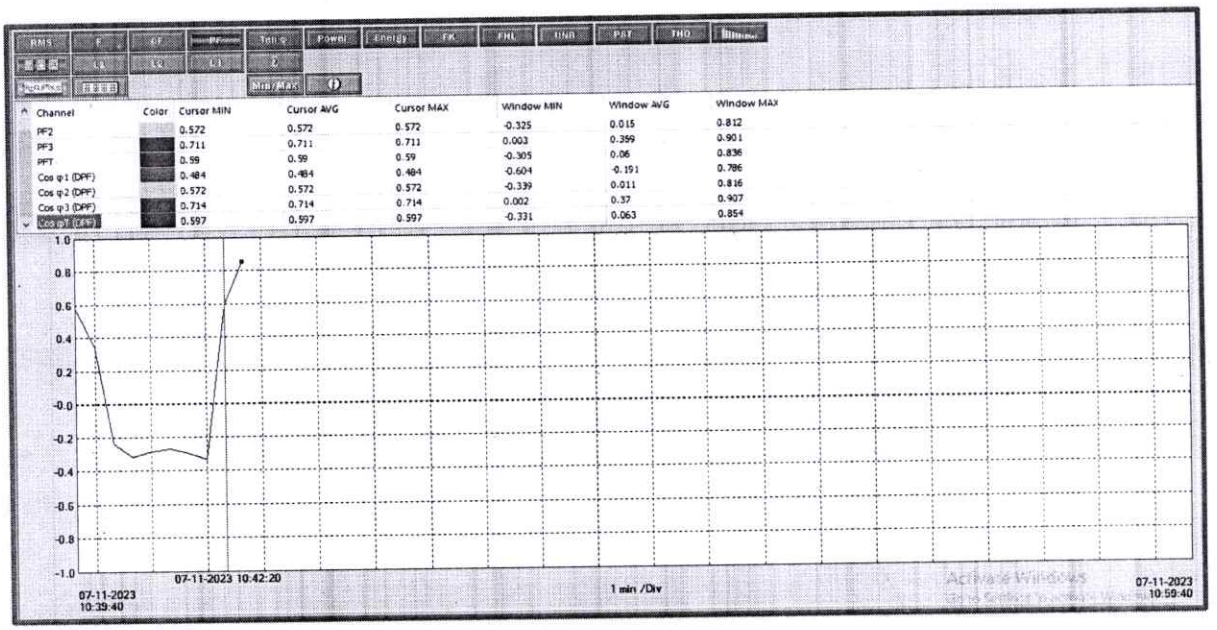


Fig. Displacement power factor trend at Mains 800 kVA Transformer

Comments

- The average power factor is observed to be 0.6 during the test period.

4.3 Capacitors Health check up

During the energy audit, the reactive power compensation capacitor banks have been examined.

The capacitors are judged on the basis of the target current which is modified according to the actual voltage and rated voltage.

CAPACITOR LT panel room (behind LT panel room)							
APFCR	CELEC			Location		LT PANEL ROOM	
S.No.	Capacitor Panel	Actual Voltage (V)	Rated voltage (V)	Ir (A)	Iy (A)	Ib (A)	Remarks
1	No.1	412	440	53.7	53.2	52.4	Balanced current
2	No.2	412	440	34.2	43.5	43.9	Unbalanced current
3	No.3	412	440	19.5	19.5	19.4	Balanced current

de-rated but balance
not operational & unbalance
ok

CAPACITOR PANEL LT PANEL (at the LT panel entrance)									
APFCR	CELEC	Panel rating		230	kVAr	Location		LT PANEL ROOM	
S.No.	Capacitor Rating (kVAr)	Actual Voltage (V)	Rated voltage (V)	Target Rating (kVAr)	Target Current (A)	Ir (A)	Iy (A)	Ib (A)	Remarks
1	25	414	440	22.1	30.9	31.5	31.1	30.6	
2	25	414	440	22.1	30.9	31.2	31.3	31.1	
3	25	414	440	22.1	30.9	27.1	27.1	0	
4	25	414	440	22.1	30.9	31.1	31.6	31.4	
5	25	414	440	22.1	30.9	0	0	0	
6	25	414	440	22.1	30.9	30.8	31.3	30.8	
7	25	414	440	22.1	30.9	0	0	0	
8	20	414	440	17.7	24.7	0	26.8	26.8	
9	25	414	440	22.1	30.9	29.1	17.3	17.5	
10	10	414	440	8.9	12.3	11.5	11.5	0	

de-rated but balance
not operational & unbalance
ok

Comments & Recommendations

- The necessary action needs to be taken as per the remarks.
- The record should be maintained as per the above format.
- The capacitor checks should be carried out once in a fortnight.
- It is recommended to install 3 phase Ampere meter on the capacitor bus so that capacitor bus current can be observed at a glance. It will enable us to identify unbalance current.
- The APFC relay functioning to be properly verified as it can adversely impact the switching of the capacitor bank according to the load requirement.

4.4 Performance assessment of DG set

The 3 nos. of DG sets are available in the plant with the specifications as mentioned below

Particulars	DG-250 kVA	DG-320 kVA	DG 400 kVA
Make	Kirloskar	Mahindra	Kirloskar
Engine Model	6SL8800TA	mPower63905G	8K15TA
Year	2009	2023	2006
Rated kVA	250	320	400
Status	In operation	In operation	Not in use

The DG set assessment was carried out as per the following method

- The power analyzer was installed at the DG set feeder to record the energy consumption during the test cycle.
- The DG set fuel consumption was recorded.

The 320 kVA and 250 kVA were considered for the study.

4.4.1 Performance assessment of 250 kVA DG set

Voltage

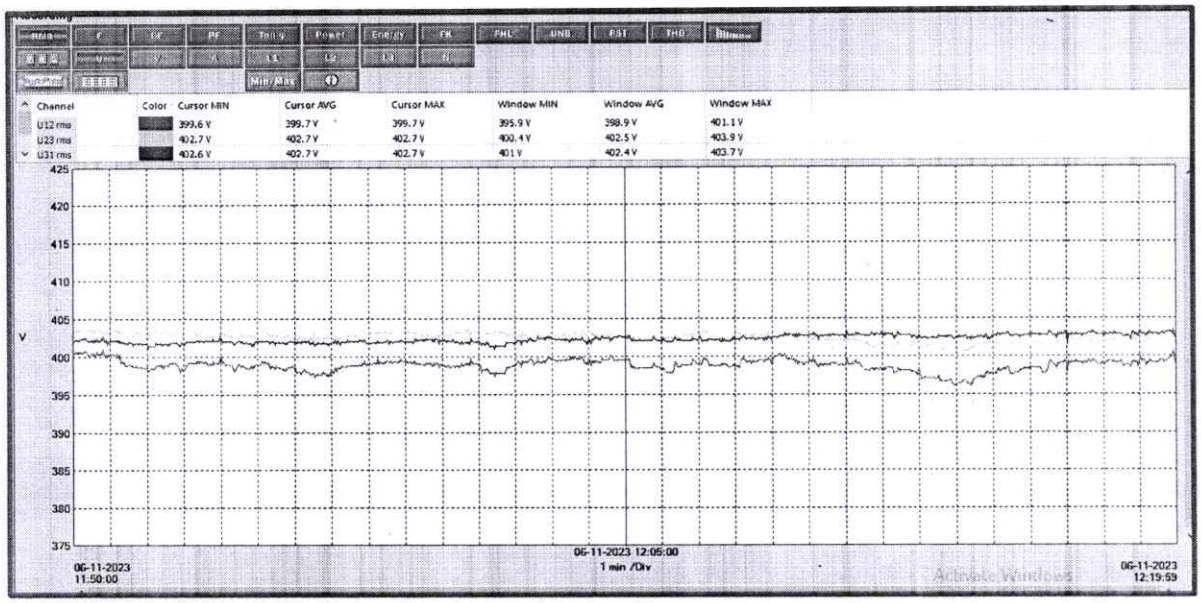


Fig. Voltage trend at DG 250 kVA

Comments

- The average voltage is maintained at 398/402/402 V which is relatively low due as there will 10–15 V drop at the application end which results in higher line losses.
- It is recommended that the voltage level be maintained between 410–415V at the DG set.

Active Energy (kWh)

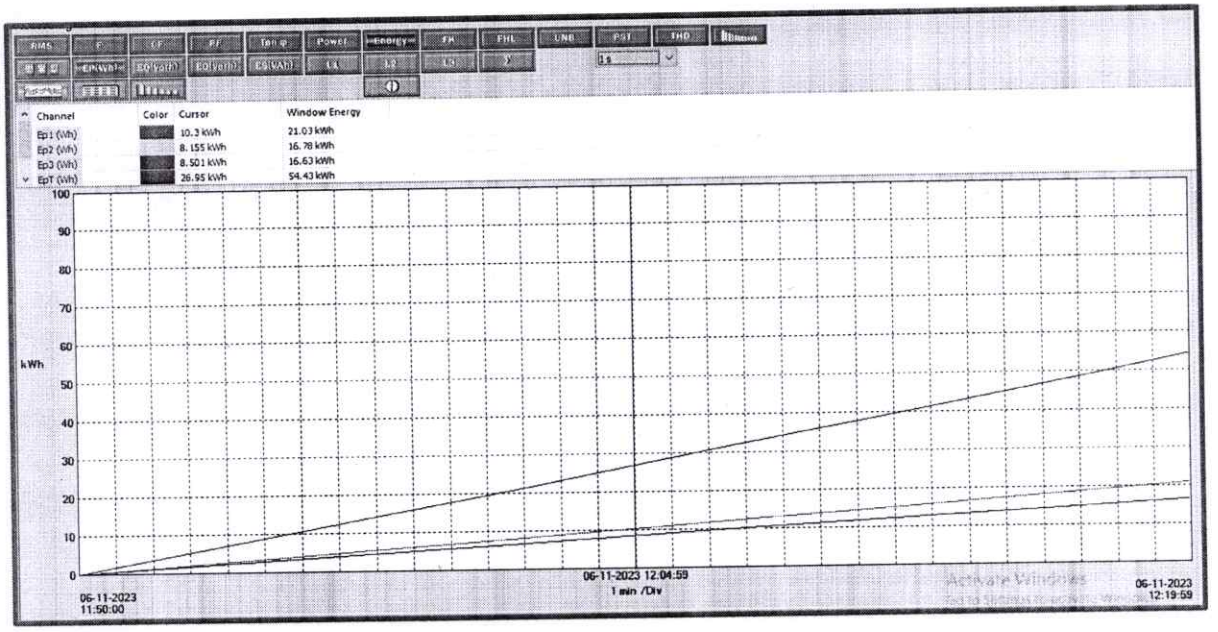


Fig. Energy (kWh) trend at DG 250 kVA

Comments

The active energy generated by 250 kVA DG set during the test period is 54.43 kWh.

Frequency

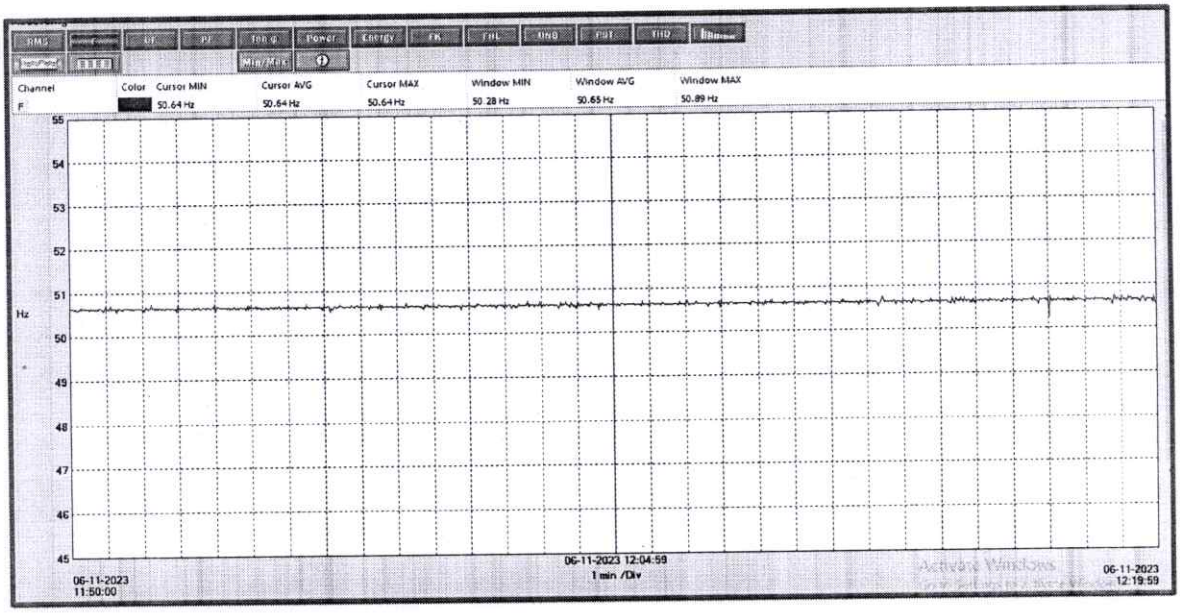


Fig. Frequency trend at DG 250 kVA

Comments

The normal frequency maintained by 250 kVA DG set is varied between 50.28 ~ 50.89Hz which is slightly higher. It is recommended that the frequency may be set between 49.5–50 Hz. The higher frequency results in higher DG set rpm which results in higher diesel consumption.

Current

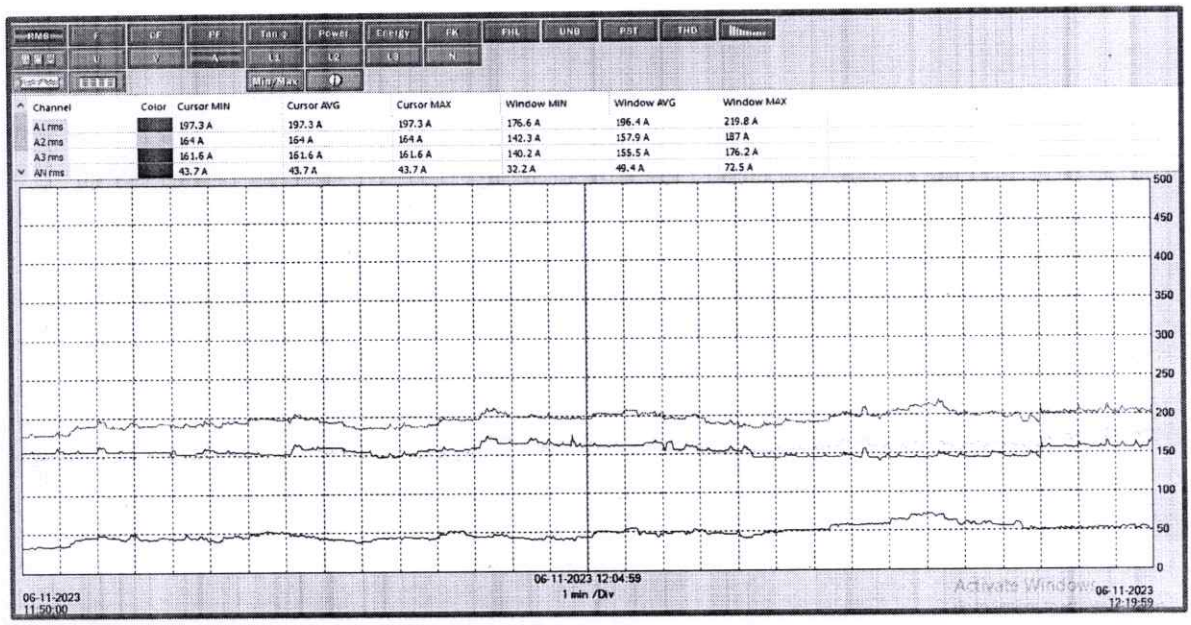


Fig. Current trend at DG 250 kVA

Comments

- The current drawn in the 3 phases is shown in the above snapshot. The unbalance current at the load end result in current flow in the neutral.

Apparent Power, kVA

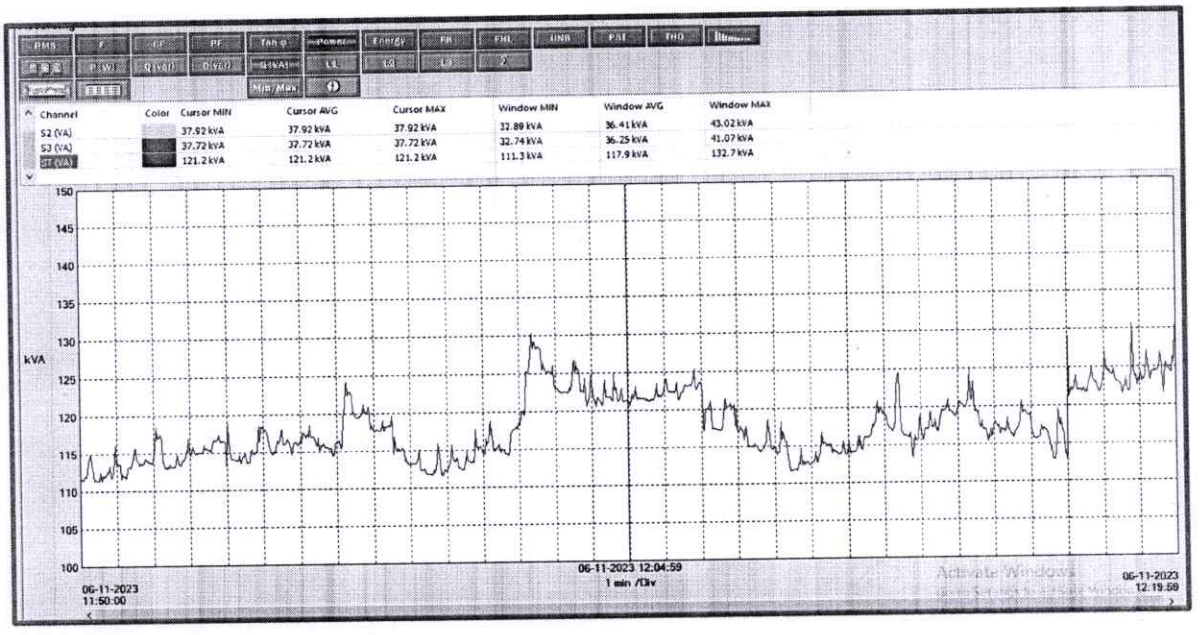


Fig. Apparent Power at DG 250 kVA

Comments

The average operating load on the DG set is observed to be 117.9 kVA. The maximum load on the DG set is observed to 132.7 kVA.

Comments & Recommendations

The name plate parameters of the DG set are tabulated as below

Make Year	Apr-09
Engine no.	F6.3810/0900094
Rated kVA	250
Alternator	Kirloskar
Engine make	Kirloskar

The SEGR calculation is shown in the table as below

Particulars	Value	Unit
Test duration	30	minutes
Rating of the DG set	250	kVA
Maximum load on the DG set	132.7	kVA
Average load on the DG set	117.9	kVA
Average loading of the DG set	47.16	%
Unit generation during the test	54.41	kWh
Fuel consumed during the test time	16.40	l
Specific energy generation ratio (SEGR)	3.32	kWh/l

The diesel consumption was measured from the separate diesel tank.

Length of tank	1222	mm
width of tank	912	mm
Wall thickness	5	mm
Level difference	15	mm
Diesel consumption	16.40	liters

The DG set display was found to be display the following engine parameters

Oil pressure	ok	
Coolant temperature	60	° C

- The DG set performance is acceptable as the test was carried out on average 47.46% loading. The SEGR shall be further increased beyond 3.6 kWh/ liter at optimum loading.
- The DG set voltage is maintained at 400 V level which should be maintained between 410–415V.
- The frequency is slightly higher between 50.28–50.89 Hz. It should be maintained between 49.5 – 50 Hz.

4.4.2 Performance assessment of 320 kVA DG set

Voltage

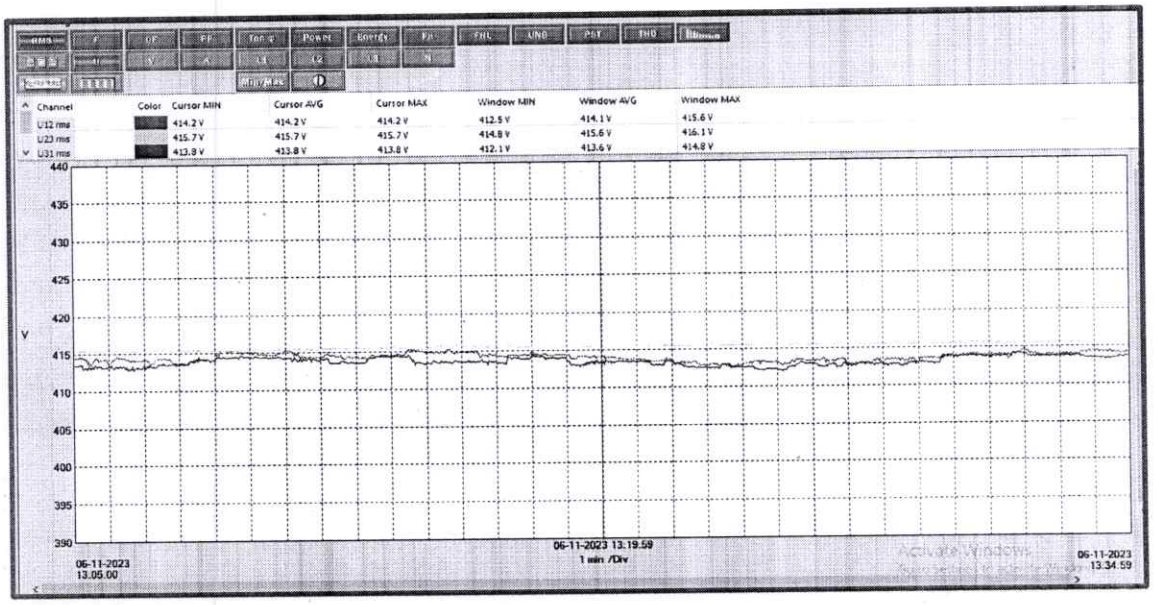


Fig. Voltage trend at DG 320 kVA

Comments

- The voltage is maintained at average voltage level of 414/415/413 V. It is recommended voltage level to maintained at DG set.

Active Energy (kWh)

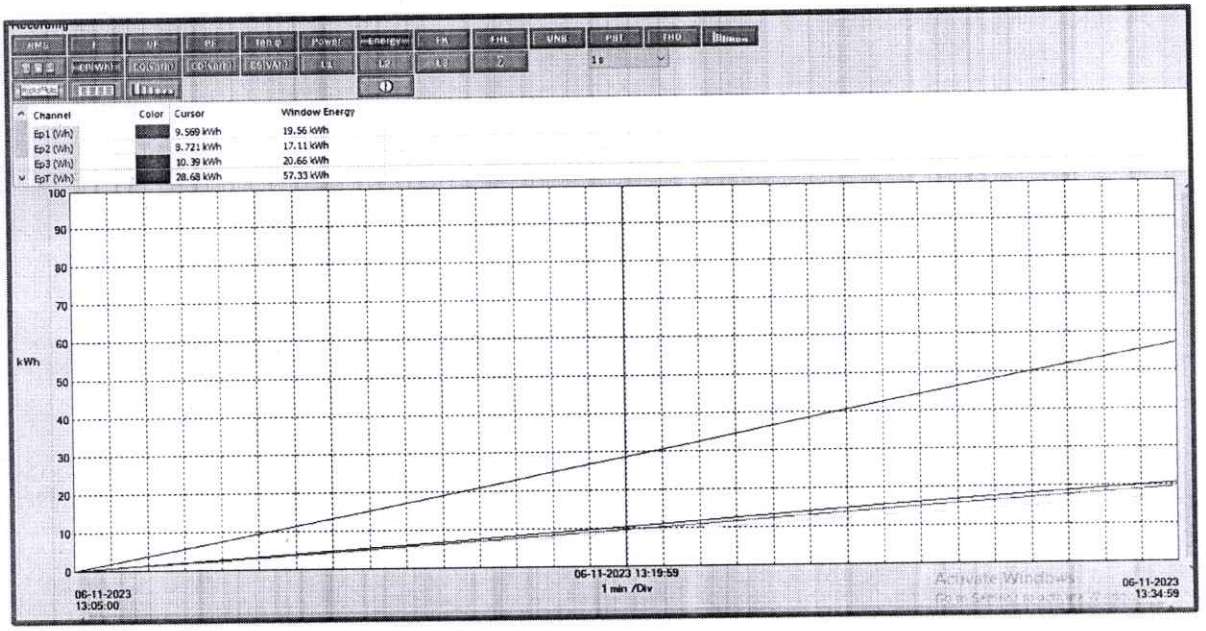


Fig. Energy (kWh) trend at DG 320 kVA

Comments

The active energy generated by 320 kVA DG set during the test period is 57.33 kWh.

Frequency

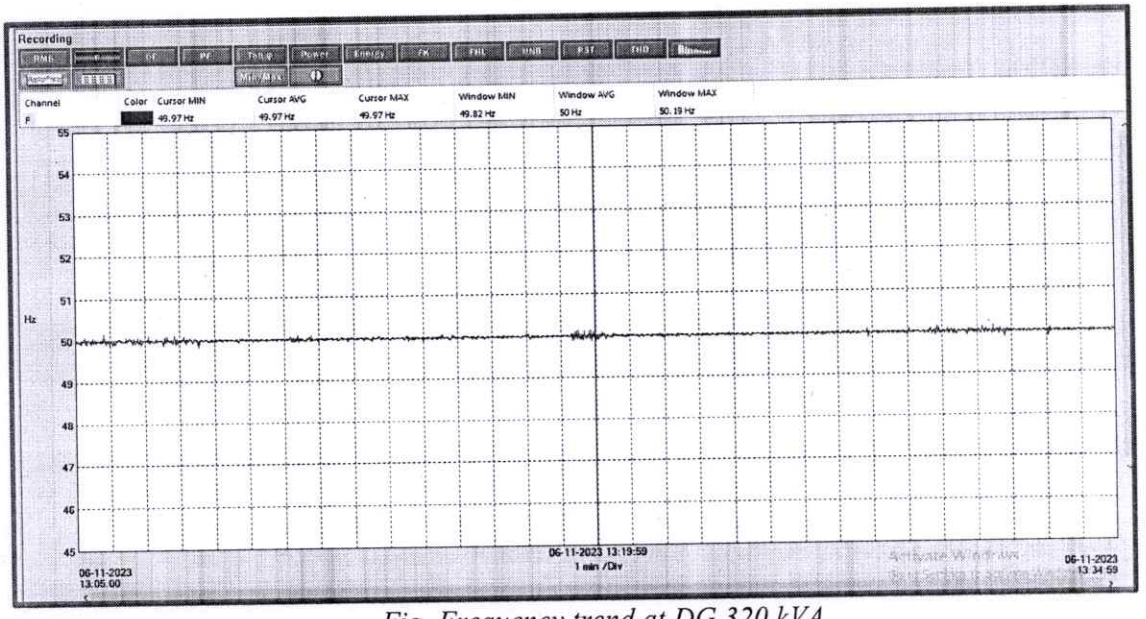


Fig. Frequency trend at DG 320 kVA

Comments

The normal frequency maintained by 320 kVA DG set is varied between 49.82 ~ 50.19Hz which is acceptable,

Current

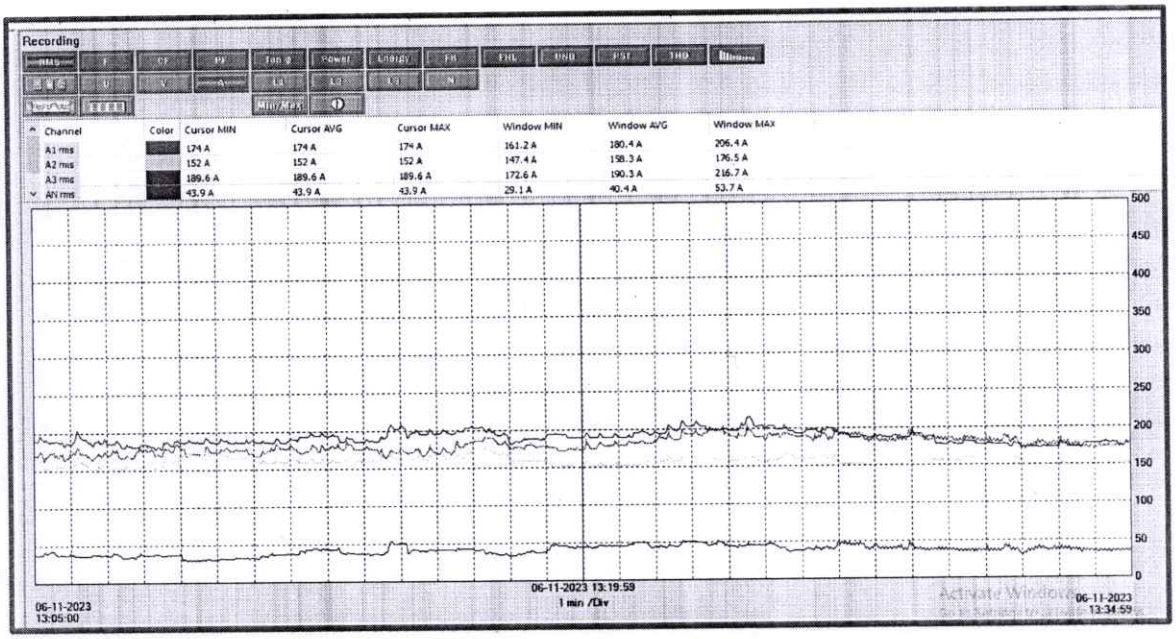


Fig. Current trend at DG 320 kVA

Comments

- The current drawn in the 3 phases is shown in the above snapshot. The unbalance current at the load end result in current flow in the neutral.

Apparent Power, kVA

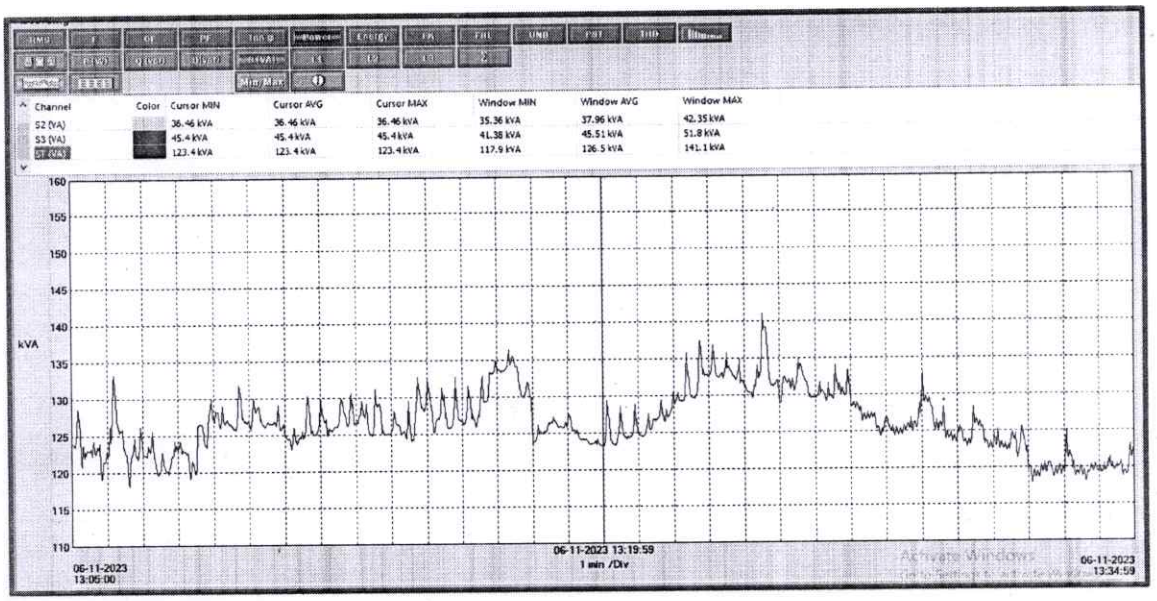


Fig. Apparent Power at DG 320 kVA

Comments

The average operating load on the DG set is observed to be 126.5 kVA. The maximum load on the DG set is observed to 141.1 kVA.

Comments & Recommendations

The operation time engine parameters were observed as follows

Oil pressure	3.4	bar(g)
Coolant temperature	86	°C
Battery voltage	28	V
Run hours	88	h
Engine speed	1500	rpm

The SEGR calculation of the DG set 320 kVA is mentioned below

Particulars	Value	Unit
Test duration	30	minutes
Rating of the DG set	320	kVA
Maximum load on the DG set	141.4	kVA
Average load on the DG set	126.5	kVA
Average loading of the DG set	39.53	%
Unit generation during the test	57.3	kWh
Fuel consumed during the test time	18	l
Specific energy generation ratio (SEGR)	3.18	kWh/l

- The energy efficiency of the 320 kVA DG set is very low, **3.18 kWh/l** which is low due to lower operating load. The SEGR will be increased upto 4 kWh/l at optimum loading of the DG set.
- The DG set performance assessment should be carried out on regular basis by measurement of the energy readings and Fuel consumption at DG set display.

4.5 Equipment Check

The Equipment available in the campus were observed. The critical observations related to electrical loads are as follows.

Submersible Pump:

- The submersible pump motor name plate data is not available due to which the judgement cannot made on the basis of current drawn by the pump.
- The monthly inspection of the motor current is recommended. Its record should be maintained.
- The flow meter data should be maintained for the water consumption check.

Water Cooler:

- The water cooler condenser cleaning is required so that the efficiency of the cooler is maintained.
- ELCB/RCCB to be installed for tripping water cooler supply in case of leakage current. This is very critical for the person safety.
- The drinking water TDS should be monitored regularly.

Air Conditioning system

- The AC pipes insulation to be maintained so that heat gain in the gas pipe can be reduced.
- The regular cleaning of the AC filters, Evaporator coil, condenser is highly recommended every fortnight or month based on the cooling effect.
- The grill temperature at AC indoor unit should be monitored and necessary action be taken accordingly.
- The monthly inspection of the AC current is recommended. Its record should be maintained.
- The name plate data of the air conditioning unit be maintained in the equipment control register.
- The energy saving practice of *Daylight saving time (DST)* may be implemented to shift the office timing during peak summer season.

Solar Water Heater (Evacuated Tube collector, ETC)

- The ETC solar water heater is installed on the hostels roof top.

- The algae were found in the solar water heater line. The regular cleaning is recommended and avoid fouling of the solar water heater tubes.
- The Boys hostel–1 no. Solar water heater was found to be broken.
- The Girls hostel–1 no. solar water heater, water supply was not happening. The switching ON of the resistive heater may result in damage of the solar water heater tank. It is recommended to ensure that the regular maintenance & checks are carried out related to solar water heater.
- There should be easy access for the visiting solar water heater.
- The TDS should be monitored regularly for water fed in solar water heater. The feed water TDS was found to be 368 ppm which is acceptable.
- The flushing of the solar water heater tubes is highly recommended.

Solar PV Power plant

- The energy monitoring data for the solar PV Power plant should be implemented as soon as possible.
- The regular cleaning of the solar PV power plant is highly recommended.
- The solar PV power plant is inactive during the DG set operation. It is recommended to operation the Solar PV power plant in synchronization with DG set. This will result in diesel bill reduction due to solar power plant operation in parallel with DG set.

The cost saving figure is tabulated as below

Tentative Average load when DG set in operation	120	kVA
Average True Power load on DG set (@0.9 PF)	108	kW
Unit generation during 8 hours shift (one day)	864	kWh
Minimum generation by solar PV power plant (one day)	500	kWh
Avoided fuel consumption for Solar PV power plant units	150.7	liters
DG set operation days (tentative)	70	days
Avoided diesel consumption	10,548	liters
Unit cost of Diesel (per liter)	90	₹
Avoided diesel cost per year	9,49,363	₹
Investment	NIL	

The calculation represents the minimum energy saving that can result from the DG set synchronization with Solar PV power plant.

Girls hostel Pump-01 (2hp)				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
1-Ø	12.3	215	1	2.64

Girls hostel Pump-02 (5hp)				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
R	6.7	222	0.57	0.85
Y	6.8	225	0.62	0.95
B	6.8	225	0.6	0.92
			Total	**2.71**

Water Cooler girls hostel 1st floor (Switch 10A)				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
1-Ø	6.7	220	0.96	1.42
			Total	**1.42**

Water Cooler girls hostel ground floor (Switch 16A)				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
1-Ø	7.6	223	0.94	1.59
			Total	**1.59**

Bus washing pump (3hp)				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
R	2.9	221	0.62	0.40
Y	2.7	219	0.63	0.37
B	2.9	218	0.62	0.39
			Total	**1.16**

Root blower (3hp)				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
R	4.5	220	0.77	0.76
Y	4.2	221	0.77	0.71
B	4.4	221	0.71	0.69
			Total	**2.17**

Boys Hostel				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
R	7	222	0.68	1.06
Y	7.8	227	0.74	1.31
B	7	233	0.74	1.21
			Total	**3.57**

STP root blower				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
R	12.5	222	0.84	2.33
Y	11.6	217	0.88	2.22
B	11.8	218	0.86	2.21
			Total	**6.76**

Boys Hostel Water Cooler				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
1-Ø	4.4			

Boys Hostel main Water Cooler				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
1-Ø	7.8			

Boys Hostel Air Cooler				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
1-Ø	1	221	0.96	0.21

Boys Hostel Roti maker				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
1-Ø	13			

Submersible Pump 5hp 3Ø (Gate)				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
R	7.2	222	0.71	1.13
Y	6.8	219	0.71	1.06
B	7.2	223	0.71	1.14
			Total	**3.33**

Pump opposite library 3Ø				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
R	8.7	221	0.61	1.17
Y	9.8	224	0.61	1.34
B	9	220	0.67	1.33
			Total	**3.84**

Water Cooler Main Canteen				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
1-Ø	7.5	218	0.88	1.44

Submersible Pump canteen				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
1-Ø	9.3	214	0.99	1.97

AC Seminar hall-01 (8.5 TON LG)				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
R	12.8	224	0.79	2.27
Y	11.4	228	0.96	2.50
B	12.4	224	0.8	2.22
			Total	**6.98**

AC Seminar hall-02 (8.5 TON LG)				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
R	14.4	225	0.73	2.37
Y	12.1	229	0.76	2.11
B	13	223	0.74	2.15
			Total	**6.62**

Main Block Classroom 101					Main Block Classroom 303				
Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)	Phase	Current (A)	Voltage (V)	Power factor	Motor Power (kW)
R	9.3	215	0.98	1.96	R	7.5	227	0.77	1.31
Y	10.1	217	0.96	2.10	Y	10	226	0.83	1.88
B	7.8	218	0.78	1.33	B	8.2	225	0.74	1.37
			Total	**5.39**				Total	**4.55**

CHAPTER 5: ELECTRICAL SAFETY OBSERVATIONS

The electrical safety audit was carried out in the plant. The safety audit observations are classified as per the following.

- **Design**
  - ***The GO switch area should be totally isolated to avoid any fatal accident.***
  - The transformer room should be ease of entrance for regular check-up of the transformer.
  - The LT panel room trench should be covered. To avoid fall in the pit.
  - The electrical panel rooms be maintained properly. The panel doors should be properly enclosed.
  - The ELCB/ RCCB should be installed in the water cooler to avoid electric shock to anyone in contact with water cooler.
- **Maintenance system**
  - The SLD should be available in the LT panel room.
  - The input- output diagram marking should be available on the LT panel.
  - The insulation mat as per IS-15652-2006 should be installed at the front and back side (wherever possible) of the panel. **NO EARTHING MAT COULD BE FOUND.**
  - The panel doors should be properly closed. It has been observed that there are panels in which the doors are not closed properly, especially in LT panel room, capacitor panel.
  - The panel fans should be operational properly for rejection of the panel heat especially in the capacitor Panel. The capacitor life will be enhanced due to proper heat rejection.
- **Training & Personnel behaviour**

- The workplace safety training should be carried out for all the electrician/ staff.

- The workplace hazard assessment should be carried out for the near miss and proactive planning.

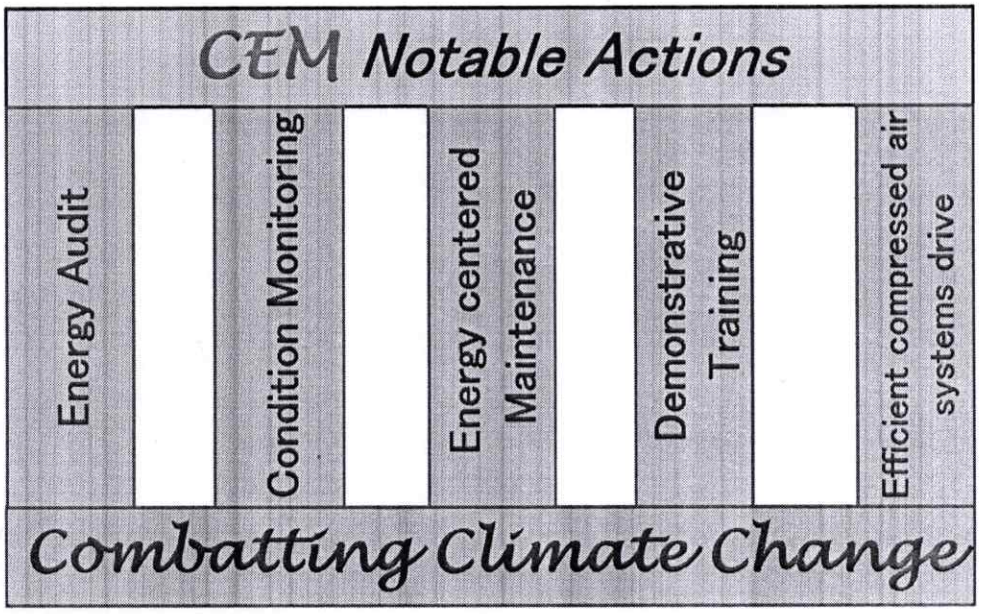
- The workplace training/ project should be taken up by the Faculty and students to facilitate

    - Energy monitoring (metering in Main LT panel and Sub-panel)
    - Regular inspection of the equipment
    - Equipment control register with detailed name plate data

Centre for Excellence in Maintenance

Centre for Excellence in Maintenance (CEM) is an organization providing services of energy performance assessment and condition monitoring in various industries.

- **Our Vision:** To be world class Centre for Excellence focussed at reduction of workplace wastages.
- **Our Mission:** To combat climate change by reducing workplace wastages using Energy Efficient maintenance practices.



- **Energy Audit:** Comprehensive energy audit of Electrical and Thermal utilities.
- **Condition Monitoring:** Thermal imaging, Vibration analysis, Bearing shock pulse testing, all equipment input/ output energy flow monitoring.
- **Energy Centered Maintenance:** Comprehensive maintenance program focussed at improvement of energy performance
- **Demonstrative Training**: We provide demonstrative training on the topics as below:
    - **Industrial Electrical system Performance assessment** (covering Power distribution system, DG set, Motors, Pump & Blower)
    - **Compressed air system Performance assessment** (covering compressed all stages from Generation to End usage)

- **Cooling system Performance assessment** (Chiller, Package AC, Cooling Tower, Humidification plant)
- **Thermal energy system Performance assessment** (Boiler, Furnace, Thermic Heater)
- **Energy conservation through improved maintenance practices** (covers all the energy systems of the plant)

- **Efficient Compressed air systems drive:** We take up improvement projects in compressed air system optimization to deliver energy savings to the plant.

Contact us at:

M/s Centre for Excellence in Maintenance
TA-524A Capital High-street Bhiwadi, Alwar Rajasthan-301019
Contact No. 9560043923
Email ID: rahul.saini@cfeim.in
www.cfeim.in