ENERGY AUDIT REPORT

OF

MADAN MOHAN MALAVIYA UNIVERSITY OF TECHNOLOGY

Madan Mohan Malaviya University of Technology, Gorakhpur, UP-273010



Submitted To

Uttar Pradesh New & Renewable Energy Development Agency (UPNEDA)

Vibhuti Khand, Lucknow,

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Executive Summary

Energy Solution Company (ESC) was entrusted to carry out the Energy Audit of the Madan Mohan Malaviya University of Technology, Gorakhpur. The site Visits for the Energy Audit were conducted on Jan 16, 2024.

Madan Mohan Malaviya University of Technology, Gorakhpur has been established in year 2013 by the Government of Uttar Pradesh in the form of a non-affiliating, teaching and research University after reconstituting the Madan Mohan Malaviya Engineering College, Gorakhpur which was established in 1962.

Fifty-Four batches of students have entered its portals to emerge after four years of rigorous education under the tutelage of some of the most venerable teachers, engineers ready to face the world and create new worlds. The University is located in the Gorakhpur-Deoria Road about 9 Km away from Gorakhpur Railway Station. In addition to UG in Civil Engineering, Chemical Engineering, Computer Science & Engineering, Mechanical Engineering, Electrical Engineering and Electronics & Communication Engineering, Information Technology, University also offers MCA, BBA, MBA, M. Tech, M.Sc. and Ph.D. courses in various specializations.

Key Points

- Madan Mohan Malaviya University of Technology, Gorakhpur draws Power from Purvanchal Vidyut Vitran Nigam Limited. at 11 KV. Subsequently, the voltage is stepped down by six transformers (CSS Transformer) of 400 kVA from 11 KV to 433 V. The Contracted load is 700 kVA.
- As per the load profile of the transformer, it can be observed from the measurements, the load on the transformer TR-1 is around 50.05%, TR-2 is 50.11%, TR-3 is 50%, TR-4 is 50.33%, TR-5 is 50.29% & TR-6 is 50.39%, which is good.
- In MMMUT Campus for cooking food LPG gas is used. The Guest House and hostel mess are maintained by a third party. In the Guest House and hostel mess, approx. 600 Nos (19 Kg) cylinders are used for cooking food.
- From the SEB Bill, it was observed that the maximum recorded demand varies from 163 kVA to 926 kVA which means the maximum recorded demand has crossed the sanctioned load (i.e., 700 kVA) in the month of Jan-23, Apr-23, May-23, Sept-23 & Nov-23 as a result of which demand penalty has been imposed.

Hence, to reduce this demand penalty, it is recommended to install Maximum demand indicator, which will help to limit the increased billing demand. In case the load exceeds the preset limits, the MD controller would isolate some of the non-essential loads/ feeders. The resultant benefits in terms of energy savings work out **to Rs. 2.56 Lacs per annum with an estimated investment of Rs. 1.5 Lacs and a simple payback period of 7-8 months**

- Madan Mohan Malaviya University of Technology, Gorakhpur management has not installed APFC for power factor improvement at LT Side. The building is being billed on a KVAh basis; therefore, the effect of the power factor is inbuilt into the billing structure. From the electricity Bill, the power factor varies from 0.967 to 0.998 and overall average Power factor is around 0.989 which is satisfactory but it can be improved to 0.999. So, we recommend to install the APFC of 50 kVAr capacity at LT Side of the transformer to achieve 0.999 Power factor and also add some additional Capacitor of Smaller Capacity (i.e., 5, 3, 1 kVAr) in it. The resultant benefits in terms of energy savings work out **to Rs. 2.17 Lacs per annum with an estimated investment of Rs. 1.0 Lacs and a simple payback period of 5-6 months.**
- During the audit, we measured the Power Quality on the LT Side and observed that the Voltage and current was balanced in all three phases.
- As per measurement on HT Side of TR, the voltage harmonics of main incomer at HT Side was around 2.01-2.10% and the levels of the current harmonics was 8.007-8.39%. **The Overall Average Voltage harmonics & Current harmonics are within the limits.**
- Window/Split/Tower.Cassette Acs are installed in the Building Complex at different locations. Performance was not evaluated on A/Cs as ACs were not operational due to the winter season. The AC is of 5/4/3/Non-Star rating installed in the building. **Energy Solution Company acknowledges and appreciates the commitment of the management toward the conservation of Energy.** It is recommended to install 5-star rated AC in place of 4/3/Non-Star, a tentative 10-15% energy saving will be saved.
- *The Management is highly conscious of its Energy Efficiency and cost and has initiated several measures to reduce energy consumption, all office lights and*

street lights are Energy Efficient LED Lights. ***ESC acknowledges and appreciates the commitment of the management toward the conservation of Energy.***

- During the audit, it was observed that at various locations in the building, lights were ON even when there was no one in the room/office. Hence, it is recommended to use motion sensors to minimize energy consumption. A motion detector is a device that detects moving objects, particularly people. These devices are actively used for street lights or indoor lights in walkways such as lobbies, stairs, and also in offices. The total lighting load of the buildings of entire institute is an average of 110 KW, But most of the buildings are Hostel & academic block so, the payback period of installation of motion sensor in offices is on the higher side so we have not recommended any recommendation on Motion sensors. We have to recommend switching off the lights in the daytime to save energy.
- Around 2,197 No's conventional ceiling fan are installed in the various locations of the building. These Fans must be replaced with energy-efficient BLDC Fans. The resultant benefits in terms of energy savings work out to **Rs. 25.88 Lacs** per annum with an estimated investment of **Rs. 89.13 Lacs** and a simple payback period of **41-42 months.**
- At MMMUT, Gorakhpur, 3 No's of Submersible pumps are installed to lift the underground water to 2 No's of OHT Tank. From these OHT Tank, water is further supplied to PVC Tank of the buildings. During the audit, we have taken the Power and flow of pumps. We have taken the discharge pressure according to the tank height as there was no pressure gauge point installed in the pipeline of the Pump. The suction head is provided by MMMUT officials.
  - ✓ The Pump is running at its rated parameters and seen that the efficiency of Pump-2 is 42.90%, **which is satisfactory.**
  - ✓ The pump is running at its rated parameters and seen that the efficiency of Pump-3 is 11.20%, **which is on lower side.**
  - ✓ The pump is running at its rated parameters and seen that the efficiency of Pump-4 is 44.10%, **which is on the lower side.**

  As the pump is not operating at duty point its efficiency has deteriorated further. Therefore, it is recommended to replace pump-3 with new energy-

efficient pumps. The resultant benefits in terms of energy savings work out to **Rs. 4.08 Lacs** per annum with an estimated investment of **Rs. 1.5 Lacs** and a simple payback period of **4-5 months.**

- One DG set of 250 kVA is installed for emergency power supply. The operation of the DG Sets is during power cuts & testing only. The operation of the DG set is limited to power cuts and testing only. The running hours of DG are very low i.e. 8-10 hr in a month, hence, no specific recommendation has been made on DG.
- The Institute building has not installed SWH on the rooftop of the building for bathing. There are hostels and guest houses in the building. These canteens normally require hot water, for the washing of utensils, the hot water is generated by using a Gas or Geyser. Because the SWH is not installed for the canteen and in the rooms of hostel and guest house. It is recommended to install a Solar Water Heating System for the bathroom and canteen, which would feed hot water at an average temperature of 70°C. This would reduce the dependence on one unit and also reduce the heat losses in the distribution lines. The resultant benefits in terms of energy savings work out to **Rs. 16.83 Lacs** per annum with an estimated investment of **Rs. 49.25 Lacs** and a simple payback period of **35-36 months.**
- The building management has installed 612 KWp solar panels on the rooftop of the building as well as Ground Mounted. Solar Photovoltaic Cell for Power Generation for lighting load at the building, which would supply light to the lighting feeder. **Solar photovoltaic technologies** convert solar energy into useful energy forms by directly absorbing solar photons—particles of light that act as individual units of energy—and converting part of the energy to electricity. The building management already installed a Solar PV System on the rooftop, so we have not recommended any recommendation on a Solar PV System. From the given data of 450 KWp SPVC the annual Solar Generation is about 5,54,278 KWh from Solar PV per annum. Hence, the average per day generation of the SPVC comes out to be about 3.38 KWp per day from Solar PV. As per the standard, the **average solar generation is about 3.4-4.5 KWp per day. The unit generation from solar is satisfactory and as per standard value**

- Up to 10-15% of Office building/ home's heat can be lost through an uninsulated roof. So, insulating the roof is one of the most effective ways to save energy. Roof insulation is a barrier of material that's placed in roof space to make it harder for heat to travel in or out. This Insulation barrier slows down the transfer of heat between living space and the outside world, creating a warmer home in winter and a cooler one in summer. **Since the Cost of PU Spray is on the higher side and payback is very high as the investment is very high. Hence, economically not Viable. So, we have not recommended any savings in the building envelope. (Cost of PU Spray approx. 4,000 Rs/ ft^2)**
- During the audit we measured the surface temperature of the roof top and bottom, as per observation from the above thermogram, the average surface temperature of the roof is around 14.46 °C (Varies from 12.5°C to 17.2°C) and the average temperature of the ceiling below the roof is around 12.53 °C (Varies from 11.1°C to 15.9°C) and the temperature difference between roof and ceiling of the building is 1.93 °C which is satisfactory.
- Thermography uses specially designed infrared video or still cameras to make images (called thermograms) that show surface heat variations. This technology has a number of applications. Thermograms of electrical systems can detect abnormally hot electrical connections or components. During the audit, we took the thermal image of some electrical panels to find the hotspot created due to loose crimp & loose scew or any other reason to avoid any mishappening. The thermogram & observation are mentioned in the respective chapter.

Cumulative Energy Saving Opportunities in Kwh/ Kg of Fuel & Oil Equivalent & Corresponding Monetary Benefits with Payback

ECMs	Energy Savings per Annum KWh	Rs	TOE	Estimated Investments (Rs.)	Payback Period (Months)	IRR %
	Small- Term (0-12 Months)					
Replacement of Pump-3 with energy efficient Pump	37,523	4,08,625.47	3.23	1,50,000	4-5	272.0%
Improvement of Power Factor up to 0.999		2,17,953.73		1,00,000	5-6	217.3%
Installation of Max Demand Controller		2,56,880.00		1,50,000	7-8	170.1%
Total	**37,523**	**8,83,459**	**3.23**	**4,00,000**	**5-6**	**220.2%**
	Large Term (More Than 24 Months)					
Installation of Solar Water Heating system	1,54,622	16,83,828.14	13.30	49,25,000.00	35-36	21.0%
Replacement of Conventional ceiling fan with 28 W BLDC Fan	2,37,680	25,88,335.20	20.44	89,13,000	41-42	13.9%
Total	**3,92,302**	**42,72,163**	**33.74**	**1,38,38,000**	**38.87**	**16.5%**
Grand Total	**4,29,825**	**51,55,623**	**36.96**	**1,42,38,000**	**33.14**	**23.7%**

FY Consumption			Saving Identified			Percentage Saving Identified		
KWh	MTOE	Tonne of CO_2	KWh	MTOE	Tonne of CO_2	KWh	MTOE	Tonne of CO_2
24,94,950	214.57	2,046	4,29,825	36.96	352	17.23%	17.23%	17.23%

Acknowledgment

M/s. Energy Solution Company places on record its sincere thanks to **Uttar Pradesh New & Renewable Energy Development Agency (UPNEDA),** Vibhuti Khand, Lucknow for its critical role in guiding and steering this prestigious assignment on **"Energy Audits of Govt. Buildings."**

We are grateful to the **Uttar Pradesh New & Renewable Energy Development Agency (UPNEDA),** Vibhuti Khand, Lucknow for giving us an opportunity to conduct the Energy Audit of Madan Mohan Malaviya University of Technology, Gorakhpur.

- Sh Anupam Shukla-Director
- Sh Pankaj Singh- Secretary & Chief Project Officer
- Sh Rakesh Kumar Agarwal- Senior Project Officer-2
- Sh Girish Kumar- Sr. Energy Consultant

We are thankful to all the officials from the Madan Mohan Malaviya University of Technology, Gorakhpur for their assistance and guidance during the execution of the Energy Audits of the building.

- Prof. J P Soni- Vice Chancelor
- Dr. Jai Prakash- Registrar
- Mr. Pradeep Kant Singh-PA to VC
- Mr. RD Patel- Dean Infrastructure
- Mr. Amit Shankar- Asst. Engineer
- Mr. Rahul Mishra- JE (Elect.)

Our sincere thanks are to the management of the Madan Mohan Malaviya University of Technology, Gorakhpur for extending necessary cooperation and providing relevant information to us for the successful completion of the study. It is not possible to name all staff for their help during the collection of data & energy audit studies.

M/s. Energy Solution Company, Ghaziabad looks forward to their continued support in all future endeavours as well.

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CHAPTER 1 INTRODUCTION

1.1 THE PROJECT

With the advent of the energy crisis and exponential hikes in the costs of different forms of energy, Energy Audit is manifesting its due importance in every establishment. An Energy Audit helps to understand more about the ways energy is used in any establishment and helps in identifying areas where waste may occur and where scope for improvement exists.

It was with this objective that **"Energy Solution Company" C-938, 9TH Floor, Tower No-10, River Heights, Raj Nagar Ext., Ghaziabad** was entrusted with the job of conducting an Energy Audit of Madan Mohan Malaviya University of Technology, Gorakhpur

1.2 SCOPE OF WORK

I) Building Energy Bills Analysis

Analysis of energy consumption pattern in the building concerning peak demand, load Pattern, and power factor for the last 1 year.

II) Electricity Supply and Distribution Network-

- **Distribution Transformer(s)**

Study and analysis of the utility pattern of the transformer(s), power quality of the transformers,

- **LT Distribution Panels**

1. General inspection of the LT distribution panel(s) for its maintenance and working including checking all the meters mounted on it.
2. Measurement and analysis of demand and power factor, suggestions to reduce the demand and improve the power factor.
3. Study on the Metering system and suggestions for improvement.
4. Study on V, I, KW fluctuation and profiling, V & I imbalances in the network.
5. Detailed examination of the existing energy use of the facility with break up.
6. Study and examination of the use of electric energy cost balance with break up.
7. Performance evaluation of installed capacitors to ensure deliverance of desired output, level of losses, management of system power factor, and operation of capacitors.

III) Air Conditioning Systems–

- **Centralized Air Conditioning System**

1. Performance evaluation of existing central air conditioning system(s) in all the areas, measurement and analysis of indoor temperatures, and suggest optimizing the energy utilization.

- **Chillers -**

1. Measuring all the operating parameters such as water flow (If the actual flow is found to be in variation with the designed flow, the same needs to be adjusted to match the designed flow

before taking observations) inlet & out water temperatures, gas suctions & discharge pressure, Power Consumption, etc. after stabilizing the parameters.

2. Calculation of operating Input KW per TR (IKW / TR) of Chiller(s) at a minimum of three different available load conditions for each chiller.

3. Comparison of actual parameters with the design values, and suggestions for corrective actions to be implemented.

- **Pumps -**

1. Measuring all the operating parameters such as water flow, suction & discharge head, power consumption, etc.

2. Performance Evaluation of chilled water & Condenser water pump and compare the same with the design or generally expected efficiency of such pumps.

- **Cooling Towers –**

1. Measurement of various parameters for cooling tower fans, water flow rate, air flow rate, dry bulb temperature (DBT) wet bulb temperature (WBT) sump temperature, relative humidity, etc.

2. Evaluation of cooling tower performance (Range, approach, and effectiveness) and comparing it with designed data.

- **Air Handling Units**

1. Measurement of airflow, Relative Humidity (RH), Supply air temperature (Tsa), Return air temperature (Tra), Chilled Water Inlet, and outlet temperature i.e. Tin, Tout through the cooling coil and energy consumption of Air Handling Units (AHUs).

2. Examination of Air Handling Units for air delivery capacity, capacity utilization, temperature pattern, pressure drop, and operational pattern concerning time to identify potential energy-saving measures.

3. Calculation of actual tonnage of AHUs and Measurement of operating zone temperatures under each unit. Comparison of actual parameters with the design values.

- **Package/ precision Air Conditioners / Split or window air conditioners**

1. Evaluation of operating Coefficient of Performance (COP) of Precision and package Air Conditioner. Identification and suggestions for performance improvement and energy-saving potential.

2. Calculation of actual tonnage and comparison of actual parameters with the design values and corrective actions.

IV) Lightning and Fans

1. Examination of the performance of the existing lighting system in all the areas, measurement of illumination levels, etc

2. To look for possibilities to reduce energy use by incorporating an energy-efficient lighting system.

3. Study of operating electrical parameters like voltage, current, etc in the lighting circuits.

V) Diesel Generator Sets

1. General Inspection of DG set.

2. The DG sets are to be tested for operational performance and parameters including fuel consumption, power generated, Voltage, Ampere, KW, KWh, KVA should be recorded during the audit.

VI) Others

1. Check the temperature of wiring and electric joints at key locations through a thermo-graphic imager. Hot spots to be identified and the image to be included in the report.

2. Measure the temperature of the roof of the top floors inside (inner surface of the roof) as well as outside (outer surface of the roof where sunshine is falling). Identify potential for heat-reflective paint on the outer surface of the roof, heat-reflective coating for the windows exposed to sunshine, etc.

3. Check the possibility of using a Concentrated Solar system in the hostel to provide steam for the cooking and calculate the energy saving potential i.e. gas saved by this system and the cost of the system including cost-benefit analysis.

4. Check the performance of the Solar PV System and the Solar water heating System.

5. Identify the feasibility and potential of installing induction cooking in the cooking areas, whether it is the canteen or hostels of the institutes, so that LPG can be replaced by electric cooking. Calculate cost benefit for the replacement of LPG by induction cookers i.e. identify the cost of the system and quantify LPG savings, payback period, etc.

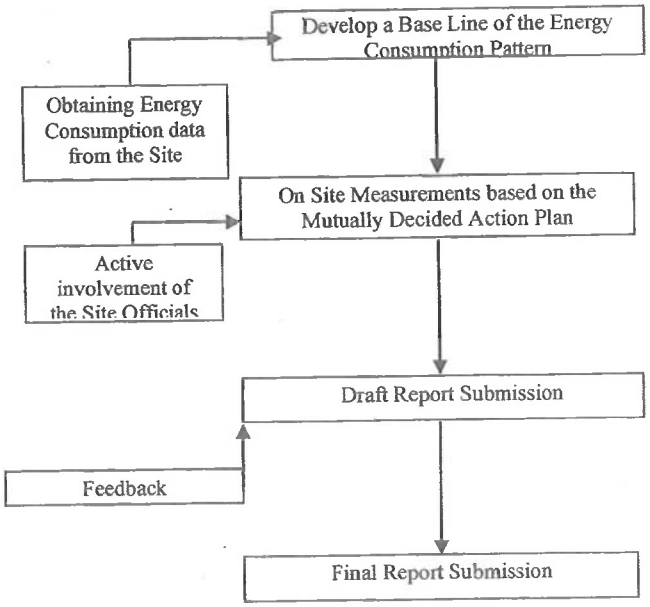
6. The entire recommendations have been backed up with techno-economic calculations including the estimated investments required for the implementation of the suggested measures and the payback period. Measurements have been made using appropriate instrumentation support for time-lapse and continuous recording of the operational parameters.

1.3 METHODOLOGY

The methodology adopted for achieving the desired objectives viz: Assessment of the Current operational status and Energy savings includes the following:

Discussions with the concerned officials for identification of major areas of focus and other related systems.

A team of engineers visited the Site and had discussions with the concerned officials/ supervisors to collect data/ information on the operations and Load Distribution within the Building. The data were analysed to arrive at a **baseline energy consumption pattern**.



Measurements and monitoring with the help of appropriate instruments including continuous and/ or time-lapse recording, as appropriate and visual observations were made to identify the energy usage pattern and losses in the system.

Computation and **in-depth analysis** of the collected data, including utilization of computerized analysis and other techniques as appropriate, were done to draw inferences and to evolve suitable energy conservation plan/s for improvements/ reduction in specific energy consumption.

1.4 INSTRUMENTATION SUPPORT

Some of the instruments used for undertaking the audit include the following:

- Electric Load Manager with appropriate CTs & PTs for Power Measurements with recording facilities.
- Dual Type Digital Temperature (°C/°F) Measuring Device with appropriate probes;
- Ultra-Sonic Flow Meter
- Pressure Gauges
- Anemometers
- Lux Meter
- Hygrometer

CHAPTER 2 BASELINE DATA

2.1 GENERAL DETAILS

Contact Details		
Brief Description of Assignment	:	Detailed Energy Audit of Electrical Systems & Utility Equipment's.
Name & Address of the Building	:	Madan Mohan Malaviya University of Technology, Gorakhpur
Operational Days	:	300 Days per annum
Working hours (e.g., day working /24-hour working)	:	9 Hrs/day
Working days/week (e.g., 5/6/7 days per week)	:	5 days a week
Contact Officer	:	Mr. Rahul Mishra-JE (Elect.)
Power		
Source	;	11 KV Supply
Account No	:	6986183000
Contracted Load KVA	:	700 KVA
Billable Demand (KVA)	:	525 KVA (75% of CD)
Average Purchased Power Consumption		
Dec-2022-Nov-2023	:	24,94,950 KWh; 25,15,180 kVAH
Average Energy Charges		
Dec-2022-Nov-2023	:	Rs 7.82 per kVAH
Average Net Amount		
Dec-2022-Nov-2023	:	Rs. 2,71,66,524
Average Purchased Power Cost		
Dec-2022-Nov-2023	:	Rs. 10.89 per kWH Rs 10.8 per kVAH
HSD		
Jan-2023-Dec-2023	:	600 Liter in DG
GAS (LPG)		
Jan-2023-Dec-2023	:	No of Cylinders per Annum 600 Nos (19 Kg) 1,36,800 Kg per Annum

2.2 RATED SPECIFICATIONS OF TRANSFORMERS

Madan Mohan Malaviya University of Technology, Gorakhpur draws Power from Purvanchal Vidyut Vitran Nigam Limited. at 11 KV. Subsequently, the voltage is stepped down by six transformer (CSS Transformer) of 400 kVA from 11 KV to 433 V. The details of Transformers are

Identification	TR-1	TR-2	TR-3

Make	ABB	ABB	ABB
KVA Rating	400 kVA	400 kVA	400 kVA
HV Voltage	11,000 V	11,000 V	11,000 V
LV Voltage	433 V	433 V	433 V
HV Ampere	21	21	21
LV Ampere	533.3	533.3	533.3
Type of Cooling	Air Cooled	Air Cooled	Air Cooled
Impedance	3.928	-	-

Identification	TR-4	TR-5	TR-6
Make	ABB	ABB	ABB
KVA Rating	400 kVA	400 kVA	400 kVA
HV Voltage	11,000 V	11,000 V	11,000 V
LV Voltage	433 V	433 V	433 V
HV Ampere	21	21	21
LV Ampere	533.3	533.3	533.3
Type of Cooling	Air Cooled	Air Cooled	Air Cooled
Impedance	-	-	-

CHAPTER 3 POWER CONSUMPTION (ENERGY BILLS ANALYSIS)

3.1 PURCHASED POWER

Madan Mohan Malaviya University of Technology, Gorakhpur draws Power from Purvanchal Vidyut Vitran Nigam Limited. at 11 KV. Subsequently, the voltage is stepped down by six transformers (CSS Transformer) of 400 kVA from 11 KV to 433 V. The Contracted load is 700 kVA.

3.2 POWER CONSUMPTION

Madan Mohan Malaviya University of Technology, Gorakhpur draws Power from Purvanchal Vidyut Vitran Nigam Limited. at 11 KV. Subsequently, the voltage is stepped down by six transformers (CSS Transformer) of 400 kVA from 11 KV to 433 V.

3.3 REACTIVE POWER COMPENSATION

The building is being billed on a kVAh basis; therefore, the effect of the power factor is inbuilt into the billing structure. As per electricity Bill, the power factor varies from 0.967 to 0.998 and overall average Power factor is around 0.989 which is satisfactory.

3.4 SELF-GENERATED POWER

One DG set of 250 kVA is installed for emergency power supply. The operation of the DG Sets is during power cuts & testing only.

3.5 LPG GAS CONSUMPTION

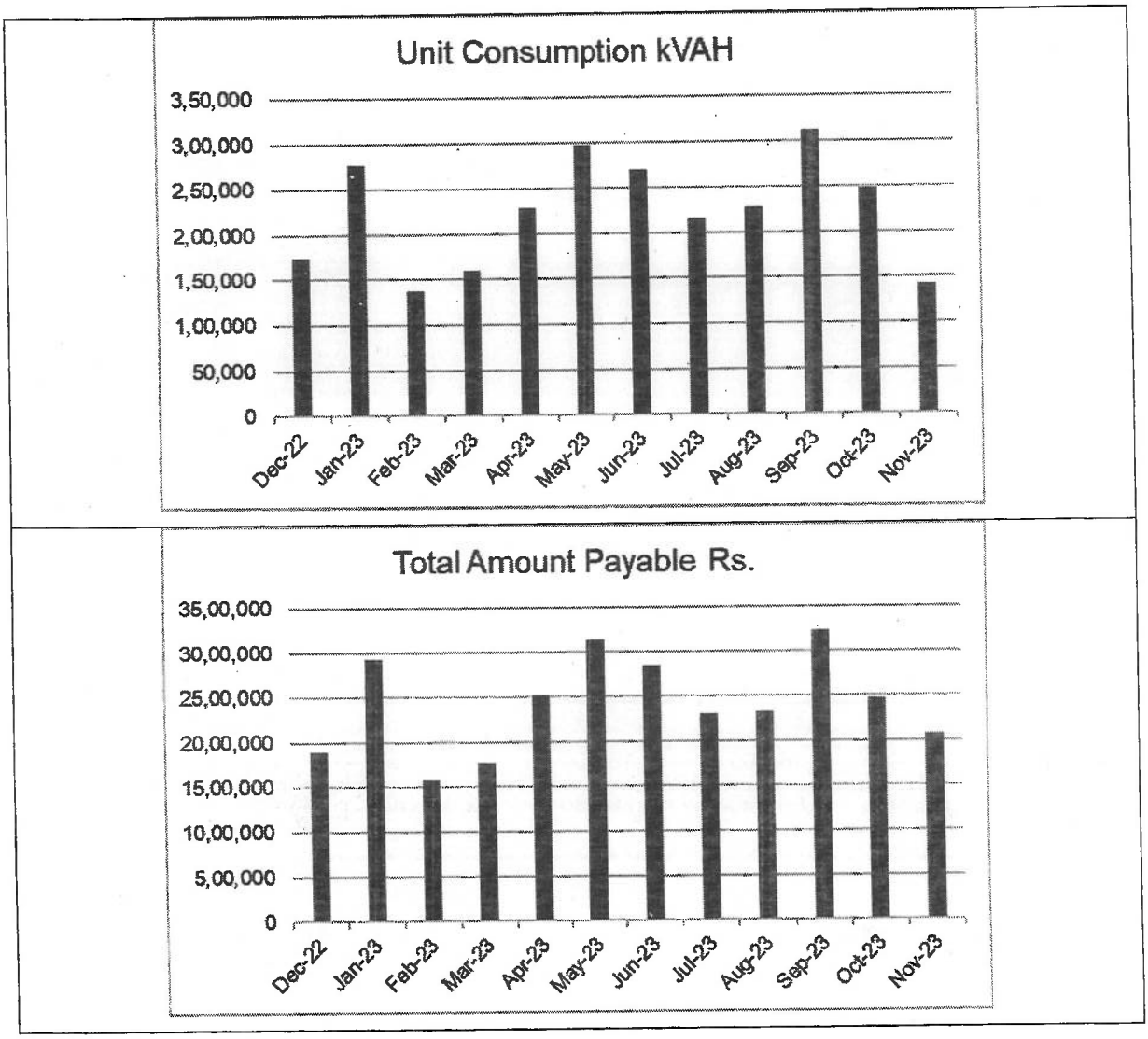
In MMMUT Campus, for cooking food LPG gas is used. The Guest House and hostel mess are maintained by a third party. In the Guest House and hostel mess, approx. 600 Nos (19 Kg) cylinders are used for cooking food.

3.6 OVERALL ENERGY BILL

Month	Sanctioned Load kVA	Billable Demand kVA	Max. Rec. Demand kVA	Unit Consumption kWH	Unit Consumption kVAH	Power Factor
Dec-22	700	525.0	431	1,71,480	1,74,100	0.985
Jan-23	700	525.0	727	2,75,270	2,77,390	0.992
Feb-23	700	525.0	357	1,33,120	1,37,450	0.968
Mar-23	700	525.0	411	1,56,890	1,59,790	0.982
Apr-23	700	525.0	719	2,27,600	2,28,550	0.996
May-23	700	525.0	732	2,96,840	2,97,480	0.998
Jun-23	700	525.0	688	2,69,430	2,70,030	0.998
Jul-23	700	525.0	598	2,15,290	2,15,860	0.997

Month	Sanctioned Load kVA	Billable Demand kVA	Max. Rec. Demand kVA	Unit Consumption kWH	Unit Consumption kVAH	Power Factor
Aug-23	700	525.0	570	2,26,090	2,27,090	0.996
Sep-23	700	525.0	761	3,10,510	3,11,330	0.997
Oct-23	700	525.0	163	2,46,820	2,48,510	0.993
Nov-23	700	525.0	926	1,37,090	1,41,700	0.967
Total				**24,94,950**	**25,15,180**	**0.989**

Month	Energy Charge	Fixed Charge	Protective Load Charge	Electricity Duty	Excess Demand Penalty	Total Amount Payable
	Rs.	Rs.	Rs.	Rs.	Rs.	Rs.
Dec-22	13,74,890	1,99,500	1,99,500	1,18,079	0	18,91,969
Jan-23	21,90,881	2,76,260	2,76,260	1,85,036	0	29,28,437
Feb-23	10,85,355	1,99,500	1,99,500	96,364	0	15,80,719
Mar-23	12,61,841	1,99,500	1,99,500	1,09,601	0	17,70,442
Apr-23	18,05,045	2,73,220	2,73,220	1,55,870	14,440	25,21,795
May-23	23,49,592	2,78,160	2,78,160	1,97,081	24,320	31,27,313
Jun-23	21,32,737	2,61,440	2,61,440	1,79,563	0	28,35,180
Jul-23	17,04,794	2,27,240	2,27,240	1,44,903	0	23,04,177
Aug-23	17,48,593	2,16,600	2,16,600	1,47,389	0	23,29,182
Sep-23	23,97,241	2,89,180	2,89,180	2,01,482	46,360	32,23,443
Oct-23	19,13,527	1,99,500	1,99,500	1,58,477	0	24,71,004
Nov-23	10,91,090	3,51,880	3,51,880	1,08,223	1,71,760	20,74,833
Total	**1,96,80,696**					**2,71,66,524**

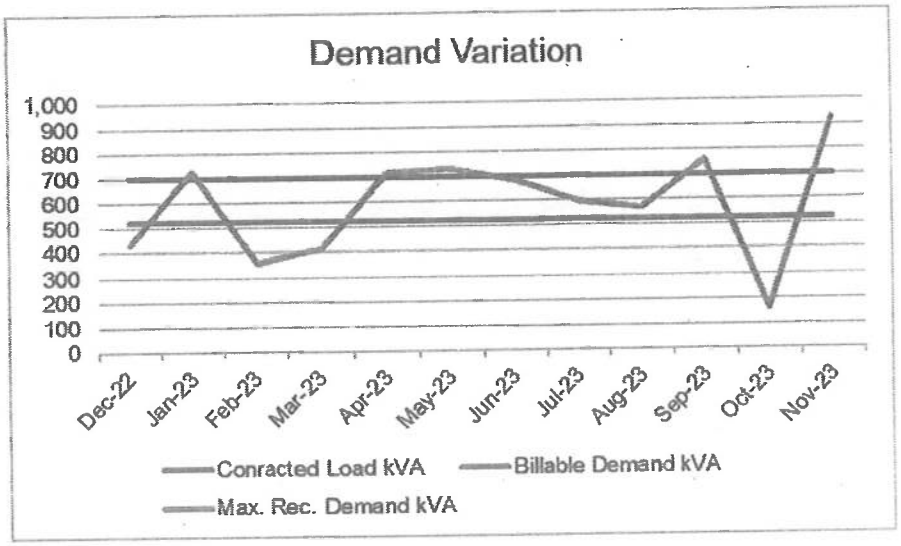


3.7 MAXIMUM DEMAND VARIATIONS

Madan Mohan Malaviya University of Technology, Gorakhpur draws Power from Purvanchal Vidyut Vitran Nigam Limited and has has a contracted load of 700 kVA and minimum billable demand is 525 kVA (@75% of sanctioned load).

Month	Contracted Load kVA	Billable Demand kVA	Max. Rec. Demand kVA
Dec-22	700	525.0	431
Jan-23	700	525.0	**727**
Feb-23	700	525.0	357
Mar-23	700	525.0	411
Apr-23	700	525.0	**719**
May-23	700	525.0	**732**

Month	Contracted Load kVA	Billable Demand kVA	Max. Rec. Demand kVA
Jun-23	700	525.0	688
Jul-23	700	525.0	598
Aug-23	700	525.0	570
Sep-23	700	525.0	**761**
Oct-23	700	525.0	163
Nov-23	700	525.0	**926**



3.7.1 OBSERVATION:

From the above data, it was observed that the maximum recorded demand varies from 163 kVA to 926 kVA which means the maximum recorded demand has crossed the sanctioned load (i.e., 700 kVA) in the month of Jan-23, Apr-23, May-23, Sept-23 & Nov-23 as a result of which demand penalty has been imposed. Hence, to reduce this demand penalty, it is recommended to install Maximum demand indicator, which will help to limit the increased billing demand. In case the load exceeds the preset limits, the MD controller would isolate some of the non-essential loads/ feeders

After Installation of Maximum Demand Indicator, the resultant savings are as follows:

Month	Contracted Load kVA	Max. Rec. Demand kVA	Fixed Charge Rs.	Excess Demand Penalty Rs.
Mar-23	700	431	1,99,500	0
Apr-23	700	**727**	2,76,260	0
May-23	700	357	1,99,500	0
Jun-23	700	411	1,99,500	0
Jul-23	700	**719**	2,73,220	14,440
Aug-23	700	**732**	2,78,160	24,320

Month	Contracted Load kVA	Max. Rec. Demand kVA	Fixed Charge Rs.	Excess Demand Penalty Rs.
Sep-23	700	688	2,61,440	0
Oct-23	700	598	2,27,240	0
Nov-23	700	570	2,16,600	0
Dec-23	700	**761**	2,89,180	46,360
Jan-24	700	163	1,99,500	0
Feb-24	700	**926**	3,51,880	1,71,760
Total			**27,72,480**	**2,56,880**

Particular	Units	Installation of Max Demand Controller
Contacted Demand	KVA	700
Minimum Billing Demand	KVA	525
Demand Penalty	Rs.	2,56,880
Savings Post Implementation of MDC	**Rs.**	**2,56,880**
Investment for MDC	**Rs.**	**1,50,000**
Payback Period	**Months**	**7-8**
IRR	**%**	**170.06 %**

3.8 POWER FACTOR VARIATIONS

Madan Mohan Malaviya University of Technology, Gorakhpur draws Power from Purvachal Vidyut Vitran Nigam Limited. at 11 KV. The building is being billed on a kVAh basis; therefore, the effect of the power factor is inbuilt into the billing structure. From the electricity Bill, the power factor varies from 0.967 to 0.998 and overall average Power factor is around 0.989 which is satisfactory.

CHAPTER 4 REACTIVE POWER COMPENSATION

4.1 CAPACITOR BANK

Madan Mohan Malaviya University of Technology, Gorakhpur management has not installed APFC for power factor improvement at LT Side. The building is being billed on a KVAh basis; therefore, the effect of the power factor is inbuilt into the billing structure. From the electricity Bill, the power factor varies from 0.967 to 0.998 and overall average Power factor is around 0.989 which is satisfactory.

4.2 RECOMMENDATIONS

4.2.1 IMPROVEMENT IN THE OPERATING POWER FACTOR

The Billing at MMMUT, Gorakhpur is done at 11 kV & the building is being billed on a KVAH basis; therefore, the effect of the power factor is inbuilt into the billing structure and as per analysis of SEB Bills it is found that the Power Factor at MMMUT, Gorakhpur varies from 0.967 to 0.998 and overall average Power factor is around 0.989 which is satisfactory. But can be improved upto 0.999 So, we recommend to install the APFC of 50 kVAr capacity at LT Side of the transformer to achieve 0.999 Power factor and also add some additional Capacitor of Smaller Capacity (i.e., 5, 3, 1 kVAr) in it.

Month	Unit Consumption	Power Factor	kVAH Consumption after improvement of PF up To 0.999	kVAH Reduction	Monetary Savings
	kVAH		kVAH	kVAH	Rs.
Dec-22	1,74,100	0.985	1,71,651.65	2,448.35	26,442.16
Jan-23	2,77,390	0.992	2,75,545.55	1,844.45	19,920.11
Feb-23	1,37,450	0.968	1,33,253.25	4,196.75	45,324.86
Mar-23	1,59,790	0.982	1,57,047.05	2,742.95	29,623.89
Apr-23	2,28,550	0.996	2,27,827.83	722.17	7,799.46
May-23	2,97,480	0.998	2,97,137.14	342.86	3,702.92
Jun-23	2,70,030	0.998	2,69,699.70	330.30	3,567.24
Jul-23	2,15,860	0.997	2,15,505.51	354.49	3,828.54
Aug-23	2,27,090	0.996	2,26,316.32	773.68	8,355.78
Sep-23	3,11,330	0.997	3,10,820.82	509.18	5,499.14
Oct-23	2,48,510	0.993	2,47,067.07	1,442.93	15,583.68
Nov-23	1,41,700	0.967	1,37,227.23	4,472.77	48,305.95
Total	**26,89,280.00**	**0.989**	**26,69,099.10**	**20,180.90**	**2,17,953.73**

Identification	Units	Savings (Rs.)
Present Operating Power Factor	PF	0.989
Power factor post improvement	PF	0.999
Total Monitory Benefit per annum post improvement of PF to 0.999	Rs. In Lacs	2.17
Estimated Investments (Maintenance of Capacitor Bank)	Rs. In Lacs	1.0
Simple Payback Period	**Months**	**5-6 months**
IRR	**%**	**217.28 %**

Note: For this, the management may also have to install multiple smaller-capacity capacitor banks of 1/3/5 KVAr in APFC. Normally, under partial load conditions, the higher rating capacitors are not triggered, leading to a low system power factor under such situations. With multiple smaller-capacity capacitor banks in place, the operation power factor would consistently be maintained around the set point.

CHAPTER 5 BUILDING LOAD PROFILE

5.1 LOADING ON MAIN INCOMER

During the audit, the total load of the college was measured at HT Side, and the averaged-out readings are given herein:

5.1.1 LOAD PROFILE OF INSTITUTE (11 KV INCOMING)

Parameter	Unit	Min	Max	Average
L12 RMS Voltage	V	6130.00	6180.00	6153.64
L23 RMS Voltage	V	6160.00	6200.00	6182.55
L31 RMS Voltage	V	6110.00	6160.00	6136.18
L1 RMS Current	Amp	25.35	27.90	26.70
L2 RMS Current	Amp	23.10	24.30	23.88
L3 RMS Current	Amp	24.90	25.95	25.48
L1 PF	-	0.997	0.998	0.997
L2 PF	-	0.994	0.997	0.996
L3 PF	-	0.986	0.992	0.989
L1 Active Power	KW	154.93	172.08	163.86
L2 Active Power	KW	141.44	150.21	146.99
L3 Active Power	KW	150.01	158.57	154.57
Total Active Power	**KW**	**446.38**	**480.86**	**465.42**
L1 Apparent Power	KVA	155.40	172.42	164.30
L2 Apparent Power	KVA	142.30	150.66	147.62
L3 Apparent Power	KVA	152.14	159.85	156.32
Total Apparent Power	**KVA**	**449.83**	**482.93**	**468.25**
Voltage Harmonics				
L1 THD Voltage	%	1.90	2.10	2.02
L2 THD Voltage	%	2.00	2.20	2.10
L3 THD Voltage	%	1.90	2.10	2.01
Current Harmonics				
L1 THD Current	%	7.80	8.90	8.39
L2 THD Current	%	7.70	8.50	8.17
L3 THD Current	%	7.60	8.50	8.07

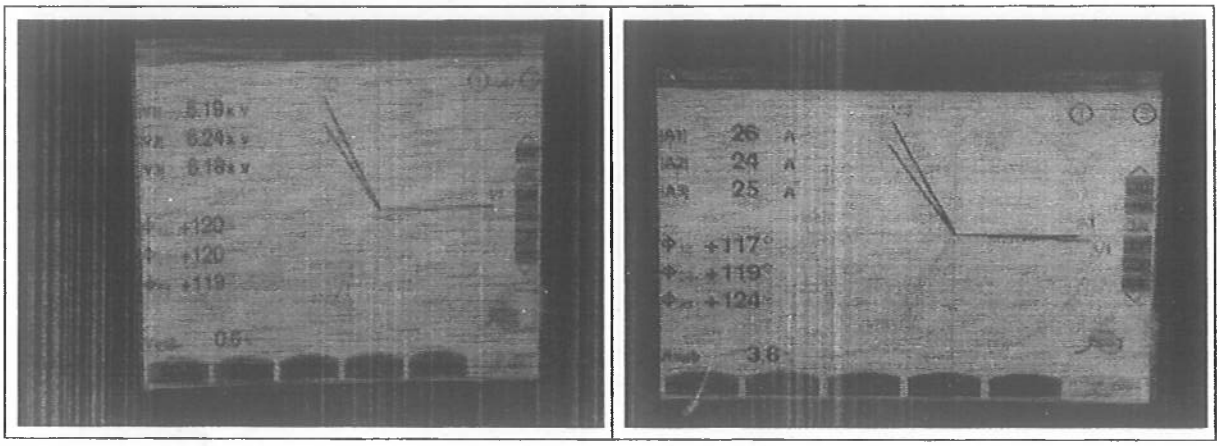
5.2 OTHERS LOAD

Parameter	TR-1	TR-2	TR-3	TR-4	TR-5	TR-6
L1 RMS Voltage	6,200	6,210	6,200	6,220	6,210	6,223
L2 RMS Voltage	6,180	6,190	6,190	6,200	6,200	6,201
L3 RMS Voltage	6,240	6,240	6,220	6,250	6,250	6,270
L1 RMS Current	10.7	10.72	10.7	10.74	10.72	10.72
L2 RMS Current	10.77	10.76	10.76	10.79	10.8	10.8
L3 RMS Current	10.79	10.78	10.78	10.82	10.82	10.83
L1 PF	0.968	0.99	0.997	0.998	0.995	0.826
L2 PF	0.992	0.981	0.908	0.988	0.993	0.94
L3 PF	0.988	0.999	0.991	0.967	0.935	0.84
L1 Active Power	64.22	65.91	66.14	66.67	66.24	55.10
L2 Active Power	66.03	65.34	60.48	66.10	66.49	62.95
L3 Active Power	66.52	67.20	66.45	65.39	63.23	57.04
Total Active Power	**196.76**	**198.44**	**193.07**	**198.16**	**195.96**	**175.09**
L1 Apparent Power	66.34	66.57	66.34	66.80	66.57	66.71
L2 Apparent Power	66.56	66.60	66.60	66.90	66.96	66.97
L3 Apparent Power	67.33	67.27	67.05	67.63	67.63	67.90
Total Apparent Power	**200.23**	**200.44**	**200.00**	**201.33**	**201.16**	**201.59**
Voltage Harmonics						
L1 THD Voltage	2.05	2.00	2.03	2.03	2.00	1.90
L2 THD Voltage	2.07	2.00	2.07	1.98	2.01	2.10
L3 THD Voltage	2.16	2.10	2.17	2.15	2.18	2.13
Current Harmonics						
L1 THD Current	12.25	1.70	4.10	1.70	9.88	41.90
L2 THD Current	10.84	2.30	5.21	3.20	68.00	36.08
L3 THD Current	10.88	1.50	6.73	3.10	8.90	30.40

Particulars	Voltage (V)	Current (A)	PF	Load (KW)
Pump-2	395.4	21.4	0.82	12.02
Pump-3	397.80	19.60	0.78	10.53
Pump-4	393.60	37.54	0.79	20.22

5.3 Unbalancing of Load

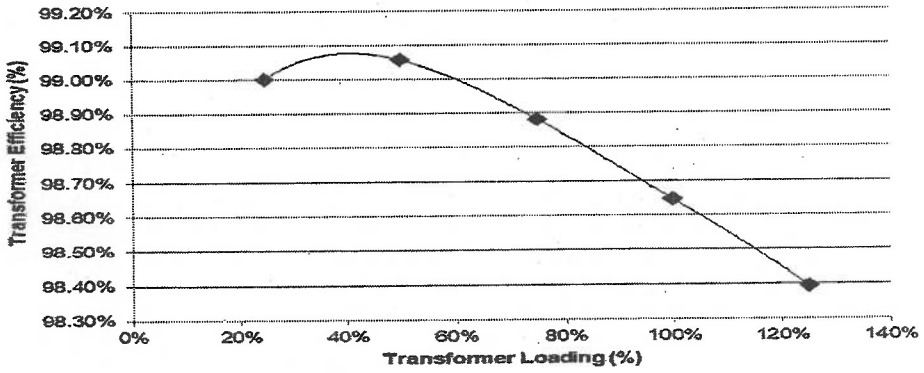
During the audit, we measured the Power Quality on the HT Side and observed that the Voltage and the current was was balanced in all three phases.



5.4 Loading Percentage of Transformers

% Loading on TR		
Rated KVA of TR-1	**= 400 KVA**	
Measured KVA of TR	= 200.23	
% Loading of TR	= 200.23 / 400	**= 50.05 %**
Rated KVA of TR-2	**= 400 KVA**	
Measured KVA of TR	= 200.44	
% Loading of TR	= 200.44 / 400	**= 50.11 %**
Rated KVA of TR-3	**= 400 KVA**	
Measured KVA of TR	= 200.00	
% Loading of TR	= 200.0 / 400	**= 50.0 %**
Rated KVA of TR-4	**= 400 KVA**	
Measured KVA of TR	= 201.33	
% Loading of TR	= 201.33 / 400	**= 50.33 %**
Rated KVA of TR-5	**= 400 KVA**	
Measured KVA of TR	= 201.16	
% Loading of TR	= 201.16/ 400	**= 50.29 %**
Rated KVA of TR-6	**= 400 KVA**	
Measured KVA of TR	= 201.59	
% Loading of TR	= 201.59/ 400	**= 50.39 %**

The following figure shows the loading Vs efficiency curve for the transformer under study.



Transformer Loading Vs Efficiency

5.4.1 OBSERVATIONS:

As per the figure, a transformer will give maximum efficiency when the loading is between 35% to 55% and as per the above data it is observed that the transformer loading of **TR-1 is around 50.05%, TR-2 is 50.11%, TR-3 is 50%, TR-4 is 50.33%, TR-5 is 50.29% & TR-6 is 50.39%, which is good**.

CHAPTER 6 POWER QUALITY

6.1 POWER QUALITY & HARMONICS

Equipment based on frequency conversion techniques generates harmonics. With the increased use of such equipment, **harmonics-related problems** have been enhanced.

The harmonic currents generated by different types of loads travel back to the source. While traveling back to the source, they generate harmonic voltages, following simple Ohm's Law. Harmonic voltages, which appear on the system bus, are harmful to other equipment connected to the same bus. In general, sensitive electronic equipment connected to this bus will be affected.

The Harmonics Level on the HT side was measured, details of which are as under: -

The Harmonic Voltage and Current Limitations set forth by IEEE 519 1992 are:

- Maximum Individual Frequency Voltage Harmonic: 3%
- Total Harmonic Distortion of the Voltage: 5%

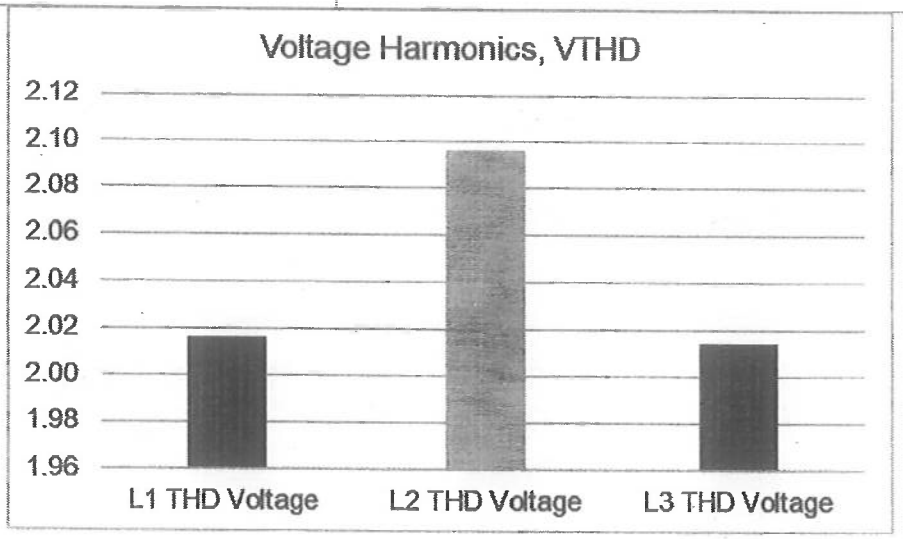
harmonic current limitations

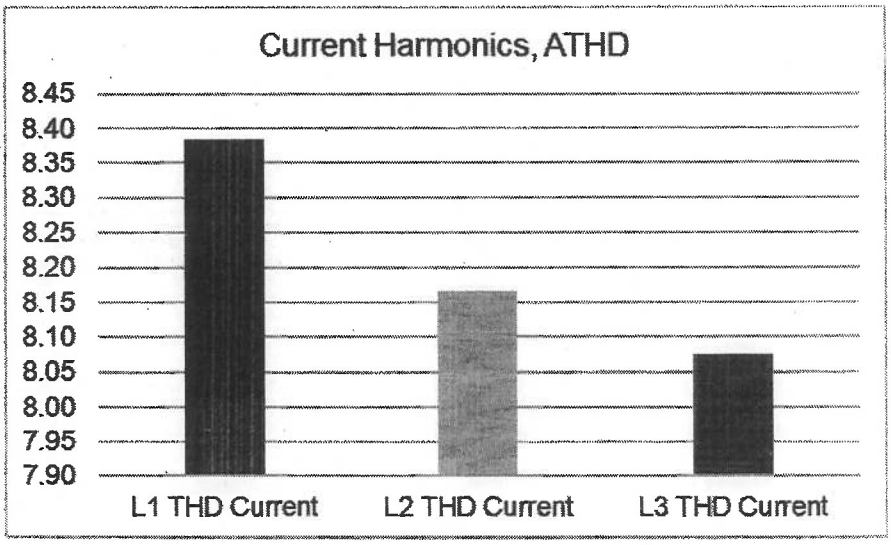
Maximum Harmonic Current Distortion in Percent of IL
120 Volt through 69 KV
Individual Harmonic Order (Odd Harmonics)

ISC/IL	h<11	11<h<17	17<h<23	23<h<35	35<h	TDD
<20*	4.0	2.0	1.5	0.6	0.3	5.0
20<50	7.0	3.5	2.5	1.0	0.5	8.0
50<100	10.0	4.5	4.0	1.5	0.7	12.0
100<1000	12.0	5.5	5.0	2.0	1.0	15.0
>1000	15.0	7.0	6.0	2.5	1.4	20.0

Even harmonics are limited to 25% of the odd harmonic limits
TDD refers to Total Demand Distortion based on the average demand current at the fundamental frequency and measured at the PCC (Point of Common Coupling).
*All power generation equipment is limited to these values of current distortion regardless of ISC/ IL value.
ISC = Maximum short-circuit current at PCC.
IL = Maximum demand load current (fundamental) at the PCC.
h = Harmonic number.

Particulars	HT Side
	Voltage Harmonics (%)
L1 THD Voltage	2.02
L2 THD Voltage	2.10
L3 THD Voltage	2.01
	Current Harmonics (%)
L1 THD Current	8.39
L2 THD Current	8.17
L3 THD Current	8.07





As detailed above, the voltage harmonics of main incomer at HT Side was around 2.01-2.10% and the levels of the current harmonics was 8.007-8.39%. **The Overall Average Voltage harmonics & Current harmonics are within the limits.**

If the Harmonics level is on the higher side, then appropriate harmonic filters may have to be installed in the system.

Different technologies are available to mitigate the harmonics of the system. These include:

Detuned or broadband harmonic filters: these filter banks are tuned to a frequency just below the predominant harmonic frequency. If the predominant harmonic frequency is say, 5th, it is normal practice to tune the filters to 189 Hz, or 3.78th harmonic, in 50 Hz systems.

Active Harmonic Filters: these units are designed in such a manner that, they will inject harmonic frequencies into the system, which will be in anti-phase of the load harmonic frequencies. This will effectively free the source being loaded due to harmonics.

6.2 Observations & Suggestions:

It is clear from the above data that the Overall Average Voltage harmonics & Current harmonics are within the limits.

Major Causes of Harmonics

Devices that draw non-sinusoidal currents when a sinusoidal voltage is applied create harmonics. Frequently these are devices that convert AC to DC. Some of these devices are listed below:

Electronic Switching Power Converters

- Computers, Uninterruptible power supplies (UPS), Solid-state rectifiers
- Electronic process control equipment, PLCs, etc.
- Electronic lighting ballasts, including light dimmer
- Reduced voltage motor controllers

Arcing Devices

- Discharge lighting, e.g. Fluorescent, Sodium, and Mercury vapor

- Arc furnaces, Welding equipment, Electrical traction system, Ferromagnetic Devices
- Transformers operating near saturation level
- Magnetic ballasts (Saturated Iron core)
- Induction heating equipment, Chokes, Motors

Appliances

- TV sets, air conditioners, washing machines, microwave ovens
- Fax machines, photocopiers, printers

These devices use power electronics like SCRs, diodes, and thyristors, which are a growing Percentage of the load in industrial power systems.

Many problems can arise from harmonic currents in a power system. Some problems are easy to detect; others exist and persist because harmonics are not suspected. Higher RMS current and voltage in the system are caused by harmonic currents, which can result in any of the problems listed below:

Blinking of Incandescent Lights	Transformer Saturation
Capacitor Failure	Harmonic Resonance
Circuit Breakers Tripping	Inductive Heating and Overload
Conductor Failure	Inductive Heating
Electronic Equipment Shutting down	Voltage Distortion
Flickering of Fluorescent Lights	Transformer Saturation
Fuses Blowing for No Apparent Reason	Inductive Heating and Overload
Motor Failures (overheating)	Voltage Drop
Neutral Conductor and Terminal Failures	Additive triplen Currents
Electromagnetic Load Failures	Inductive Heating
Overheating of Metal Enclosures	Inductive Heating
Power Interference on Voice Communication	Harmonic Noise
Transformer Failures	Inductive Heating

CHAPTER 7 STUDY OF AIR CONDITIONS SYSTEMS

7.1 SYSTEMS INSTALLED

In a building complex Window/Split AC of different make are installed at various locations. The details are as follows,



Particulars	Tonnage	Qty	Total Tonnage
Ductable AC	8	4	32
Cassette Unit	2.5	1	2.5
Cassette Unit	3	1	3
Cassette Unit	3.5	5	17.5
Cassette Unit	4	12	48
Split AC	1	5	5
Split AC	1.25	4	5
Split AC	1.5	237	355.5
Split AC	2	56	112
Window AC	1.5	23	34.5
Window AC	2	23	46
Tower AC	3	4	12
Total		**375**	**673**

VRF Outdoor Unit

Particulars	Make	HP	Qty	Total
Administrative Building				
Outdoor Unit	LG	22	4	88 HP
Outdoor Unit	LG	24	2	48 HP
Outdoor Unit	LG	10	1	10 HP
Outdoor Unit	LG	16	1	16 HP
Outdoor Unit	LG	18	1	18 HP

Remark: Window/Split Acs are installed in the Building Complex at different locations. Performance was not evaluated on A/Cs as ACs were not operational due to the winter season. The AC is of 5/4/3/No-Star rating installed in the building. **Energy Solution Company acknowledges and appreciates the commitment of the management toward the conservation of Energy.** It is recommended to install 5-star rated AC in place of 4/3/Non-Star, a tentative 10-15% energy saving will be saved.

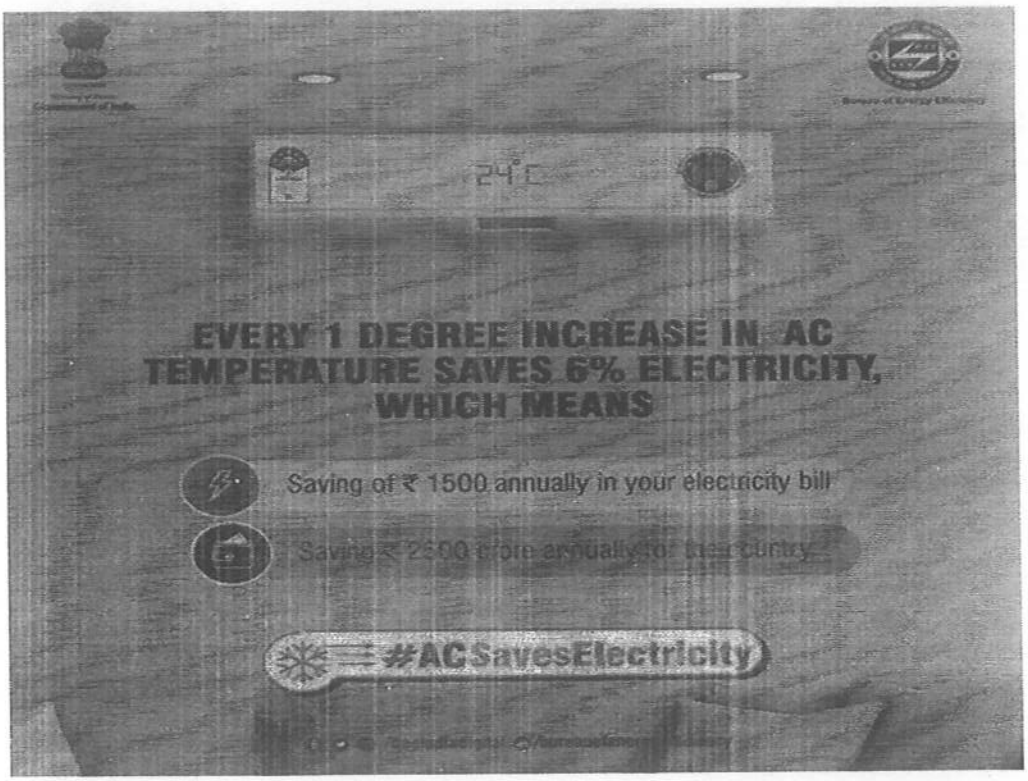
7.2 PERFORMANCE ASSESSMENT

➢ Indicative TR Load Profile for Air Conditioning

o Small Office Cabins	:	0.1 TR m^2
o Medium Size Office with 10-30 people occupancy with Central A/c	:	0.06 TR/m^2
o Large Multi-storeyed office complex with Central A/c	:	0.04 TR/m^2

➢ Criteria Considered for Performance Evaluation of Split & Window A/Cs

Type of AC	Capacity (TR)	Specific Power Consumption (SPC) range of Star Labelled A/Cs (KW/TR)		The permissible Limit is 5% higher than the SPC of Star Labelled A/Cs (KW/TR)
Window	1.5	1.24	1.43	1.5
Window	2	1.27	1.33	1.39
Split	1.5	1.1	1.32	1.38
Split	2	1.06	1.31	1.37



CHAPTER 8 LIGHTING SYSTEMS

8.1 SYSTEMS INSTALLED

In the building complex, most lights are LED but at some locations around 119 No's of (4X18W) conventional Tube light fitting are installed in the MMMUT, Gorakhpur. These lights must be replaced with energy-efficient PL LED Lights. Details are as follows

Particular	LED (10W)	STL (18W)	PL (36W)
Substation		8	
Sarojani Bhawan Girls Hostel			
Hostel Room	44	44	
Mess		13	
Common Room		8	
Warden Office		2	
Bathroom	32	4	
Sarswati Bhawan Girls Hostel			
Hostel Room	86	172	
Warden Office		4	
mess		12	
Common Room		12	
Guest Room	1	2	
Bathroom	40	10	
Kalplana Girls Hostel			
Hostel Room	72	72	
Mess		13	
Common Room		12	
Bathroom	24	6	
Corridor		20	
Kasturva Girls Hostel			
Hostel Room (25 No's)		100	
Hostel Room (18 No's)		36	
Hotel Room (New)		32	
Mess		14	
Common Room		12	
Warden Office		6	
Guest Room	1	2	
yoga Room		6	
Bathroom	20	5	

Particular	LED (10W)	STL (18W)	PL (36W)
New Girls Hostel			
Hostel Room	70	140	
Warden Office	2	4	
Mess		23	
Common Room	4	16	
Bathroom	32	8	
Ramanujan Boys Hostel			
Hostel Room	82	164	
Warden Office	1	2	
Mess		30	
Common Room		10	
Bathroom	18	18	
Guest Room	1	2	
Ambedkar Boys Hostel			
Hostel Room+ Warden Office	243	243	
Mess		28	
Common Room		12	
Bathroom	32	8	
Guest Room	1	2	
Tilak Boys Hostel			
Hostel Room	40	80	
Warden Office	2	4	
Mess		24	
Common Room		6	
Bathroom	8	8	
VS Boys Hostel			
Hostel Room	130	130	
Warden Office	1	1	
Mess		84	
Common Room		12	
Bathroom	32	8	
Tagore Boys Hostel			
Hostel Room	121	162	
Warden Office		2	

Particular	LED (10W)	STL (18W)	PL (36W)
Mess		36	
Common Room		22	
Bathroom	32	8	
Subhas Boys Hostel			
Hostel Room (Single Sitted)	160	160	
Hostel Room (Triple Sitted)		330	
Hostel Room (Old)		126	
Warden Office		2	
Mess		30	
Common Room		15	
Bathroom	100	30	
Raman Boys Hostel			
Hostel Room (Old Single Sitted)	127	127	
Hostel Room (Old triple Sitted)	86	43	
Hostel Room (New Single Sitted)	4	4	
Hostel Room (New triple Sitted)	160	240	
Warden Office		8	
Mess		160	
Common Room		18	
Bathroom		56	
Admin Building		119	
Civil		170	
Applied Science	13	199	54
Computer Science	30	140	193
ITRC	40	124	
Electrical		109	
Electronic		80	
Library		231	
MBA		102	
Total Count	**1,892**	**4,547**	**247**
Total Wattage	**18,920**	**81,846**	**8,892**

8.2 STREET LIGHT

Particular	Street Light (45 W)
Raman Hosel	4
Subhash Hostel	4
Tilak Hostel	6
Ambedkar Hostel	10
Ramanujan Hostel	17
Kasturba Girls Hostel	8
SK Girls Hostel	12
Sarojani Girls Hostel	8
Kalpana Girls Hostel	8
VS Hostel	9
Tagore Hostel	9
Main Rode Pole	110
Colony Road Pole	70
Total	**275**
Total Wattage	**12,375**

8.3 RECOMMENDATIONS

8.3.1 IMPROVEMENT OF VOLTAGE LEVEL IN THE LIGHTING CIRCUIT

We have measured the Instantaneous load of the equipment on the LT Side. The average lighting Voltage is 228.4 Volt. The overall Lighting load including the operating Voltage, Current, Power Factor, etc. was recorded on the LT side of the transformer during the site visit, which is enclosed as a respective chapter.

Normally, the lighting circuit voltage should be around 220 volts (phase to neutral) as against the volts measured at present.

All lights installed in the building are LED lamps the effect of voltage reduction in terms of power-saving will be almost negligible. However, reduction and stabilization of voltage will improve the life of lamps.

8.3.2 Installation of Motion Sensor

During the audit, it was observed that at various locations in the building, lights were ON even when there was no one in the room/office. Hence, it is recommended to use motion sensors to minimize energy consumption. A motion detector is a device that detects moving objects, particularly people. These devices are actively used for street lights or indoor lights in walkways such as lobbies, stairs, and also in offices. The total lighting load of the buildings of entire institute is an average of 110 KW, But most of the buildings are Hostel & academic block so, the payback period of installation of motion sensor in offices is on the higher side so we have not recommended any recommendation on Motion sensors. We have to recommend switching off the lights in the daytime to save energy.

8.3.3 Lighting Control

Although there is no simpler way to reduce the amount of energy consumed by the lighting system than to manually turn it OFF whenever not needed, this is not done as often as it could be. In response, automatic lighting control strategies can be adopted:

- Scheduling Control: Use a time scheduling device to control lighting systems according to predetermined schedules

A central processor with relays is usually capable of controlling several output channels, each of which may be assigned to one or more lighting circuits. Overrides can be provided to accommodate individuals who use the space during scheduled off-hours.

- Daylighting: Control lights in response to the presence of daylight illumination in the space
- Lumen Maintenance: gradually adjust the electric light levels over time to correspond with the depreciation of light output from aging lamps.

Occupancy Sensing: Control light in response to the presence or absence of people in the space.

CHAPTER 9 STUDY OF FANS & OTHER LOAD

9.1 SYSTEMS INSTALLED AND OPERATIONAL PERFORMANCE

Around 545 No's conventional ceiling fan & 19 Nos Wall Fan are installed in the various locations of the building. These Fans must be replaced with energy-efficient BLDC Fans.

Particular	Fan (60W)
Substation	7
Sarojani Bhawan Girls Hostel	
Hostel Room	44
Mess	8
Common Room	6
Warden Office	1
Bathroom	
Sarswati Bhawan Girls Hostel	
Hostel Room	86
Warden Office	2
mess	8
Common Room	8
Guest Room	2
Bathroom	
Kalplana Girls Hostel	
Hostel Room	72
Mess	7
Common Room	7
Bathroom	
Corridor	
Kasturva Girls Hostel	
Hostel Room (25 No's)	50
Hostel Room (18 No's)	18
Hotel Room (New)	16
Mess	7
Common Room	8
Warden Office	3
Guest Room	2
yoga Room	6
Bathroom	
New Girls Hostel	

Particular	Fan (60W)
Hostel Room	140
Warden Office	4
Mess	16
Common Room	12
Bathroom	
Ramanujan Boys Hostel	
Hostel Room	246
Warden Office	3
Mess	14
Common Room	12
Bathroom	
Guest Room	3
Ambedkar Boys Hostel	
Hostel Room+ Warden Office	243
Mess	15
Common Room	12
Bathroom	
Guest Room	2
Tilak Boys Hostel	
Hostel Room	80
Warden Office	4
Mess	10
Common Room	4
Bathroom	
VS Boys Hostel	
Hostel Room	130
Warden Office	1
Mess	66
Common Room	6
Bathroom	
Tagore Boys Hostel	
Hostel Room	162
Warden Office	2
Mess	22

Particular	Fan (60W)
Common Room	16
Bathroom	
Subhas Boys Hostel	
Hostel Room (Single Sitted)	160
Hostel Room (Triple Sitted)	110
Hostel Room (Old)	84
Warden Office	1
Mess	20
Common Room	9
Bathroom	
Raman Boys Hostel	
Hostel Room (Old Single Sitted)	127
Hostel Room (Old triple Sitted)	43
Hostel Room (New Single Sitted)	4
Hostel Room (New triple Sitted)	160
Warden Office	4
Mess	96
Common Room	9
Bathroom	
Admin Building	67
Civil	
Applied Science	
Computer Science	139
ITRC	58
Electrical	84
Electronic	55
Library	76
MBA	72
Total Count	**2,971**
Total Wattage	**1,78,260**

9.2 OTHER LOAD

Particular	Exhaust (60W)	Exhaust (150W)	Geyser (2000 W)
Substation	6		
Sarojani Bhawan Girls Hostel			

Particular	Exhaust (60W)	Exhaust (150W)	Geyser (2000 W)
Hostel Room			
Mess		1	
Common Room			
Warden Office			
Bathroom			4
Sarswati Bhawan Girls Hostel			
Hostel Room			
Warden Office			
mess		1	
Common Room			
Guest Room			
Bathroom			8
Kalpana Girls Hostel			
Hostel Room			
Mess		1	
Common Room			
Bathroom			
Corridor			
Kasturva Girls Hostel			
Hostel Room (25 No's)			
Hostel Room (18 No's)			
Hotel Room (New)			
Mess		1	
Common Room			
Warden Office			
Guest Room			
yoga Room			
Bathroom			5
New Girls Hostel			
Hostel Room			
Warden Office			
Mess			
Common Room			
Bathroom			8

Particular	Exhaust (60W)	Exhaust (150W)	Geyser (2000 W)
Ramanujan Boys Hostel			
Hostel Room			
Warden Office			
Mess		5	
Common Room	4		
Bathroom			9
Guest Room			
Ambedkar Boys Hostel			
Hostel Room+ Warden Office			
Mess			
Common Room			
Bathroom			8
Guest Room			
Tilak Boys Hostel			
Hostel Room			
Warden Office			
Mess			
Common Room			
Bathroom			4
VS Boys Hostel			
Hostel Room			
Warden Office			
Mess			
Common Room			
Bathroom			8
Tagore Boys Hostel			
Hostel Room			
Warden Office			
Mess			
Common Room			
Bathroom			8
Subhas Boys Hostel			
Hostel Room (Single Sitted)			
Hostel Room (Triple Sitted)			
Hostel Room (Old)			

Particular	Exhaust (60W)	Exhaust (150W)	Geyser (2000 W)
Warden Office			
Mess	5		
Common Room			
Bathroom			16
Raman Boys Hostel			
Hostel Room (Old Single Sitted)			
Hostel Room (Old triple Sitted)			
Hostel Room (New Single Sitted)			
Hostel Room (New triple Sitted)			
Warden Office			
Mess		10	
Common Room			
Bathroom			16
Admin Building	7		
Civil			
Applied Science			
Computer Science	6		
ITRC	2	1	
Electrical	1		
Electronic	3		
Library	2		
MBA	3		
Total Count	**39**	**20**	**94**
Total Wattage	**2,340**	**3,000**	**1,88,000**

9.3 Recommendations

9.3.1 Replacement of Conventional Fans with BLDC Fans

Around 2,971 No's conventional ceiling fan are installed in the various locations of the building. These Fans must be replaced with energy-efficient BLDC Fans. The resultant savings are as follows:

Particulars	Present Situation	Post Implementation
Conventional Ceiling Fan may be replaced with Energy Efficient (EE) BLDC Ceiling Fan		
Power is drawn per Ceiling Fan (Watts)	60	28
No Fans to be replaced	2,971 Nos	

Particulars	Present Situation / Post Implementation
Net Reduction in the Power Drawn (A)	95,072 Watts
➲ **The total reduction in the power Drawn (A)**	= **95,072 Watts**
➲ Working Hours per annum	= 2,500 hrs. (250 days X 10 hrs.)
➲ Energy Savings per annum	= 2,37,680 kWh
➲ Electric Power Rate	= Rs 10.89 per kWh
➲ Monetary Benefit	= **Rs 25.88 Lacs**
➲ Estimated Investments BLDC Ceiling/Wall Fan 28 W @ Rs 3,000 per Fan	= **Rs 89.13 Lacs**
➲ Simple Payback Period	= **41-42 months**
➲ IRR	= **13.87%**

CHAPTER 10 STUDY OF WATER SUPPLY PUMPS

10.1 WATER SUPPLY TO BUILDING

At MMMUT, Gorakhpur, 3 No's of Submersible pumps are installed to lift the underground water to 2 No's of OHT Tank of 1,12,500 gallon & 2,25,000 Gallon. Out of 3 No's of pump, One Pump (Pump-2) supplied Water to 1,12,500 Gallon OHT and other 2 No's Pump (Pump-3 & Pump-4) supplied water to 2,25,000 Gallon OHT. From these OHT Tank, water is further supplied to PVC Tank of the buildings. The Capacity of Submersible Pump-2 is 15 HP, Pump-3 is 15 HP & Pump-4 is 20 HP. is 2 HP X 2 No's & 1.5 HP X 3 No's and overall average running hour of the Pumps is 10-12 hrs. per day. The details of a drinking water pump are as follows,

Particulars	Rated Power	Running Hr./Day
Submersible Pump-2	15 HP	10-12
Submersible Pump-3	15 HP	10-12
Submersible Pump-4	20 HP	10-12

10.2 SUBMERSIBLE PUMPS

At MMMUT, Gorakhpur, 3 No's of Submersible pumps are installed to lift the underground water to 2 No's of OHT Tank of 1,12,500 gallon & 2,25,000 Gallon. Out of 3 No's of pump, One Pump (Pump-2) supplied Water to 1,12,500 Gallon OHT and other 2 No's Pump (Pump-3 & Pump-4) supplied water to 2,25,000 Gallon OHT. From these OHT Tank, water is further supplied to PVC Tank of the buildings.

10.3 MEASUREMENTS MADE & ANALYSIS

At MMMUT, Gorakhpur, 3 No's of Submersible pumps are installed to lift the underground water to 2 No's of OHT Tank. From these OHT Tank, water is further supplied to PVC Tank of the buildings. During the audit, we have taken the Power and flow of pumps. We have taken the discharge pressure according to the tank height as there was no pressure gauge point installed in the pipeline of the Pump. The suction head is provided by MMMUT officials. The following table shows the efficiency of the pump

Particulars	Unit	Pump-2	Pump-3	Pump-4
Flow	(m3/hr.)	40.20	9.20	69.52
Suction Pressure	m	-20.00	-20.00	-20.00
Discharge Pressure	m	20.00	20.00	20.00
Head	(meter)	40.00	40.00	40.00
Density of Fluid	(Kg/m3)	1,000.00	1,000.00	1,000.00
Acceleration due to gravity	(m/s2)	9.81	9.81	9.81

Particulars	Unit	Pump-2	Pump-3	Pump-4
Hydraulic Power	(KW)	4.38	1.00	7.58
Actual Power Consumption	(KW)	12.02	10.53	20.22
Motor Efficiency	%	85.00	85.00	85.00
System Efficiency	%	36.46	9.52	37.48
Pump Efficiency	**%**	**42.90**	**11.20**	**44.10**

- The Pump is running at its rated parameters and seen that the efficiency of Pump-2 is **42.90%, which is satisfactory.**
- The pump is running at its rated parameters and seen that the efficiency of Pump-3 is **11.20%, which is on the lower side.**
- The pump is running at its rated parameters and seen that the efficiency of Pump-4 is **44.10%, which is satisfactory.**

10.4 Performance Evaluation of Pump

At MMMUT, Gorakhpur, 3 No's of Submersible pumps are installed to lift the underground water to 2 No's of OHT Tank. From these OHT Tank, water is further supplied to PVC Tank of the buildings. The pump is running at its rated parameters and seen that the efficiency of Pump-2, Pump-3 & Pump-4 is **42.90%, 11.20% & 44.10% respectively.** The efficiency of all pump is satisfactory except the efficiency of the Pump-3 is **11.20%, which is on the lower side.**

As the pump is not operating at duty point its efficiency has deteriorated further. Therefore, it is recommended to replace this pump with new energy-efficient pumps. The tentative savings are as follows

Particulars	UOM	Pump-3
Pump Efficiency	%	**11.20**
Average Power Consumption of Pump	KW	10.53
Operating days per annum	days	365
Operating hours per day	hrs.	12
Energy consumption	kWh	46,136
Proposed System		
Pump Efficiency	%	60
Power consumption	KW	1.97
Operating days per annum	days	365

Particulars	UOM	Pump-3
Operating hours per day	hrs	12
Energy consumption	kWh	8,612
A net reduction in power consumption	kWh	37,523
Electric Power Rate	Rs per kWh	10.89
Monetary Saving for One Pump	Rs Lacs	**4.09**
Investment Pump Cost	Rs Lacs	**1.5**
Payback Period	**Months**	**4.40**
IRR	**%**	**272.03%**

CHAPTER 11 STUDY OF DG SETS

11.1 RATED SPECIFICATIONS

One DG set of 250 kVA is installed for emergency power supply. The operation of the DG Sets is during power cuts & testing only. The details of DG Set is as follows

Identification	TR-1
Alternator	
Make	Kirloskar
KVA Rating	250 kVA
Voltage	415
Rated Current	347.6
RPM	1500
Engine	
Make	Kirloskar
Mfg	-

11.2 HISTORICAL DATA OF DG

The historical data of DG is not maintained by MMMUT Officials. But as per discussion, Officials informed us that around 600 liter of HSD is used for testing & Power Generation during emergency.

11.3 REMARKS

The operation of the DG set is limited to power cuts and testing only. The running hours of DG are very low i.e. 8-10 hr in a month, hence, no specific recommendation has been made on DG.

Note: It is suggested that proper log sheets (sample enclosed as Annexure-2) may be maintained for each DG Set. This would help to evaluate the performance of the DG Set periodically.

CHAPTER 12 OTHER POSSIBLE AREAS FOR ENERGY SAVINGS

12.1 Solar Water Heating System (SWHS)

The Institute management has not installed SWH on the rooftop of the building for Kitchen & bathing. There are hostels and guest houses in the building. These canteens normally require hot water, for the washing of utensils, the hot water is generated by using a Gas or Geyser. Because the SWH is not installed for the canteen and in the rooms of hostel and guest house. It is recommended to install a Solar Water Heating System for the bathroom and canteen, which would feed hot water at an average temperature of 70°C. This would reduce the dependence on one unit and also reduce the heat losses in the distribution lines.

The resultant Monetary benefit has been worked out as follows:

• Average Hot Water Temp from the SWHS	= 70 °C (Net temperature gain – 45°C)
• Total Capacity of SWHS	= 100 LPD X 17 Nos for Canteen = 1,500 LPD x 12 Nos for Hostel & Guest House
• Heat Gain by Hot Water (considering 860 kcal/KWh)	= 8,86,500 Kcal/day Equivalent Power Saving 1,030.81 KWh / day
• Electric Power Rate	= Rs 10.89 per kWh
• Annual Energy Savings (considering 150 sunny days per year)	= Rs 16.83 Lacs (1,54,621.5 KWh)
• Estimated Investments	= Rs 49.25 lacs
• **Simple Payback period**	= **35-36 months**
• **IRR**	= **21.02%**

12.2 Solar Photovoltaic Cell (SPV)

The building management has installed 512 kWp solar PV System on the rooftop of the building & 100 kWp Solar PV System on the ground. Solar Photovoltaic Cell for Power Generation for lighting load at the building, which would supply light to the lighting feeder. **Solar photovoltaic technologies** convert solar energy into useful energy forms by directly absorbing solar photons—particles of light that act as individual units of energy—and converting part of the energy to electricity.

The building management already installed a Solar PV System on the rooftop of Buildings as well as ground of the institute, so we have not recommended any recommendation on a Solar PV System. The details are as follows

Particulars	Installed Capacity (KWp)
Ground Mounted (Infront of Admin Building)	100
Academic Building & Hostel (Rooftop)	450
Classroom (Rooftop)	62
Total	**612**

12.2.1 Solar Unit Generation

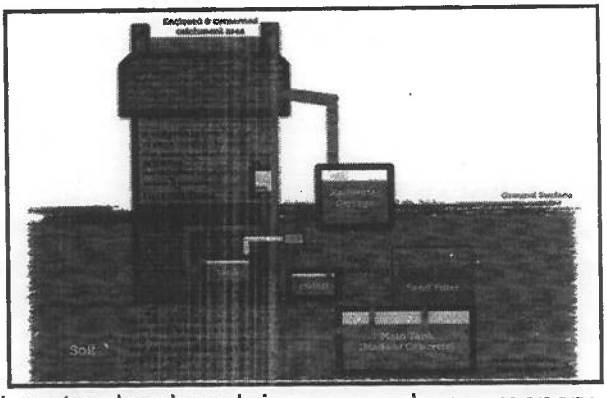
The annual Solar Unit Generation is about 5,54,278 kWh per annum for 450 kWp.

Month	Unit Generation (Kwh)	Unit Generation (Kwh/day)
Jan-23	26,906	1.93
Feb-23	42,753	3.39
Mar-23	51,803	3.71
Apr-23	59,285	4.39
May-23	63,095	4.52
Jun-23	60,808	4.50
Jul-23	49,648	3.56
Aug-23	41,356	2.96
Sep-23	47,011	3.48
Oct-23	46,863	3.36
Nov-23	31,025	2.30
Dec-23	33,725	2.42
Total	**5,54,278**	**3.38**

12.2.2 Key Observation

From the above-given data of 450 KWp SPVC the annual Solar Generation is about 5,54,278 KWh from 450 kWp Solar PV per annum. Hence, the average per day generation of the SPVC comes out to be about 3.38 KWp per day from Solar PV. As per the standard, the average solar generation is about 3.4-4.5 KWp per day. The unit generation from solar is satisfactory and as per standard value.

12.3 RAIN WATER HARVESTING



Rainwater harvesting is the accumulating and storing, of rainwater for reuse. It has been used to provide drinking water, water for irrigation, as well as other typical uses given to water. Rainwater collected from the roofs of the buildings can make an important contribution to rainwater harvesting. It can supplement the subsoil water level and improve urban greenery. Rainwater harvesting systems can be simple to construct from inexpensive local materials and are potentially successful in most habitable locations.

Roof rainwater can't be of good quality and may require treatment before consumption. Rainwater harvesting systems channel rainwater that falls onto a roof into storage via a system of gutters and pipes. The first flush of rainwater after a dry season should be allowed to run to waste as it will be contaminated with dust, bird droppings, etc. Roof gutters should have sufficient incline to avoid standing water. They must be strong enough, and large enough to carry peak flows. Storage tanks should be covered to prevent mosquito breeding and to reduce evaporation losses, contamination, and algal growth. Rainwater harvesting systems require regular maintenance and cleaning to keep the system hygienic.

There are several types of systems to harvest rainwater ranging from very simple to complex systems. The rate at which water can be collected from either' system is dependent on the plan area of the system, its efficiency, and the intensity of rainfall.

CHAPTER 13 BUILDING ENVELOPE

13.1 BUILDING ENVELOPE

The building envelope (or the more modern term, **building enclosure**) is all of the elements of the outer shell that maintain a dry, heated, or cooled indoor environment and facilitate its climate control. Building envelope design is a specialized area of architectural and engineering practice that draws from all areas of building science and indoor climate control.

The many functions of the building envelope can be separated into three categories:

- Support (to resist and transfer structural and dynamic loads)
- Control (the flow of matter and energy of all types)
- Finish (to meet desired aesthetics on the inside and outside)

The control function is at the core of good performance, and in practice focuses, in order of importance, on rain control, air control, heat control, and vapor control.

INDIA IS A TROPICAL COUNTRY

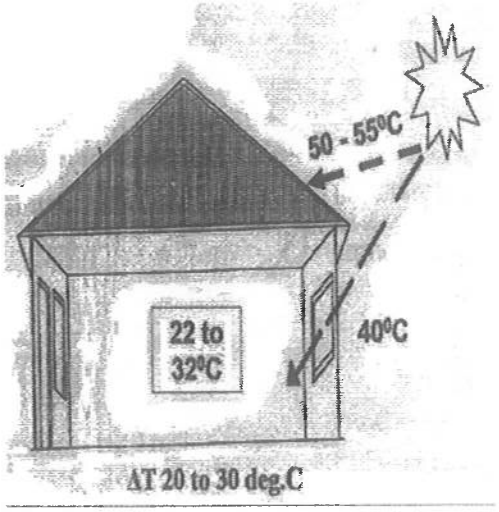
- ❖ High Ambient Mostly 35 To 45^0 C, even 50^0 C
- ❖ Low Winter Temps. 4 To 10^0 C, even minus Temps.
- ❖ High Humidity 60 To 98 percent, even 100 Percent

HIGH AMBIENT & HIGH HUMIDITY

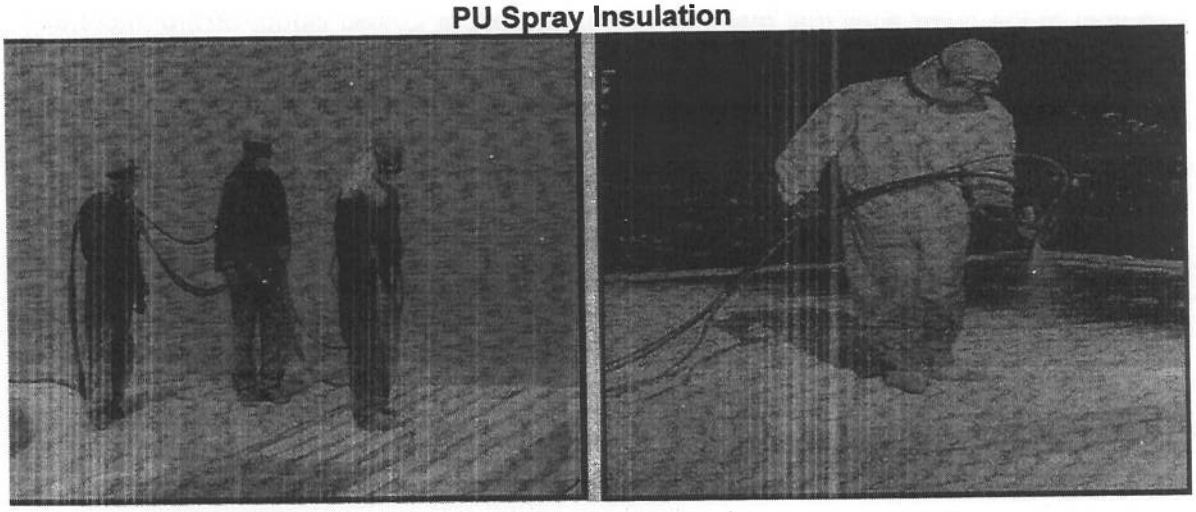
- ❖ Makes Life Miserable
- ❖ Un-Workable Office Atmosphere
- ❖ Continuous Flow of Heat from Environment to Inside of Building

THERMAL INSULATION

- ❖ Thermal Insulation Is the System, Provided to Retard the Flow of Heat or Cold from the Environment to the Inside of the Building and Vice-Versa.
- ❖ 'Cooling of Inside Air in Buildings'
- ❖ Thermal Insulation Is Supposed to Withstand High Ambient & Humid Conditions Predominant in Tropical Indian Environments.



PU Spray Insulation



13.2 HEAT INGRESS WITH AND WITHOUT INSULATION

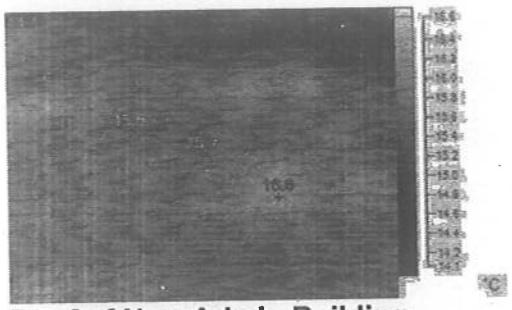
Up to 10-15% of Office building/ home's heat can be lost through an uninsulated roof. So, insulating the roof is one of the most effective ways to save energy.

Roof insulation is a barrier of material that's placed in roof space to make it harder for heat to travel in or out. This Insulation barrier slows down the transfer of heat between living space and the outside world, creating a warmer home in winter and a cooler one in summer.

Since the Cost of PU Spray is on the higher side and payback is very high as the investment is very high. Hence, economically not Viable. So, we have not recommended any savings in the building envelope. (Cost of PU Spray approx. 4,000 Rs/ ft^2)

During the audit we measured the surface temperature of the roof top and bottom, as per observation from the above thermogram, the average surface temperature of the roof is around 14.46 °C (Varies from 12.5°C to 17.2°C) and the average temperature of the ceiling below the roof is around 12.53 °C (Varies from 11.1°C to 15.9°C) and the temperature difference between roof and ceiling of the building is 1.93 °C which is satisfactory. The temperature measurement photographs are as follows,

13.3 Temperature Measurement of Roof Top and Bottom Surface



Roof of New Admin Building
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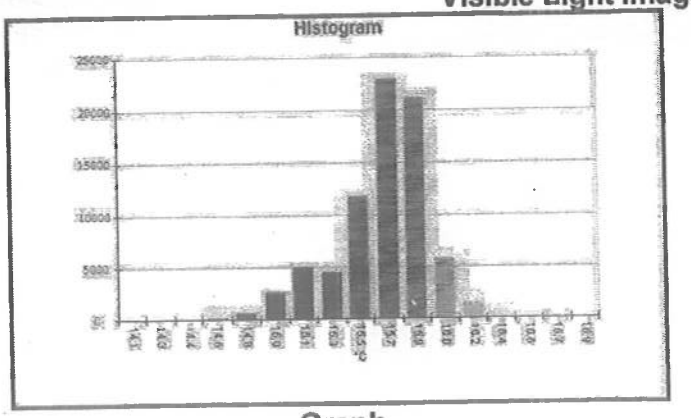
Visible Light Image



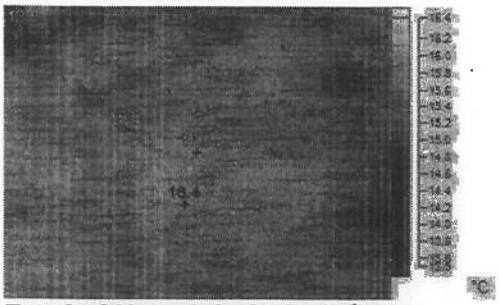
Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	15.6°C
Image Range	14.1°C to 16.6°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:22:06 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	15.7°C	0.95	21.7°C
Hot	16.6°C	0.95	21.7°C
Cold	14.1°C	0.95	21.7°C
P0	15.5°C	0.95	21.7°C



Roof of New Admin Building
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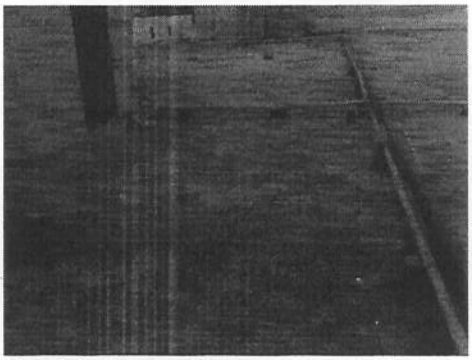
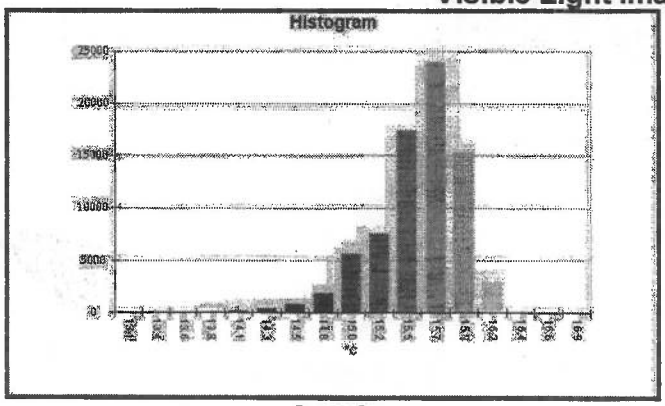


Visible Light Image



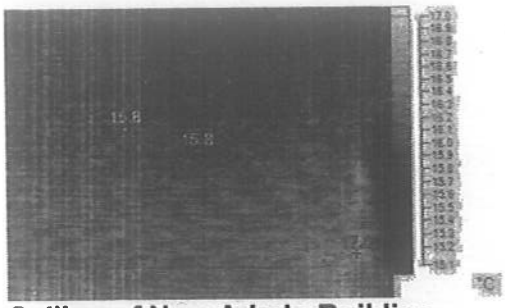
Graph

Image Info

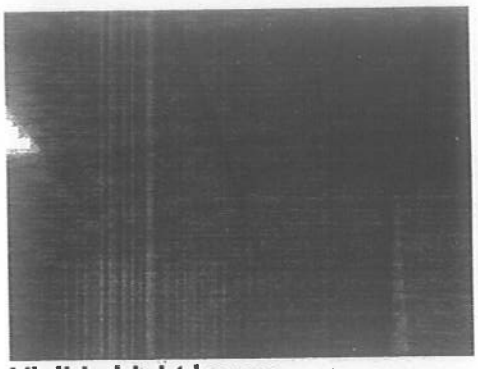
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	15.6°C
Image Range	13.5°C to 16.4°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:23:41 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

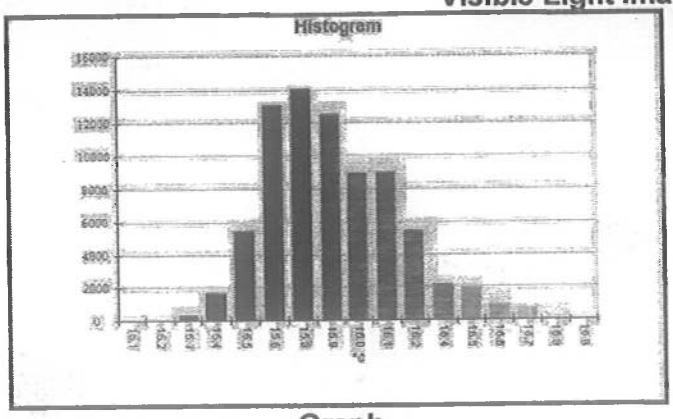
Name	Temperature	Emissivity	Background
Centerpoint	15.9°C	0.95	21.7°C
Hot	16.4°C	0.95	21.7°C
Cold	13.5°C	0.95	21.7°C
P0	15.5°C	0.95	21.7°C



Ceiling of New Admin Building
1/16/2024 12:24:48 PM



Visible Light Image



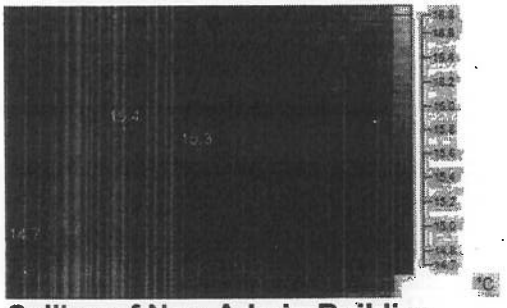
Graph

Image Info

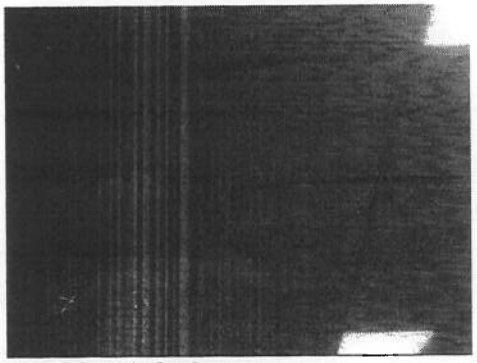
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	15.9°C
Image Range	15.1°C to 17.0°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:24:48 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

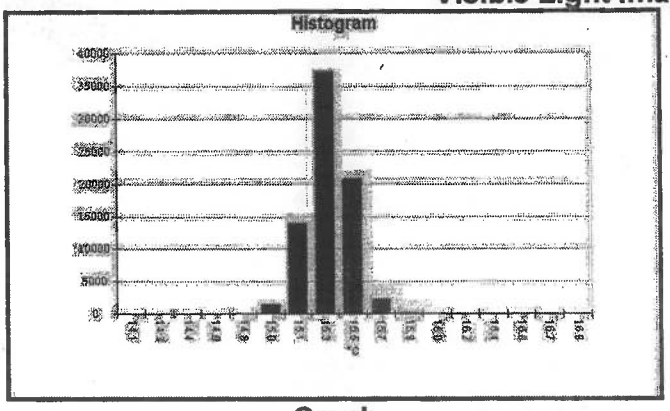
Name	Temperature	Emissivity	Background
Centerpoint	15.8°C	0.95	21.7°C
Hot	17.0°C	0.95	21.7°C
Cold	15.1°C	0.95	21.7°C
P0	15.8°C	0.95	21.7°C



Ceiling of New Admin Building
1/16/2024 12:24:57 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	15.3°C
Image Range	14.7°C to 16.7°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:24:57 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

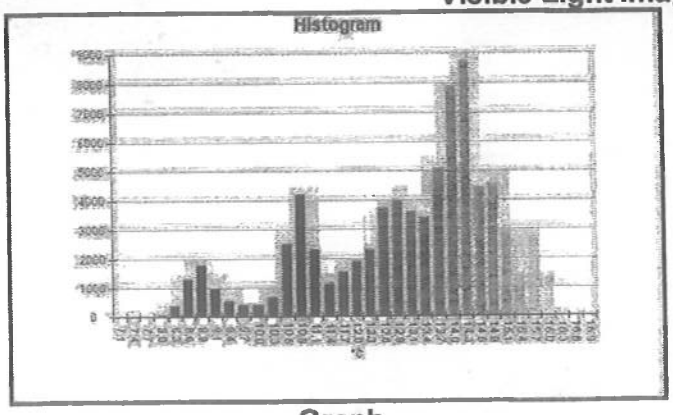
Name	Temperature	Emissivity	Background
Centerpoint	15.3°C	0.95	21.7°C
Hot	16.7°C	0.95	21.7°C
Cold	14.7°C	0.95	21.7°C
P0	15.4°C	0.95	21.7°C



Roof of Old Admin Building
1/16/2024 12:32:00 PM



Visible Light Image



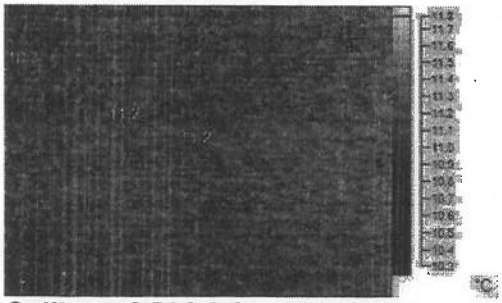
Graph

Image Info

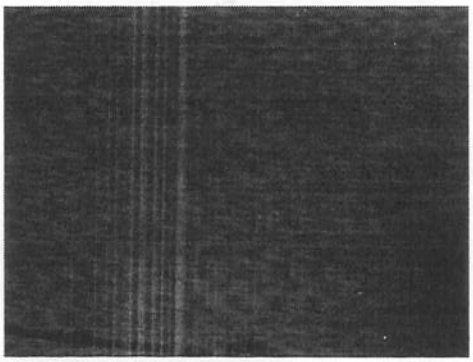
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	13.1°C
Image Range	7.9°C to 16.2°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:32:00 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

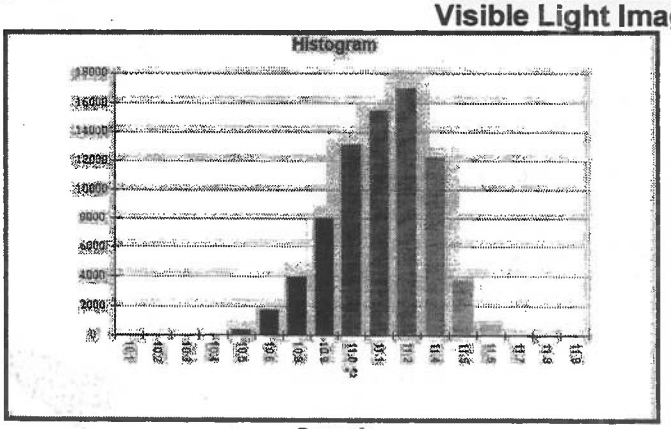
Name	Temperature	Emissivity	Background
Centerpoint	14.4°C	0.95	21.7°C
Hot	16.2°C	0.95	21.7°C
Cold	7.9°C	0.95	21.7°C
P0	13.3°C	0.95	21.7°C



Ceiling of Old Admin Building
1/16/2024 12:32:50 PM



Visible Light Image



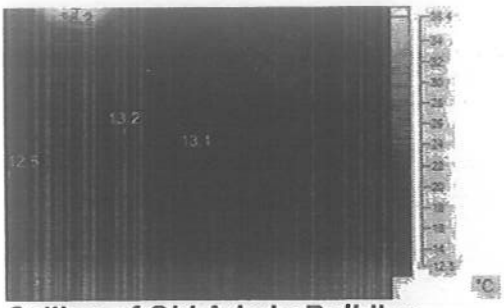
Graph

Image Info

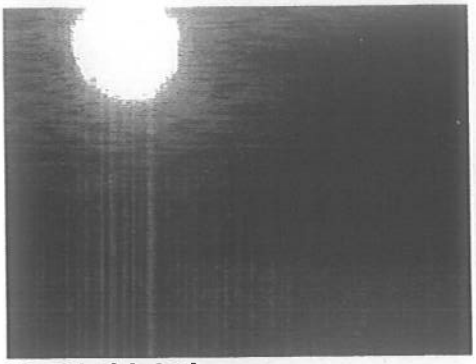
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	11.1°C
Image Range	10.3°C to 11.7°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:32:50 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

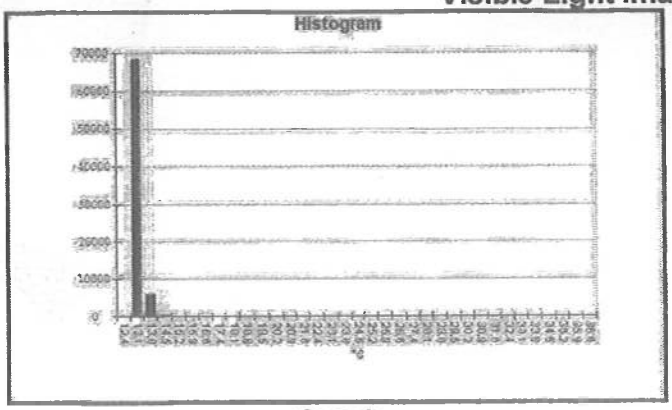
Name	Temperature	Emissivity	Background
Centerpoint	11.2°C	0.95	21.7°C
Hot	11.7°C	0.95	21.7°C
Cold	10.3°C	0.95	21.7°C
P0	11.2°C	0.95	21.7°C



Ceiling of Old Admin Building
1/16/2024 12:33:00 PM



Visible Light Image



Graph

Image Info

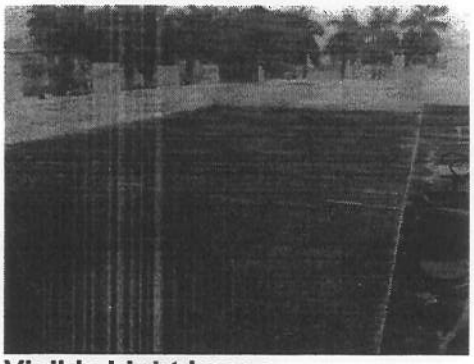
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	13.4°C
Image Range	12.5°C to 36.2°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:33:00 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

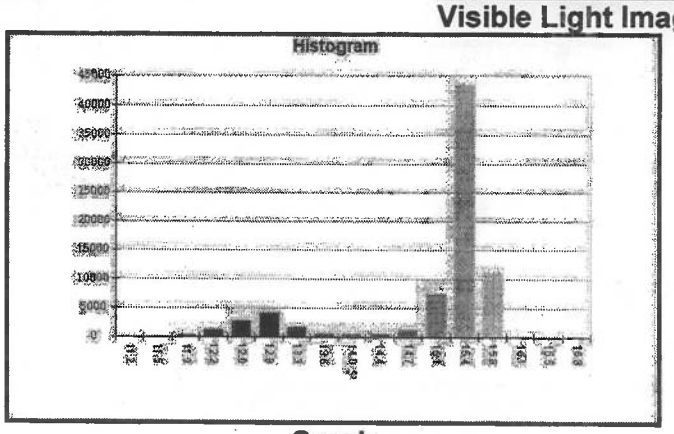
Name	Temperature	Emissivity	Background
Centerpoint	13.1°C	0.95	21.7°C
Hot	36.2°C	0.95	21.7°C
Cold	12.5°C	0.95	21.7°C
P0	13.2°C	0.95	21.7°C



Roof of Civil 1st Building
1/16/2024 12:35:15 PM



Visible Light Image



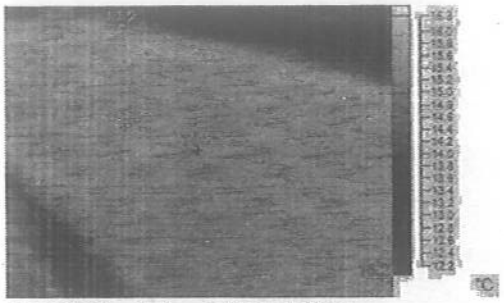
Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	15.0°C
Image Range	11.5°C to 16.2°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:35:15 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

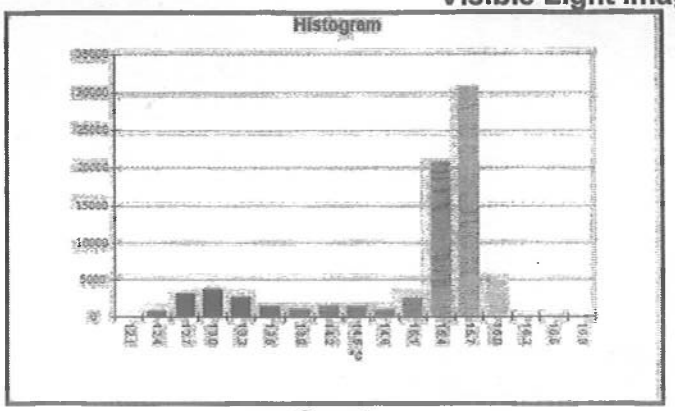
Name	Temperature	Emissivity	Background
Centerpoint	15.3°C	0.95	21.7°C
Hot	16.2°C	0.95	21.7°C
Cold	11.5°C	0.95	21.7°C
P0	15.7°C	0.95	21.7°C



Roof of Civil 1st Building
1/16/2024 12:35:24 PM



Visible Light Image



Graph

Image Info

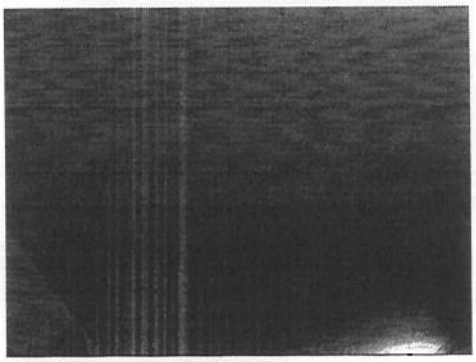
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	15.1°C
Image Range	12.2°C to 16.2°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:35:24 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

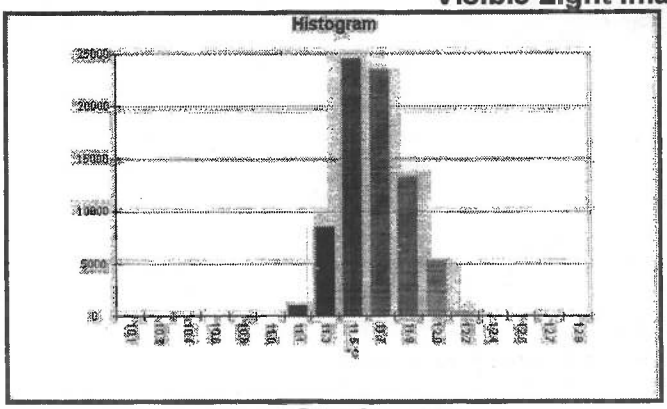
Name	Temperature	Emissivity	Background
Centerpoint	15.8°C	0.95	21.7°C
Hot	16.2°C	0.95	21.7°C
Cold	12.2°C	0.95	21.7°C
P0	15.6°C	0.95	21.7°C



Ceiling of Civil 1st Building
1/16/2024 12:36:05 PM



Visible Light Image



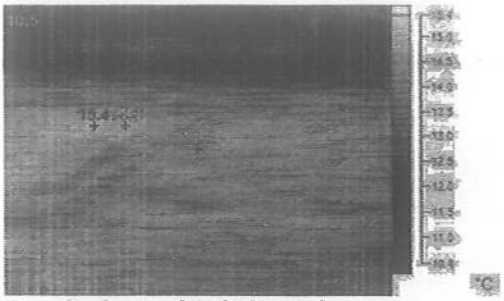
Graph

Image Info

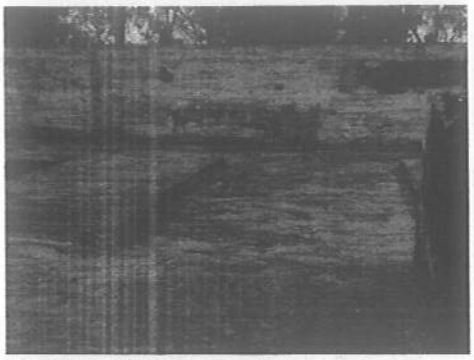
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	11.6°C
Image Range	10.7°C to 12.5°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:36:05 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

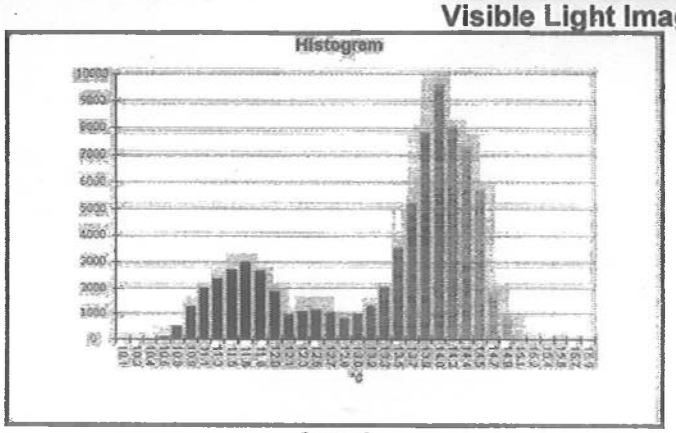
Name	Temperature	Emissivity	Background
Centerpoint	11.5°C	0.95	21.7°C
Hot	12.5°C	0.95	21.7°C
Cold	10.7°C	0.95	21.7°C
P0	11.6°C	0.95	21.7°C



Roof of sarojani Hostel
1/16/2024 12:58:23 PM



Visible Light Image



Graph

Image Info

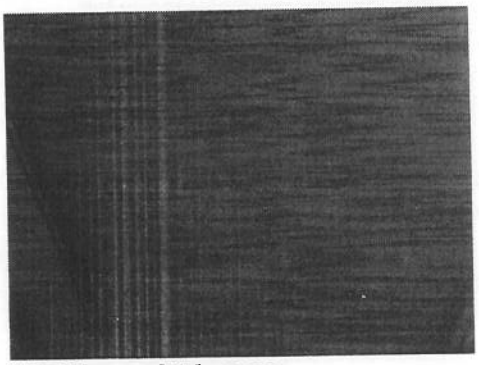
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	13.4°C
Image Range	10.5°C to 15.4°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:58:23 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

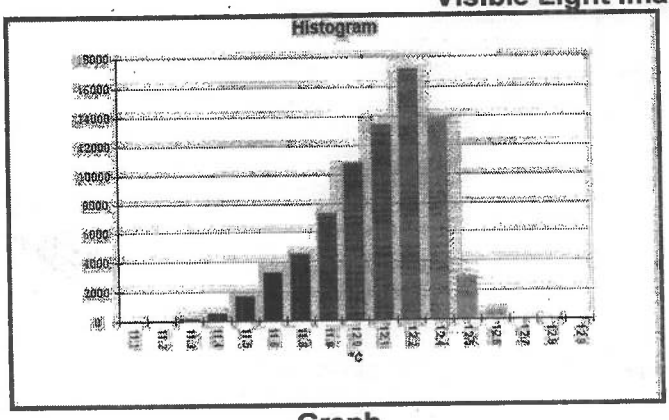
Name	Temperature	Emissivity	Background
Centerpoint	14.6°C	0.95	21.7°C
Hot	15.4°C	0.95	21.7°C
Cold	10.5°C	0.95	21.7°C
P0	14.6°C	0.95	21.7°C



Ceiling of sarojani Hostel
1/16/2024 12:59:25 PM



Visible Light Image



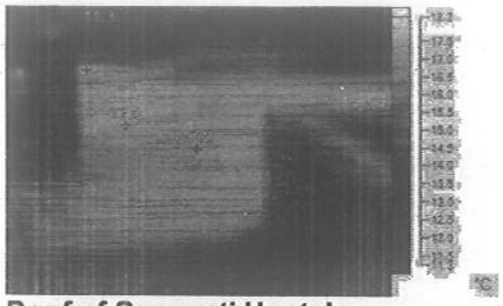
Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	12.1°C
Image Range	11.1°C to 12.8°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:59:25 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

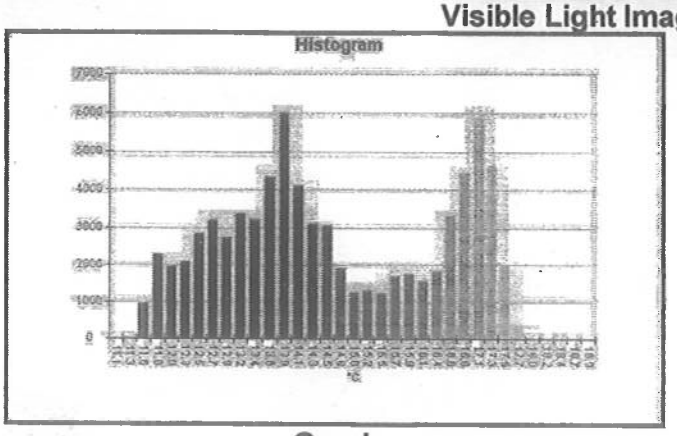
Name	Temperature	Emissivity	Background
Centerpoint	12.2°C	0.95	21.7°C
Hot	12.8°C	0.95	21.7°C
Cold	11.1°C	0.95	21.7°C
P0	12.1°C	0.95	21.7°C



Roof of Sarswati Hostel
1/16/2024 1:14:40 PM



Visible Light Image



Graph

Image Info

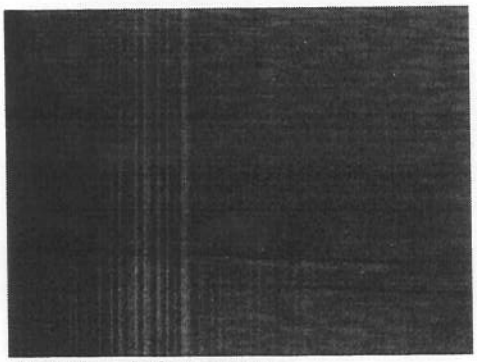
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	14.7°C
Image Range	11.3°C to 18.1°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 1:14:40 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

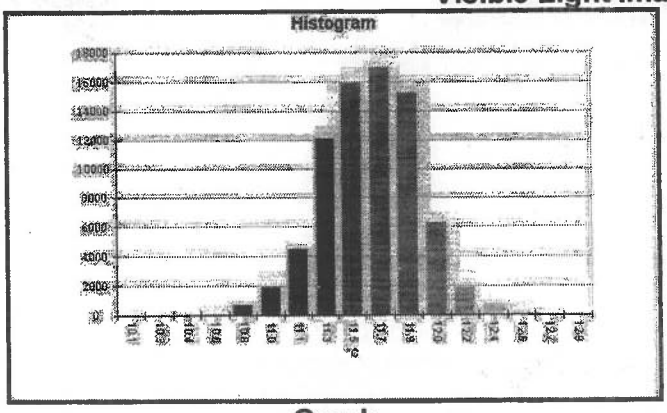
Name	Temperature	Emissivity	Background
Centerpoint	17.2°C	0.95	21.7°C
Hot	18.1°C	0.95	21.7°C
Cold	11.3°C	0.95	21.7°C
P0	17.0°C	0.95	21.7°C



Ceiling of Sarswati Hostel
1/16/2024 1:15:37 PM



Visible Light Image



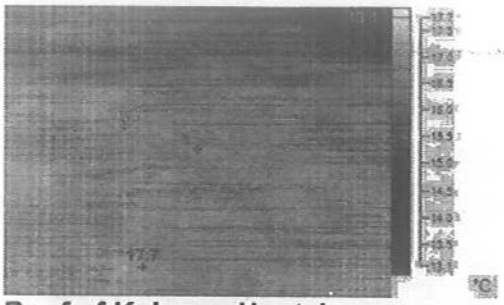
Graph

Image Info

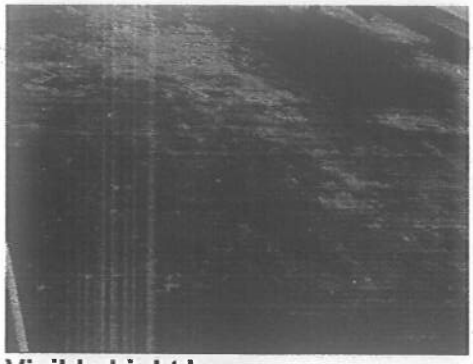
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	11.6°C
Image Range	10.5°C to 12.7°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 1:15:37 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

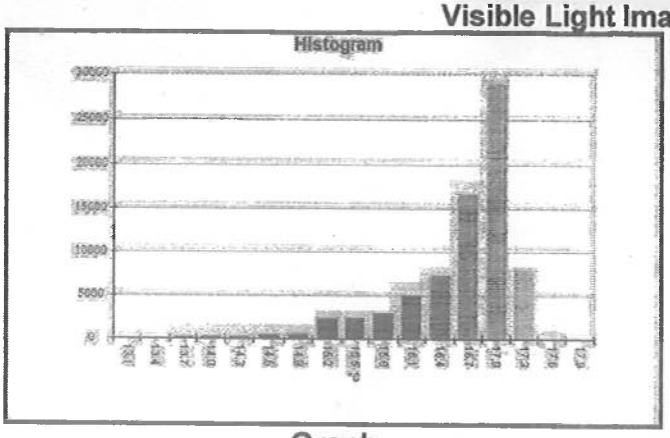
Name	Temperature	Emissivity	Background
Centerpoint	11.7°C	0.95	21.7°C
Hot	12.7°C	0.95	21.7°C
Cold	10.5°C	0.95	21.7°C
P0	11.5°C	0.95	21.7°C



Roof of Kalpana Hostel
1/16/2024 1:26:09 PM



Visible Light Image



Graph

Image Info

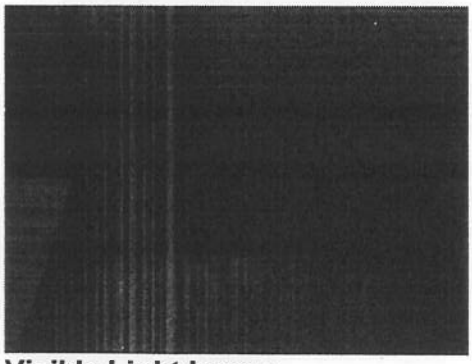
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	16.6°C
Image Range	13.1°C to 17.7°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 1:26:09 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

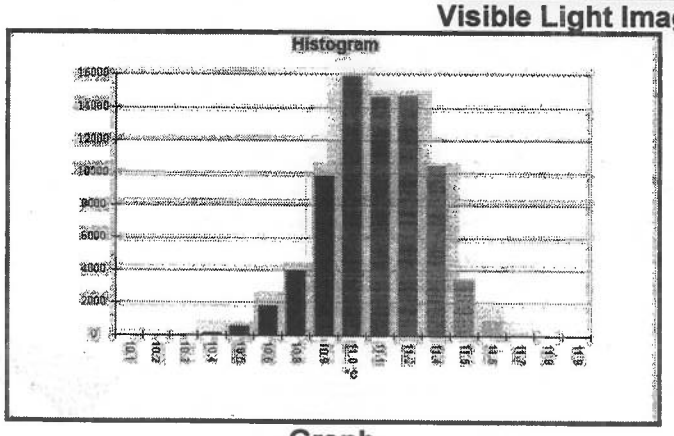
ss	Temperature	Emissivity	Background
Centerpoint	17.0°C	0.95	21.7°C
Hot	17.7°C	0.95	21.7°C
Cold	13.1°C	0.95	21.7°C
P0	16.7°C	0.95	21.7°C



Ceiling of Kalpana Hostel
1/16/2024 1:26:41 PM



Visible Light Image



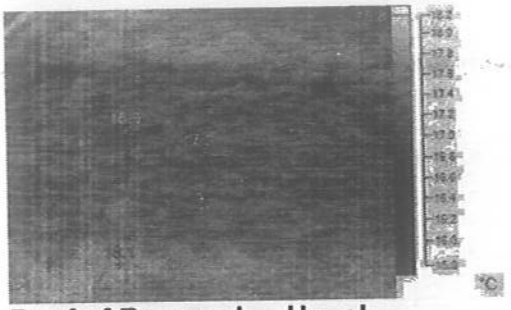
Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	11.1°C
Image Range	10.2°C to 11.8°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 1:26:41 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

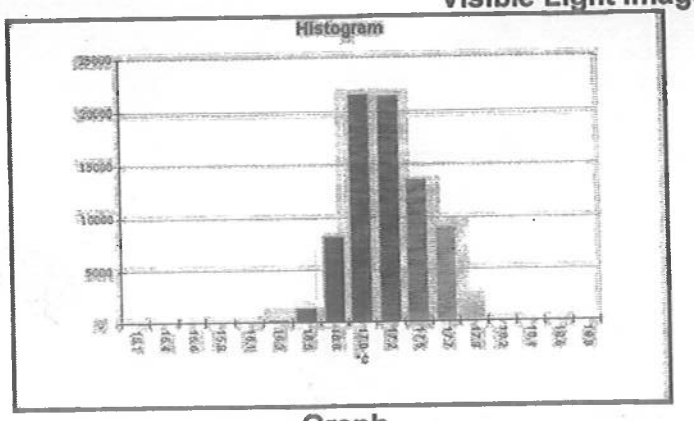
Name	Temperature	Emissivity	Background
Centerpoint	10.8°C	0.95	21.7°C
Hot	11.8°C	0.95	21.7°C
Cold	10.2°C	0.95	21.7°C
P0	11.2°C	0.95	21.7°C



Roof of Ramanujan Hosel
1/16/2024 3:55:16 PM



Visible Light Image



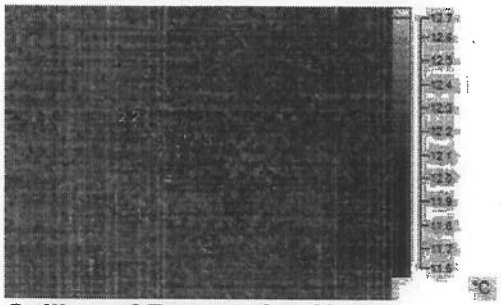
Graph

Image Info

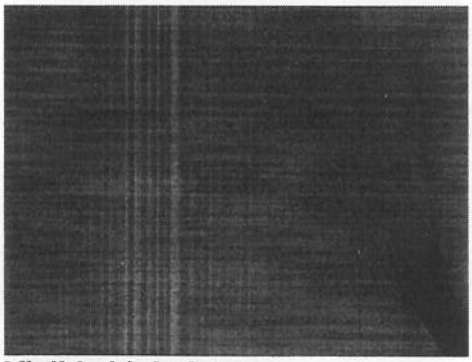
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	17.2°C
Image Range	15.8°C to 18.1°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 3:55:16 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	17.3°C	0.95	21.7°C
Hot	18.1°C	0.95	21.7°C
Cold	15.8°C	0.95	21.7°C
P0	16.9°C	0.95	21.7°C



Ceiling of Ramanujan Hostel
1/16/2024 3:56:50 PM



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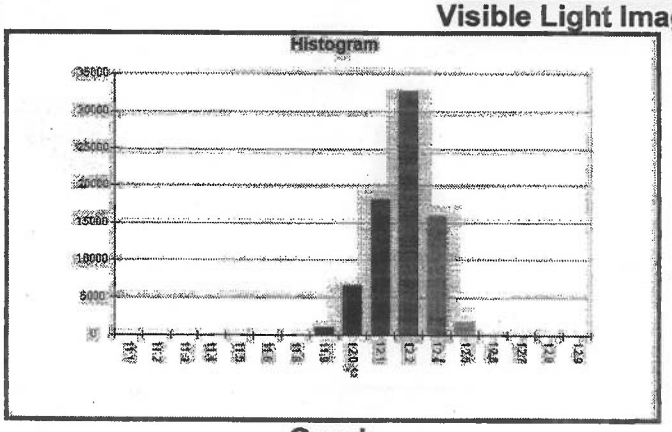


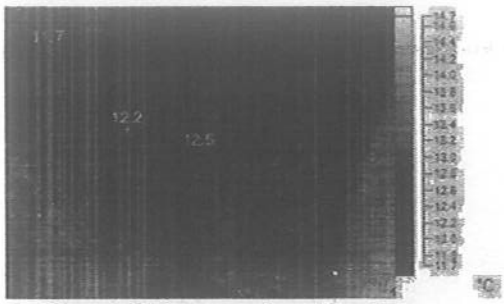
Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	12.2°C
Image Range	11.6°C to 12.7°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 3:56:50 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	12.3°C	0.95	21.7°C
Hot	12.7°C	0.95	21.7°C
Cold	11.6°C	0.95	21.7°C
P0	12.2°C	0.95	21.7°C



Ceiling of Ramanujan Hostel
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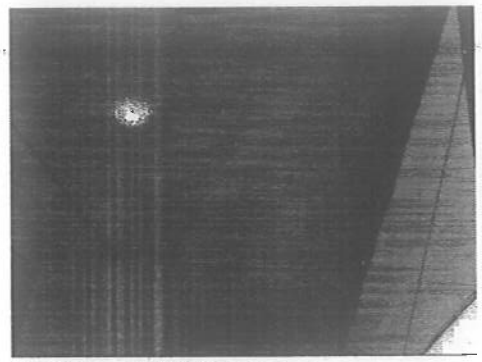
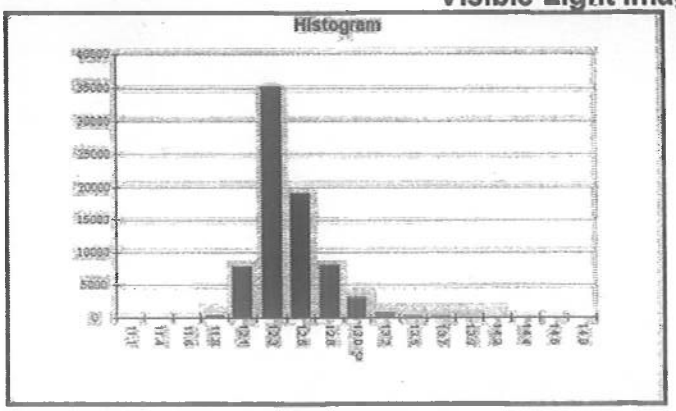


Visible Light Image



Graph

Image Info

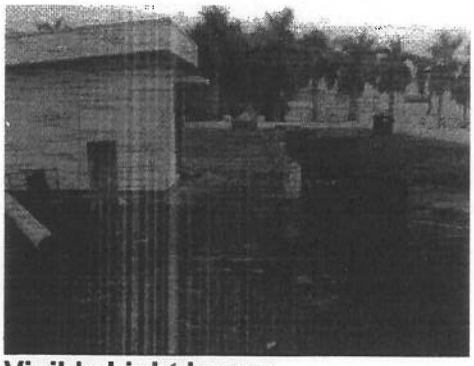
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	12.5°C
Image Range	11.7°C to 14.7°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 3:56:57 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

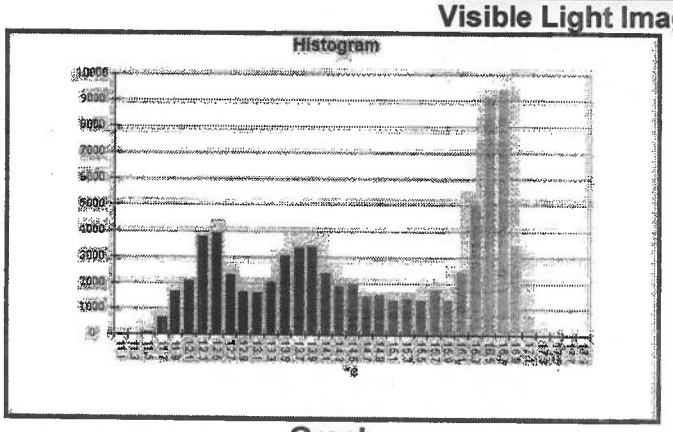
Name	Temperature	Emissivity	Background
Centerpoint	12.5°C	0.95	21.7°C
Hot	14.7°C	0.95	21.7°C
Cold	11.7°C	0.95	21.7°C
P0	12.2°C	0.95	21.7°C



Roof of Civil 2nd Building
1/16/2024 12:38:54 PM



Visible Light Image



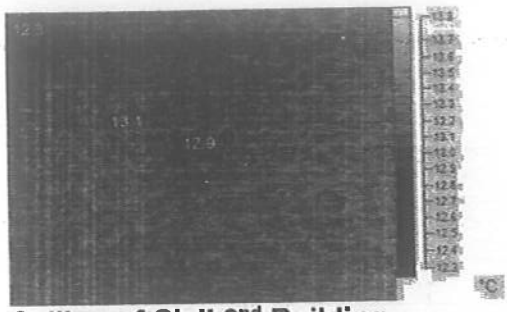
Graph

Image Info

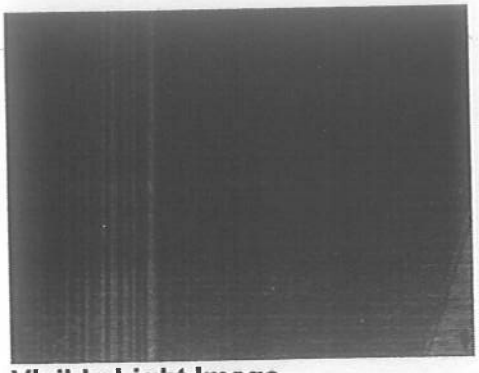
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	14.8°C
Image Range	11.3°C to 17.5°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:38:54 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

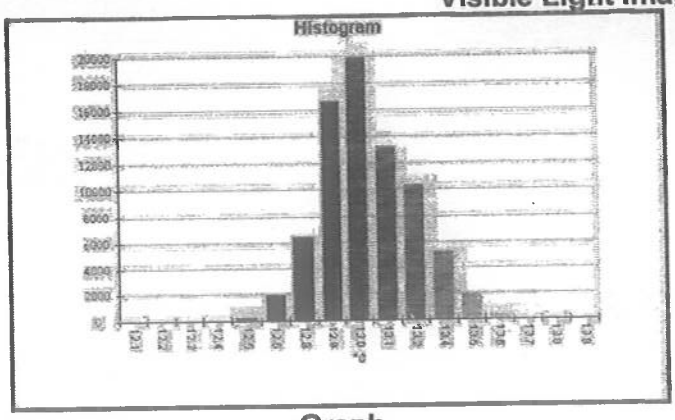
Name	Temperature	Emissivity	Background
Centerpoint	16.7°C	0.95	21.7°C
Hot	17.5°C	0.95	21.7°C
Cold	11.3°C	0.95	21.7°C
P0	14.2°C	0.95	21.7°C



Ceiling of Civil 2nd Building
1/16/2024 12:40:14 PM



Visible Light Image



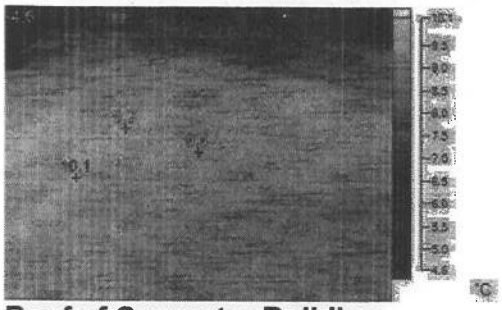
Graph

Image Info

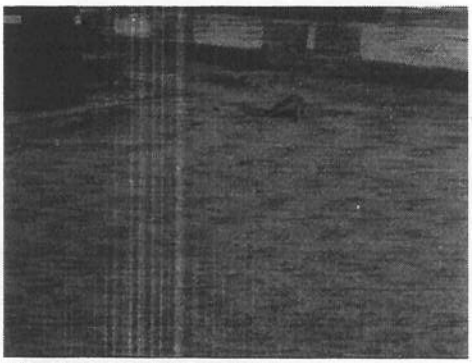
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	13.0°C
Image Range	12.3°C to 13.8°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:40:14 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

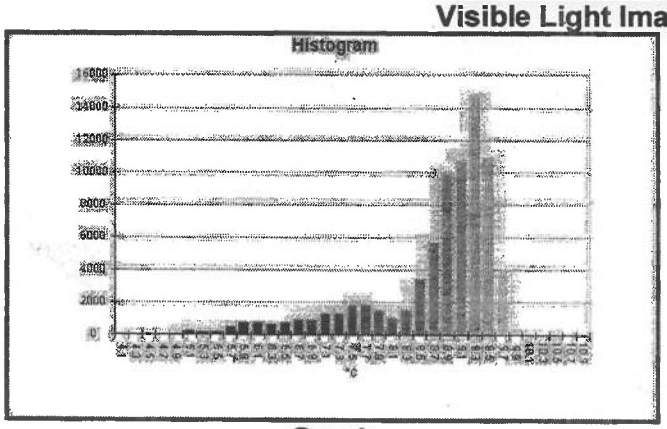
Name	Temperature	Emissivity	Background
Centerpoint	12.9°C	0.95	21.7°C
Hot	13.8°C	0.95	21.7°C
Cold	12.3°C	0.95	21.7°C
P0	13.1°C	0.95	21.7°C



Roof of Computer Building
1/16/2024 12:44:49 PM



Visible Light Image



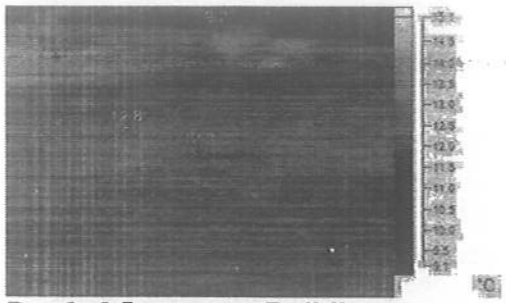
Graph

Image Info

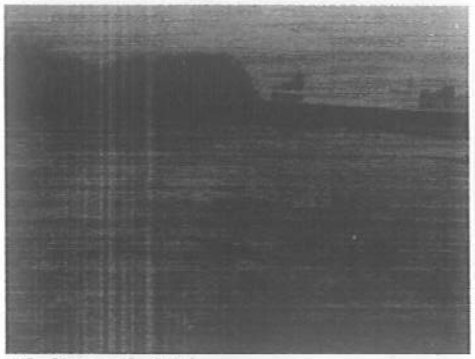
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	8.7°C
Image Range	4.6°C to 10.1°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:44:49 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

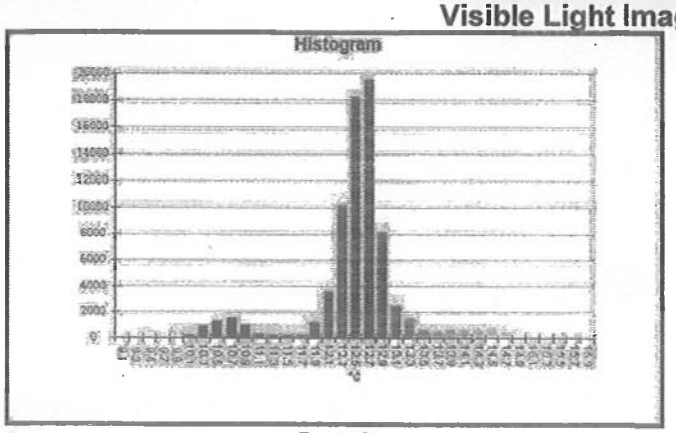
Name	Temperature	Emissivity	Background
Centerpoint	9.4°C	0.95	21.7°C
Hot	10.1°C	0.95	21.7°C
Cold	4.6°C	0.95	21.7°C
P0	9.7°C	0.95	21.7°C



Roof of Computer Building
1/16/2024 12:45:03 PM



Visible Light Image



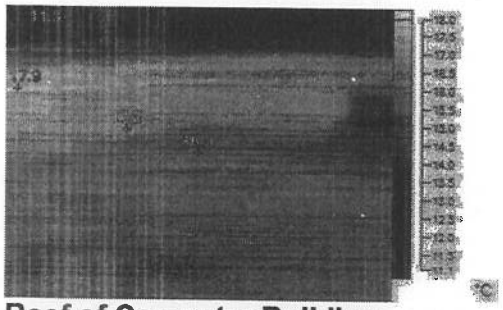
Graph

Image Info

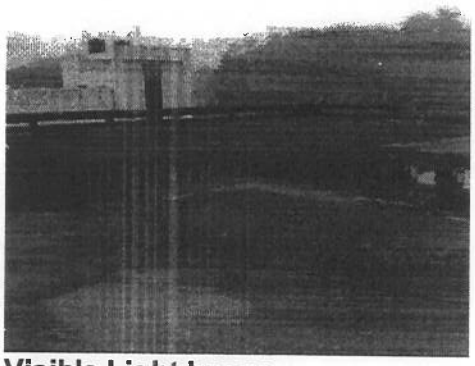
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	12.5°C
Image Range	9.2°C to 15.0°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:45:03 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

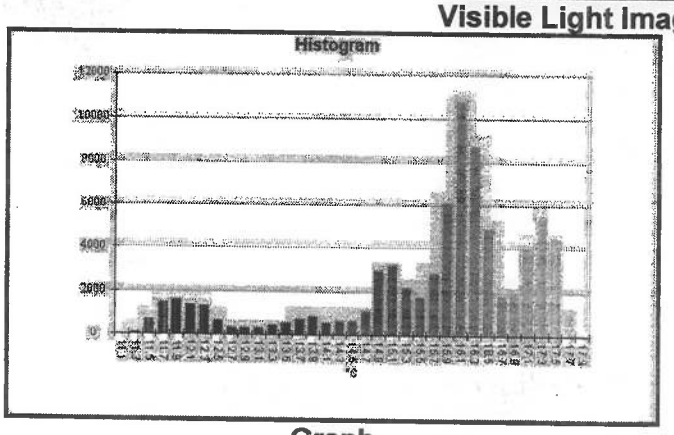
Name	Temperature	Emissivity	Background
Centerpoint	12.3°C	0.95	21.7°C
Hot	15.0°C	0.95	21.7°C
Cold	9.2°C	0.95	21.7°C
P0	12.8°C	0.95	21.7°C



Roof of Computer Building
1/16/2024 12:47:14 PM



Visible Light Image



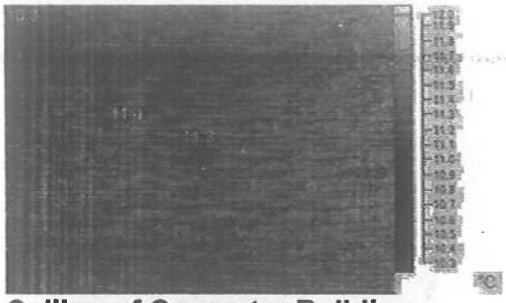
Graph

Image Info

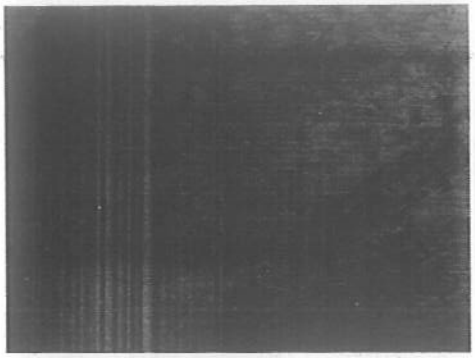
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	15.7°C
Image Range	11.2°C to 17.9°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:47:14 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

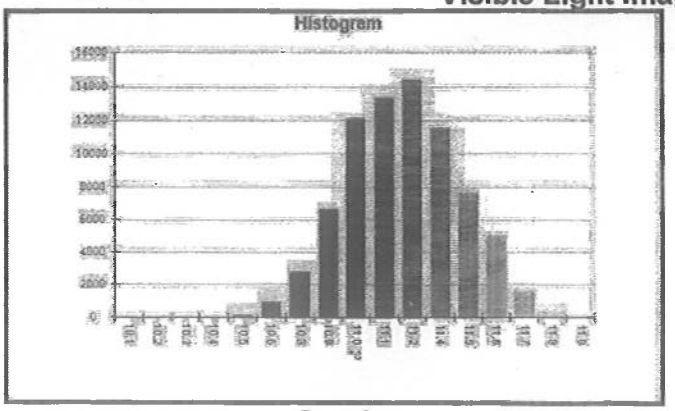
Name	Temperature	Emissivity	Background
Centerpoint	16.3°C	0.95	21.7°C
Hot	17.9°C	0.95	21.7°C
Cold	11.2°C	0.95	21.7°C
P0	17.2°C	0.95	21.7°C



Ceiling of Computer Building
1/16/2024 12:48:15 PM



Visible Light Image



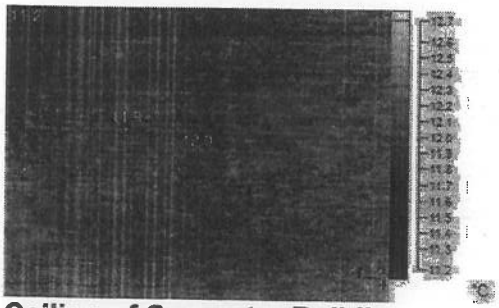
Graph

Image Info

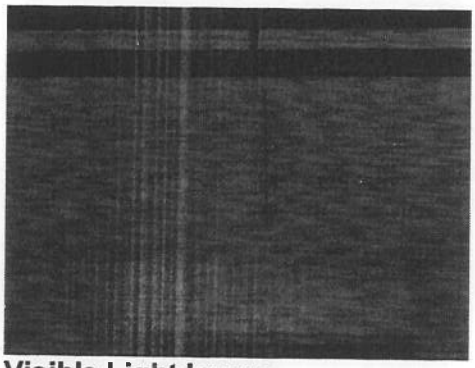
Background temperature	21.7°C
Emissivity	0.95
Average Temperature	11.2°C
Image Range	10.3°C to 11.9°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:48:15 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

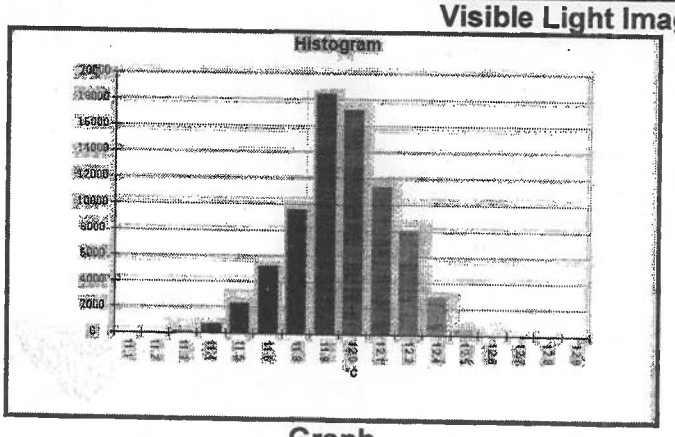
Name	Temperature	Emissivity	Background
Centerpoint	11.3°C	0.95	21.7°C
Hot	11.9°C	0.95	21.7°C
Cold	10.3°C	0.95	21.7°C
P0	11.0°C	0.95	21.7°C



Ceiling of Computer Building
1/16/2024 12:48:29 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	12.0°C
Image Range	11.2°C to 12.7°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:48:29 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	12.0°C	0.95	21.7°C
Hot	12.7°C	0.95	21.7°C
Cold	11.2°C	0.95	21.7°C
P0	11.9°C	0.95	21.7°C

13.4 VENTILATION SYSTEM

During the audit, a ventilation system was observed for the building. It was observed around 10-15% ventilation area is available with windows in almost every room. In the washroom, exhaust fans are installed and are properly operational and ventilated.

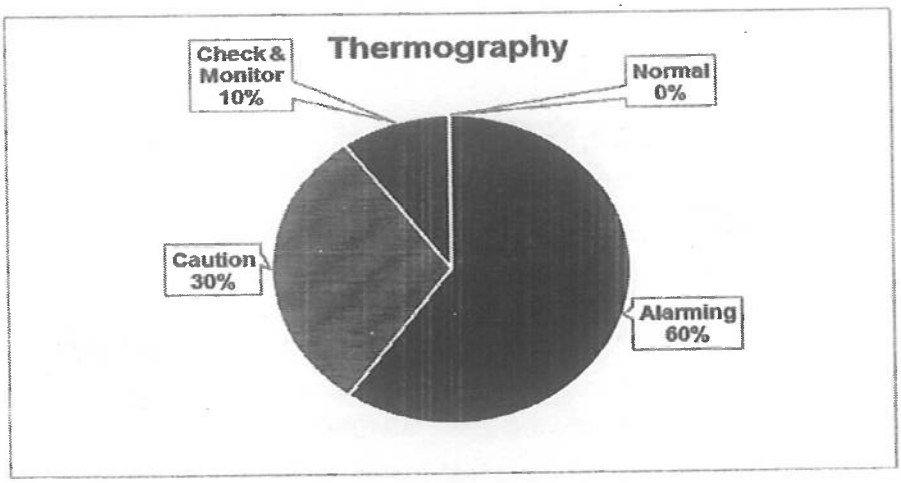
CHAPTER 14 THERMOGRAPHY

14.1 THE PROJECT

Thermography uses specially designed infrared video or still cameras to make images (called thermograms) that show surface heat variations. This technology has a number of applications. Thermograms of electrical systems can detect abnormally hot electrical connections or components.

The salient findings, which require immediate attention of the management, are presented in this section. The HOTSPOTS detected were highlighted in discussion with technical staff after the Thermal Imaging Survey.

Particulars	Nos
Total Areas/Feeders Scanned	10
Total Thermal Images Captured	10
Risk Level	Number
Alarming	6
Caution	3
Check & Monitor	1
Normal	0



NOTE:

As per NFPA 70 (B) & NETA Standards, the Risk Category is defined as below:

Alarming	Delta T temperature is more than 15°C.
Caution	Delta T temperature is between 4°C to 15°C
Check and Monitor	Delta T temperature is between 1°C and 4°C
Normal	Normal temperature

Delta T (differential temperature between the maximum & minimum/temperature near the object) temperatures & corrective actions defined are based on National Fire Protection Association (NFPA) 70B, section 21.17.5.6 of NFPA 70B, 2010 & International Electrical Testing Association (NETA) Standard.

NETA Maintenance Testing Specifications, for electrical equipment

Priority	Delta T between similar components under similar load	Delta T over ambient air temperature	Recommended Action
4	<1°C	1C° to 10C°	Possible deficiency; warrants
3	1 to 3C°	11C° to 20C°	Indicates probable deficiency; repair as time permits
2	4 to 15C°	21C° to 40C°	
1	>15C°	>40C°	

Infrared Thermal Imaging-Principle:

All objects that have a temperature above absolute zero (0 Degree Kelvin) emit infrared radiation, which can be measured on the infrared spectral band of the electromagnetic spectrum. The technique of measuring & viewing this energy is called infrared thermography or thermal imaging. Most thermal imaging systems respond to wavelengths of 3 - 5 micrometers or 8 –12 micrometers.

Why Thermal Imaging?

Thermography is nothing but *'capturing heat images on film'*. Swedish power board began inspecting a large number of electrical components (1.5 lakhs plus) way back in 1965 &UK power generation board began effectively utilizing Thermography for predictive maintenance of transmission lines.

The application of both Thermal imaging & Ultra sonic detection techniques is based on a fundamental principle, *'Electrical Failures are preceded by rise in temperature & sound'*. If you understand this basic principle, carry out effective techniques to detect these failure 'pre-cursors' and take timely corrective action, electrical equipment failures can be avoided. Although T-imaging applications are numerous (quality checks, tank level monitoring, detection of steam leaks, integrity of furnace refractory lining, etc.), we will discuss electrical applications in this application note.

The electrical maintenance practices evolved over a period of time. Breakdown to preventive to predictive to risk /reliability-based maintenance practices. Logically, high reliability plant & equipment requires to be maintained accordingly. In countries like USA, UK, France, Netherlands, etc., infrared Inspections are now recognized and recommended as a best practice for the inspection of electrical installations. In order to assess the equipment condition by predicting failures, without losing production, applications such as thermal imaging are gaining importance.

14.2 THERMAL IMAGES- RISK CATEGORIZATION PROCEDURE

14.3 WHY CATEGORIZER IMAGES?

Although it is ideal that corrective action is taken on all thermal images that indicate a potential problem, categorizing helps the plant to take corrective action depending on the severity of the problem since all corrections may not require immediate action.

The risk levels are determined by the Thermographer based on the following factors and aspects:

- Relative temperature difference (Delta T).
- Industrial experience gained over the years to assess equipment conditions
- Thermal imaging & analytical expertise
- Equipment age
- Environmental conditions (ambient temperature, dust, humidity, wind)
- Load level
- Criticality (from a safety, and reliability point of view)
- Past equipment reliability data
- Expertise gained as a Certified Reliability Professional (CRP)

14.4 RISK LEVELS:

14.5 ALARMING LEVEL:

- Delta temperature (differential temperature between the maximum & minimum/temperature near the object) more than 15 degrees centigrade
- Failure could result in a major fire/explosion/over-pressure situation /major abnormality
- Any of the hazardous situations mentioned in Note 1

14.6 CAUTION:

- Delta temperature (differential temperature between the maximum & minimum temperature) between 4 to 15 degrees centigrade.

- The impact may be confined to the equipment.
- Failure may not have a large impact on safety/environment/production but repair costs may not be insignificant.

14.7 CHECK & MONITOR:

- Delta temperature (differential temperature between the maximum & minimum temperature) is between 1 and 4 degrees centigrade.
- Mostly of a minor/regular disruption that will not affect safety/production/environment.

14.8 NORMAL LEVEL:

- Normal temperatures

Risk Level	Interpretation	Corrective Action Priority levels
	Major deficiency	Immediate repair
CAUTION	Deficiency	In the next available opportunity
	Possible deficiency	Warrants investigation
	No deficiency	No action warranted

Notes:

1) Critical equipment is that equipment the failure of which can result in a hazardous condition such as over pressure explosions / toxic releases / explosions / fires / production disruption / environmental pollution / DCS PLC disruptions / battery banks supplying power to protection relays or DCS / Process upsets / Run Away Reactions / Reactors / Boilers / Turbines / Transformers.

2) Delta T temperatures & corrective actions defined above are based on National Fire Protection Association (NFPA) 70B, section 21.17.5.6 of NFPA 70B, 2010 International Electrical Testing Association (NETA) standards

3) **The thermal Image is attached as per Annexure-A**

14.9 THERMAL IMAGES SURVEY REPORT

The salient findings, which require immediate attention of the management, are presented in this section. The HOTSPOTS detected were highlighted in discussion with technical staff after the Thermal Imaging Survey.

Risk Level	Annexure
Alarming	Annexure-A
Caution	
Check & Monitor	
Normal	

14.10 THERMOGRAPHY REPORT OF HOT SPOT POINTS:

S.No	Thermogram Location	Risk Category	Page No.
1	New Admin Building Panel	check & Monitor	
2	Boys Hostel Panel	Caution	
3	Pump House-4 Panel	Alarming	
4	Pump House-4 Cable Joint	Alarming	
5	Pump House-4 Panel	Alarming	
6	Pump House-4 Panel	Alarming	
7	SS Panel	Alarming	
8	Panel near Computer Dept	Caution	
9	Panel Near Civil Dept	Caution	
10	Panel Near Civil Dept	Alarming	

The thermal Image is attached as per Annexure-A

CHAPTER 15 PROJECT FINANCIALS

15.1 COST OF PROJECT AND SAVINGS

Total ECM in Numbers	Total Cost of Projects in Rs Lakhs	Total Savings/Annum in Rs Lakhs	Payback Period (Month)
5	142.38	51.55	33-34

15.2 CASH FLOW STATEMENT

S. No.	Particular	Cash Flow	1st Year	2nd Year	3rd year	4th Year	5th Year	IRR
	Small- Term (0-12 Months)							
1	Replacement of Pump-3 with energy efficient Pump	-1,50,000	4,08,625	4,08,625	4,08,625	4,08,625	4,08,625	272.03%
2	Improvement of Power Factor up to 0.999	-1,00,000	2,17,954	2,17,954	2,17,954	2,17,954	2,17,954	217.28%
3	Installation of Max Demand Controller	-1,50,000	2,56,880	2,56,880	2,56,880	2,56,880	2,56,880	170.06%
	Total	**-4,00,000**	**8,83,459**	**8,83,459**	**8,83,459**	**8,83,459**	**8,83,459**	**220.21%**
	Large Term (More Than 24 Months)							
4	Installation of Solar Water Heating system	-49,25,000	16,83,828	16,83,828	16,83,828	16,83,828	16,83,828	21.02%
5	Replacement of Conventional ceiling fan with 28 W BLDC Fan	-89,13,000	25,88,335	25,88,335	25,88,335	25,88,335	25,88,335	13.87%
	Total	**-1,38,38,000**	**42,72,163**	**42,72,163**	**42,72,163**	**42,72,163**	**42,72,163**	**16.46%**
	Grand Total	**-1,42,38,000**	**51,55,623**	**51,55,623**	**51,55,623**	**51,55,623**	**51,55,623**	**23.72%**

CHAPTER 16 GENERAL TIPS FOR ENERGY CONSERVATION IN DIFFERENT UTILITY SYSTEMS

16.1 ELECTRICITY

- Schedule your operations to maintain a high load factor
- Minimize maximum demand by tripping loads through a demand controller
- Use standby electric generation equipment for on-peak high load periods.
- Correct power factor to at least 0.99 under rated load conditions.
- Set transformer taps to optimum settings.
- Shut off unnecessary computers, printers, and copiers at night.

16.2 MOTORS

- Properly sized to the load for optimum efficiency.
- (High-efficiency motors offer 4 - 5% higher efficiency than standard motors)
- Check alignment.
- Provide proper ventilation
- (For every 10°C increase in motor operating temperature over the recommended peak, the motor life is estimated to be halved)
- Check for under-voltage and over-voltage conditions.
- Balance the three-phase power supply.
- (An Imbalanced voltage can reduce 3 - 5% in motor input power)
- Demand efficiency restoration after motor rewinding.

16.3 FANS

- Use smooth, well-rounded air inlet cones for fan air intakes.
- Avoid poor flow distribution at the fan inlet.
- Minimize fan inlet and outlet obstructions.
- Clean screens, filters, and fan blades regularly.
- Use aerofoil-shaped fan blades.
- Minimize fan speed.
- Use low-slip or flat belts.
- Check belt tension regularly.
- Eliminate variable pitch pulleys.
- Use variable speed drives for large variable fan loads.
- Use energy-efficient motors for continuous or near-continuous operation
- Eliminate leaks in ductwork.
- Minimize bends in ductwork

- Turn fans off when not needed.

16.4 PUMPS

- Operate pumping near the best efficiency point.
- Modify pumping to minimize throttling.
- Adapt to wide load variation with variable speed drives or sequenced control of smaller units.
- Stop running both pumps -- add an auto-start for an online spare or add a booster pump in the problem area.
- Use booster pumps for small loads requiring higher pressures.
- Increase fluid temperature differentials to reduce pumping rates.
- Repair seals and packing to minimize water waste.
- Balance the system to minimize flows and reduce pump power requirements.
- Use siphon effect to advantage: don't waste pumping head with a free-fall (gravity) return.

16.5 HVAC (HEATING / VENTILATION / AIR CONDITIONING)

- Tune up the HVAC control system.
- Consider installing a building automation system (BAS) or energy management system (EMS) or restoring an out-of-service one.
- Balance the system to minimize flows and reduce blower/fan/pump power requirements.
- Eliminate or reduce reheat whenever possible.
- Use appropriate HVAC thermostat setback.
- Use building thermal lag to minimize HVAC equipment operating time.
- In winter during unoccupied periods, allowing temperatures to fall as low as possible without freezing water lines or damaging stored materials.
- In summer during unoccupied periods, allowing temperatures to rise as high as possible without damaging stored materials.
- Improve control and utilization of outside air.
- Use air-to-air heat exchangers to reduce energy requirements for heating and cooling of outside air.
- Reduce HVAC system operating hours (e.g. -- night, weekend).
- Optimize ventilation.

- Ventilate only when necessary. To allow some areas to be shut down when unoccupied, install dedicated HVAC systems on continuous loads (e.g. -- computer rooms).
- Provide dedicated outside air supply to kitchens, cleaning rooms, combustion equipment, etc. to avoid excessive exhausting of conditioned air.
- Use evaporative cooling in dry climates.
- Clean HVAC unit coils periodically and comb mashed fins.
- Upgrade filter banks to reduce pressure drop and thus lower fan power requirements.
- Check HVAC filters on a schedule (at least monthly) and clean/change if appropriate.
- Check pneumatic control air compressors for proper operation, cycling, and maintenance.
- Isolate air-conditioned loading dock areas and cool storage areas using high-speed doors or clear PVC strip curtains.
- Install ceiling fans to minimize thermal stratification in high-bay areas.
- Relocate air diffusers to optimum heights in areas with high ceilings.
- Consider reducing ceiling heights.
- Eliminate obstructions in front of radiators, baseboard heaters, etc.
- Check reflectors on infrared heaters for cleanliness and proper beam direction.
- Use professionally designed industrial ventilation hoods for dust and vapor control.
- Use local infrared heat for personnel rather than heating the entire area.
- Use spot cooling and heating (e.g. -- use ceiling fans for personnel rather than cooling the entire area).
- Purchase only high-efficiency models for HVAC units.
- Put HVAC window units on timer control.
- Don't oversize cooling units. (Oversized units will "short-cycle" which results in poor humidity control.)
- Install multi-fueling capability and run with the cheapest fuel available at the time.
- Consider dedicated make-up air for exhaust hoods. (Why exhaust the air conditioning or heat if you don't need to?)
- Minimize HVAC fan speeds.

- Consider desiccant drying of outside air to reduce cooling requirements in humid climates.
- Seal leaky HVAC ductwork.
- Seal all leaks around the coils.
- Repair loose or damaged flexible connections (including those under air handling units).
- Eliminate simultaneous heating and cooling during seasonal transition periods.
- Zone HVAC air and water systems to minimize energy use.
- Inspect, clean, lubricate, and adjust damper blades and linkages.
- Establish an HVAC efficiency maintenance program. Start with an energy audit and follow-up, then make an HVAC efficiency-maintenance program a part of your continuous energy management program.

16.6 LIGHTING

- Reduce excessive illumination levels to standard levels using switching; de-lamping, etc. (Know the electrical effects before doing de-lamping.)
- Aggressively control lighting with clock timers, delay timers, photocells, and/or occupancy sensors.
- Install Energy Efficient alternatives to incandescent lighting, mercury vapor lighting, etc.
- Upgrade obsolete fluorescent systems, Compact fluorescents and electronic ballasts to Energy Efficient LED lights.
- Consider lowering the fixtures to enable using less of them.
- Consider daylighting, skylights, etc.
- Consider painting the walls a lighter color and using less lighting fixtures or lower wattages.
- Use task lighting and reduce background illumination.
- Re-evaluate exterior lighting strategy, type, and control. Control it aggressively.
- Change exit signs from incandescent to LED.

16.7 DG SETS

- Optimize loading
- Use waste heat to generate steam/hot water /power an absorption chiller or preheat process or utility feeds.
- Use jacket and head cooling water for process needs
- Clean air filters regularly

- Insulate exhaust pipes to reduce DG set room temperatures
- Use cheaper heavy fuel oil for capacities more than 1MW

16.8 BUILDINGS

- Seal exterior cracks/openings/gaps with caulk, gas kiting, weather tripping, etc.
- Consider new thermal doors, thermal windows, roofing insulation, etc.
- Install windbreaks near exterior doors.
- Replace single-pane glass with insulating glass.
- Consider covering some window and skylight areas with insulated wall panels inside the building.
- If visibility is not required but the light is required, consider replacing exterior windows with an insulated glass block.
- Consider tinted glass, reflective glass, coatings, awnings, overhangs, draperies, blinds, and shades for sunlit exterior windows.
- Use landscaping to your advantage.
- Add vestibules or revolving doors to primary exterior personnel doors.
- Consider automatic doors, air curtains, strip doors, etc. at high-traffic passages between conditioned and non-conditioned spaces. Use self-closing doors if possible.
- Use intermediate doors in stairways and vertical passages to minimize the building stack effect.
- Use dock seals at shipping and receiving doors.
- Bring cleaning personnel in during the working day or as soon after as possible to minimize lighting and HVAC costs.

16.9 WATER & WASTEWATER

- Recycle water, particularly for uses with less critical quality requirements.
- Recycle water, especially if sewer costs are based on water consumption.
- Balance closed systems to minimize flows and reduce pump power requirements.
- Eliminate once-through cooling with water.
- Use the least expensive type of water that will satisfy the requirement.
- Fix water leaks.
- Test for underground water leaks. (It's easy to do over a holiday shutdown.)
- Check water overflow pipes for proper operating level.
- Automate the blowdown to minimize it.
- Provide proper tools for washing down -- especially self-closing nozzles.

- Install efficient irrigation.
- Reduce flows at water sampling stations.
- Eliminate continuous overflow at water tanks.
- Promptly repair leaking toilets and faucets.
- Use water restrictors on faucets, showers, etc.
- Use self-closing type faucets in restrooms.
- Use the lowest possible hot water temperature.
- Do not use a heating system hot water boiler to provide service hot water during the cooling season -- install a smaller, more efficient system for the cooling season service hot water.
- If water must be heated electrically, consider accumulation in a large insulated storage tank to minimize heating at on-peak electric rates.
- Use multiple, distributed, small water heaters to minimize thermal losses in large piping systems.
- Use freeze protection valves rather than manual bleeding of lines.
- Consider leased and mobile water treatment systems, especially for deionized water.
- Seal sumps to prevent seepage inward from necessitating extra sump pump operation.
- Install pretreatment to reduce TOC and BOD surcharges.
- Verify the water meter readings. (You'd be amazed how long a meter reading can be estimated after the meter breaks or the meter pit fills with water)
- Verify the sewer flows if the sewer bills are based on them.

16.10 Miscellaneous

- Meter any unmetered utilities. Know what is normal efficient use. Track down causes of deviations.
- Shut down spare, idling, or unneeded equipment.
- Make sure that all of the utilities to redundant areas are turned off -- including utilities like compressed air and cooling water.
- Install automatic control to efficiently coordinate multiple air compressors, chillers, cooling tower cells, boilers, etc.
- Renegotiate utility contracts to reflect current loads and variations.
- Consider buying utilities from neighbors, particularly to handle peaks.

- Leased space often has low-bid inefficient equipment. Consider upgrades if your lease will continue for several more years.
- Adjust fluid temperatures within acceptable limits to minimize undesirable heat transfer in long pipelines.
- Minimize the use of flow bypasses and minimize bypass flow rates.
- Provide restriction orifices in purges (nitrogen, steam, etc.).
- Eliminate unnecessary flow measurement orifices.
- Consider alternatives to high-pressure drops across valves.
- Turn off the winter heat tracing that is on in summer.

CHAPTER 17 ENERGY MANAGEMENT STRATEGY

Energy Management should be seen as a continuous process. Strategies should be reviewed annually and revised as necessary. The key activities suggested have been outlined below:

17.1 IDENTIFY A STRATEGIC CORPORATE APPROACH

The starting point in energy management is to identify a strategic corporate approach to energy management. Clear accountability for energy usage needs to be established, appropriate financial and staffing resources must be allocated and reporting procedures initiated. An energy management program requires commitment from the whole organization to be successful. A record of Energy consumption must be kept and monitored on a regular basis, to optimize Energy consumption. For this, various meters may have to be installed.

17.2 DESIGNATE AN ENERGY MANAGER

An Energy Manager must be identified and time-bound responsibility must be given to him in getting to implement the findings of the Energy Audit points, which the Building / Establishment has planned to implement.

17.3 SET UP AN ENERGY MONITORING AND REPORTING SYSTEM

Successful energy management requires the establishment of a system to collect/ analyse and report energy costs and consumption patterns. This will enable an overview of energy use and its related costs, as well as facilitate the identification of savings that might otherwise not be detected. The system needs to record both historical and ongoing energy use, as well as cost information from billing data, and be capable of producing summary reports regularly. This information will provide how trends can be analysed and reviewed for corrective measures.

17.4 IMPLEMENT A STAFF AWARENESS AND TRAINING PROGRAM

A key ingredient to the success of an energy management program is maintaining a high level of awareness among staff. This can be achieved in several ways, including formal training, newsletters, posters, and publications. It is important to communicate program plans and case studies that demonstrate savings and to report results at least at 12-month intervals. Staff may need training from specialists on energy-saving practices and equipment.

Annexure-I

List of Energy-Efficient Equipment Suppliers

Particulars	Address with Phone No
Automatic Power Factor Controler	Treffer Power System Solution Private Limited, Gat No. 1538, Dehu Alandi Road Tal. Haveli, Chikhali, Pune - 411062, Dist. Pune, Maharashtra, Phone 08048962794
Automatic Power Factor Controler	A. D. Electric Co., 281/1/1 C, B.B. Ganguly Street, Near Poddar Court, Tiretti, Kolkata-700012, West Bengal, India, Phone 08047631944
Automatic Power Factor Controler	Vikash Enterprises, 37/A/H/2, Cossi Pore Road, Pugulia Petrol Pump, Satchasi Para, Kolkata-700002, West Bengal, India Phone 8046069158
Automatic Power Factor Controler	Indian Power Systems, Er 22, Inder Puri Near PVR Cinema, New Delhi-110012, Delhi, India, Phone 7942561179
Maximum Demand Controller	Crystal Controls, 601, 6Th, Elanza Vertex, B/H Armieda House Off S.G.Highway, Bodakdev, Sindhu Bhavan Road, Ahmedabad-380054, Gujarat, India, Phone 8043890355
Maximum Demand Controller	Electrical Controls & Switchgears, No. 984 - A - 1, Saraswati Marg, Near Jaidi Market, Mandawali, Fazalpur, Vinod Nagar North, New Delhi - 110092, Delhi, India, Phone 08047647360
Maximum Demand Controller	JMD Infra Power, B-4/153-A, Khasra No-19/8/1 19/8/2, Harsh Vihar, Gali No 6, Near Sunday Bazar, North East, Mandoli, Delhi - 110093, India, Phone 08046077065
Maximum Demand Controller	Metalink Engineers, 3636, Sector-32-A, Urban Estate, Chandigarh Road, Sector 32A, Ludhiana-141010, Punjab, India Phone 08048269253
BLDC Fan	Bhosle Engineers, E-203, Panchvati Nest, Chikhali Road, Keshav Nagar, Talwade, Pune - 412114, Dist. Pune, Maharashtra
	Phone 8046032058
BLDC Fan	Electronics, TOP Floor, 2067-68, Namdhari Building Chah Indara, Bhagirath Palace, Chandni Chowk, Delhi - 110006, Delhi Phone 8048977604
BLDC Fan	Indium Technologies LLP, Survey No. 272/1, Plot No.19, Indium Technologies LLP, Opp. Avadh CNG Station, Shaper, Behind Hariom Petrol Pump, Piplana, Rajkot-360024, Gujarat, India Phone 8048209482

Particulars	Address with Phone No
BLDC Fan	Jai Hanuman Enterprises, 25A, Chandney Chowk Street, Princep Street, Kolkata-700072, West Bengal, India Phone 8048209482
BLDC Fan	Digismart Electricals, First Floor, Plot no -51, Sector - 18, Rohini, Block -H, pocket -3, Rohini, New Delhi - 110085, Dist. New Delhi, Delhi, Phone 7942560890
Split AC/Window AC	Perfect Air Conditioning Trading Company, A- 269, Okhla Industrial Area, Phase- 1, Okhla Industrial Estate, New Delhi - 110020, Delhi, India Phone 8046043306
Split AC/Window AC	VV Enterprises, Plot No. 163, Sector- 59, (Huda) Faridabad, Ballabhgarh, Faridabad - 121003, Dist. Faridabad, Haryana Phone 8048954880
Split AC/Window AC	V.K Electronics, Ground Floor, Khasra No. 33/16, Guru Nanak Vihar Extn, Chander Vihar Main Road, Nilothi, West, New Delhi - 110041, Delhi, India Phone +91-7949224205
Split AC/Window AC	Wiscon Industries Limited, C-64, DDA Complex, Okhla Industrial Phase 1 Road, New Delhi C-64, DDA Complex, New Delhi - 110020, Dist. New Delhi, Delhi Phone 7948220704
Split AC/Window AC	Mahesh Traders, SCR 89, Phase 2 Ramdarbar, Ram Darbar, Chandigarh - 160002, Dist. Chandigarh, Chandigarh, Phone 8047683946
Split AC/Window AC	Leopardmob, 9/52, Krishnagiri Road, Nanawati Estate Pal Bagan Lane, Belurmath, Pal Bagan Lane, Belurmath, Howrah - 711202, Dist. Howrah, West Bengal Phone 8047829932
Pumps	Amrut Energy Private Limited, B-1308, 13th Floor, Empire Business Hub Science City Road, Sola, Ahmedabad - 380060, Dist. Ahmedabad, Gujarat, Phone 8048956627
Pumps	Kashinath Engineering Private Limited, A-29, Sector-10,, Sector 10, Noida - 201301, Dist. Gautam Buddha Nagar, Uttar Pradesh Phone 7942533288
Pumps	IB Monotaro Private Limited, Khasra No. 401 and 402, First Floor, Kaluram Market, M G Road, Ghitorni, Delhi, Ghitorni, New Delhi - 110030, Dist. New Delhi, Delhi, Phone 8047530688
Pumps	Jalsons Pump, Umiya Industrial Zone-2, Plot No-9, Opp Umiya Steel, Near Teraflow Pipe, Ribda, Kothariya, Gondal - 360311, Dist. Rajkot, Gujarat, Phone 8047655338

Particulars	Address with Phone No
Pumps	Jagdish Industrial Corporation, No. 13A, East Mohan Nagar, Industrial Area 100 Feet Road, Sudarshan Nagar, Amritsar - 143001, Dist. Amritsar, Punjab Phone 8048984380
Solar PV System	Thermosun Engineering Power India Pvt. Ltd. Head office: Malviya Nagar Main Market Delhi, Branch office: New Gagan Vihar, Nehru Road, Near Railway Station, Baraut U.P. M- 9999664087, 8077914097
Solar PV System	Surya Kiran Enterprise, Office No 8, 9, Second Floor, Sunrise Mall Vasundhara, Ghaziabad - 201012, Uttar Pradesh, India Phone 07942562189
Solar PV System	Bright Solar Energy Solutions, 6-248, Near Taluk Office, Udupi, Karkal - 574104, Karnataka, India Phone +91-7942833423
Solar PV System	Alien Energy, A-16/6, Om Sai Complex, Sahibabad Industrial Area Site 4 Sahibabad, Ghaziabad, Uttar Pradesh 201010 Phone +9199582 86100
Solar PV System	Solar.In, Suraj Apartment New Town, Action Area 1 Opposite Of DLF IT Park 1, Kolkata, India 700156 Phone +91 9438478290
Solar Water Heating System	Chandrlok International, No. 114, Daryaganj, Daryaganj, New Delhi - 110002, Dist. New Delhi, Delhi, Phone 8048987567
Solar Water Heating System	Hotter Solar Equipments, BH Bharat Steel Plot No 172 Gondal Highway Veraval, Piplana, Shaper - 360024, Dist. Rajkot, Gujarat, Phone 8046058403
Solar Water Heating System	Vaishnavi Solar, 525, Phonix Complex, Sayaji Gunj Makarpura Road, Manjalpur, Vadodara - 390005, Dist. Vadodara, Gujarat Phone 8046062184
Solar Water Heating System	Shree Ashoka Solar And Energy Pvt. Ltd., Plot No 3\B, 1st Floor, Buggewar Layout, T- Point, Ishwar Nagar, Nagpur - 440009, Dist. Nagpur, Maharashtra Phone 8046051062
Solar Water Heating System	Manish Enterprises, No. 2314, Behind Royal Challange Hotel Next To Kiran Educare, Near Korum Mall, Wagle Estate, Thane West, Thane - 400604, Dist. Thane, Maharashtra Phone 8046041483
Solar Water Heating System	Sudarshan Solar House, 546, New Shukrawari, Nagpur, Nagpur, Mominpura, Nagpur - 440002, Dist. Nagpur, Maharashtra, Phone 8048968037

Note: - The suppliers mentioned above are not the only ones or the best in the market. The management may contact other suppliers for competitive rates/ specifications.

Annexure-2

Recommended Lux Levels for different locations

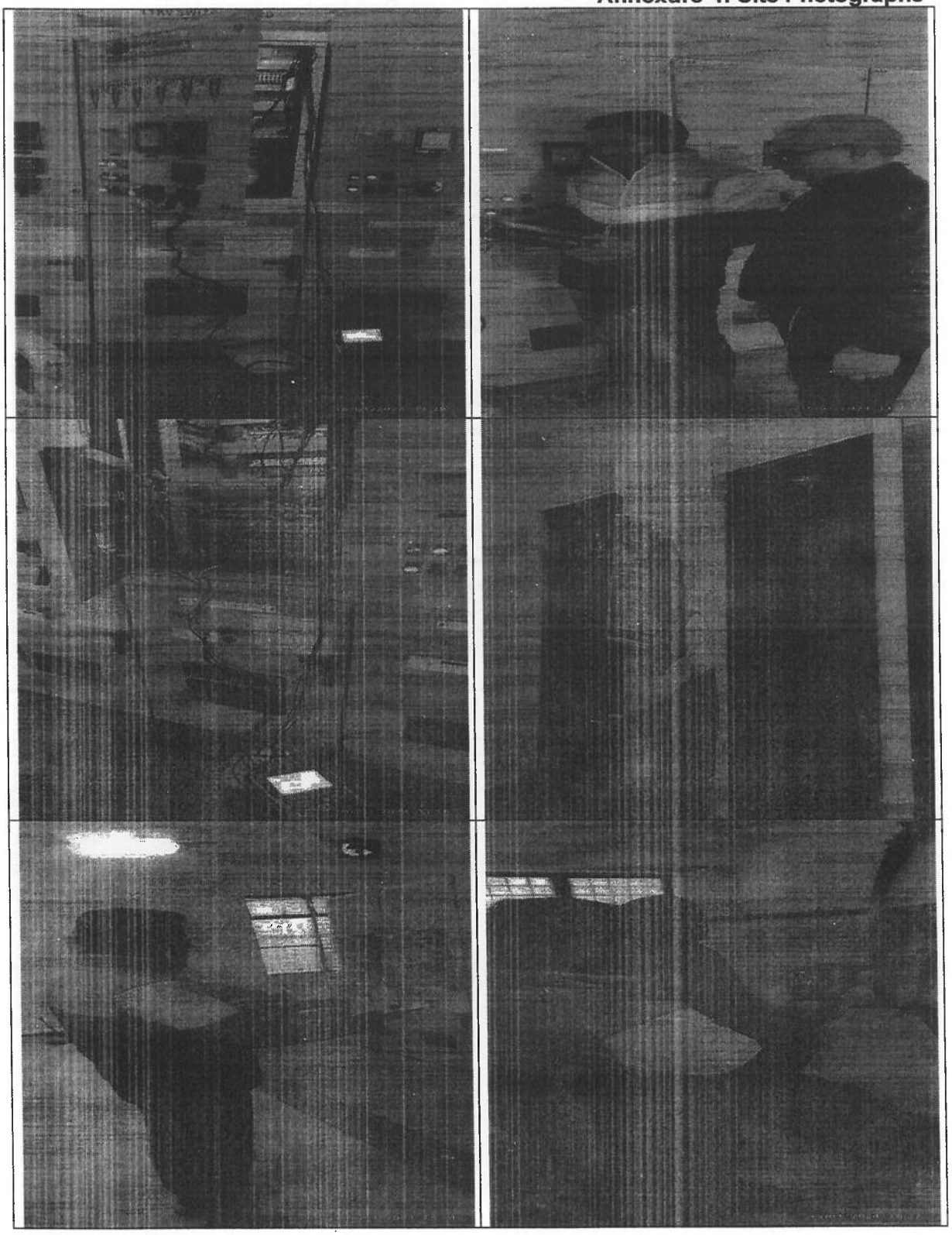
➢ **Entrance**	
Entrance halls, lobbies, waiting rooms	= 200
Inquiry Desks	= 500
Gate Houses	= 200
➢ **Circulation Areas**	
Lifts	= 100
Corridors, passageways, stairs	= 100
Escalators, revelators	= 150
➢ **Medicine & First Aid Centers**	
Consulting Rooms, Treatment Rooms	= 500
Rest Rooms	= 150
Medical Stores	= 150
➢ **Staff Rooms**	
Offices	= 300
Changing, locker and cleaners room, Cloakrooms, lavatories	= 100
Rest Rooms	= 150
➢ **Staff Restaurants**	
Canteens, Cafeterias, dining rooms, mess rooms	= 200
Survey, vegetable preparation, washing up area	= 300
Food preparation & cooking	= 500
Food stores, cellars	= 150
➢ **Communication**	
Switchboard rooms	= 300
Telephone, apparatus rooms	= 150
Telex room, post rooms	= 500
Reprographic room	= 300

Annexure-3

Sample Log Sheet for DG Performance Monitoring

A	B	C	D	E	F	G	H	I
Date	Time Start	Time Stop	Running Hours	Power Generated (Kwh)	Fuel Tank			Specific Power Consumption (Kwh/ ltr)(E/H)
					Initial Dip (mm)	Final Dip (mm)	Consumption (Lts)	

Annexure-4: Site Photographs



Annexure-5: Load Profile of the Building
Main Incomer HT Line

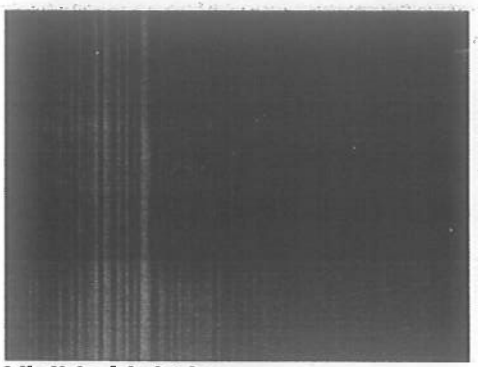
Date	Time	Freq.	Voltage (Volt)			Current (Amp)			Power Factor			Load (KW)			Total Load	V THD %			A THD %		
		(Hz)	R-Phase	Y-Phase	B-Phase	R-Phase	Y-Phase	B-Phase	R-Phase	Y-Phase	B-Phase	R-Phase	Y-Phase	B-Phase	(KW)	R-Phase	Y-Phase	B-Phase	R-Phase	Y-Phase	B-Phase
16-01-2024	11:25:25	49.99	6180	6200	6150	25.8	24	25.2	0.997	0.994	0.991	158.97	147.91	153.59	460.46	2	2.1	2.1	8.7	8	8.1
16-01-2024	11:25:30	49.98	6180	6200	6150	25.65	24	25.2	0.997	0.994	0.991	158.04	147.91	153.59	459.53	2.1	2.1	2.1	8.8	8.1	8.2
16-01-2024	11:25:35	49.97	6180	6200	6150	25.5	24.15	25.05	0.997	0.994	0.992	157.12	148.83	152.83	458.77	2.1	2.1	2.1	8.8	8.1	8.2
16-01-2024	11:25:40	49.95	6170	6200	6150	25.35	23.85	24.9	0.997	0.994	0.992	155.94	146.98	151.91	454.83	2.1	2.1	2.1	8.9	8.2	8.3
16-01-2024	11:25:45	49.95	6180	6190	6150	25.5	23.7	24.9	0.997	0.994	0.991	157.12	145.82	151.76	454.70	2.1	2.1	2.1	8.8	8.3	8.4
16-01-2024	11:25:50	49.95	6180	6190	6160	25.8	23.55	25.05	0.997	0.995	0.99	158.97	145.05	152.76	456.78	2.1	2.1	2.1	8.8	8.4	8.4
16-01-2024	11:25:55	49.94	6180	6190	6160	25.8	23.4	25.2	0.997	0.994	0.989	158.97	143.98	153.52	456.47	2.1	2.1	2.1	8.8	8.4	8.4
16-01-2024	11:26:00	49.94	6170	6190	6150	25.8	23.4	25.05	0.997	0.995	0.989	158.71	144.12	152.36	455.19	2.1	2.1	2.1	8.8	8.4	8.3
16-01-2024	11:26:05	49.94	6170	6190	6150	25.65	23.25	24.9	0.997	0.995	0.989	157.79	143.20	151.45	452.43	2.1	2.1	2.1	8.8	8.4	8.4
16-01-2024	11:26:10	49.94	6170	6190	6150	25.95	23.25	25.05	0.997	0.995	0.989	159.63	143.20	152.36	455.19	2.1	2.1	2.1	8.7	8.4	8.4
16-01-2024	11:26:15	49.94	6170	6190	6150	25.95	23.1	24.9	0.997	0.995	0.988	159.63	142.27	151.30	453.20	2.1	2.1	2.1	8.8	8.5	8.5
16-01-2024	11:26:20	49.94	6170	6190	6150	26.25	23.1	25.35	0.997	0.995	0.988	161.48	142.27	154.03	457.78	2.1	2.1	2	8.9	8.5	8.4
16-01-2024	11:26:25	49.93	6170	6180	6150	26.1	23.25	25.2	0.997	0.995	0.989	160.55	142.97	153.28	456.80	2.1	2.1	2	8.5	8.1	8.1
16-01-2024	11:26:30	49.94	6160	6190	6150	26.1	23.55	25.35	0.997	0.995	0.99	160.29	145.05	154.34	459.68	2	2.1	2	8.3	7.7	7.8
16-01-2024	11:26:35	49.95	6160	6190	6150	26.1	23.55	25.2	0.997	0.995	0.989	160.29	145.05	153.28	458.61	2	2.1	2	8.7	8.2	8.3
16-01-2024	11:26:40	49.94	6160	6190	6150	26.25	23.55	24.9	0.997	0.996	0.988	161.21	145.19	151.30	457.70	2	2.1	2	8.6	8.3	8.4
16-01-2024	11:26:45	49.94	6160	6190	6150	26.4	23.7	25.2	0.997	0.996	0.989	162.14	146.12	153.28	461.53	2	2.1	2	8.6	8.2	8.3
16-01-2024	11:26:50	49.94	6160	6190	6140	26.55	24	25.2	0.997	0.996	0.989	163.06	147.97	153.03	464.05	2	2.1	1.9	8.6	8.2	8.3
16-01-2024	11:26:55	49.94	6150	6190	6140	26.25	24	25.05	0.997	0.996	0.99	160.95	147.97	152.27	461.19	2	2.1	2	8.6	8.2	8.3
16-01-2024	11:27:00	49.94	6150	6190	6140	26.1	24	25.05	0.997	0.995	0.99	160.03	147.82	152.27	460.12	1.9	2.1	1.9	8.4	7.9	8
16-01-2024	11:27:05	49.93	6160	6190	6140	26.1	24	25.05	0.997	0.995	0.99	160.29	147.82	152.27	460.38	2	2.1	2	8.6	8.1	8.2
16-01-2024	11:27:10	49.93	6160	6190	6150	26.4	24.15	25.35	0.997	0.995	0.99	162.14	148.74	154.34	465.22	2	2.1	2	8.5	8.1	8.2
16-01-2024	11:27:15	49.93	6160	6190	6150	26.4	24	25.35	0.997	0.996	0.991	162.14	147.97	154.50	464.60	2	2.1	2	8.4	8	8.1
16-01-2024	11:27:20	49.93	6160	6190	6150	26.4	24	25.5	0.997	0.995	0.991	162.14	147.82	155.41	465.37	2	2.1	2	8.5	8.1	8.2
16-01-2024	11:27:25	49.93	6160	6190	6140	26.55	24	25.8	0.997	0.995	0.99	163.06	147.82	156.83	467.70	2	2.1	2	8.3	7.8	7.9
16-01-2024	11:27:30	49.93	6160	6190	6150	26.55	24	25.95	0.997	0.995	0.99	163.06	147.82	158.00	468.87	2	2	2	8.4	8	7.9
16-01-2024	11:27:35	49.93	6160	6190	6150	26.4	23.85	25.8	0.998	0.995	0.99	162.30	146.89	157.08	466.28	2	2	2	8.3	8	8
16-01-2024	11:27:40	49.93	6160	6190	6140	26.55	23.85	25.8	0.998	0.995	0.989	163.22	146.89	156.67	466.78	2	2.1	2	8.3	8.1	7.9
16-01-2024	11:27:45	49.93	6160	6190	6140	26.7	23.85	25.8	0.997	0.995	0.989	163.98	146.89	156.67	467.54	1.9	2	2	8.2	7.9	7.9
16-01-2024	11:27:50	49.94	6160	6190	6140	26.85	24	25.95	0.998	0.995	0.989	165.07	147.82	157.58	470.46	2	2.1	2	8	7.8	7.9
16-01-2024	11:27:55	49.94	6160	6190	6140	26.7	23.85	25.8	0.997	0.995	0.989	163.98	146.89	156.67	467.54	2	2.1	2	8.3	8.2	7.9

Date	Time	Freq.	Voltage (Volt)			Current (Amp)			Power Factor			Load (KW)			Total Load	V THD %			A THD %		
		(Hz)	R-Phase	Y-Phase	B-Phase	R-Phase	Y-Phase	B-Phase	R-Phase	Y-Phase	B-Phase	R-Phase	Y-Phase	B-Phase	(KW)	R-Phase	Y-Phase	B-Phase	R-Phase	Y-Phase	B-Phase
16-01-2024	11:28:00	49.94	6160	6190	6140	26.7	24	25.8	0.997	0.995	0.989	163.98	147.82	156.67	468.47	2	2.1	1.9	8.3	8.2	8
16-01-2024	11:28:05	49.94	6150	6180	6130	26.85	24.15	25.8	0.997	0.996	0.989	164.63	148.65	156.41	469.70	2	2.1	1.9	8.3	8.2	7.9
16-01-2024	11:28:10	49.94	6150	6180	6130	27	24.15	25.65	0.997	0.996	0.989	165.55	148.65	155.50	469.71	2	2.1	2	8.3	8.2	8
16-01-2024	11:28:15	49.94	6150	6180	6130	27	24	25.5	0.997	0.996	0.988	165.55	147.73	154.44	467.72	2	2.1	2	8.2	8.3	8
16-01-2024	11:28:20	49.95	6140	6170	6130	27	23.85	25.65	0.997	0.996	0.988	165.28	146.57	155.35	467.20	2	2.1	2	8.4	8.3	8
16-01-2024	11:28:25	49.95	6140	6170	6120	27.15	23.85	25.65	0.998	0.996	0.988	166.37	146.57	155.09	468.03	2	2.1	2	8.3	8.2	8
16-01-2024	11:28:30	49.95	6140	6180	6120	27	23.85	25.65	0.997	0.996	0.988	165.28	146.80	155.09	467.18	2	2.1	2	8.3	8.2	8.1
16-01-2024	11:28:35	49.95	6140	6170	6120	27.15	24.15	25.5	0.997	0.996	0.988	166.20	148.41	154.19	468.80	2	2.1	2	8.3	8.3	8
16-01-2024	11:28:40	49.95	6130	6170	6120	27.45	24.3	25.8	0.998	0.997	0.988	167.93	149.48	156.00	473.41	2	2.1	2.1	7.9	7.9	7.8
16-01-2024	11:28:45	49.95	6140	6170	6120	27.6	24.3	25.65	0.998	0.997	0.988	169.13	149.48	155.09	473.70	2	2.1	2	7.8	7.7	7.6
16-01-2024	11:28:50	49.95	6130	6170	6120	27.6	24.3	25.65	0.997	0.997	0.987	168.68	149.48	154.94	473.10	2	2.1	2	8.2	8.1	8
16-01-2024	11:28:55	49.95	6130	6170	6120	27.6	24.3	25.65	0.997	0.997	0.988	168.68	149.48	155.09	473.26	2	2.1	2	8.2	8.2	8
16-01-2024	11:29:00	49.95	6130	6170	6120	27.6	24.15	25.65	0.997	0.997	0.988	168.68	148.56	155.09	472.33	2	2.1	2	8.3	8.3	8.1
16-01-2024	11:29:05	49.95	6140	6170	6120	27.6	24.3	25.8	0.998	0.997	0.988	169.13	149.48	156.00	474.61	2	2.1	2	8.3	8.2	8
16-01-2024	11:29:10	49.95	6130	6170	6120	27.75	24.3	25.8	0.998	0.997	0.988	169.77	149.48	156.00	475.25	2	2.1	2	8.1	8.1	8
16-01-2024	11:29:15	49.95	6140	6170	6120	27.75	24	25.65	0.998	0.997	0.987	170.04	147.64	154.94	472.62	1.9	2.1	2	8	8.1	7.9
16-01-2024	11:29:20	49.94	6130	6170	6120	27.75	24.15	25.8	0.998	0.997	0.987	169.77	148.56	155.84	474.17	2	2.1	2	8.1	8.2	7.8
16-01-2024	11:29:25	49.94	6130	6170	6110	27.75	24	25.65	0.998	0.997	0.987	169.77	147.64	154.68	472.09	2	2.2	2	8	8.3	8
16-01-2024	11:29:30	49.94	6140	6170	6120	27.6	24	25.8	0.998	0.997	0.987	169.13	147.64	155.84	472.60	2	2.1	2	8.1	8.3	8
16-01-2024	11:29:35	49.94	6140	6170	6120	27.45	23.7	25.65	0.998	0.997	0.987	168.21	145.79	154.94	468.93	2	2.1	2	8	8.2	7.9
16-01-2024	11:29:40	49.94	6140	6160	6120	27.45	23.7	25.65	0.998	0.997	0.986	168.21	145.55	154.78	468.54	2	2.1	2	8	8.2	7.9
16-01-2024	11:29:45	49.95	6140	6160	6120	27.6	23.85	25.8	0.998	0.997	0.987	169.13	146.48	155.84	471.44	2	2.1	2	8.1	8.3	7.9
16-01-2024	11:29:50	49.95	6130	6170	6110	27.75	24	25.95	0.998	0.997	0.987	169.77	147.64	156.49	473.90	2	2.1	2	7.9	8.3	7.8
16-01-2024	11:29:55	49.95	6130	6170	6110	27.9	24	25.95	0.998	0.997	0.987	170.68	147.64	156.49	474.81	2	2.1	2	8.1	8.3	7.9
	Minimum	**49.93**	**6130**	**6160**	**6110**	**26.35**	**23.1**	**24.9**	**0.997**	**0.994**	**0.986**	**155.94**	**142.27**	**151.30**	**452.43**	**1.9**	**2**	**1.9**	**7.8**	**7.7**	**7.6**
	Maximum	**49.99**	**6180**	**6200**	**6160**	**27.9**	**24.3**	**25.95**	**0.998**	**0.997**	**0.992**	**170.68**	**149.48**	**158.00**	**475.25**	**2.1**	**2.2**	**2.1**	**8.9**	**8.5**	**8.5**
	Average	**49.94**	**6153.64**	**6182.55**	**6136.18**	**26.70**	**23.88**	**25.48**	**1.00**	**1.00**	**0.99**	**163.85**	**146.99**	**154.57**	**465.41**	**2.02**	**2.10**	**2.01**	**8.39**	**8.17**	**8.07**

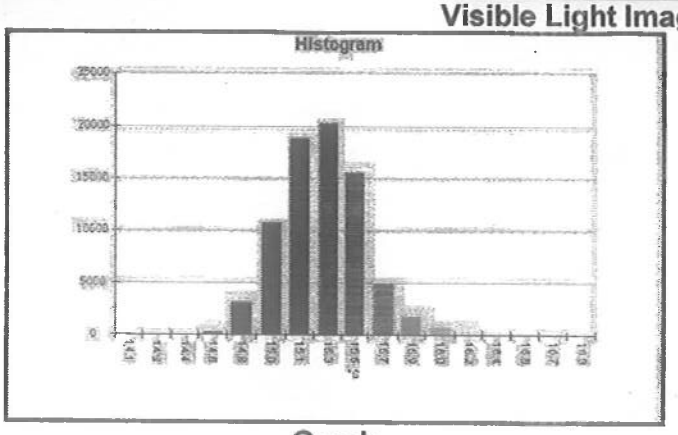
Annexure-A



New Admin Building Panel
1/16/2024 12:28:08 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	15.3°C
Image Range	14.5°C to 16.5°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:28:08 PM
Calibration Range	-20.0°C to 80.0°C

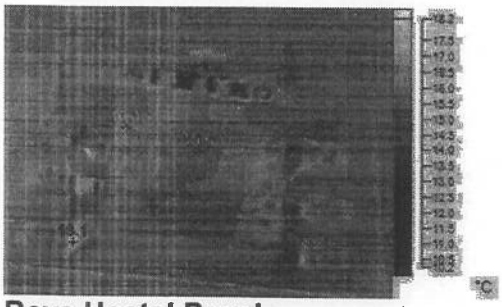
Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	15.4°C	0.95	21.7°C
Hot	16.5°C	0.95	21.7°C
Cold	14.5°C	0.95	21.7°C
P0	15.1°C	0.95	21.7°C

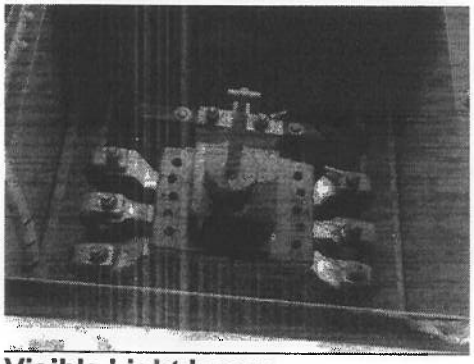
Remark: In the above thermogram the temperature varies from 14.5°C-16.5°C and Temperature difference (ΔT) is 2.0°C.

As per NFPA & NETA guidelines the about thermogram is classified **under check.**

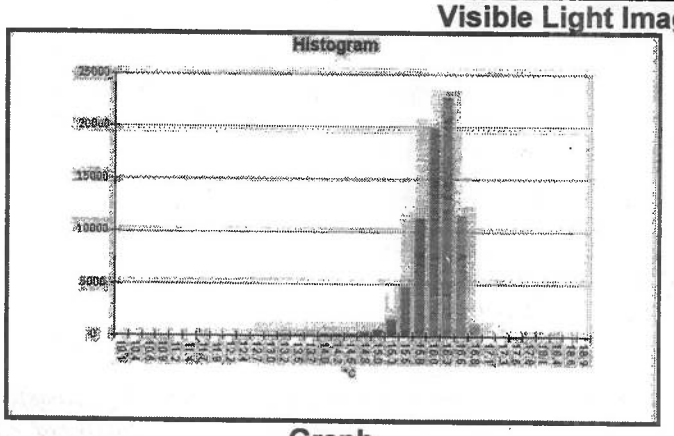
Check and Monitor: Delta T temperature is between 1°C and 4°C



Boys Hostel Panel
1/16/2024 4:12:32 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	16.0°C
Image Range	10.3°C to 18.1°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 4:12:32 PM
Calibration Range	-20.0°C to 80.0°C

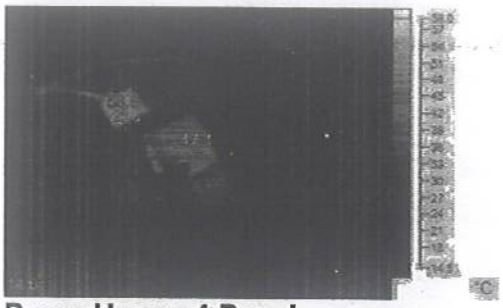
Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	15.6°C	0.95	21.7°C
Hot	18.1°C	0.95	21.7°C
Cold	10.3°C	0.95	21.7°C
P0	16.1°C	0.95	21.7°C

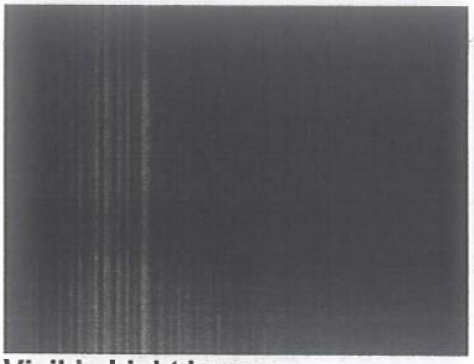
Remark: In the above thermogram the temperature varies from 10.3°C-18.1°C and Temperature difference (ΔT) is 7.8°C.

As per NFPA & NETA guidelines the about thermogram is classified under **Caution**. This may be due to lose connections or poor lug crimping and it is recommended to retighten the connection & recrimp the cable terminals property.

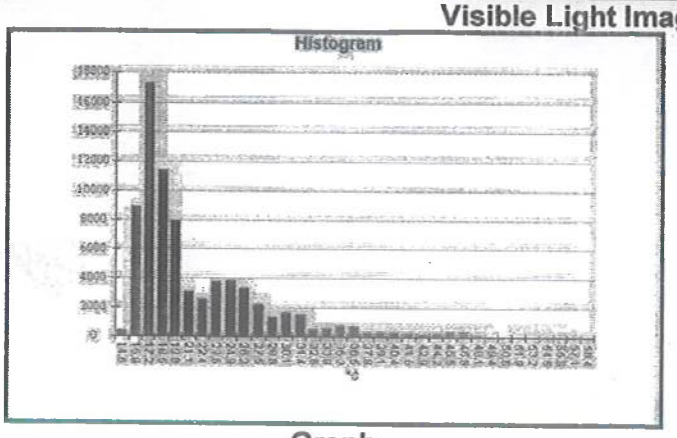
Caution: Delta T temperature is between 4°C to 15°C



Pump House-4 Panel
1/16/2024 4:19:51 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	22.1°C
Image Range	14.9°C to 58.6°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 4:19:51 PM
Calibration Range	-20.0°C to 80.0°C

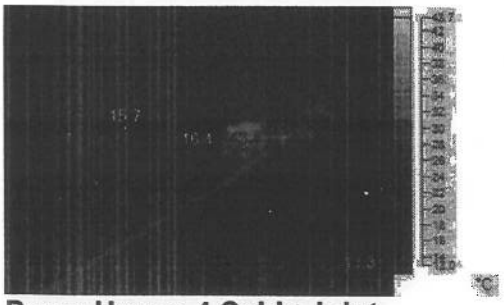
Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	47.1°C	0.95	21.7°C
Hot	58.6°C	0.95	21.7°C
Cold	14.9°C	0.95	21.7°C
P0	27.6°C	0.95	21.7°C

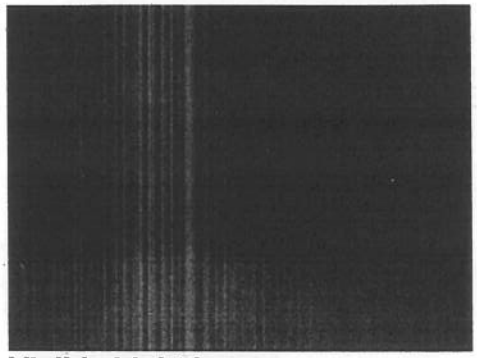
Remark: In the above thermogram the temperature varies from 14.9°C-58.6°C and Temperature difference (ΔT) is 37.7°C.

As per NFPA & NETA guidelines the about thermogram is classified under **Alarming**. This may be due to lose connections or poor lug crimping and it is recommended to retighten the connection & recrimp the cable terminals property

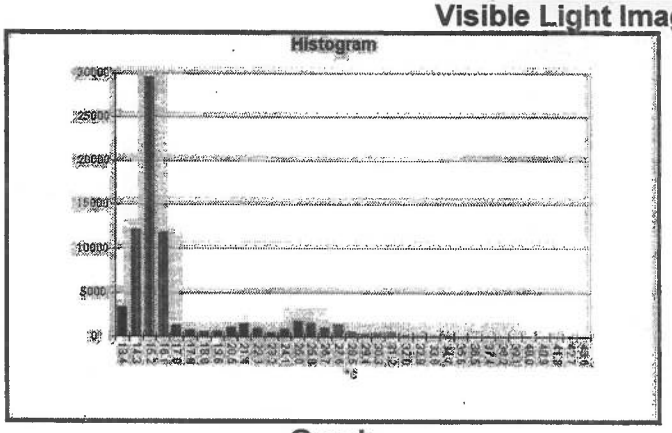
Alarming: Delta T temperature is more than 15°C



Pump House-4 Cable Joint
1/16/2024 4:20:12 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	17.6°C
Image Range	13.3°C to 43.4°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 4:20:12 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	16.4°C	0.95	21.7°C
Hot	43.4°C	0.95	21.7°C
Cold	13.3°C	0.95	21.7°C
P0	15.7°C	0.95	21.7°C

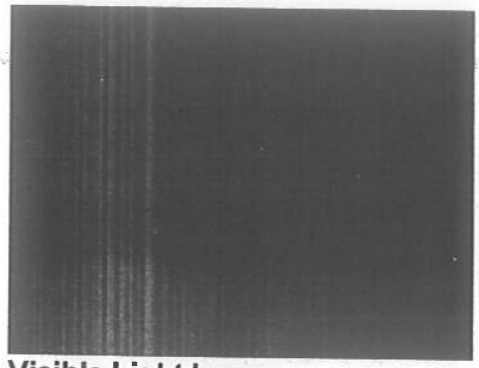
Remark: In the above thermogram the temperature varies from 13.3°C-43.4°C and Temperature difference (ΔT) is 30.1°C.

As per NFPA & NETA guidelines the about thermogram is classified under **Alarming**. This may be due to lose connections or poor lug crimping and it is recommended to retighten the connection & recrimp the cable terminals property

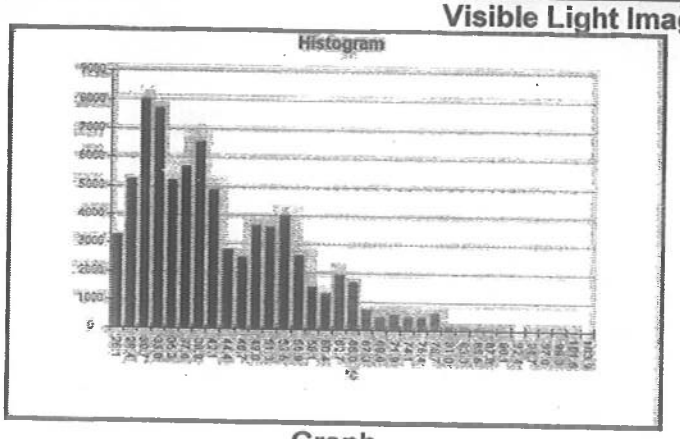
Alarming: Delta T temperature is more than 15°C



Pump House-4 Panel
1/16/2024 4:21:44 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	43.0°C
Image Range	25.2°C to 104.7°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 4:21:44 PM
Calibration Range	-20.0°C to 350.0°C

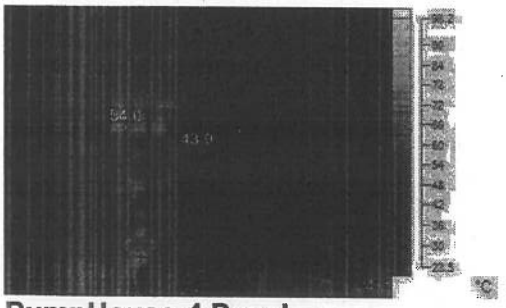
Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	57.3°C	0.95	21.7°C
Hot	104.7°C	0.95	21.7°C
Cold	25.2°C	0.95	21.7°C
P0	35.2°C	0.95	21.7°C

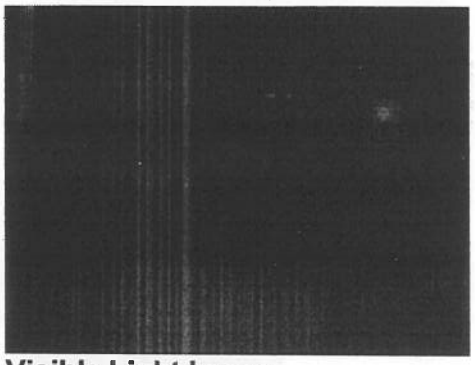
Remark: In the above thermogram the temperature varies from 25.2°C-104.7°C and Temperature difference (ΔT) is 79.5°C.

As per NFPA & NETA guidelines the about thermogram is classified under **Alarming**. This may be due to lose connections or poor lug crimping and it is recommended to retighten the connection & recrimp the cable terminals property

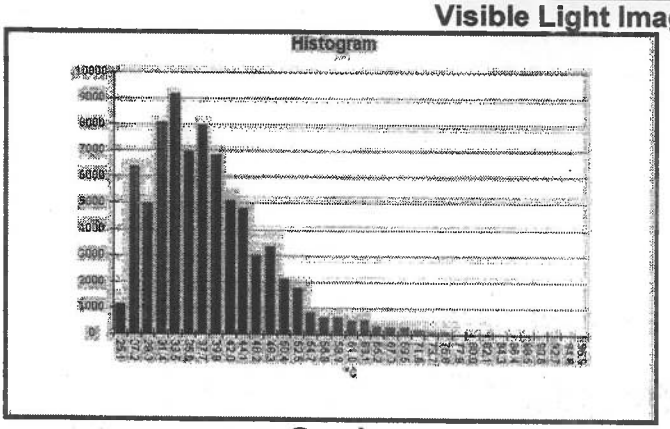
Alarming: Delta T temperature is more than 15°C



PumpHouse-4 Panel
1/16/2024 4:22:20 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	38.8°C
Image Range	24.2°C to 97.4°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 4:22:20 PM
Calibration Range	-20.0°C to 350.0°C

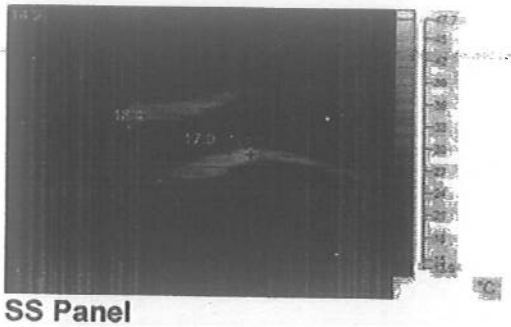
Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	43.0°C	0.95	21.7°C
Hot	97.4°C	0.95	21.7°C
Cold	24.2°C	0.95	21.7°C
P0	54.0°C	0.95	21.7°C

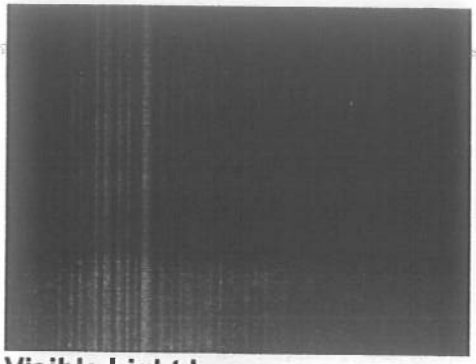
Remark: In the above thermogram the temperature varies from 24.2°C-97.4°C and Temperature difference (ΔT) is 73.2°C.

As per NFPA & NETA guidelines the about thermogram is classified under **Alarming**. This may be due to lose connections or poor lug crimping and it is recommended to retighten the connection & recrimp the cable terminals property

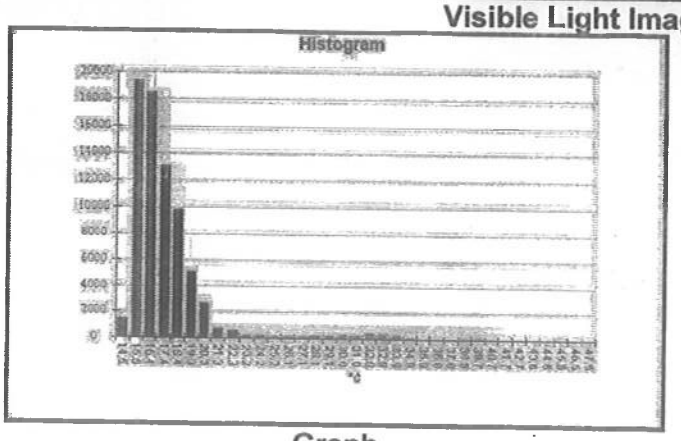
Alarming: Delta T temperature is more than 15°C



SS Panel
1/16/2024 4:31:27 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	18.0°C
Image Range	14.2°C to 47.3°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 4:31:27 PM
Calibration Range	-20.0°C to 80.0°C

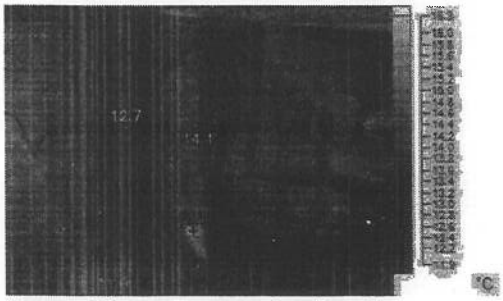
Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	17.0°C	0.95	21.7°C
Hot	47.3°C	0.95	21.7°C
Cold	14.2°C	0.95	21.7°C
P0	18.4°C	0.95	21.7°C

Remark: In the above thermogram the temperature varies from 14.2°C-47.3°C and Temperature difference (ΔT) is 33.1°C.

As per NFPA & NETA guidelines the about thermogram is classified under **Alarming**. This may be due to lose connections or poor lug crimping and it is recommended to retighten the connection & recrimp the cable terminals property

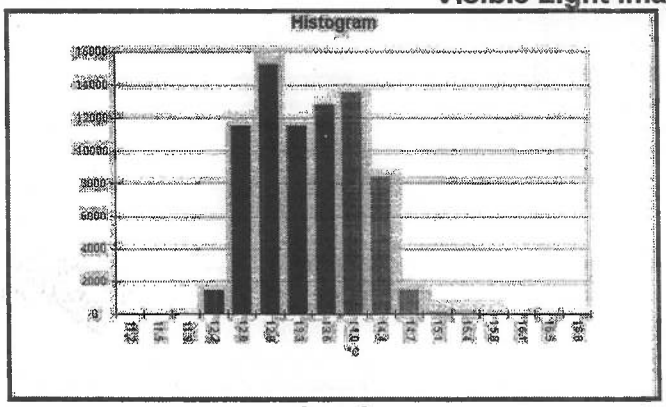
Alarming: Delta T temperature is more than 15°C



Panel Near Computer Dept
1/16/2024 12:52:07 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	13.4°C
Image Range	11.9°C to 16.3°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:52:07 PM
Calibration Range	-20.0°C to 80.0°C

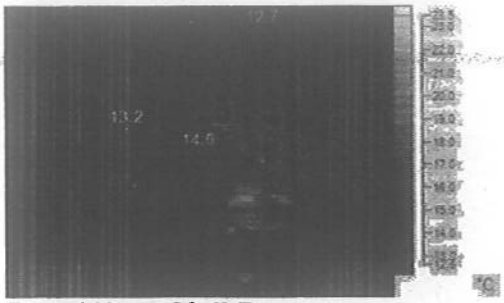
Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	14.1°C	0.95	21.7°C
Hot	16.3°C	0.95	21.7°C
Cold	11.9°C	0.95	21.7°C
P0	12.7°C	0.95	21.7°C

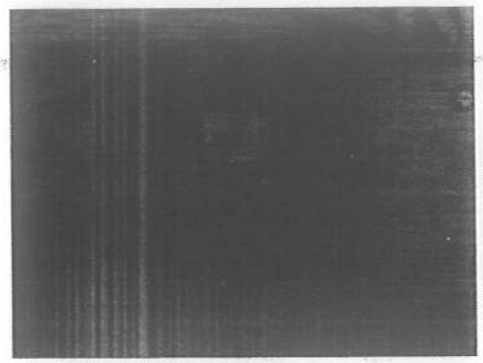
Remark: In the above thermogram the temperature varies from 11.9°C-16.3°C and Temperature difference (ΔT) is 4.4°C.

As per NFPA & NETA guidelines the about thermogram is classified under **Caution**. This may be due to lose connections or poor lug crimping and it is recommended to retighten the connection & recrimp the cable terminals property.

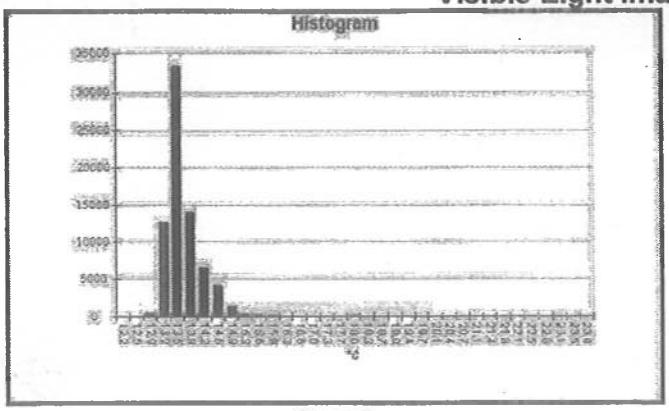
Caution: Delta T temperature is between 4°C to 15°C



Panel Near Civil Dept
1/16/2024 12:36:57 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	13.9°C
Image Range	12.7°C to 23.4°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:36:57 PM
Calibration Range	-20.0°C to 80.0°C

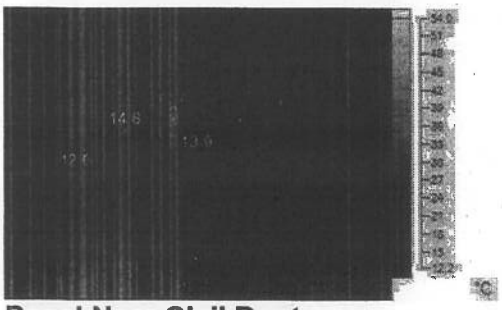
Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	14.6°C	0.95	21.7°C
Hot	23.4°C	0.95	21.7°C
Cold	12.7°C	0.95	21.7°C
P0	13.2°C	0.95	21.7°C

Remark: In the above thermogram the temperature varies from 12.7°C-23.4°C and Temperature difference (ΔT) is 10.7°C.

As per NFPA & NETA guidelines the about thermogram is classified under **Caution.** This may be due to lose connections or poor lug crimping and it is recommended to retighten the connection & recrimp the cable terminals property.

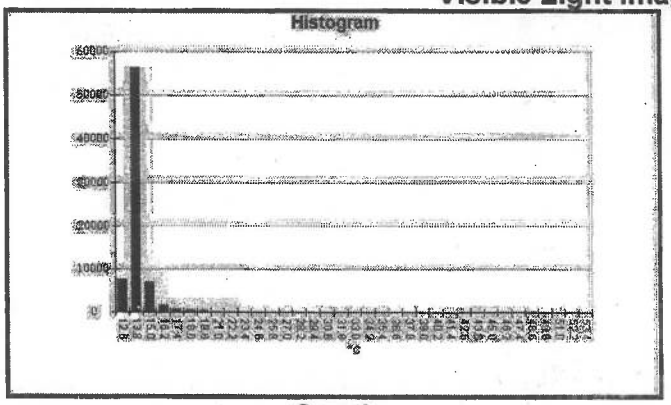
Caution: Delta T temperature is between 4°C to 15°C



Panel Near Civil Dept
1/16/2024 12:37:08 PM



Visible Light Image



Graph

Image Info

Background temperature	21.7°C
Emissivity	0.95
Average Temperature	14.2°C
Image Range	12.6°C to 53.6°C
Camera Model	TiS45
IR Sensor Size	160 x 120
Image Time	1/16/2024 12:37:08 PM
Calibration Range	-20.0°C to 80.0°C

Main Image Markers

Name	Temperature	Emissivity	Background
Centerpoint	13.9°C	0.95	21.7°C
Hot	53.6°C	0.95	21.7°C
Cold	12.6°C	0.95	21.7°C
P0	14.6°C	0.95	21.7°C

Remark: In the above thermogram the temperature varies from 12.6°C-53.6°C and Temperature difference (ΔT) is 41.0°C.

As per NFPA & NETA guidelines the about thermogram is classified under **Alarming**. This may be due to lose connections or poor lug crimping and it is recommended to retighten the connection & recrimp the cable terminals property

Alarming: Delta T temperature is more than 15°C