AN ANALYSIS OF THE EXISTING LITHIUM BROMIDE VAPOUR ABSORPTION CHILLER FOR ITS CAPACITY MATCHING AND EXPLORING THE POSSIBILITY OF REDUCING THE AIR CONDITIONING LOAD

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ABSTRACT

The aim of this project is to analyze the existing lithium bromide vapour absorption chiller for its capacity matching and exploring the possibility of reducing the air conditioning load. The project is carried out on a 45TR (Ton Rating) vapour absorption chillers installed by ABT info System Pvt. Ltd., for Air-conditioning its Data Centre. The Data Centre is located in Nachimuthu Polytechnic College campus, Pollachi. The complete project embraces following five steps. Calculating the cooling load assuming required conditions before the establishment of the data center and the project center. Checking for the matching of cooling load calculated with the machine capacity as it is fixed at 45 TR.

Re – calculating the cooling load of the established center considering the real conditions applied.

Re – checking for the matching of the cooling load calculated with the machine capacity as it is fixed at 45TR. Identifying the reasons for the deviation if any and suggesting methods for reducing the load and also for improving the operational efficiency of the VAM, AHU, and cooling tower. Financial gain on implementing the justified suggestions is also analyzed and reported.

INTRODUCTION

The total heat required to be removed from the space in order to bring it to the desired temperature by the air conditioning and refrigeration equipment is known as cooling load.The purpose of load estimation is to

1. Determine the size of the air conditioning and refrigeration equipment.
2. Run the equipment at optimum capacity and hence save on energy.
3. Explore the possibility of reducing the cooling load by providing required insulation for the conditioned room and also by reducing the sources of internal heat generation.
4. Install the equipment as per the manufactures specification so that his performance guaranty is met.

Components of cooling load.

The two main components of a cooling load imposed on an air conditioning plant operating during hot weather are as follows.

1. Sensible heat gain. When there is a direct addition of heat to the enclosed heat is to be removed during the process of summer air-conditioning. The sensible heat gain may occur due to any or all of the following sources of heat transfer.
a. The heat flowing into the building by conduction through exterior walls, floors, ceiling, doors and windows due to the temperature difference on their two sides.

b. The heat received from solar radiation. It consists of
I. The heat transmitted directly through glass of windows, ventilations or doors and
II. The heat absorbed by walls and roofs exposed to solar radiation and later on transferred to the room by conduction.
c. The heat conducted through interior partition from rooms in same building which are not conditioned.
d. The heat given off by light, motors, machinery, cooking operations computers, industrial processes etc.
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f. The heat carried by the infiltrated and/or ventilated air.
g. The heat gain through the walls of the ducts carrying conditioned air through unconditioned space in the building.
h. The heat gain from the fan work of the AHUs.

2. Latent heat gain. When there is an addition of water vapour to the air of enclosed space, a gain in latent heat is said to occur. This latent heat is to be removed during the process of summer air-conditioning. The latent heat gain may occur due to any or all of the following sources.
a. The heat gain due to moisture in the outside air entering by infiltration and / or ventilation.
b. The heat gain due to condensation of moisture from occupants.
c. The heat gain due to condensation of moisture from any process such as cooking foods inside the conditioned space.
d. The heat gain due to moisture passing directly into the conditioned space through permeable walls or partitions from the outside or from adjoining regions where the water vapour pressure is higher.
The total heat load to be removed by the air-conditioning and refrigeration equipment is the sum of sensible and latent heat loads.

In this project the cooling load calculated by the air-conditioning erection engineers required for the data center is taken as the reference. This load is compared with the existing capacity of the installed vapour absorption machine. The cooling load for the existing data center and project centers were calculated taking into account the real situations. This is compared with the available capacity of the machine and also with the reference value calculated by the erection engineers. The

reason for the deviation if any is analyzed and the implement able methods for reducing the load were suggested with cost benefits.

SYSTEM DESCRIPTION

The data center and the project centers cooling load were offset by the 45 TR capacity vapour absorption chillers machine. The various process elements of the air-conditioning system circuit are discussed.

System Components

1. Vapour absorption chiller

The chiller unit works on vapour absorption principle. Li.Br. is the absorbent and w ater is the water is the refrigerant.

In the evaporator shell of the unit the pressure maintained is 6mm of Hg and the refrigerant water evaporates at 4^0C. The specification of the installed chiller is

1. Make - Thermax
2. Capacity – 50 TR (15 KW) de-rated to 45TR.
3. Refrigerant – DM Water (Demineralised water)
4. Absorbent – Lithium Bromide (Li.Br) (450 kg)
5. Sources of heat to the Chiller generator – LPG

6. Fuel pressure – 0.2 bar
7. Chilled water inlet temperature 12^0C.
8. Chilled water outlet temperature 7^0C.
9. Mass flow rate of chilled water 8.4 Kg/sec
10. Volume flow rate of chilled water 30 m^3/hr (Density of water 1000 kg/m^3)
11. Volume flow rate of cooling water 50 m^3/hr

Air handling unit

It is a heat exchanger where the air to be conditioned is cooled when passed over the cooling coil through which chilled water from the chiller unit is flowing. For the data centre two types of air handling unit are used. Precision air handling unit which can control RH and the temperature with help of a micro processor are used for supplying the conditioned air to the serve farm of the data center. Two such AHUs are used with one acting as the stand by. Three the data center and two for the project centers). The specifications of the air handling units are.

Precision AHU

1. Make = TATA Liebert Microprocessor controlled Precision AHU (2 Nos.)
2. Tonnage - 11.5 Tons/machine
3. CFM - 8500 CFM at 20^0C indoor conditions
4. Entry Temperature of Chilled water – 8^0C
5. Filter - Micro – Vee level (Ensures air filtration up to 5 microns with 95% efficiency.

Non Precision AHU

1. Make - Blue star.
2. Capacity - 22500 kcal/Hr.
3. CFM - 3000CFM

Cooling Tower

Cooling tower is used for cooling the water carrying heat from the condenser of the vapour absorption chiller. In the condenser of the vapour absorption chiller the refrigent water released from the Li.Br. Absorbent at the generator and which is a high pressure vapour is condensed in the condenser by releasing heat to cold water from the cooling tower.

The specifications of the cooling tower are.

1. Make – Paharpour, FRP cooling tower.
2. Type – Horizontal air movement, induced draft, FRP Construction.
3. It cools 50 m3/hr of water from 35^0C to 30^0C at design wet bulb temperature of 27.2^0C

4. Pumps are used for circulating chilled water between the chiller and the AHUs and hot water between the chiller and the cooling tower.

DATA CENTRE AND PROJECT CENTRE DETAILS

All the inputs that are required for calculating the cooling load are measured and the conditions to be maintained in each farm are also noted.

Data Centre

Location : Pollachi
Outdoor Condition : 40deg C DBT, 27 deg C WBT

Data centre is located in the first floor of the building and its roof is an open terrace with weather proof tiles. Ground floor is meeting hall and office rooms.

Server Farm

Indoor Condition : 21 + -2 deg C DBT, 50% RH
No.of. People : 2+/-2
Room size : 10.98 x 6.95 x 4.5 (h) m
North partition : 10.98 x 4.5 m
East wall : 6.95 x 4.5 m
West wall : 6.95 x 4.5 m
South wall : 10.89 x 4.5 m
South window : 6 x 0.95 x 2.1 m
West window : 2 x 1.4 x 2.1
East window : 1x 1.4 x 2.1
Supply air : Bottom throws.
Return air : through the false ceiling.

Inside wall is finished with gypsum board of thickness 0.01 m with glass wool in between of thickness 0.07m.

Network Farm

Indoor Condition	:	21 + -2 deg C DBT, 50% RH
No. of. People	:	0
Room size	:	3.4 x 2.6 x 4.5 (h) m
North partition	:	2.6 x 4.5 m
East partition	:	2.6 x 4.5 m
West wall	:	2.6 x 4.5 m
South partition	:	2.6 x 4.5 m
West window	:	1 x 1.4 x 2.1
Supply air	:	Bottom throws.
Return air	:	through the false ceiling.

Server Admin and User Farm

Indoor Condition	:	24 + / -2 deg C DBT, 50%RH
No.of . People	:	18 +/-2
No.of system	:	18
Room size	:	10.98 x 8.8 x 4.5 (h) m
North partition	:	10.98 x 4.5 m
East wall	:	8.8 x 4.5 m
West wall	:	8.8 x 4.5 m
South partition	:	10.98 x 4.5 m
West window	:	3 x 1.4 x 2.1 m
Supply air	:	Throw from the ceiling through supply air duct
Return ai		

UPS ROOM

Indoor Condition	:	24 +/-2 deg C DBT. 50%RH
No.of . People	:	0
No.of . UPS	:	2
Room size	:	7.50 X 4.5 m
North wall	:	7.5 x 4.5 m
East partition	:	3.02 x 4.5 m
West wall	:	3.02 x 4.5 m
South partition	:	7.5 x 4.5 m
West window	:	1 x 1.4 x 2.1 m
Supply air	:	FCU
Return air	:	Through the false ceiling. The entire false ceiling area 4 x 9 m

is
Used as the plenum

Ahu Room (For the Data Center)

Indoor Condition : 24 +/-2 deg C DBT. 50%RH
No.of. People : 0
No.of . AHUS : 3 (2 precession AHU and 1 conventional AHU)
Room size : 13.3 X 2.55 X 4.5 (h) m
North partition : 2.55 X 4.5 m
East partition : 13.3 x 4.5 m
West wall : 13.3 x 4.5 m
South partition : 2.55 x 45 m
East window : 13.3 x 2m

Project Centre 1

Indoor Condition : 24 +/-2 deg C DBT. 50%RH
No. of. People : 40 +/-2
No.of . Systems : 40
Room size : 10.98 x 12.8 x 4.5 (h) m
North wall : 10.8 x 4.5 m
East partition : 12.8 x 4.5 m
West wall : 12.8 x 4.5 m
South partition : 10.8 x 4.5 m
West window : 4 x 1.4 x 2.1 m
Supply air : Throw from the ceiling trough supply air duct
Return air : Through the false ceiling. The entire false ceiling area is used as the plenum

Project Centre 2

Indoor Condition : 24 +/-2 deg C DBT. 50%RH
No.of. People : 30 +/-2
No.of. Systems : 30
Room size : 9.3 x 8.8 x 4.5 m
North wall : 8.8 x 4.5 m
East partition : 9.3 x 4.5 m
West wall : 9.3 x 4.5 m
South wall : 8.8 x 4.5 m
South window : 1 x 1.4 x 2.1 m
North window : 3 x 1.85 x 2.1 m
Supply air : Throw from the ceiling trough supply air duct
Return air : Through the false ceiling. The entire false ceiling area is used as the plenum

Project Centre 3 (Work In Progress)

Indoor Condition	:	24 +/-2 deg C DBT. 50%RH
No.of. People	:	30 +/-2
No.of. Systems	:	30
Room size	:	9.3 X 9.06 X 4.5 (h) m
North wall	:	9.06 x 4.5 m
East wall	:	9.3 x 4.5 m
West partition	:	9.3 x 4.5 m
South wall	:	9.06 x 4.5 m
South window	:	1 x 1.4 x 2.1 m
North window	:	3 x 1.85 x 2.1 m
Supply air	:	Throw from the ceiling trough supply air duct
Return air	:	Through the false ceiling. The entire false ceiling area is used as the plenum.

AHU Room (For the Project Centre)

Indoor Condition	:	24 +/-2 deg C DBT. 50%RH
No. of. People	:	0
No.of. AHUs	:	1 (conventional AHU)
Room size	:	3.4 x 3 x 4.5 (h) m
North wall	:	3.4 x 4.5 m
East partition	:	3 x 4.5 m
West wall	:	3 x 4.5 m
South wall	:	9.06 x 4.5 m
South partition	:	3.4 4.5 m
North window	:	1 x 1.85 x 2.1 m

COMMON INPUTS

1. The entire ceiling including the AHU rooms is insulated with thermo Cole of thickness 5 cm

2. The wall is covered with gypsum board of thickness 1 cm with glass wool in between of thickness 7 cm.

3. The partition wall is made of gypsum board of thickness 1 cm on both sides with glass wool in between of thickness 7 cm.

COOLING LOAD – ORIGINAL ESTIMATION

The original cooling load estimation done by the commercial air conditioning engineers for the data center and the project centers is presented below which may be compared with the actual cooling load estimation done during this project.

BASIS OF DESIGN

1. Server Farm and Network Farm

Location : Pollachi
Outdoor : 40^0C DBT and 27^0C WBT
Indoor conditions required : 21+/-20C DBT and 50+/-5 % RH
Area : 10.98 x 6.95 x 4.5 (h) m
Roof : Exposed RCC
Floor : Ground floor non air conditioned.
Occupancy : 04 Persons
Ventilation considered : 2 fresh air changes per hour
Power Load : 20 KW (Computer servers)
Lighting Load Considered : 1 Watts per SFT
The capacity of AC system required to offset the above loads 14.4 TR with 7950 CFM of air flow.

2. Server Admin and User Farm

Location : Pollachi
Outdoor : 400C DBT and 270C WBT
Indoor conditions required : 24+/-20C DBT and 50+/-5 % RH
Area : 10.98 x 8.8 x 4.5 (h) m
Roof : Exposed RCC roof and the AHU room roof
Floor : Ground floor non air conditioned
Occupancy : 15 Persons
Power Load : 5 KW (Computers & Servers).
Lighting Load Considered : 1 Watts per SFT
The capacity of AC system required to offset the above loads 13.6 TR with 5494 CFM of air flow.
Total load
Server room : 14.4 TR
User area : 13.6 TR 28.0 TR – A
VAM Capacity : 45.0 TR – B
Available capacity (B-A) : 17.0 TR
The 17TR available capacity is shared by the three project centers.

Machine capacity shared by the data center and project center

S.No	Location	Capacity TR
1.	Server farm and network farm	14.4
2.	Server admin and user farm	13.6
3.	Project centre 1	6.0
4.	Project centre 2	5.5

5.	Project centre 3	5.5
	Total	**45.0**

COOLING LOAD – ACTUAL ESTIMATION

The cooling load is calculated for the fully furnished and fully functional data center and two project centers and the third to be established project center.

Actual condition

The cooling load is calculated using the Microsoft Excel spread sheet, considering following assumptions and actual situations.

- The roof of the conditioned space and the AHU rooms are provided with under duct insulation with thermo Cole of thickness 5cm.
- The roof of the condition space and the AHU rooms is open terrace.
- The ground floor is non air conditioned.
- No provision for air change (ventilation).
- The coefficient of heat transfer for single pane glass takes into account the heat transfer due to radiation also.
- Though false ceiling is provided, actual wall height between the floor and the ceiling is considered for load calculation. This consideration will take into account the heat gain by the supply air duct and the return air above the entire false ceiling acting as the plenum.
- The AHU and UPS room loads are accounted for the total load as there is appreciable heat gain through the glass partitions provided for the these rooms.
- No anti room between each AHU room.
- The infiltration load is calculated based on the CMM of the AHU.
- The glass windows provided for the partition walls inside the conditioned space is neglected as there is no effect of radiation heat transfer and the temperature difference between the adjacent rooms are negligible.
- The heat from the AHU blower is neglected.
- For the project center 3 (work on the anvil) the inputs for the second project center are applied.

COMPARISION OF RESULTS

The results of the original cooling load estimation and that of the actual is compared, tabulated and interpreted.

Table Comparison of results

S.No.	Location	Original Capacity TR	Actual Capacity TR
1.	Server farm and network farm	14.4	16.0
2.	Server admin and user farm	13.6	5.0
3.	AHU room	-	2.5
4.	UPS room	-	2.0
5.	Project center 1	6.0	8.0
6.	Project center 2	5.5	6.8
7	Project center 3 (work on the anvil)	5.5	5.9
8	AHU room		0.5
9	Total	45.0	46.7

REASON FOR THE DEVIATION AND FEASIBLE SUGGESION FOR REDUCING THE LOAD

1. Server farm and net work farm: The reason for the increase in load is, the south and the west wall are exposed to the direct sun. The equipment load is also very high. The heat flow through the west windows is also appreciably high. The feasible solution to reduce the load may be provided an extra layer of insulation on the existing inside surface of the south and west wall or some form of white shades on the outside of the west windows.

2. Server admin and user farm: The actual capacity is less than 50% of the original calculated value. South partition is exposed to the server farm whose temperature is maintained at 21 deg C. The north partition is exposed to the project center 1 whose temperature is maintained at 24deg. C the result wall is exposed to the AHU room where the del T is only 2.5 deg C. Further reduction in load can be achieved by providing an extra layer of insulation on the existing inside surface of the west wall or some form of white shades on the outside of the west windows.

3. AHU room: The presence of load is because the AHU wall in the east is exposed to the direct sunlight. Also the entire length of the wall above is sill level is covered with single pane glass of size 13.3 x 2 m. The AHU room temperature is 26.5 deg. C instead of 21 deg and 24 deg respectively for the server farm AHU room and user farm AHU room. There is also no anti room in between the two AHU rooms. The load can be negated to significant extend by providing some form of insulation on the inside or outside of the glass partition on the eastern wal.

4. UPS room: This load is because the southern side wall is fully covered with single pane glass. The heat is also conducted from the rest three sides wall the ceiling as no any form of insulation is provided some form of insulation on the inside or outside of the glass window.

5. Project center 1, 2, 3 and the AHU room: The major contributor for this load is the human occupancy and the possibility of reducing it is less. The AHU room load can be reduced by providing wall and ceiling insulation.

CONCLUSION

The project has been completed, attempting to meet the objectives mentioned in the synopsis. Though Rs. 63229.00 incurred for reducing the load from 46.7 TR to 44.9 TR is exceptionally high, the machine is ensured of running within its rated capacity. This will improve not its own efficiency but also of the other components in the system and enhance their life term.

The option of material and method of insulation chosen, to reduce the load of each section of the data center and the project centers, is after complete on the outside of all the available glass window, providing thick white shades respect to reducing solar gain due to both radiation and conductance on the one hand and this alteration work do not in any way affect the routine business of the data center and the project center.

In data center and project center AHU room, 10cm thick, extra thermo cole insulation for the ceiling is provided apart from the white shades for its windows. This type of insulation though comparatively cheap, Rs70/f2, and effective in preventing heat gain into the conditioned space as its thermal conductivity is centers as it calls for cut open the architecturally fabricated false ceiling and also disturbing AC ducts, electric cables, fire prevention pipes, etc., that are laid between the true and the false ceiling.

REFERENCES

(1) Roy J. Dossart, Principles of Refrigeration, fourth edition pearson Education Asis PP 151 – 175.
(2) Wibert F.Stocker / Jerold W.Jones, Refrigeration and air conditioning. McGraw – Hill International editions PP 59-85
(3) Manohar Prasad. Refrigeration and air-conditioning. Second edition, New age international publishers, PP 236 – 65 & 408 – 420
(4) R.S. Khurmi & J.K. Gupta, Atext book of refrigeration and air – conditioning Eurasia publishing house (P) Ltd. PP 476 – 568.
(5) S.C Arora and S. Domkundwar. A course in refrigeration and air conditioning Danapat Rai and Co (P) Ltd., PP 19.1 – 19.53
(6) C.P. Arora Refrigeration and air conditioning. Second edition. Tata McGraw – Hill Publishing Company Ltd., PP 675 – 710.
(7) Aashrae guide and data book, Applications Volume, 1964.