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FINAL REPORT

COMPARISON OF CHILLER PERFORMANCE OF HYDROMX HEAT TRANSFER SOLUTION AT İÇERENKÖY-CARREFOUR AVM

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FOREWORD

Carrefour AVM a multi-national retailer operating throughout Europe has, under the management of Bainbridge Holding A.S who provides technical services to Carrefour AVM, completed a pilot project lasting one year where the Hydromx Energy Saving Solution was used in the chiller system of the Kozyatağı shopping centre.

The Kozyatağı Carrefour shopping centre, which attracts 15 million visitors per year, was opened in 1996 and comprises of 141 stores in 45,000m^2 of rentable space. Half of the total indoor area is utilized by Carrefour and is cooled by three Lennox Ecomax air-cooled chillers with 1560 k W nominal cooling capacity.

A contract was agreed between the building operation's & management company Bainbridge Holding (CEFIC) and the Hydromx Energy Saving Solution project partner Banes Kimya Ltd to conduct tests to compare and assess, data of the water and Hydromx solution in the chiller system at the Kozyatağı Carrefour shopping centre, through scientific methodology.

I was tasked with carrying out independent and objective the report on this matter. At the beginning, the assessment a technical examination of the cooling system was completed and the selection of the apparatus to obtain results from the project was presented and agreed. The chillers' instantaneous energy consumption values were tracked and logged using an "Energy Analyzer" and inside-outside environment temperature sensors installed with the chillers.

Through comparison of these instantaneous energy consumptions values changes to the chiller systems starting-stopping-restarting and active energy consumption was analysed in relation with the inside-outside environment temperatures. This identified some maintenance requirements with the chillers, and these were remedied before recording of healthy data that was to form the basis of the assessment. Using water only as the heat transfer-fluid data was obtained for the 127-day period between 27.07.2013 and 28.11.2013.

The application of Hydromx was carried out in two stages; the applications of Chillers 1 and 2 were completed in the first stage, and the application Chiller 3 was completed later. A total of 25.000 liters of fluid was in the system with 12.500 litres of Hydromx half the fluid.

On 28.11.2013, Hydromx solution with 50% volume ratio with respect to water was introduced to the system and recording of healthy data for Hydromx in Chiller 2 started as of 29.11 .2013.

Historical data for the energy consumption of the chillers using water in the 19-month period between December 2011 and July 2013 was provided by CEFIC management from their logging system. Data for the energy consumption of the chillers using the Hydromx Energy Saving Solution was also recorded during the assessment covering the 17-month period between July 2013 and December 2014 by the CEFIC management logging system.

Cooling Degree Day analysis – CDD[1] was used for the comparison and analysis of the energy consumption. Data from the nearest meteorology station in the region was used in order to calculate the CDD values with actual temperature values for each day.

[1] http://www.carbontrust.com/resources/guides/energy-efficiency/degree-days

EXECUTIVE SUMMARY

1. Cooling Degree Days analysis was performed using the equilibrium temperature T_{base}= 22C to normalize the energy consumption data of the preceding 3-years obtained from the logging system of CEFIC management. When comparing the normalized energy consumption in the 19-month when using water with the following 17-months period using Hydromx 22.5% energy saving was calculated.

2. During the summer months of high cooling demand in May to Oct 2014 using Hydromx a normalised energy consumption of 30% energy saving was calculated compared to water in the previous high-demand period of 2013.

3. When the Active Energy Consumption data of Chiller 2 for the hottest summer month of August 2013 (water) was compared with August 2014 (Hydromx) using Cooling Degree Days analysis, it was seen that Hydromx heat transfer solution provided a high level of 20% energy saving in comparison to water.

4. The Hydromx Energy Saving Solution did not have any corrosive or other unfavourable effects on the chiller systems during the 17 month application period and was noted in a statement from the CEFIC management.

5. When the system's installation purpose of performing cooling in a hot environment is considered, it was determined that Hydromx application provides maximum, minimum and average energy savings of 30%, 20% and 25% respectively.

6. The average energy saving of 25%, equates to a decrease in the carbon emissions generated by the system of approximately 157 tonnes of CO_2 for each year.

COMPREHENSIVE REPORT

1 INTRODUCTION

Heat-transfer fluids (anti-freeze such as ethylene glycol and propylene glycol) are used in various industrial applications to prevent the freezing and boiling of water in the system. This is achieved by mixing the heat-transfer fluid into the water, at specific volume ratios thereby decreasing the water's freezing point and increasing its boiling point. The reason for adding such fluids into the water is NOT to increase the heat convection and conductivity capability of the water and thus to increase the heat-transfer performance.

Contrarily, the heat-transfer efficiency of both glycol mixtures is lower than water's. These types of heat transfer fluids require higher or larger heat-transfer surface area in the heat exchangers in order to acquire the same level of heat efficiency as with water. Depending on the viscosity of the fluid, higher fluid flow rate, can increase the pressure loss, the energy consumption in the pumps and the wear of the devices.

By using heat transfer fluids, which have better heat transfer properties with respect to water, significant energy savings can be achieved in the system and energy costs can be decreased. Increasing the heat transfer properties of the heat transfer fluid can be possible through the improvement of physical and chemical properties of the fluid in question. It is possible to reach higher heat transfer coefficients in the heat exchangers, particularly by improving the thermal conductivity and/or specific heat value of the fluid.

Heating systems and casual heat gains from people, lights, machines, solar contribute to the heating within the building. When the heating system is turned off there will be an outdoor temperature when casual heat gains equal the building heat loss, and the cooling system will not need to run. This is the balance point temperature and is the building Base Temperature (T_{base}).

The T_{base} for each building is different due to the building thermal mass, insulation, heating and cooling systems and occupational use.

When outside temperatures are above this equilibrium point or Base Temperature (T_{base}) the cooling system runs to remove heat from the building. Each degree of outside temperature above T_{base} is a measure of the amount of cooling demand for the building. The summation of this cooling demand over 24 hours is known as a Cooling Degree Day and is the basis for an industry-standard method for analyzing the energy efficiency of buildings and their systems - Cooling Degree Days analysis method (CDD).

In this study, the "Total Energy Consumption Performance" of the Hydromx Energy Savings Solution used in the chillers in Kozyatağı Carrefour shopping centre was compared with water, and the energy-saving ratio was calculated using the Cooling Degree Days analysis method (CDD).

$CDD = (T_m - T_{base}) * d$

T_m = Daily mean temperature, T_{base} = equilibrium point, d= number of days.

In the method, if $Tm \leq T_{base}$ then CDD = 0 , because there is no cooling demand.

T_{base} = 22°C is used for the Kozyatağı Carrefour shopping centre as the normal value for the Marmara Region of Turkey.

CDD data is calculated from hourly temperature taken by reliable and robust meteorological stations can be obtained from the General Directorate of Meteorology and publicly available sources on the internet.

Data from Istanbul Sabiha International Airport was used as the source of reliable and well maintained temperature recordings for the CDD values, İn the analysis of Kozyatağı Carrefour energy consumption

2 ASSESSMENT OF THE MEASUREMENT RESULTS

2.1 Analysis of the Periodically Measured Total Active Power Consumption Values

In this section, the Active Energy kWh values consumed by each of the chiller groups during the test were compared on a periodic basis using the Energy Network Analyzer installed in the system. This took into account the outside environment and inside environment temperature changes. The effect of the cooling system's operation time, stop-start and entering into regime times on the active energy consumption was also taken into consideration.

Using the Energy Network Analyzer maintenance issues was identified and remedied, and the system was ready for performing measurements of water as of 27th July 2013. For water, healthy data that form the basis of assessment were obtained for the 127-day period between 27.07.2013 and 28.11.2013. On 28.11.2013, Hydromx solution with 50% volume ratio with respect to water was introduced to the system and recording of healthy data for Hydromx in Chiller 2 started as of 29.11.2013.

Since in Turkey's cooling becomes a major requirement between the months of May and October, the comparison values of water and Hydromx solution were taken into consideration between these months and the periods when the system was malfunctioning were excluded.

In the measurement of Chiller 1 and Chiller 3's active energy consumption values, when the measured values were completed during the period in question, it was seen that they were not fit for assessment due to a system malfunction encountered in this chiller group. Therefore, the data from May-October, 2013 was not taken into consideration for Chiller 1 & 3. For Chiller 2, the data from the 27.07.2013 - 31.08.2013, period was compared for water and data from the 24.07.2014 - 07.08.2014 period was compared for Hydromx solution.

2.2 Period values of Chiller 2

In Table 2.1, the active energy consumption values for water and Hydromx solution were compared by taking Cooling Degree Days into account, in other words, performing normalization. In this comparison the equilibrium temperature was taken as T_{base} = 22°C and the average of the period's outdoor environment temperatures was taken as basis for the outdoor temperature.

As a result of the normalization procedure, the active consumption values for water and Hydromx solution were compared in terms of kWh/CDD. A high-energy saving level of 20.02% is observed as a result of this comparison. During the 36-day period when water was used as the heat-transfer fluid, 73761.2 kWh was used, which required 482.89 kWh/CDD energy for each CDD (Cooling Degree Day). During the 15-day period when Hydromx Energy Saving solution was used as the heat-transfer fluid, this dropped to 386.18 kWh/CDD and 28046.9 kWh was used. When the increase in the total cooling requirement and the effect of the outside environment temperatures was taken into consideration, the total energy-saving amount was calculated to be **20.02%.**

START DATE AND TIME		END DATE AND TIME	Measurement Period (Days)	Active Energy Received kWh	kWh /DAY	CDD 22°C	kWh /CDD 22° C	AVERAGE OUTSIDE ENV. TEMP.	AVERAGE INSIDE ENV. TEMP
FOR WATER									
27.07.2013	00:00	31.08.2013 23:00	36	73.361.2	2037.81	151.92	482.89	26.22	24.96
FOR HYDROMX									
24.07.2014	00:00	31.07.2014 23:00	8	15.005.20	1,875.65	46.24	324.50	27.78	26.00
01.08.2014	00:00	07.08.2014 23:00	7	13.041.70	1.863.10	29.12	447.86	26.16	27.21
					Average		386.18	26.97	26.60
					Savings		**20.02%**		

Table 2.1

Comparison of Active Energy Consumption Values for Water and Hydromx as Cooling Degree Day as kWh/CDD for T_{base}*=22°C*

2.3 Comparison of Energy Consumption Values as Cooling Degree Days according to Years

The comparison results for different equilibrium temperatures of T_{base}=18°C, 20 °c and 22°C are given in Table 2.2, Table 2.3 and Table 2.4.

During the 19-month long first period when water was used as the heat-transfer fluid, 2.149 mWh requiring 1655.96 kWh/CDD was used as can be seen in Table 2.3 for each CDD (Cooling Degree Day). During the 17-month second period after the use of Hydromx Energy Saving Solution, this amount decreased to 1914 mWh and was realized as 1290.78 kWh/CDD. According to Table 2.2, Table 2.3 and Table 2.4, when comparison was made through normalization in accordance with Cooling Degree Day (CDD) analysis method, it is seen that approximately 22% savings were achieved.

Heat Transfer Fluid	Start	End	Duration (months)	Cooling Degree Day (CDD)	Chiller Energy (kWh)	kWh /CDD	Saving (%)
Water	Dec'11	Jul '13	19	1298	2, 149,440	1655.96	
Hydromx	Jul'13	Nov '14	17	1483	1 ,914,240	1290.78	**22.05%**

Table 2.2
Comparison of Periodical Consumption Values for Water and Hydromx Solution for T_{base}= 18°C, as Cooling Degree Days in terms of k Wh/CDD

Heat Transfer Fluid	Start	End	Duration (months)	Cooling Degree Day (CDD)	Chiller Energy (kWh)	kWh /CDD	Saving (%)
Water	Dec'11	Jul '13	19	887	2, 149,440	2423.26	
Hydromx	Jul'13	Nov '14	1 7	1 023	1 ,914,240	1871.20	**22 .78%**

Table 2.3
Comparison of Periodical Consumption Values for Water and Hydromx Solution for T_{base}=20 °C, as Cooling Degree Days in terms of kWh/CDD

Heat Transfer Fluid	Start	End	Duration (months)	Cooling Degree Day (CDD)	Chiller Energy (kWh)	kWh /CDD	Saving (%)
Water	Dec'11	Jul '13	19	555	2, 149,.440	3872.86	
Hydromx	Jul'13	Nov '14	17	638	1 ,914,240	3000.38	**22.53%**

Table 2.4
Comparison of Periodical Consumption Values for Water and Hydromx Solution for T_{base}= 22°C, as Cooling Degree Days in terms of kWh/CDD

Cooling becomes a major requirement in the Marmara Region in Turkey between the months of May and October. Hydromx was installed in July 2013 and therefore a comparison was made in Table 2.6, using a T_{base}= 22 °C equilibrium temperature, of the 2 month period between May and June 2013 as basis for water and the period between May 2014 and October 2014 as basis for Hydromx as the heat transfer solution.

When Table 2.5 is examined, it is seen that while there is an energy requirement of 3330 kWh/CDD for water in 2013, this value decreases to 2334 k Wh/CDD using Hydromx heat transfer solution in 2014. It is calculated that a 30% saving was achieved during the period considered. This result supports the analysis in Table 2.5.

Heat Transfer Fluid	Start	End	Duration (months)	Cooling Degree Day (CDD)	Chiller Energy (kWh)	kWh /CDD	Saving (%)
Water	May '13	Jun '13	2	88	293,040	3330	
Hydromx	May '14	Oct '14	6	348	812,400	2334	30%

Table 2.5
Comparison of Periodical Consumption Values for Water and Hydromx Solution for T_{base}= 22°C, as Cooling Degree Days in terms of kWh/CDD

3 CONCLUSION

In conclusion, as a result of the Hydromx application carried out at the Carrefour – Kozyatağı ACM unit during a period over one year and the comparison of this application with using water as a heat-transfer fluid, the following general assessments were made, and a significant energy-saving performance was observed when using Hydromx.

In the Cooling Degree Days calculations, it was observed that only air circulation was carried out and not cooling during the winter months since the energy data of the chiller system in the building also included the pump circulation in the winter months. When the CEFIC management's month-based annual energy consumption data for water were taken into consideration, and the water data of a 15-month period which includes the winter months was compared with the 6 month data corresponding to the summer period (taking T_{base}= 22°C), the monthly savings during the summer when the cooling demand is higher was calculated to be at a level of 30%.

Furthermore, when the Cooling Degree Days analysis was performed by taking the equilibrium temperature for the energy consumption data of the preceding three years obtained from the logging system of CEFIC management, approximately 22.5% energy saving was calculated for the 19-17-month long term analysis, from the comparison of the period during which water was used and the period during which Hydromx heat-transfer solution.

For water and Hydromx, when the Active Energy Consumption data for August, which is the hottest month during the summer period were normalized following Cooling Degree Days analysis and compared; it was seen that Hydromx heat transfer solution provided a high level of 20% energy saving in comparison to water.

That the Hydromx did not have any corrosive or other non favourable effects on the chiller systems during the 19-month application period was noted from the statement of CEFIC management.

When the system's installation purpose of performing cooling in a hot environment is considered, it was determined that Hydromx application provides maximum, minimum and average energy savings of 30%, 20% and 25% respectively.

According to this saving average, it follows that the carbon emission from the system will decrease by approximately 157 tons of CO_2 per year.

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